Does Futures Trading Destabilize Cash Prices? Evidence for U.S. Live Beef Cattle

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INTRODUCTION

Futures trading in beef cattle has drawn varying degrees of criticism from both cash market participants and hedgers. Since 1981, opponents of futures trading have actively sought federal legislative intervention ranging from greater regulation of the cattle futures market to its outright abolition. Although criticisms vary in what economists might accept as reasonable or plausible, they generally contend that futures trading in cattle causes instability of cattle cash prices by sending false signals about market forces and causing severe misallocation of resources in the cattle feeding industry.[1] Some authors have questioned the extent to which futures markets in live animals represent an institutional alternative for provision of accurate cash price forecasts, (see Martin and Garcia (1981)). These dual concerns have been voiced in a variety of commodity and financial markets and most recently in the context of program trading of stock index futures and corporate stock portfolios. This article tests hypotheses that are consistent with critics' allegations that futures trading destabilizes cash prices for live cattle.

In contrast to critic's allegations, economic theory suggests that if cash markets are perfectly competitive, the introduction of an informationally efficient futures market would introduce no new information into the cash price formation process leaving the cash price performance undisturbed. The contribution of futures trading is argued to be the facilitation of the price formation process through centralization of trading, reduction in transaction and information costs through enhanced public availability of information concerning future price levels, and risk transfer, (see Samuelson (1965), Telser and Higinbotham (1977), or Bray (1981).

[1]Historically these criticisms have been most virulent for nonstorable or semi-perishable commodities such as onions (late 1950's), potatoes (early 1960's), and beef cattle (early 1980's). Numerous Congressional Hearings have documented these charges; see an account in Working (1970). Helmuth (1981) alleged that collusive trading practices among large cattle traders were responsible for there being only two hours throughout 1981 during which the typical farmer-feeder could hedge in a profit. Palme and Graham (1981) strongly questioned Helmuth's analysis. Pluhar, Shafer, and Sporleder (1985) re-examined Helmuth's analysis and found evidence to support his conclusions.

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Nonetheless, futures prices can play an important role in the cash market decisions such as production, marketing, or storage decisions of farm products (Gardner (1976), Peck (1976), Danthine (1977), Turnovsky (1979 and 1983), and Kawai (1983)). Perhaps for this reason the neutrality of futures trading effects on cash price performance has been repeatedly reconsidered. Tomek and Gray (1970), Powers (1970), and Cox (1976) have argued that informationally efficient futures markets will stabilize prices in associated cash markets, in part due to their effects on the efficiency of the synthesis of information. In contrast, Stein recently argued that futures trading introduces new speculators to cash markets. Stein (1987) demonstrated that if information is asymmetrically distributed, the information content of cash prices changes and cash prices may be destabilized (variance increased) and welfare reduced.

Empirical evidence concerning the impacts of futures trading on cash price performance characteristics is mixed. Several studies of cash price performance before and after the institution of futures trading have found evidence of greater stability after futures trading or no effect (see Working (1970), Gray (1963), Powers (1970), Taylor and Leuthold (1974), Cox (1976), and Froewiss (1978)). Others have found contrary or inconclusive evidence (see Tomek (1979–80) and Figlewski (1981)). Further, evidence has been found that suggests that futures markets are not informationally efficient, implying they would not be expected to stabilize cash prices (see Mann and Heifner (1976), Leuthold and Hartmann (1979), Martin and Garcia (1981), and Rendleman and Carabini (1979)).

Past studies have addressed the question of futures trading effects on cash price performance through analysis of various measures of the variation of prices before and after futures trading. While this approach can establish changes in sample variation of prices, a comparison of sample estimates of variance fails, in general, to provide a basis for inferring whether the underlying population stochastic processes generating the samples have changed. Further, changes in variance measures fail to explain the origins of the observed changes. Results are consistent with, but do not imply that, futures trading is the cause of the observed change. Importantly, variation based measures leave open the more central question of whether cash prices are dynamically stable in the presence of futures trading.

The variance of a stochastic process is a static concept, only indicating the dispersion of observations about the population mean at a point in time. By definition, variance for a stochastic process is likely to change over time. Of greater interest than the static concept of variance is the dynamic concept of stability which indicates whether a shock to a stochastic process can be expected to result in a time series of sample observations which diverges from the original process, or converges back to it. Dynamically stable stochastic processes adjust to shock such that after the adjustment they are characterized by the same asymptotic distribution as they were before the shock. While this implies that population variance does not change, change in sample variances may be observed and would be expected. After a shock, the observed price series remains a sample (realization) of the same process. Alternatively, where a time series is dynamically unstable, the population variance could change from a shock to the process. For this reason, differing sample estimates of variance can not be used to test for a change in the population stochastic process unless that process is first inferred to be stable.

In this article, two aspects of the stability effect of futures trading on cash prices are examined for the case of cattle: (1) whether the information content of cash prices is affected by futures trading, and (2) whether cash prices are dynamically stable in the presence of futures trading. The central hypothesis tested is that in the presence of futures trading, portfolio trading introduces new information to the determination of cash prices for commodities which would be unrelated in cash markets in the absence of futures trading. This new information is external to the fundamentals of their respective cash markets. By introducing external information, the possibility is introduced of destabilization of cash prices under futures trading. The hypothesis is developed in Section II and provides a basis for an empirical test of the role of external information in the determination of cattle cash and future prices. The empirical approach is outlined in Section III and results for the case of cattle are reported in Section IV. Conclusions are drawn in Section V.

AN OVERVIEW OF A HYPOTHETICAL CASE CONSISTENT WITH CRITICS ALLEGATIONS

Modelling of futures and cash trading which is consistent with observed trader and market characteristics would call for a general equilibrium framework which includes a broad spectrum of markets for commodities and assets which are linked by jointness in production, nonseparable consumption demands, or nonseparability in trading. As suggested by past literature, the perishability and storage feasibility of the commodity, the role of risk-response, and the way in which information is synthesized by traders are important aspects of the market that need to be incorporated in a model. Specification of such a model is restricted by the limited extent of our understanding of the structure and complexity of the price determination process. Rather than use such a model, a taxonomical approach is adopted here to provide motivation for an empirical approach. The objective of the approach is to develop a null hypothesis which is both plausible from the standpoint of economic theory and consistent with the view of critics of futures markets that futures trading changes the information content of cash prices and through this mechanism destabilizes cash prices.

Define *related commodities* as those which are horizontally or vertically linked in their cash markets even without futures trading. Because of the interrelatedness of their cash markets, their cash market fundamental information sets are overlapping. Define *unrelated commodities* as those which would not be linked in cash markets in the absence of futures. Although it might be argued that all prices are interrelated, of concern here is the extent of empirical relatedness. For example, cattle and corn or cattle and hogs could be defined as related pairs due to vertical linkages resulting from derived demand for feed and horizontal linkages due to demand substitution. Conversely, cattle and plywood exemplify a pair which would have no strong direct relation in cash markets in the absence of futures trading and could be labelled here as an unrelated pair. Cash prices of related commodities are determined in a common multimarket equilibrium (i.e., nonindependently) while cash prices of unrelated commodities would, in the absence of futures trading, be determined in distinct, or separable markets (i.e., independently). An empirical criterion is introduced later in the article to identify candidates for unrelated commodities.

