Futures Trading and Market Information

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This paper investigates the effect of organized futures trading on information in spot markets. First, a model is developed that relates spot-price behavior and market information. The model can be viewed as a particular efficient markets model; this connection provides additional implications about price behavior and information. Next, price series for six different commodities are investigated for an information effect of futures trading. For each commodity, the empirical evidence indicates that futures trading increases traders' information about forces affecting supply and demand.

The influence of futures trading on commodity prices has long been a controversial subject. For some 80 years, there have been farmers and other agricultural interests who have claimed that futures trading destabilizes spot prices and thereby imposes losses on producers and consumers. Congress has decided that futures trading frequently causes unreasonable price fluctuations and has enacted several laws regulating organized trading in commodity futures: trading in onion futures is prohibited, and futures trading in all other commodities is regulated by the Commodity Futures Trading Commission.[1] The congressional hearings on regulation of futures markets show that the regulators have neither a theory of destabilizing futures trading nor empirical evidence of destabilized prices. Several economists have studied futures trading and price variability by comparing price ranges or variances in a period of no

This paper is drawn from my doctoral dissertation ("The Regulation of Futures Trading," University of Chicago, 1975). I am indebted to George Stigler, Lester Telser, and the late Reuben Kessel for valuable advice and criticism.

[1] Trading in onion futures is prohibited by P.L. 85-839, August 28, 1958, 72 Stat. 1013. Trading in other commodities is regulated by the Commodity Futures Trading Commission Act of 1974, P.L. 93-463, 88 Stat. 1389. Prior to 1974, futures trading in most agricultural products was regulated by the Commodity Exchange Act.

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futures trading and a period of active futures trading.[2] Some conclude that futures trading reduces price fluctuations; others find no difference. None of these studies offer much theoretical explanation of the empirical results.

This paper takes a different approach to the price effects of futures trading. I consider the relation between futures trading, market information, and spot prices, and I develop a model to analyze the information effect of futures trading. In the context of the model, empirical evidence on commodities' price behavior indicates that futures trading increases the information incorporated in a commodity's spot price. The results are inconsistent with the view that futures trading destabilizes spot prices in a way that is harmful to traders who handle the physical commodity.

I. Price Effects of Futures Trading

The relation between spot and futures prices together with certain characteristics of futures markets suggest that price effects of futures trading result from a change in the state of firms' price expectations. Telser (1958, 1967) shows that a futures price is an average of traders' expectations of the spot price that will prevail at the futures contract's maturity, and that for storable commodities, expected and current spot prices differ only by the net marginal cost of storage. Expected and current spot prices are determined simultaneously, and any change in expected prices induces a reallocation of the commodity between storage and current supply, thereby affecting the spot price. Futures trading can effect a state change in price expectations by altering the quantity of traders' information. Expected prices depend on current information about future supply and demand: more informed predictions are more accurate than less informed predictions. If information were free, all firms would have full knowledge of the evidence on future conditions and there would be no reason to believe that futures trading could influence price expectations. However, in real markets bits of information are dispersed among numerous individuals, the information changes frequently and is costly to acquire and communicate. Therefore, firms' price expectations reflect information that is neither complete nor perfectly

[2] Hieronymus (1960), Working (1960), Gray (1963), and Johnson (1973) studied onions. Working, Hieronymus, and Gray concluded that futures trading stabilized onion prices, but Johnson concluded that there was no price effect of futures trading. Naik (1970) analyzed groundnut, linseed, and hessian. He concluded that futures trading reduced the variation in groundnut and linseed prices but did not affect hessian prices. Hooker (1901) and Tomek (1971) studied wheat; both concluded that the variation in wheat prices decreased in periods with futures trading. Emery (1896) studied cotton and concluded that futures trading reduced the yearly range of cotton prices. Taylor and Leuthold (1974) investigated cattle and Powers (1970) investigated pork bellies and cattle. Both studies concluded that short-term price variations are significantly reduced when there is futures trading.

accurate, and the introduction of futures trading can produce either more or less informed price expectations.

There are at least two reasons for believing that futures trading can alter the amount of information reflected in expected prices. First, organized futures trading attracts an additional set of traders to a commodity's market: speculators who acquire and evaluate information in order to predict prices but who do not handle the physical commodity.[3] When these speculators have either a net long or short position in the futures market, hedgers (firms that deal in the physical commodity) have a corresponding net short or long position which causes the amount of stocks held for later consumption to be different than it would have been in the absence of futures trading. With different stocks, firms' price expectations are different too. Because the speculators added by futures trading may be more or less informed about future conditions than traders who handle the physical commodity, the futures price can be consistently either a more or less accurate prediction of the spot price than the firms' expectations without futures trading. Critics of futures trading sometimes contend that speculators in futures markets are generally uninformed amateurs, while those more favorable to speculators emphasize that specialization should bring efficiency in price predictions. Relatively informed speculators would earn profits, while relatively uninformed speculators would find themselves suffering losses over time. Nevertheless, if uninformed speculators are willing to pay for the chance to earn profits from trading, and if new uninformed speculators enter the market and replace those who cannot sustain losses, a set of uninformed speculators would survive. A priori, it is impossible to determine whether speculators attracted by futures trading are more or less informed on average than other traders in the market. Empirical evidence on this question is inconclusive: the results of several studies indicate that large-scale, professional speculators can profitably forecast commodity prices, but small traders cannot.[4]

[3] Speculators take a long or short position in the futures market when they expect the futures price to rise or fall. Relatively low costs of transacting in futures markets make it worthwhile for these speculators to close out their positions with an offsetting sale or purchase of futures contracts rather than accepting delivery of and selling, or acquiring and delivering, the physical commodity. With futures trading, speculators can bear price risks whenever they expect profits without establishing trade connections for merchandising the commodity. This is not to say that there are no speculators trading a commodity in the absence of futures trading. Whenever stocks of a commodity are held in an uncertain world, someone speculates by bearing the price risk of stockholding. Futures trading attracts additional speculators who would not trade the commodity without a futures market.