To elaborate these concepts, suppose no futures trading exists. Demand and supply histories and expectations are regarded as market information for a commodity. Such an information set may be defined for each commodity's cash market and is labelled fundamental cash market information set (FCMI). All information extraneous to the cash market for a commodity is defined as that commodity's external cash market information set (ECMI). In the absence of futures, FCMI would provide the basis for traders to plan and execute trades in cash commodity markets, while ECMI would be definitionally irrelevant. For related commodities, respective FCMI sets might overlap due to structural market linkages, but for unrelated commodities, FCMI for one commodity would be ECMI for another. This implies that for related commodities, overlapping FCMI would force their respective cash prices to be determined nonindependently while for unrelated commodities disjoint FCMI would ensure that their respective cash prices would be independently determined. This logic provides the basis for an empirical approach when futures trading is introduced.

Linkages between commodities which are unrelated in the absence of futures could only occur as a result of changes in opportunities for price arbitrage. In this sense, "relatedness" could result from changes in technology, preferences, or institutions. That is, "relatedness" could be established by the introduction of futures trading. The role of futures trading in the creation of such market linkages between commodities which are unrelated when only cash markets exist represents a mechanism through which futures trading could affect cash price formation and information content. By introducing elements of ECMI to the FCMI that exists in the absence of futures trading, new linkages among commodities or assets may be established by futures trading. This expansion of the FCMI would cause commodities that are unrelated in the absence of futures trading to be related in the presence of futures trading. This possibility presents the basis for a testable null hypothesis concerning the effects of futures trading which is consistent with the contention of critics that futures trading destabilizes cash price formation through changes in the information content of cash prices. The alternative hypothesis in this case may be interpreted as consistent with neoclassical economic theory, namely that futures trading introduces no new information into already informationally efficient cash markets.

To further elaborate the null hypothesis, consider the following scenario for futures trading. It is generally accepted (see Working (1970), Streit (1983), Yamey (1983)) that hedging in futures markets serves both a risk-shifting function and a profit-making function. By definition, hedging (whether hedging a given commodity or cross hedging different commodities) requires taking opposing positions (though not necessarily equal) in different contracts. Define *cross futures trading* as the act of taking uncovered simultaneous positions in different commodity contracts (possibly of different maturities) to satisfy portfolio trading objectives (not necessarily pure price arbitrage). Importantly, cross futures trading does not necessarily imply that positions in unrelated commodities are specifically motivated to offset a position in a particular commodity. In fact, cross futures trading might equivalently be labelled portfolio diversification in unrelated commodities. For example, investors typically find incentive to hold portfolio investments in commodity contracts as well as corporate stocks, financial instruments, foreign exchange, or precious metals. A commodity producer who, having financed his operations principally through bank loans and credit, may opt to minimize his interest rate risks by simultaneously investing in Treasury Bills, allied interest rate futures, precious metals, or more risky assets. Conventional portfolio theory (see Allen (1983)) clearly provides a basis for cross futures trading in related commodities. In the absence of futures trading, prices of unrelated commodities would be uncorrelated. Nonetheless, cross futures trading of these commodities could occur if traders maximize expected utilities that are functions of both expected portfolio returns and portfolio risk, or if trading costs are joint.

Cross futures trading immediately implies that portfolio decisions (possibly including production, inventory, and futures positions) would depend on both related and unrelated commodity cash and futures prices, or equivalently, fundamental and external information. Market equilibrium would lead both cash and futures prices to reflect both fundamental and external information. In sum, cross futures trading of unrelated commodities can be interpreted as a working hypothesis that is consistent with the introduction of external information (ECMI) into the determination of the unrelated commodity cash and futures prices. This would not happen in the absence of futures trading in unrelated commodities. The implication of this possibility is that futures trading could affect the formation, level, and stability of cash prices, a hypothesis consistent with critic's allegations.

AN ILLUSTRATIVE MODEL

To illustrate the hypothesis for a two commodity case, consider market-level supply, inventory, and futures position functions derived by aggregating individual trader decision functions over all traders. These would provide cash and futures market structural equations. The addition of market-clearing conditions for cash and futures respectively would make it possible to obtain market specific reduced form equations for the endogenous cash and futures prices determined in each market equilibrium in any period. Assume and t and $t + \tau$ are contract maturity dates for commodity A and B, respectively, $t - j - m$ is the date when traders first make inventory, supply, and futures decisions, and market participants are risk averse. All cash prices are subscripted once by an observation date but all futures prices are subscripted twice, the first subscript referring to the contract maturity date and the second to the observation date. Note that A and B have noncoinciding futures maturities whenever τ is not zero.

For the pair of commodities A and B, market specific reduced form price functions in period $t - j$ can be written as follows.

Cash Market Partial Equilibrium Price

$$P^A_{t-j} = P^A(P^A_{t-j-m}, F^A_{t,t-j-m}, F^B_{t+\tau,t-j-m}; Z^A_{t-j-m}, Z^A_{t-j}, X^A_{D,t-j}, I^A_{t-j-l}) \tag{1}$$

$$P^B_{t-j} = P^B(P^B_{t-j-m}, F^A_{t,t-j-m}, F^B_{t+\tau,t-j-m}; Z^B_{t-j-m}, Z^B_{t-j}, X^B_{D,t-j}, I^B_{t-j-l}) \tag{2}$$

Futures Market Partial Equilibrium Price

$$F^A_{t,t-j} = F^A(Z^A_{t-j}) \tag{3}$$

$$F^B_{t+\tau,t-j} = F^B(Z^B_{t-j}) \tag{4}$$

where

P refers to cash price, F to futures price,
Z is a vector of information and endowment variables (here, containing the expanded *FCMI* set as discussed above),
X_D is final consumption demand related variables,
I is aggregate inventory carryover from prior periods, and superscripts A and B indicate the two commodities.

Equilibrium at $t - j$ requires physical balance in each of the cash and futures markets. Importantly, arbitrage of a physical commodity between the cash and futures settlement markets is not assumed to be possible at $t - j$, implying that P^k_{t-j} and $F^k_{t,t-j}$ for any commodity k are not driven to equality as they are in the closing market at t. At closing, arbitrage forces P^k_t and $F^k_{t,t}$ to equality, implying that in the closing period the reduced forms for prices have identical determinants. That is, at closing cash and futures prices are jointly determined by the complete set of exogenous variables in (1)–(4) dated as t. These equations could easily be restricted to reflect special conditions. For instance, for a nonstorable commodity the inventory carryover term may be suppressed and the appropriate z vector redefined to not include storage-related information.