[4] Stewart (1949) analyzed futures-trading accounts that were mainly for small-scale speculators and found that losses greatly exceeded profits. Houthakker (1957) and Rockwell (1967) used data on futures prices and traders' commitments and assumptions about trading to estimate gains and losses. Both found that large speculators earned profits and small speculators incurred losses. Using a similar method, Working (1931) estimated that speculators in wheat futures, as a group, incurred losses.

A second reason why futures trading can change the amount of traders' information concerns the cost of transacting. Without futures trading, individuals' expectations may differ widely, but often it is not worthwhile to communicate that information. A formal futures market reduces the cost of transacting because trading is completely centralized. Relative to dispersed trading and private negotiations, it is cheaper to identify potential traders, search for the best bid or offer, and negotiate a contract in a futures market. It becomes worthwhile for more individuals to trade and thereby communicate their information. The dispersed information on supply and demand is concentrated in one place and is all reflected in a single futures price.[5] All futures traders acquire this information, and because futures prices are widely publicized, the information incorporated in a futures price can be acquired cheaply by individuals who do not trade in futures markets. The magnitude of this effect depends upon the amount of the reduction in the cost of transacting. Organized futures trading should produce a larger effect the more decentralized a commodity's spot market is and the more numerous a commodity's traders are, since it is likely that the reduction in transacting cost will vary directly with these factors.

In order to investigate these effects of futures trading, it is necessary to specify the relations between information, price expectations, and the behavior of spot prices.

Market Information and Price Behavior

Consider a market with the following characteristics: Demand for the commodity fluctuates over time due to random shocks. Production is subject to a fixed lag, so the quantity produced depends on producers' price forecasts. Stocks of the commodity are held to smooth consumption over time. Information consists of a knowledge of the random shocks that affect demand, and, due to the cost of information, not all traders possess the most recent information. Expectations are formed as if the market calculates expected values conditional on the traders' information and the structure of the market. Although price expectations differ among firms—there is some distribution of price expectations—the model developed here does not take account of the dispersion of expectations. Firms' expectations are represented by a single expected price that is defined as an average of individual expected prices.[6] The following

[5] The role of a market price in summarizing and communicating information is discussed by Hayek (1945).

[6] Telser (1958) has used a market's expected price as an analytical device to develop an industry stockholding schedule. He suggests that the expected price can either be defined as an average or be derived from the relation between individual schedules and total market quantities. Houthakker (1968) has severely criticized the use of an expected

equations, based on a model by Muth (1961), describe the market and the effect on price behavior of a change in the quantity of traders' information:

$$C_t = \beta_0 - \beta P_t - \varepsilon_t \qquad \text{(Consumption demand)}, \tag{1a}$$

$$S_t = \gamma_0 + \gamma P_t^e \qquad \text{(Production)}, \tag{1b}$$

$$I_t = \alpha_0 + \alpha(P_{t+1}^e - P_t) \qquad \text{(Supply of storage)}, \tag{1c}$$

$$C_t + I_t = S_t + I_{t-1} \qquad \text{(Market equilibrium)}, \tag{1d}$$

where P_t is the price in period t; P_t^e is the market's expectation of the price that will prevail in period t, given the traders' information through period $t - 1$; and ε_t is a random disturbance affecting demand, C_t.[7] Assume that the ε's are independent and identically distributed, and that expected prices can be expressed as linear combinations of these disturbances. The current price, then, is a linear function of the ε's,

$$P_t = \sum_{i=0}^{\infty} V_i \varepsilon_{t-i} + K. \tag{2}$$

From the expectations assumption, the expected price is the expected value of P_t conditional on the traders' information through period $t - 1$.

$$\begin{aligned} P_t^e &= V_0 E(\varepsilon_t) + (1 - f) V_1 E(\varepsilon_{t-1}) + f V_1 \varepsilon_{t-1} + \sum_{i=2}^{\infty} V_i \varepsilon_{t-i} + K \\ &= f V_1 \varepsilon_{t-1} + \sum_{i=2}^{\infty} V_i \varepsilon_{t-i} + K, \end{aligned} \tag{3}$$

where f is the fraction of the traders that possesses the information ε_{t-1} in period $t - 1$.

In investigating a market for the effects of a change in the quantity of market information, that is, a change in f, neither the price expectations nor the random shocks can be observed directly. The actual prices,

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price for analysis of futures trading. One of his major objections is that the procedure by which individual expected prices should be aggregated has not been specified. Furthermore, he objects to focusing exclusively on price expectations, as I do in this essay, because he argues that individual expected prices have ambiguous effects on traders' behavior unless a number of other variables, e.g., the wealth effect of price changes, are taken into account. Clearly, there are variables other than price expectations that influence price movements, and an average of expected prices is only an approximation, but my goal is to concentrate on information and the behavior of spot prices. Whether my model is useful for analyzing this problem depends on its ability to predict actual price behavior.