The main implications of these reduced form price equations are as follows. First, before closing (period $t - j$), equilibrium cash and futures prices are functions of planning period $(t - j - m)$ and period $t - j$ variables. The intuition here is simple: planning period decisions for inventory, production, and futures are all based on period $t - j - m$ information including prices prevailing at $t - j - m$. If these decisions are not revised between $t - j - m$ and $t - j$, the final equilibrium prices at $t - j$ should additionally reflect only adjustment on the basis of period $t - j$ variables. If revisions are possible between $t - j - m$ and $t - j$, a more detailed partial reduced form system can be specified to allow explicitly for variables arising between $t - j - m$ and $t - j$. In the specification above, Z vectors are defined at $t - j$ broadly enough to include these intermediate period variables.

Second, the presence of Z in (1) and (3) implies that A's cash and futures prices at $t - j$ must be nonindependently determined even before the closing process forces strict cash-futures equilibrium. The same follows for B's prices from (2) and (4). This result is a familiar one if the Z vectors contain solely inventory-related terms since that implies cash-futures arbitrage via stock adjustment. However, the result is clearly more general in that the nonindependence of cash and futures prices continues to hold even if A and B are nonstorable and if the Z vectors contain more than just inventory-related terms.

Also, the two cash prices are determined nonindependently as are the two futures prices whenever Z^A and Z^B are correlated or contain common information. If market information present in the two Z vectors consists of FCMI as well as ECMI, then the reason for nonindependence of prices is clear. This holds true even if A and B are unrelated as long as cross trading and jointness of costs force market information to contain the expanded rather than the original FCMI.

In sum, the hypothesis of cross trading between unrelated commodities implies general conditions in which cash and futures prices may be nonindependently determined even for nonstorable commodities before the closing process forces their joint determination. For a general case, economic theory and institutional knowledge may provide the basis for specifying cash and futures prices for related commodities, and factors which may affect specific prices. However, detailed knowledge of the interaction of prices and determinants across markets is limited. The stated partial reduced form price functions express succinctly the expected relationships among the prices and provide insight into the role of information in determining those relationships. The hypothesis of cross futures trading presents a plausible mechanism for cash prices of unrelated commodities to be affected by futures trading through the introduction of information external to their cash markets. Also, the statistical and dynamic stability properties of these prices would be conditioned by the type and nature of such external information. In this sense, external information would be interpretable as a contaminant in the cash price formation process which would not be present in the absence of futures trading. This hypothesis is consistent with critics' allegations that futures trading is in some way responsible for creating unstable cash prices which convey false signals for resource allocation.

EMPIRICAL APPROACHES GIVEN WEAK PRIORS

Although Peck (1976) presented partial equilibrium theoretic models which acknowledged the need for focus on dynamic stability, such models are inadequate bases for specification of empirical models of the complex general equilibrium processes of cash and futures price formation. Past empirical studies have employed single equation models which rely on theory only for specification of relevant variables. However, eqs. (1)–(4) suggest that cash and futures prices emerge from a dynamic multivariate model. For related commodities, this model would involve at least prices and elements of FCMI. Under the null hypothesis of cross-futures trading, the model would include prices and elements of FCMI for unrelated commodities. The approach taken here is to employ a dynamic reduced form representation as suggested by eqs. (1)–(4). However, in the absence of knowledge of the structure of the dynamic reduced form, the approach adopted here is to identify the structure using empirical means.

Direct estimation of an ARMA model does not uniquely identify temporal structure and, thereby, fails to provide an adequate basis for causal inference. Instead, state space methods are adopted which allow unique identification of an ARMA representation as Akaike (1974 and 1976) has established. The estimated state space model is employed in two approaches to estimation of a dynamic reduced form. First, estimates are employed to directly derive a parameterization of the ARMA representation. Second, state space results are employed as a basis for specifying an AR representation which is directly estimated. Both approaches lead to systems of dynamic reduced form equations which provide evidence concerning causal structure. Further, they provide for a determination of the dynamic stability of the price series based on the identified model structure. Details concerning the empirical approach are presented in the appendix.

THE EMPIRICAL APPROACH FOR ANALYSIS OF U.S. LIVE BEEF CATTLE

Sampling of cash and futures prices requires adoption of a theory of the stochastic process(es) generating observed prices. If daily cash and futures prices follow unique stochastic processes for each day of the week, then it is appropriate to construct a sample of observations from a particular day-of-week to characterize the stochastic process generating prices on that day-of-week. This is the approach taken here. Mid-week prices were employed to avoid opening and closing market effects. Weekly or monthly averages were not used because the temporal aggregation involved obscures the fundamental daily stochastic process that the prices follow.

The price series were constructed as follows. As noted above, closing arbitrage forces cash and futures prices to be jointly determined. However, before closing, for nonstorable commodities, cash and futures prices of related commodities may be jointly determined due to joint trading costs, or jointness in portfolio trading. For unrelated commodities, joint determination of cash prices prior to closing could occur due to cross futures trading. It is of interest to sample futures and cash prices in the periods prior to and at maturity of futures contracts. It is assumed that the underlying stochastic process that generates prices for a particular day-of-week prior to closing is the same for all maturity dates. Based on this assumption, the stochastic process generating mid-week prices may be characterized by a sample of observations for the last four weeks of trading for a set of contracts. Observations were pooled across delivery dates. This procedure has been used by several authors (see Leuthold (1974), Scobie and Gellatly (1979), and Martin and Garcia (1981)). For futures prices of a contract with maturity in period t, the mid-week prices were sampled for the last four weeks of every contract between 1972 and 1981 and then stacked. For example, since cattle futures contracts mature in the months of February, April, June, August, October, and December, for one calendar year four weekly observations for each delivery month provide a total of 24 observations of the stochastic process generating mid-week cattle futures prices over the ten year sample period, this gives a sample of 240 observations. This type of sampling procedure was followed for all prices in the study.

Related and unrelated commodities were identified as follows. Commodities related to cattle through horizontal market linkages included hogs and broilers (representing demand substitutes). Vertical linkages with cattle through derived input demand exist between feed commodities such as wheat, corn, and soybean meal and feeder cattle. Of this set of related commodities, hogs, corn and soybean meal were employed in the empirical test as related commodities. Unrelated commodities were chosen to reflect strong potential for use in cross futures trading. To strengthen their interpretation as unrelated (in the portfolio-risk management sense) commodities that had cash prices of insignificant, contemporaneous correlation with live cattle cash prices were chosen. Cotton, silver, and copper were chosen as unrelated commodities. In addition, the interest rate for 3–5 year issue of U.S. government securities was used as a measure of the long-term opportunity cost of capital. The choice of commodities was constrained by the existence of trading during the sample period.

The price equations derived from theory might be summarized as linear reduced forms such as (1)–(4). Although little may be known before estimation concerning the causal structure of such equations, the nature of time lags in planning and production provides a basis for temporal ordering of the variables. Following (1)–(4), in the multivariate case, period t cash and futures prices can be written as reduced form functions of "past" prices from the production planning period $t - m$ (e.g., P_{t-m}). For the case of live cattle, the production period (m) is approximately 26 weeks. In the current application, it is the causal organization of prices/or commodities such as A and B in (1)–(4) that is of interest. The dynamic and causal structure of the price equations are explored through estimation of generalized forms in which both present and past prices are lagged, e.g., $P_{t-\tau}$ and $P_{t-m-\tau}$, respectively. $P_{t-\tau}$ is labelled as a lagged present variable, while $P_{t-m-\tau}$ is a lagged past variable.

Table I
DEFINITION OF VARIABLES

Label	Description/Market
CTC_t	Present cash price of live beef cattle / Omaha, Nebraska
CTF_t	Present futures price of live beef cattle (for contract maturing at t) / Chicago Mercantile Exchange
HGC_t	Present cash price of hogs / Omaha, Nebraska
CNF_t	Present futures price of cotton (No. 2) (for contract maturing at or "shortly after" t) / New York Cotton Exchange
CPF_t	Present futures price of copper (for contract maturing at or "shortly after" t) / Commodity Exchange, New York
SVF_t	Present futures price of silver (for contract maturing at or "shortly after" t) / Commodity Exchange, New York
CNF_{t-m}	Past futures price of cotton (for contract maturing at or "shortly after" t) / New York Cotton Exchange
CTF_{t-m}	Past futures price of live beef cattle (for contract maturing at t) / Chicago Mercantile Exchange
COC_{t-m}	Past cash price of corn / Chicago Board of Trade
SMC_{t-m}	Past cash price of soybean meal / Decatur, Illinois
IRC_{t-m}	Past interest rate on U.S. Government Securities (3 to 5 year issues of Notes and Bonds) / Federal Reserve System

Note that a label ending in a '*C*' signifies a cash price and a label ending in an '*F*' signifies a futures price. Data for the variable IRC_{t-m} were obtained from several issues of the *Federal Reserve Bulletin* of the Board of Governors, The Federal Reserve System, Washington, D.C. All other price data were obtained from the Commodity Data base of the Center for the Study of Futures Markets, Columbia University.

The specific variables employed are defined with acronyms in Table I. From Table I, the prices involved in the model include those that are related either in the present period (HGC_t), or during the production period (CNF_{t-m}, CTF_{t-m}, COC_{t-m}, SMC_{t-m}, IRC_{t-m}). Further, to allow consideration of the null hypothesis, unrelated present period prices (CNF_t, CPP_t, SVF_t) are included.

An important prerequisite of any empirical inquiry utilizing time series data is that the series is covariance stationary. In the absence of covariance stationarity, a relationship cannot be established between sample estimates and the statistical characteristics of the population stochastic process generating the sample series. The sample series of price levels could not be inferred to be covariance stationary; however, the first difference of the series appeared covariance stationary and was utilized in the analysis to establish covariance stationarity. The series of differences was constructed by taking first differences of the price levels within the closing period for each contract. In results reported below, all price changes are characterized by the prefix '*D*' on the price labels. For example, $DCTF_t$ is the cattle futures price change at t.

As explained in the appendix, the first step in identifying the structure of the multivariate relationship among prices in Table I was the estimation of a state-space model. Next, a unique and parsimonious ARMA model was recovered from the state-space model. The ARMA model derived expresses each endogenous variable as a function of predetermined variables. In Step 3, the derived ARMA model was transformed to an AR form which provided indirect estimates that could be used for testing the null hypothesis. This test was indirect since the AR form was indirectly achieved through derivation from the ARMA model identified by state-space estimates. In Step 4, the AR form derived in Step 3 was directly estimated to provide estimates of the parameter covariance matrix of the AR form. Using these estimated covariances, a direct test of the null hypothesis was conducted. Specifically, two alternative specifications of the AR form were estimated in Step 4:

(1) The AR-SS specification based exactly on the AR model derived from the structure identified from the state-space model in Steps 1–3, and
(2) The AR-N specification in which the only past period prices in Table I are assumed to be exogenous.

In the AR-N model, each endogenous is expressed as a function of current and lagged values of all predetermined variables identified by the state space model; however the lag structures identified by the state space model are not imposed as restrictions. In the AR-SS model the lag structure is restricted according to qualitative results obtained from the state space model. In this sense, the AR-SS model is nested by further restriction of the AR-N model.

Consistent estimates of the AR forms of AR-SS and AR-N models were obtained. To obtain asymptotic estimates of the coefficient covariance matrix an iterative seemingly unrelated regression (ISUR) estimator was employed. The ISUR estimates are presented in Table II (AR-SS) and Table III (AR-N). In most cases, convergence to reported estimates occurred within 5 to 7 iterations. In Tables II and III, only the statistically significant coefficients are reported to conserve space.

RESULTS: ESTIMATED RELATIONSHIPS AMONG PRICES OF COMMODITIES RELATED AND UNRELATED TO U.S. LIVE BEEF CATTLE

Under the null hypothesis, futures trading can affect the formation and performance of cash prices by expanding the information set determining a cash price to include what

Table II.
ITERATIVE SUR ESTIMATES IN AR-SS MODEL

	$DCNF_{t-m}$	$DIRC_{t-m}$	$DCOC_{t-m}$	$DSMC_{t-m}$	$DCTF_{t-m}$	$DCNF_t$	$DCPF_t$	$DSVF_t$	$DHGC_t$	$DCTC_t$	$DCTF_t$
$DCNF_t$	0.175	0	0	$0.257L^3$	0	$0.127L^3$	0	0	0	0	0
$DCPF_t$	0.675	0	0	0	0	0	$-0.280L$ $-0.195L^2$	$0.129L^2$ $-0.151L^3$	0	0	0
$DSVF_t$	0	0	0	$0.907L^3$	0	0	$0.357L^3$ $+0.457L^3$	$0.280L$ $-0.440L^4$	0	0	0
$DHGC_t$	0	0	0	0	$0.156L$	$-0.104L^2$	0	0	$0.151L^2$	0	0
$DCTC_t$	0	0	0	0	0	$-0.089L^4$	0	0	0	$-0.374L$	$0.479L$
$DCTF_t$	0	0	$0.153L^4$	0	0	$-0.106L^4$	$0.017L^2$	0	0	$0.172L$ $0.383L^2$ $0.363L^3$	$-0.421L^2$ $-0.344L^3$ $-0.111L^4$

Note: All coefficient estimates are statistically significant at the 0.05 level, unless otherwise noted.