[7] In this model, random disturbances affect only demand because that is sufficient to make P_t a stochastic variable. Although it would seem more realistic to include a random term in production too, adding a disturbance like ε_t to (1b) neither increases nor changes the model's implications about information and price behavior. Under different assumptions about the disturbances, however, this conclusion does not hold. See Nelson (1975).

however, are observable. Therefore, to make this model operational it is necessary to solve for the expected price in terms of past prices. That is,

$$P_t^e = \sum_{j=1}^{\infty} Z_j P_{t-j} + H. \tag{4}$$

With equations (1) and (4), it is possible to derive a testable hypothesis about the effect of futures trading on the behavior of market prices. Hence, the task is to solve for the Z's of (4) in terms of the parameters of equations (1), then to find the effect of a change in f on the relation between prices. To do so, it is convenient to start by specifying the relationship between the V's implied by equations (1)–(3).

Substituting (2) and (3) into (1) yields the transformed market equilibrium equation:

$$\begin{aligned}[(\beta_0 + \alpha_0) - \beta K] - (\beta + \alpha) \sum_{i=0}^{\infty} V_i \varepsilon_{t-i} + \alpha \left(f V_1 \varepsilon_t + \sum_{i=2}^{\infty} V_i \varepsilon_{t+1-i} \right) \\ = [(\gamma_0 + \alpha_0) + \gamma K] + (\gamma + \alpha) \left(f V_1 \varepsilon_{t-1} + \sum_{i=2}^{\infty} V_i \varepsilon_{t-i} \right) \\ - \alpha \sum_{i=0}^{\infty} V_i \varepsilon_{t-1-i} + \varepsilon_t. \end{aligned} \tag{5}$$

For (5) to hold for all possible shocks, the coefficients of the corresponding ε's must be equal, and the constant terms in brackets must be the same. Hence,

$$-(\alpha + \beta) V_0 + \alpha f V_1 = 1 \tag{6a}$$

$$\alpha V_0 - [\alpha(1 + f) + \beta + \gamma f] V_1 + \alpha V_2 = 0 \tag{6b}$$

$$\alpha V_{i-1} - (2\alpha + \beta + \gamma) V_i + \alpha V_{i+1} = 0 \qquad (i = 2, 3, 4, \ldots). \tag{6c}$$

Equation (6c) is a homogeneous, second-order difference equation for which the solution is:

$$V_i = r^{i-1} V_1 \qquad (i = 2, 3, 4, \ldots), \tag{7}$$

where r is the smaller root $(0 < r < 1)$ of the characteristic equation for (6c) and is a function of α, β, and γ.[8]

Substituting (7) into (6b) and transforming yields

$$\phi \equiv \frac{V_1}{V_0} = \frac{\alpha}{[\alpha(1 + f - r) + \beta + \gamma f]}. \tag{8}$$

[8] Sufficient conditions for real and distinct roots in the characteristic equation for (6c) are $\alpha > 0$ and $(\beta + \gamma) > 0$. The roots occur in reciprocal pairs, so only one root is less than one in absolute value. From (2), it follows that (6c) is stable or P_t would be infinite. That is, the requirement that all bounded sequences of disturbances produce only bounded sequences of prices implies that (6c) is stable. Therefore, the coefficient of the larger root in the general solution must be zero.

Now the solution of (4) follows easily; substituting (2) and (3) into (4) yields

$$fV_1\varepsilon_{t-1} + \sum_{i=2}^{\infty} V_i\varepsilon_{t-i} = \sum_{i=1}^{\infty}\left(\sum_{j=1}^{i} Z_jV_{i-j}\right)\varepsilon_{t-i} + K\left(\sum_{j=1}^{\infty} Z_j - 1\right) + H. \tag{9}$$

Like (5), (9) must hold for all possible shocks, so the corresponding coefficients of the ε's are equal:

$$fV_1 = Z_1V_0 \tag{10a}$$

$$V_i = \sum_{j=1}^{i} Z_jV_{i-j} \qquad (i = 2, 3, 4, \ldots). \tag{10b}$$

Substituting (7), (8), into (10) and solving for Z_i gives

$$Z_1 = f\phi \tag{11a}$$

$$Z_i = (r - f\phi)\phi(r - \phi)^{i-2} \qquad (i = 2, 3, 4, \ldots). \tag{11b}$$

Equations (11) produce the desired form for (4):

$$P_t^e = f\phi P_{t-1} + \sum_{j=2}^{\infty}[(r - f\phi)\phi(r - \phi)^{j-2}]P_{t-j} + H. \tag{12}$$

Combining (12) and (1), the market equilibrium equation yields

$$P_t = \frac{(\gamma_0 - \beta_0 + \gamma H)}{(\alpha f\phi - \alpha - \beta)} + \phi P_{t-1} + \frac{(r - f\phi)\phi[(\alpha + \gamma) - \alpha(r - \phi)]}{(\alpha f\phi - \alpha - \beta)}\sum_{j=2}^{\infty}(r - \phi)^{j-2}P_{t-j} + \frac{\varepsilon_t}{(\alpha f\phi - \alpha - \beta)}. \tag{13}$$

Let

$$b_0 = \frac{(\gamma_0 - \beta_0 + \gamma H)}{(\alpha f\phi - \alpha - \beta)} \tag{14a}$$

$$b_1 = \phi \tag{14b}$$

$$b_j = \frac{(r - f\phi)\phi[(\alpha + \gamma) - \alpha(r - \phi)](r - \phi)^{j-2}}{(\alpha f\phi - \alpha - \beta)} \qquad (j = 2, 3, 4, \ldots) \tag{14c}$$

$$u_t = \frac{\varepsilon_t}{(\alpha f\phi - \alpha - \beta)} \tag{14d}$$

then

$$P_t = b_0 + \sum_{j=1}^{\infty} b_jP_{t-j} + u_t. \tag{15}$$

Analysis of equations (14) shows that the b_j's have the following properties:

$$b_1 > 0$$

$$b_j \begin{cases} >0 \text{ if } j \text{ is odd} \\ <0 \text{ if } j \text{ is even} \end{cases} \quad \text{for} \quad 0 < f < 1 \quad \text{and} \quad (j = 2, 3, 4, \ldots)$$

$$|b_j| > |b_{j+1}| \qquad (j = 1, 2, 3, \ldots)$$

$$|b_j| < 1 \qquad (j = 2, 3, 4, \ldots).$$

Thus the model implies that when some traders have not acquired the most recent market information, the current market price will equal a linear combination of past prices plus a random-error term, that is, equation (15). The coefficients of past prices alternate in sign starting with a positive coefficient for the price immediately preceding the current price and the earlier the price, the smaller in absolute value is its coefficient.

An increase in market information acquired by the traders is equivalent to an increase in f. The effect of increased information on the relationship between the prices is found by differentiating b_j with respect to f. By equations (14):

$$\frac{\partial |b_j|}{\partial f} < 0 \qquad (j = 1, 2, 3, \ldots). \tag{16a}$$

With an increase in market information, the coefficients of past prices in equation (15) all decrease in absolute value. Also, it follows from equations (14d) and (15) that an increase in information decreases the variance of the price-forecast error.

$$\frac{\partial \sigma_u^2}{\partial f} < 0. \tag{16b}$$

In the extreme case where all traders know the latest market information, that is, in the case where $f = 1$, equation (8) shows that $\phi = r$. Therefore, by (14)

$$b_1 = r, \tag{17a}$$

$$b_j = 0 \qquad (j = 2, 3, 4, \ldots), \qquad f = 1. \tag{17b}$$

Equation (15) then becomes

$$P_t = b_0 + rP_{t-1} + u_t. \tag{18}$$

Why are price effects of uninformed traders not eliminated by traders with complete information? Put another way, why would fully informed traders limit their market positions instead of trading so that price is pegged at the level consistent with the unbiased estimate of the future price? One reason is related to the idea that individuals' expectations can differ for the same information set; the theory requires only that a weighted average of individual expectations based on complete information equal the expected value of the future price. Also, the fully informed traders need not be the same individuals in every period. Consequently, lack of confidence in his price forecast would limit the commitment made by each informed trader even though the completely informed traders will, as a group, earn profits at the expense of the group of traders with incomplete information. If there is no risk aversion to limit the commitments of fully informed traders, then price effects of uninformed traders would persist only to the extent that costs of transacting make it unprofitable to completely eliminate them.

Market Efficiency

The preceding implications about information and price behavior are compatible with theory developed in the efficient-markets literature—the model itself can be viewed as a particular efficient-markets model.[9] The work on efficient markets assumes that market equilibrium can be stated in terms of expected values of price changes, and that prices in an efficient market fully reflect available information. From these assumptions, it follows that the expected value of P_t conditional on all information at $t - 1$ is an unbiased estimate of P_t. That is,

$$E[P_t - E(P_t \mid \text{all information at } t - 1)] = 0. \tag{19}$$

For the model developed above, the assumption that market expectations equal conditional expected values allows equilibrium to be expressed in terms of expected values; available information is fully reflected in the price when all traders are informed. So price in an efficient market is represented by (18), from which the "fair game" property (19) follows directly:

$$E\{P_t - E[P_t \mid (\varepsilon_{t-1})]\} = E(u_t) = 0. \tag{20}$$

Implications about the sequence of observed prices in an efficient market depend upon the stochastic processes generating price changes. Several efficient-markets studies assume that successive price changes are independent, identically distributed random variables, which implies that the sequence of price changes is a random walk. In my model, however, both systematic and random factors generate price changes. Systematic changes are due to storage costs, and random changes are due to the disturbances that affect demand. Hence, successive price changes are not independent, and the sequence of price changes is not a random walk even when

[9] The efficient-markets literature is summarized in Fama (1970).

current information is fully reflected in the market price. To see this consider first differences of (18):

$$P_t - P_{t-1} = r(P_{t-1} - P_{t-2}) - u_{t-1} + u_t. \tag{21}$$

Equation (21) shows that successive price changes are correlated, although the history of earlier price changes $(P_{t-2} - P_{t-3}, P_{t-3} - P_{t-4}, \ldots)$ adds no additional information about $P_t - P_{t-1}$. If there were no storage in the model, only the independent, identically distributed disturbances in demand (ε_t) would cause price changes and the sequence of price changes would be a random walk.