Table III.
ITERATIVE SUR ESTIMATES IN AR-N MODEL

	$DCNF_{t-m}$	$DIRC_{t-m}$	$DCOC_{t-m}$	$DSMC_{t-m}$	$DCTF_{t-m}$	$DCNF_t$	$DCPF_t$	$DSVF_t$	$DHGC_t$	$DCTC_t$	$DCTF_t$
$DCNF_t$	0	0	0	$0.178L^3$	$0.248L^4$	0	$0.085L^4$	$0.030L^4$	0	0	0
$DCPF_t$	0.859	0	0	0	−0.667 −0.596L	0	−0.294L $-0.124L^2$	$-0.096L^3$ $-0.151L^3$	0	0	0
$DSVF_t$	0	7.978 −4.963L	0	0	−0.906	0	$0.324L^3$ $+0.457L^4$	0.284L $-0.413L^3$	0	0	0
$DHGC_t$	0	0	0	0	0	0	0	0	$0.143L^2$ $-0.107L^4$	0	0
$DCTC_t$	0	0	0	$0.221L^4$	0	0	0	0	0	$0.201L^4$	0.096L $-0.278L^4$
$DCTF_t$	0	0	0	$0.286L^4$	0	0	0	0	0	0.646L $0.467L^2$ $0.427L^3$ $0.243L^4$	−0.491L $-0.492L^2$ $-0.413L^3$ $-0.425L^4$

Note: All coefficient estimates are statistically significant at the 0.05 level.

has been defined as external cash market information. An empirical implication of the null hypothesis is that prices of what have been defined as unrelated commodities would be found to be structurally related and exogenous to the cash and futures prices of the commodity of interest.

The causal organization among the variables may be deduced by examining evidence from the directly estimated AR models. The results from the two models are jointly considered in setting up the following classification of results. If a predetermined variable is found to have a statistically significant effect in either of the two AR models, then that finding is regarded as "weakly corroborative" of exogeneity and the nature of the implied causal relationship is described as "possible." If a predetermined variable appears in a given equation of both AR models, there is stronger corroboration and the implied causal relationship is termed "probable." Results are reported in Table IV.

Evidence is reported in Table IV that does not allow rejection of the hypothesis that futures trading establishes linkages among prices which in the absence of futures markets would not be expected. Specific results are as follows:

> For the cattle futures and cash prices, evidence supports the conclusion that the prices are simultaneously determined as suggested by evidence of mutual feedbacks of at least four weeks.
>
> Evidence was found that causal linkages may exist from cotton and copper futures to cattle prices. If cotton and copper are accepted as unrelated commodities relative to cattle, then this evidence supports the conclusion that futures trading introduced external information into the formation of the cattle prices.
>
> Table IV also reports that evidence was found of a linkage between soybean and corn prices and cattle prices. If these commodities are accepted as related to cattle through their role as feed inputs to cattle production, then this causal relation confirms an expected linkage among related commodities.
>
> Evidence from estimated models of cotton, copper, and silver corroborate the conclusions drawn from cattle price models. Evidence was found that copper, silver, and cattle futures are exogenous to cotton futures, that cotton and cattle futures are exogenous to silver futures. Each of these linkages represents linkages with commodities which can be interpreted as unrelated in the absence of futures trading.
>
> For the cash hogs price, evidence of linkage with the related commodity cattle futures and with the unrelated commodity cotton futures was found.
>
> There does not appear to be any contemporaneous relationship between the price changes of substitute livestock commodities, i.e., between $DHGC_t$ and ($DCTC_t$, $DCTF_t$). Perhaps, this can be attributed to the marked seasonality of hog production in contrast to beef cattle production.

The interest rate series selected for this study (3–5 year rate on bills and notes) appears to be a statistically insignificant factor in the determination of the six commodity prices. There appears to be only a weak effect of the interest rate change series, $DIRC_{t-m}$, on the silver futures price change series, $DSVF_t$. A more significant effect may be discernible from another surrogate for interest rates such as the Treasury Bond or the Treasury Bill futures price. Unfortunately, complete data on these series were not available for the period of study.

RESULTS: EVIDENCE OF DYNAMIC STABILITY OF CASH AND FUTURES PRICES

Since the *AR-SS* model is nested within the *AR-N*, dynamic stability analysis is conducted using only the *AR-N* estimates. The stability test is conducted at two levels. At

Table IV.

NATURE OF CASUAL ORGANIZATION IDENTIFIED FROM THE TWO ESTIMATED MODELS

Current Endogenous Variable	Nature of Causal Effect from Predetermined Variables: Probable	Possible
$DCNF_t$	$DCTF_{t-m}$ (Cattle Futures)	Lags of $DCNF_t$ (Cotton Futures) (SS)
Cotton Futures	$DSMC_{t-m}$ (Soybean Cash)	Lags of $DCPF_t$ (Copper Futures) (N)
		Lags of $DSVF_t$ (Silver Futures) (N)
$DCPF_t$	Lags of $DCPF_t$ (Copper Futures)	$DCTF_{t-m}$ (Cattle Futures) (N)
Coppr Futures	Lags of $DSVF_t$ (Silver Futures)	
	Lags of $DCNF_t$ (Cotton Futures)	
$DSVF_t$	Lags of $DSVF_t$ (Silver Futures)	$DCTF_{t-m}$ (Cattle Futures) (N)
Silver Futures	Lags of $DCPF_t$ (Copper Futures)	$DSMC_{t-m}$ (Soybean Cash) (SS)
		$DIRC_{t-m}$ (Interest Rate) (N)
$DHGC_t$	Lags of $DHGC_t$ (Hogs Cash)	Lags of $DCNF_t$ (Cotton Futures) (SS)
Hogs Cash		$DCTF_{t-m}$ (Cattle Futures) (SS)
$DCTF_t$	Lags of $DCTF_t$ (Cattle Futures)	Lags of $DCMF_t$ (Cotton Futures) (SS)
Cattle Futures	Lags of $DCTC_t$ (Cattle Cash)	Lags of $DCPF_t$ (Copper Futures) (N)
		$DSMC_{t-m}$ (Soybean Cash) (N)
		$DCOC_{t-m}$ (Corn Cash) (SS)
$DCTC_t$	Lags of $DCTF_t$ (Cattle Futures)	Lags of $DCNF_t$ (Cotton Futures) (SS)
Cattle Cash	Lags of $DCTC_t$ (Cattle Cash)	$DSMC_{t-m}$ (Soybean Cash)

Note: All "present" variables are measured at time t and all "past" variables are measured at time $t-m$ (see text and Table I for definitions). In the category of "Possible Causal Effect," letters in parentheses (N or SS) correspond to the *AR CDRFM* model. The maximal lag of any "present" variable is smaller than the m-period lag implied by time $t-m$. In some instances, lags of a "present" variable classified as predetermined may include the zero lag. For example, $DCPF_t$ and $DSVF_t$ are contemporaneously (zero-lag) related and also related with positive lags.

the first level, the full system of the *AR-N* is analyzed. Cattle price changes are treated as integral parts of the six equation system which would characterize prices if cross futures trading occurred. At the second level, the sub-system formed only by the two equations for the cattle price changes is analyzed.

For both the full and sub-system, characteristic roots of the estimated parameter matrix are estimated, following an approach proposed by Theil and Boot (1962) or Brissimis (1976). Significance tests for the hypothesis that estimated Frobenius roots are unitary were based on computed standard errors, see Oberhofer and Kmenta (1973), or Gantmacher (1960). Frobenius roots for both the systems were real:

	Frobenius Root	Standard Error
Full System:	−.9526	.000096
Sub-system:	.8094	.022906

Given these estimated values, the null hypothesis that prices are dynamically stable under futures trading can be tested. *t*-Statistics of the characteristic roots were employed leading to the following results:

	t-Statistic	Probability Value
Full System:	493.75	.001
Sub-system:	8.32	.01

Since the alternative hypothesis is that the true characteristic roots are less than unity in absolute value, one-tailed tests were used. The probability values for each test suggests that there is no statistical evidence of dynamic instability in either the full system or in the sub-system of cattle prices.

Results indicate that the stochastic process underlying the analyzed cash and future price series is dynamically stable, and that observed samples provide useful information for the characterization of that process. Futures trading during the sample period 1972–1981 apparently did not introduce dynamic instability to cash prices. Importantly, this result was found despite evidence already reviewed that futures trading may have changed the information set reflected in prices by introducing external information. As explained above, these results do not address static variation, nor do they provide comment on changes in the extent of dynamic stability resultant from futures trading. Although the role of futures trading in establishing the observed stability cannot be inferred, evidence was not found that cash prices of cattle are dynamically unstable in the presence of futures trading.

CONCLUSIONS

The estimated models provide evidence concerning two characteristics of prices under futures trading: (1) the role of external information in their determination and (2) their dynamic stability. Evidence did not support the rejection of the null hypothesis that external information (*ECMI*) has statistically discernible effects on the cash and futures price changes of cattle. Evidence was found that external information from such unrelated commodities as cotton and copper may be introduced to cattle prices through futures trading. The soybean meal cash price change lagged four weeks appears as a source of *FMCI* in the determination of the two cattle price changes (the cash price change of corn, interest rates, and the cash price change of hogs are not statistically related to the two cattle price changes). There is evidence of feedback among the cash and futures price changes of cattle which is consistent with the theoretical prediction that the two prices are nonindependently determined.

Despite the presence of external information as a factor influencing the behavior of cattle prices, the extent of dynamic stability of cattle prices (cash and futures) in the presence of futures trading remains an open question and was investigated. Estimated characteristic roots of the dynamic reduced forms are consistent with the conclusion that the observed cattle price series were dynamically stable during the sample period. Despite the finding of an apparent role for external information in determining cattle prices, these results support the conclusion that futures trading of cattle and other related commodities during the sample period did not lead to dynamic instability of cattle prices during the sample period.

Appendix

THE MULTIVARIATE ARMA MODEL

Following Zellner and Palm (1974) and Wallis (1977), the multivariate *ARMA* model may be written in terms of polynomials in the backward shift operator L:

$$\phi(L)z_t = \theta(L)w_t$$

or in expanded form as

$$\begin{vmatrix} A(L) & B(L) \\ C(L) & D(L) \end{vmatrix} \begin{vmatrix} X_t \\ Y_t \end{vmatrix} = \begin{vmatrix} E(L) & F(L) \\ G(L) & H(L) \end{vmatrix} \begin{vmatrix} u_t \\ v_t \end{vmatrix}$$

where

$$\phi(L) = \begin{vmatrix} A(L) & B(L) \\ C(L) & D(L) \end{vmatrix}, \theta(L) = \begin{vmatrix} E(L) & F(L) \\ G(L) & H(L) \end{vmatrix}, z_t = \begin{vmatrix} X_t \\ Y_t \end{vmatrix}, w_t = \begin{vmatrix} u_t \\ v_t \end{vmatrix}.$$

and X_t and Y_t are covariance stationary time series components of z_t, u_t and v_t are mutually orthogonal white noise disturbance components of w_t, and the inverses $\phi^{-1}(L)$ and $\theta^{-1}(L)$ exist.

If the restrictions $B(L) = F(L) = G(L) = 0$ can be maintained, then the system is causally-organized in the sense that X causes Y but Y does not cause X ("cause" in the sense of Granger (1969)):

$$A(L)X_t = E(L)u_t, \tag{A1(a)}$$

$$C(L)X_t + D(L)Y_t = H(L)v_t, \tag{A1(b)}$$

where (A1(a)) describes the evolution of the exogenous variables only and can be called the Exogenous Variable Evolution Model (*EVEM*), and (A1(b)) is often referred to in the literature (see Geweke (1978)) as the Complete Dynamic Simultaneous Equation Model (*CDSEM*). Given priors concerning the form of the *ARMA* model which allow its representation as (A1), estimation could be accomplished and dynamic stability properties investigated.

In the absence of such priors, an approach must be adopted which allows unique identification of the empirical structure of the *ARMA* representation. The *CDSEM* is written as a reduced form through a causality preserving transformation. The *CDSEM* is simply the dynamic analog of the more familiar static simultaneous equation structural model.

If $D(L)$ is a nondiagonal, full-rank matrix of lag polynomials, then premultiplication of the *CDSEM* by d_0^{-1}, the inverse of the zero-lag component of $D(L)$, and some rearrangement produces the dynamic reduced form system

$$Y_t = [\overset{*}{d}_1 L + \overset{*}{d}_2 L_2 + \ldots]Y_t - \overset{*}{C}(L)X_t + \overset{*}{H}(L)v_t \qquad \text{(A2)}$$

in which every endogenous variable is expressed as a function of only the predetermined variables. This transformation, being linear, is also causality-preserving if

$$A^*(L) = a_0 - a_1 L - a_2 L^2 - \ldots \text{ and } a_0^{-1}$$

exists. Normalized equations for the evolution of the exogenous variables can be obtained from (A 1(a)) by premultiplying through by a_0^{-1}. This gives

$$A^*(L)X_t = E^*(L)u_t$$

where $A^*(L) = [I - a_0^{-1}a_1 L - a_0^{-1}a_2 L^2 - \ldots]$ and $E^*(L) = a_0^{-1}E(L)$.

Now, (A2) can be re-written as

$$D^*(L)Y_t + C^*(L)X_t = H^*(L)v_t$$

where $D^*(L) = [I - d_1^* L - d_2^* L^2 - \ldots]$. Then, (A1(a)) and (A1(b)) with these new interpretations will form the system

$$\begin{vmatrix} A^*(L) & 0 \\ C^*(L) & D^*(L) \end{vmatrix} \begin{vmatrix} X_t \\ Y_t \end{vmatrix} = \begin{vmatrix} E^*(L) & 0 \\ 0 & H^*(L) \end{vmatrix} \begin{vmatrix} u_t \\ v_t \end{vmatrix} \qquad \text{(A3)}$$

The top half of (A3) expresses the normalized version of the *EVEM* and the lower half expresses what is called here the Complete Dynamic Reduced Form Model (*CDRFM*).

The transformations employed in deriving (A3) are linear, implying causality from X to Y is preserved. In parametric terms, any test of causality from X to Y does not directly involve the reduced form lag polynomials $C^*(L)$, $D^*(L)$, and $H^*(L)$, but instead requires testing the restrictions $B^*(L) = F^*(L) = G^*(L) = 0$, where $B^*(L) = a_0^{-1}B(L)$, $F^*(L) = a_0^{-1}F(L)$, and $G^*(L) = d_0^{-1}G(L)$. Note that as long at a_0^{-1} and d_0^{-1} exist, the equivalent test is $B(L) = F(L) = G(L) = 0$. Hence, the *CDRFM* in (A3) is an acceptable model for an analysis of dynamic reduced form relationships among the variables of interest, particularly since the underlying dynamic structural model (*CDSEM*) may not be identifiable from what information is available.