If information is not fully reflected in the price, efficient-markets theory implies only that the fair-game property will not hold. Other than this, price behavior depends on the particular price-formation process and the information that does influence price. The model in the present work focuses on differences in price behavior when more or less information is reflected in price, so it specifies both price formation and information in order to show how the relation between prices depends on the quantity of information (15). Since (15) is just one of many possible ways that a price series can behave, empirical analysis is necessary to determine if it corresponds to actual price behavior. However, (15) is consistent with efficient-markets theory in that the sequence of differences between observed and expected price is not a fair game. When P_t is given by (15), expected value conditional on *all* information at $t - 1$ is the expected value of (18); hence:

$$E\{P_t - E[P_t \mid (\varepsilon_{t-1})]\} = (\phi - r)P_{t-1} + \sum_{j=2}^{\infty} b_j P_{t-j} + \text{constant}. \tag{22}$$

The history of past prices can be used to make a price forecast that is on average more accurate than the conditional expected value. As a result, when there are uninformed traders in the market, it may be possible for a chart reader to devise a profitable trading rule based only on past spot prices.

The preceding model provides a framework for testing the hypothesis that commodity futures trading affects spot prices by increasing the market's information about forces influencing supply and demand. The coefficients of past prices in (15) reflect the quantity of the market's information, and since (15) is an autoregressive process, the coefficients can be estimated empirically from a time series of a commodity's prices. If the estimated coefficients are consistent with the implications of the model, and if there is a difference between the coefficients for periods with and without futures trading, the change can be interpreted as the contribution of futures trading to market information. Furthermore, an increase in information should decrease the returns from a trading rule. This too can be tested with a series of spot prices. The next section investigates the price behavior of six different commodities.

II. Empirical Analysis

Evidence on price effects of futures trading is presented here for onions, potatoes, pork bellies, hogs, cattle, and frozen concentrated orange juice (FCOJ). For each of these commodities, price effects of futures trading are estimated by comparing price behavior in a period with no futures trading to price behavior in a period when the commodity is traded in a formal futures market.

The most important conclusions of this empirical analysis are: (1) futures trading in a commodity increases the quantity of traders' information, (2) a spot market is more efficient in the sense that price more fully reflects available market information when there is futures trading, (3) the behavior of prices does not support the claim that producers and consumers are harmed by price effects of futures trading.

Data and Periods Examined

Price series for each commodity are compiled from trade journals that report wholesale spot prices.[10] The prices are observed on 1 day at weekly intervals in the market where futures trading occurs and are for commodities with the same specifications as the basis grade for futures trading.

Sample periods depend on the length of time that a continual price series has been reported and on the date when futures trading in a commodity began. Periods when a commodity's prices were publicly controlled are also recognized in choosing the sample periods, since reported and transaction prices often differ during times of price controls.[11] Consequently, the lengths of the sample periods vary considerably; the longest sample contains 856 observations and the shortest contains 220 observations. The commodities, markets, and periods examined are listed in table 1.

[10] Onion prices are taken from two basic sources: for the period 1928–59, prices are from the *Chicago Packer*, a trade journal for the Chicago wholesale vegetable market; for the period 1960–71, prices are from *Chicago Fresh Fruit and Vegetable Wholesale Market Prices*, a publication of the U.S. Department of Agriculture. Two data sources are used because the *Packer* frequently failed to report onion prices after 1959, and the weekly price reports made available by the USDA were only for the years 1960 and later. Potato prices are all from the *Journal of Commerce*. All prices for pork bellies, hogs, and cattle are from the *National Provisioner*. Frozen concentrated orange juice prices are taken from the *Journal of Commerce*.

[11] The series for onions and potatoes exclude the period of World War II price controls because reported prices were constant at ceiling levels and were not transaction prices. The other commodities' series start after World War II controls ended. Potatoes, pork, and cattle were subject to price controls for different periods during the Korean war, but prices for these periods are included in the samples for potatoes, pork bellies, hogs, and cattle because the periods of price control were relatively short and the data indicate that ceilings were not effective for most of those periods. After August 1971, various price-control programs at different times set ceilings on prices of all the commodities or their processed forms. Therefore, all of the price series end prior to, or at the start of, controls in 1971.

TABLE 1

COMMODITIES, MARKETS, AND SAMPLE PERIODS

Commodity	Market	Futures Trading Started	Sample Period with No Futures Trading	Sample Period with Futures Trading
Yellow onions	Chicago	Sept. 8, 1942;* terminated Nov. 6, 1959†	Sept. 1928–Apr. 1942 Nov. 1959–Apr. 1971	Sept. 1948–Oct. 1959
Maine potatoes	New York	Dec. 2, 1941‡	Oct. 1925–July 1941	Oct. 1947–July 1971
Pork bellies	Chicago	Sept. 19, 1961	Oct. 1949–Sept. 1961	Oct. 1961–Sept. 1971
Hogs	Chicago§	Feb. 28, 1966	Oct. 1949–Feb. 1966	Mar. 1966–May 1970
Cattle	Chicago‖	Nov. 30, 1964	May 1949–Nov. 1964	Dec. 1964–July 1971
Frozen concentrated orange juice (FCOJ)	New York	Oct. 26, 1966	Jan. 1957–Oct. 1966	Nov. 1966–Aug. 1971

* Onion and potato prices were subject to U.S. government price controls from November 7, 1942 to September 6, 1946.
† Public Law 85-839 prohibiting trading in onion futures became effective November 6, 1959.
‡ Futures trading in potatoes was suspended during World War II and reopened January 17, 1946.
§ Trading in live hogs at the Union Stockyards in Chicago stopped in May 1970.
‖ Trading in live cattle at the Union Stockyards in Chicago stopped in July 1971.