THE STATE SPACE APPROACH

The *CDRFM* in (A3) provides the basis for the following strategy. Rather than investigate causality in single equation models, a multivariate *ARMA* model is estimated unrestricted by priors concerning causality. Little is known about the causal structure among the variables except that all past variables are, by definition, exogenous with respect to all present variables. Estimation of the state space model is pursued because it does not depend on precise prior knowledge of this causal structure. The causal organization of the variables is then inferred from the structure of the estimated parameter matrices. The resulting model, written in the form of (A3) is interpreted as the *CDRFM*. The choice of this approach follows from the fact that *ARMA* representations are not uniquely identifiable using traditional time series methods.

Akaike (1974 and 1976) proposed an indirect identification method that allows the identification of unique and parsimonious (also called canonical) *ARMA* models. This method relies on the one-to-one correspondence that exists between canonical forms of state space models and canonical forms of their *ARMA* counterparts. The state space model can be written as

$$x_{t+1} = Fx_t + Ge_{t+1} \tag{A4(a)}$$

$$X_t = Hx_t \tag{A4(b)}$$

where

F is a transition matrix establishing the one-period relationship between the state vectors x_t and x_{t+1} (that contain predictors for the variables of interest),
G is an input matrix containing the additive input of the innovation vector e_{t+1} (assumed to be white noise), and
H is an observation matrix relating the state vector x_t to the vector of current variables X_t.

Akaike (1976) proposed the following procedure. First, identify the canonical forms of the state vectors x_t and x_{t+1} by use of the method of canonical correlations and an information criterion such as the Akaike Information Criterion, *AIC*. Next, given the canonical state vectors, use a maximum likelihood routine to estimate the parameters in matrices F and G. Finally, recover *ARMA* parameter estimates from the state space parameter estimates. This means that the state space model of (A4(a)) and (A4(b)) yields the general multivariate *ARMA* model for the covariance stationary variable vector z_t, where the parameters in the lag polynomial matrices $\phi(L)$ and $\theta(L)$ are recovered from the estimated state space parameter matrices F and G.

AN INDIRECT CDRFM APPROACH

The *CDRFM* model (A3) may be re-written in the so-called autoregressive (*AR*) form:

$$\hat{D}(L)Y_t = \hat{C}(L)X_t + v_t \tag{A5}$$

provided that $H^{*-1}(L)$ exists and v_t is white noise. Here $D(\hat{L}) = H^{*-1}(L)D^*(L)$, $\hat{C}(L) = H^{*-1}(L)C^*(L)$. As a practical matter, $\hat{D}(L)$ and $\hat{C}(L)$ can be obtained from $D^*(L)$, $C^*(L)$, and $H^*(\hat{L})$ which, in turn are solved out from the *ARMA* lag polynomial matrices $\phi(L)$ and $\theta(L)$.

Although the state space approach allows consideration of causal structure through derivation of parameters of a uniquely identified *ARMA* model, the nonlinearity and complexity of transformations involved do not currently allow recovery of estimates of standard errors of the identified *ARMA* representation. This constraint limits the present usefulness of the state space results to qualitative inference based on overall fit of the state space model, and quantitative magnitude, rather than statistical significance, of the derived parameters of the *ARMA* form. An extension of this approach would be to utilize causal structure inferred from the state space model as a prior for specification of *AR* representation as in (A5) of the *CDRFM* (A3). Direct estimation of this form will provide a basis for statistical inference concerning causal structure.

IDENTIFICATION OF A UNIQUE ARMA REPRESENTATION

The state model of the type of (A4(a)) and (A4(b)) was estimated for a 11×1 vector of current variables, X_t, containing each of the prices in Table I. This identification step yields a state vector which is then used to obtain maximum likelihood estimates of the state space model. The state vector x_t (here, of size 21) was identified by use of canonical correlations analysis and the Akaike Information Criterion (*AIC*). The estimated state space model was based on this state vector. Conventional t-statistics were used to determine the statistical significance of the estimated coefficients in matrices F and G. Insignificant coefficients were then restricted to zero and the state space model re-estimated.

Coefficient values as derived from the estimated state space model are not reported here to conserve space. A test of the null hypothesis discussed above can be conducted by determining whether or not the present period variables measuring related and unrelated commodity prices are jointly endogenous. However, the parameters of the state space identified ARMA model involve nonlinear transformations of the coefficients of the state space model. Convenient estimates of the covariance of derived *ARMA* coefficients are not available. Instead the magnitudes of estimated *ARMA* coefficients and their conditionality on the overall fit of the state space model are used to evaluate the significance of relationships in the derived *ARMA* model.

RESTRICTED CDRFM REPRESENTATIONS USED IN HYPOTHESIS TESTING

With the restriction $G^*(L) = 0$ applied to the *ARMA* model as derived from the estimated state space model, the general form of the *CDRFM* is given by (A5). However, (A5) can be expressed as

$$W(L)z_t = v_t, \tag{A6}$$

where

$$W(L) = \begin{vmatrix} \hat{C}(L) & 0 \\ 0 & \hat{D}(L) \end{vmatrix} \text{and } z_t = \begin{vmatrix} X_t \\ Y_t \end{vmatrix},$$

Thus, the *CDREM* restricted by $G^*(L) = 0$ is clearly a multivariate *AR* if v_t is white noise (which it is, by assumption). The usefulness of the *AR* form is two-fold. First, attention is focused exclusively on just one matrix of lag polynomials, such as $W(L)$ in (A6), leaving the right-hand-side to be simply a contemporaneous white noise term not attached to any matrix of coefficients. Second, derivation of $\hat{C}(L)$ and $\hat{D}(L)$ in (A5) is derived from the state space model and provides at least a qualitative impression of the relationships among the variables in the *CDRFM*. This enables direct specification, estimation, and testing of alternative specifications of this *AR* form of the *CDRFM*, something that is not possible with the *CDRFM* derived from the state space model.

Models *AR-SS* and *AR-N* estimated in Step 4 may be illustrated with (A6). In particular, because $W(L)$ represents an *AR* form of a *CDRFM*, not a *CDSEM*, it omits all past variables, e.g., X_{t-m}. By adding these past variables to the suggested form of the *CDRFM*, a model (*AR-SS*) which fully reflects a specification suggested by the state space model is derived. Alternatively, for *AR-N* $W(L)$ is unrestricted by any prior information as to the lag structures in the reduced form equations.

For the investigation of dynamic stability, the characteristic roots of the polynomial matrix $D(L)$ in (A6) are estimated. Direct calculation of the characteristic roots of estimates of $D(L)$ and $D^S(L)$ for the sub-system of cattle price equations is intractable since the elements of each matrix are coefficient polynomials in the lag operator L. When account is taken of the four lags of every endogenous variable that appears, the matrices $D(L)$ and $D^S(L)$ become 6×24 and 2×8 in dimension. These matrices are padded with identities to produce square expanded matrices used in the stability analysis. Because the matrices can not in general be expected to be symmetric, all roots may not be real, in fact many were complex.

Bibliography

Akaike, H. (1974): "Markovian Representation of Stochastic Processes and its Relation to the Analysis of Autoregressive Moving Average Processes," *Annals of The Institute of Statistical Mathematics*, 26:363–387.

Akaike, H. (1976): "Canonical Correlation Analysis of Time Series and the Use of an Information Criterion," *System Identification: Advances and Case Studies*, R. K. Mehra and D. G. Lainiotis, Eds., New York: Academic Press.

Allen, D. E. (1983): *Finance: A Theoretical Introduction*, Oxford: Basil Blackwell.

Bray, M. (1981): "Futures Trading, Rational Expectations, and the Efficient Markets Hypothesis," *Econometrica*, 49:575–596.

Brissimis, S. N. (1976): "Multiplier Effects for Higher than First Order Linear Dynamic Econometric Models," *Econometrica*, 44:593–595.

Cox, C. C. (1976): "Futures Trading and Market Information," *Journal of Political Economy*, 84:1215–1237.

Danthine, J. P. (1977): "Martingale, Market Efficiency and Commodity Prices," *European Economic Review*, 10:1–17.

Figlewski, S. (1981): "Futures Trading and Volatility in the GNMA Market," *Journal of Finance*, 36:445–456.

Froewiss, K. (1978, Spring): "GNMA Futures: Stabilizing or Destabilizing?" *Economic Review of Federal Reserve Bank of San Francisco*.

Gantmacher, F. R. (1960): *The Theory of Matrices*, New York: Chelsea Publishing Co.

Gardner, B. (1976): "Futures Prices in Supply Analysis," *American Journal of Agricultural Economics*, 58:81–84.

Geweke, J. (1978): "Testing the Exogeneity Specification in the Complete Dynamic Simultaneous Equations Model," *Journal of Econometrics*, 7:163–185.

Granger, C. W. J. (1969): "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods," *Econometrica*, 37:424–438.

Gray, R. W. (1963): "Onions Revisited," *Journal of Farm Economics*, 45:273–276.

Helmuth, J. W. (1981): "A Report on the Systematic Downward Bias in Live Cattle Futures Prices," *Journal of Futures Markets*, 1:347–358.

Kawai, M. (1983): "Spot and Futures Prices of Nonstorable Commodities Under Rational Expectations," *Quarterly Journal of Economics*, 98:235–254.

Leuthold, R. M. (1974): "The Price Performance on the Futures Market of a Non-Storable Commodity: Live Beef Cattle." *American Journal of Agricultural Economics*, 55:271–279.

Leuthold, R. M., and Hartmann, P. A. (1979): "A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market," *American Journal of Agricultural Economics*, 61:482–489.

Livestock, Dairy, and Poultry Hearings. Committee on Agriculture, House of Representatives, Ninety-Seventh Congress, Second Session, Feb. 26, 1982, Ames, Iowa.

Mann, J. S. and Heifner, R. G. (1976): *The Distribution of Short Run Commodity Price Movements*, USDA, ERS, Tech. Bull. 1536, Washington, D.C.

Martin, L., Garcia, P. (1981): "The Price-Forcasting Performance of Futures Markets for Live Cattle and Hogs: A Disaggregated Analysis," *American Journal of Agricultural Economics*, 63:209–215.

Oberhofer, W., and Kmenta, J. (1973): "Estimation of Standard Errors of the Characteristic Roots of a Dynamic Econometric Model," *Econometrica*, 41:171–177.

Palme, L. A., and Graham, J. (1981): "The Systematic Downward Bias in Live Cattle Futures: An Evaluation," *Journal of Futures Markets*, 1:359–366.

Peck, A. E. (1976): "Futures Markets, Supply Response and Price Stability," *Quarterly Journal of Economics*, 3:407–423.

Pluhar, D. M., Shafer, C. E. and Sporleder, T. F. (1985): "The Systematic Downward Bias in Five Cattle Futures: A Further Evaluation," *Journal of Futures Markets*, (5) 11–20.

Powers, M. J. (1970): "Does Futures Trading Reduce Price Fluctuations in the Cash Markets?," *American Economic Review*, 60:460–464.

Rendleman, R. J., and Carabini, C. E. (1979): "The Efficiency of the Treasury Bills Futures Market," *Journal of Finance*, 34:895–914.

Samuelson, P. A. (1965): "Proof that Properly Anticipated Prices Fluctuate Randomly," *Industrial Management Review*, 6:41–49.

Scobie, G. M., and Gellatly, C. (1979): "Incorporating Futures Prices in Commodity Models: The U.S. Broiler Sector," R. M. Leuthold and P. Dixon, Ed., *Livestock Futures Research Symposium*, Chicago Merchantile Exchange, 1979.

Stein, J. C. (1987): "Informational Externalities and Welfare-reducing Speculation," *Journal of Political Economy*, 95 No. 6:1123–1145.

Streit, M. E. (1983): *Futures Markets: Modelling, Managing and Monitoring Futures Trading*, Oxford: Basil Blackwell.

Taylor, G. S., and Leuthold, R. M. (1974): "The Influence of Futures Trading on Cash Cattle Price Variations," *Food Research Institute Studies*, 13:29–35.

Telser, L. G., and Higinbotham, H. N. (1977): "Organized Futures Markets: Costs and Benefits," *Journal of Political Economy*, 85:969–1000.

Theil, H., and Boot, J. C. G. (1962): "The Final Form of Econometric Equation Systems," *Review of the International Statistical Institute*, 30:136–152.

Tomek, W. G. (1979–80): "Futures Trading and Market Information: Some New Evidence," *Food Research Institute Studies*, 17:351–359.

Tomek, W. G., and Gray, R. W. (1970) "Temporal Relationships Among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles," *American Journal of Agricultural Economics*, 52:372–380.

Turnovsky, S. J. (1979): "Futures Markets, Private Storage, and Price Stabilization," *Journal of Public Economics*, 12:301–327.

Turnovsky, S. J. (1983): "The Determination of Spot and Futures Prices With Storable Commodities," *Econometrica*, 51:1363–1387.

Wallis, K. F. (1977): "Multiple Time Series Analysis and the Final Form of Econometric Models," *Econometrica*, 45:1481–1497.

Working, H. (1970): "Economic Functions of Futures Markets," *Futures Trading in Livestock-Origins and Concepts*, H. Bakken, Ed., Chicago: Chicago Mercantile Exchange.

Yamey, B. S. (1983): "Economics of Futures Trading: Some Notes and Queries," *Futures Markets: Modelling, Managing and Monitoring Futures Trading*, M. E. Streit, Ed., Oxford: Basil Blackwell.

Zellner, A., and Palm, F. (1974): "Time Series Analysis and Simultaneous Equation Econometric Models," *Journal of Econometrics*, 2:17–54.

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