The Econometric Model

To investigate the impact of organized futures trading on traders' information an autoregression of the following form is estimated for periods with and without futures trading:

$$P_t = b_0 + \sum_{j=1}^{n} b_j P_{t-j} + u_t, \tag{23}$$

where P_t is the spot price at time t, u_t is a random term, j is an interval of 1 week. The expected values of the coefficients in (23) are

$$|b_j| > |b_{j+1}|,$$

$$|b_j| < 1 \qquad (j = 2, \ldots, n)$$

$$b_j \begin{cases} >0 \text{ if } j \text{ is odd} \\ <0 \text{ if } j \text{ is even,} \end{cases}$$

for the fraction of fully informed traders $f < 1$. For $f = 1$, $0 < b_1 < 1$ and $b_j = 0$ $(j = 2, \ldots, n)$. A priori, the value of b_0 is not determined. Equations (16) show that for a change in the state of traders' information

$$\frac{\partial |b_j|}{\partial f} < 0 \qquad \text{and} \qquad \frac{\partial \sigma_u^2}{\partial f} < 0.$$

An increase in the fraction of traders with a knowledge of the current market information decreases both the coefficients of past prices and the mean-square error of estimate. Therefore, effects of futures trading on market information can be analyzed by comparing estimates of (23) for periods with and without futures trading.

The theory in Section I shows price as an infinite-order autoregression (15), so the number of lagged prices in the econometric model (23) is determined on the empirical basis of minimum mean-square error of estimate. The best-fitting regressions for the sample periods with no futures trading are all obtained with five to 10 lagged prices. Autoregressions of the same order are then estimated for the periods with futures trading in order to compare parameters with and without futures trading.

The procedure used to estimate (23) is ordinary least squares, which yields consistent estimates of autoregressive parameters if the time series is stationary with independent and identically distributed disturbance terms. The price series investigated here are weakly stationary—they all exhibit seasonal patterns, but for periods spanning several years the prices vary about a fixed mean like a stationary series. Also, the sample correlograms damp out without peaks at the seasonal lags. Hence, the series are treated as stationary and no adjustments are made for seasonality. Analysis of residuals suggests that the disturbances are well behaved.

Only one of the regressions (FCOJ, 1957–66) has significant autocorrelation in the residuals.[12]

The price series used here are all nominal prices. This is dictated by the fact that there is no weekly price index for the entire sample period that can be used to transform the series into real prices. Deflating the prices with the monthly BLS Wholesale Price Index produces only minor changes in the regression results that are reported below. But this may result because the procedure does not change the relation between prices that are observed in the same month.

The Effect of Futures Trading on Market Information

The regressions in table 2 estimate (23) and compare spot-price behavior in the absence of futures trading to spot-price behavior during periods of futures trading. The evidence strongly supports the hypothesis that futures trading increases the quantity of traders' market information.

First, it is reasonable to interpret differences in the regression estimates as changes in information because the model is able to predict relations between prices. Estimated coefficients for each of the regressions conform to the expected values. For each of the 13 regressions, the absolute values of the coefficients b_2 through b_n are less than one and tend to conform to the prediction that $|b_j| > |b_{j+1}|$. Only one equation fits this pattern perfectly, but there are only three regressions for which half or more of the coefficients do not fit this pattern. As expected, the coefficients tend to alternate in sign, and there is a tolerable correspondence between predicted and actual signs. The regressions have, on average, 71 percent of the expected runs of signs. For one regression all of the signs are the same as predicted, and only three regressions have as many as four coefficients that differ from the predicted signs. The interval of 1 week between price observations is arbitrary, and this interval influences the actual patterns of coefficients. The agreement between the estimated and expected patterns of coefficients, therefore, suggests that the model is useful for analyzing week-to-week price behavior.

Second, for every commodity comparisons of the regression estimates with and without futures trading indicate more informed traders during periods of futures trading. As predicted for an increase in market information, the estimated coefficients during periods of futures trading are generally less in absolute value than the same coefficients in periods without futures trading. Thirty-five of the 48 coefficients decrease in absolute value, and only one of seven comparisons has an increase in as

[12] Residuals for each regression are tested for autocorrelation according to the procedure developed for autoregressions by Box and Pierce (1970). The Durbin-Watson statistic which is usually used to test for autocorrelated disturbances is biased toward accepting the null hypothesis of independent disturbances for any autoregression.

many as half of the coefficients.[13] However, the results are striking when significance of the coefficients is considered. In the absence of futures trading, all of the commodities have one or more of the coefficients b_2 through b_n that are significantly different from zero at the 5 percent level. For the regressions during periods of futures trading, only two of the 37 coefficients b_2 through b_n are different from zero at the 10 percent level! That is, the regression estimates not only show increased information during periods of futures trading for each commodity, for four of the commodities the estimates are consistent with all traders knowing the latest market information.

Put another way, increased market information reduces the relation between current and past prices. When all traders know the latest information, the current price "depends" only on the immediately preceding price. Therefore, the evidence reflected in comparisons of regression coefficients with and without futures trading can be conveniently summarized by testing the joint influence of P_{t-2} through P_{t-n} on P_t. The appropriate analysis-of-variance test is equivalent to testing the null hypothesis that $b_2 = b_3 = b_4 = \cdots = b_n = 0$. Table 3 reports this test for each regression. The results add evidence that futures trading increases market information. In the absence of futures trading, the set of lagged prices P_{t-2} through P_{t-n} is significant at high levels for every commodity. For periods of futures trading, all the sets of lagged prices are insignificant even at low critical levels when the regression coefficients have low t-ratios. So there is a consistent and significant decrease in the influence of past prices on the current price.

The results for onions are important because trading in onion futures is prohibited, and it is possible to analyze onion prices both prior to and after the time of futures trading. In both of the periods with no futures trading, 1928–42 and 1959–71, the current price depends significantly on lagged prices other than P_{t-1} as expected for a market with uninformed traders. But during the period of futures trading, 1948–59, lagged prices other than P_{t-1} are insignificant as predicted for a market with fully informed traders. Besides indicating increased information during the time of futures trading, this finding provides evidence that the information is due to futures trading rather than some other force that increases information over time. The same difference in significance of lagged prices is exhibited by pork bellies, hogs, and FCOJ when the periods prior to futures trading are compared to periods with futures trading. On the other hand, potatoes and cattle are noteworthy because the regression results indicate increased information with futures trading, but even then

[13] Although two-thirds of the coefficients decrease when there is futures trading, the set of coefficients $b_0, b_1, \ldots, b_n$ differs significantly (at the 5 percent level) from the set when there is no futures trading for only two of the seven tests. The significantly different regressions are for onions prior to futures trading and potatoes.

TABLE 2

SPOT-PRICE REGRESSIONS

$$\left(P_t = b_o + \sum_{j=1}^{n} b_j P_{t-j} + u_t\right)$$

Commodity and Period	b_o	b_1	b_2	b_3	b_4	b_5	b_6	b_7	b_8	b_9	b_{10}	R^2	SE of Estimate	Sample Size
Onions:														
Sept. 1928–Apr. 1942 . .	0.051	0.657	0.257	−0.139	0.093	0.075	. . .	. . .	. . .	. . .	. . .	.794	0.249	473
	(2.281)	(13.746)	(4.355)	(−2.335)	(1.568)	(1.524)								
Sept. 1948–Oct. 1959 . .	0.131	0.963	−0.065	0.021	−0.062	0.063	. . .	. . .	. . .	. . .	. . .	.844	0.358	369
	(3.147)	(18.377)	(−0.898)	(0.295)	(−0.850)	(1.205)								
Nov. 1959–Apr. 1971 . .	0.131	1.018	0.018	−0.194	0.144	−0.052	. . .	. . .	. . .	. . .	. . .	.889	0.259	382
	(3.366)	(19.706)	(0.250)	(−2.728)	(2.018)	(−1.019)								
Potatoes:														
Oct. 1925–July 1941 . .	0.066	0.893	0.148	−0.077	−0.155	0.102	0.049	. . .	. . .	. . .	. . .	.918	0.256	618
	(2.850)	(22.101)	(2.744)	(−1.441)	(−2.894)	(1.906)	(1.235)							
Oct. 1947–July 1971 . .	0.267	0.872	0.103	0.0004	−0.073	0.023	−0.005	. . .	. . .	. . .	. . .	.849	0.414	809
	(5.093)	(24.685)	(2.196)	(0.009)	(−1.560)	(0.491)	(−0.131)							

TABLE 2 (*Continued*)

Pork bellies:														
Oct. 1949– Sept. 1961 . .	0.804	1.013	0.003	−0.148	0.190	−0.085	. . .	. . .	. . .	. . .	. . .	.951	1.728	621
	(2.844)	(25.213)	(0.052)	(−2.524)	(3.244)	(−2.074)								
Oct. 1961– Sept. 1971 . .	0.678	0.968	−0.038	0.037	0.050	−0.038	. . .	. . .	. . .	. . .	. . .	.956	1.708	517
	(2.179)	(21.865)	(−0.622)	(0.596)	(0.810)	(−0.852)								
Hogs:														
Oct. 1949– Feb. 1966 . .	0.413	1.005	0.013	−0.001	−0.046	0.076	−0.057	0.090	−0.102	. . .	. . .	.965	0.667	848
	(3.171)	(29.267)	(0.264)	(−0.021)	(−0.944)	(1.574)	(−1.178)	(1.842)	(−2.936)					
Mar. 1966– May 1970 . .	0.672	0.954	0.096	−0.020	−0.084	0.060	−0.081	0.065	−0.020	. . .	. . .	.945	0.753	212
	(1.705)	(13.617)	(0.996)	(−0.204)	(−0.877)	(0.624)	(−0.841)	(0.674)	(−0.282)					
Cattle:														
May 1949– Nov. 1964 . .	0.358	0.791	0.116	0.176	−0.140	0.132	−0.031	0.034	−0.040	−0.052	. . .	.973	0.704	804
	(2.315)	(22.344)	(2.568)	(3.880)	(−3.064)	(2.895)	(−0.675)	(0.751)	(−0.893)	(−1.472)				
Dec. 1964– July 1971 . .	0.623	0.787	0.235	0.057	−0.057	0.014	0.004	−0.098	−0.039	0.074	. . .	.954	0.552	339
	(1.828)	(14.295)	(3.351)	(0.807)	(−0.797)	(0.201)	(0.056)	(−1.372)	(−0.547)	(1.329)				
FCOJ:														
Jan. 1957– Oct. 1966 . .	0.754	0.930	0.070	0.027	0.100	−0.204	0.103	0.007	−0.049	0.128	−0.131	.976	1.772	502
	(2.563)	(20.793)	(1.143)	(0.443)	(1.639)	(−3.333)	(1.691)	(0.113)	(−0.803)	(2.101)	(−2.957)			
Nov. 1966– Aug. 1971 . .	0.706	1.013	−0.030	0.076	−0.072	0.001	−0.002	0.006	0.044	−0.054	−0.003	.965	1.224	242
	(1.618)	(15.396)	(−0.321)	(0.811)	(−0.769)	(0.012)	(−0.026)	(0.061)	(0.470)	(−0.568)	(−0.047)			

NOTE.—Figures in parentheses are t-ratios.

TABLE 3

ANALYSIS-OF-VARIANCE TEST FOR THE CONTRIBUTION OF $P_{t-2}, P_{t-3}, \ldots, P_{t-n}$ TO THE EXPLAINED SUM OF SQUARES

COMMODITY AND PERIOD	df		F-VALUE	SIGNIFICANCE LEVEL
	Numerator	Denominator		
Onions:				
Sept. 1928–Apr. 1942.....	4	467	10.674	.01
Sept. 1948–Oct. 1959.....	4	363	0.600	*
Nov. 1959–Apr. 1971.....	4	376	2.702	.05
Potatoes:				
Oct. 1925–July 1941......	5	611	4.350	.01
Oct. 1947–July 1971......	5	802	1.463	.25[a]
Pork bellies:				
Oct. 1949–Sept. 1961.....	4	615	3.050	.05
Oct. 1961–Sept. 1971.....	4	511	0.556	*
Hogs:				
Oct. 1949–Feb. 1966.....	7	839	2.321	.05
Mar. 1966–May 1970.....	7	203	0.456	*
Cattle:				
May 1949–Nov. 1964.....	8	794	7.887	.01
Dec. 1964–July 1971.....	8	329	2.508	.05[b]
FCOJ:				
Jan. 1957–Oct. 1966......	9	491	2.918	.01
Nov. 1966–Aug. 1971.....	9	231	0.283	*

[a] The F-value for the contribution of $P_{t-3}, P_{t-4}, P_{t-5}, P_{t-6}$ is 1.182, which is not significant at the .25 level.
[b] The F-value for the contribution of $P_{t-3}, P_{t-4}, \ldots, P_{t-9}$ is 1.093, which is not significant at the .25 level.
* Not significant at .25 level.

all traders are not fully informed. For both commodities, P_{t-2} remains highly significant in the periods of futures trading.

Another implication of increased information is a decrease in the variance of the price-forecast error. The empirical counterpart of σ_u^2 in (16) is the standard error of estimate for the regressions in table 2. However, the levels of prices differ between the sample periods, tending to reduce the standard errors in periods of relatively low prices which correspond to periods without futures trading. To remove the price level effect, the standard errors of estimate are expressed as coefficients of variation in table 4. The results support the other evidence of increased information due to futures trading: six of the seven comparisons show a smaller coefficient of variation with futures trading. The conflicting result is for onions, where the coefficient of variation decreases when onion futures are prohibited.

In sum, the tests for each commodity strongly support the hypothesis that additional traders are informed of the latest market information due to futures trading. The evidence on the information effect of futures trading is remarkably consistent over different commodities and time

TABLE 4

STANDARD ERRORS OF ESTIMATE AS PERCENTAGES OF THE SAMPLE MEANS

Commodity and Period	SE of Estimate	Sample Mean	Coefficient of Variation
Onions:			
Sept. 1928–Apr. 1942	0.249	0.804	30.996
Sept. 1948–Oct. 1959	0.358	1.646	21.760
Nov. 1959–Apr. 1971	0.259	1.995	13.006
Potatoes:			
Oct. 1925–July 1941	0.256	1.707	15.014
Oct. 1947–July 1971	0.414	3.323	12.473
Pork bellies:			
Oct. 1949–Sept. 1961	1.728	29.947	5.771
Oct. 1961–Sept. 1971	1.708	31.881	5.357
Hogs:			
Oct. 1949–Feb. 1966	0.667	18.602	3.585
Mar. 1966–May 1970	0.753	22.445	3.355
Cattle:			
May 1949–Nov. 1964	0.704	25.730	2.737
Dec. 1964–July 1971	0.552	27.336	2.019
FCOJ:			
Jan. 1957–Oct. 1966	1.772	39.467	4.490
Nov. 1966–Aug. 1971	1.224	32.950	3.714

periods. This leads me to conclude that a significant price effect of futures trading reflects an increase in market information.

The Returns to a Trading Rule

A major empirical implication from the theory of efficient markets is that a trading rule based solely on the history of a commodity's price will not be profitable if the market's expected price fully reflects current market information. Evidence for the six commodities presented above indicates that those prices do not fully reflect available information in the absence of futures trading. In periods with futures trading, however, prices of four commodities behave as if market information is fully reflected in the price and the other two commodities show increased information. Hence, it is possible that a chartist could earn profits from a trading rule in the periods with no futures trading, but the spot markets become more efficient when there is futures trading and a chartist's profits should be eliminated or sharply reduced. There may not be actual commodity markets where price changes are random—Houthakker (1961) has shown that trading rules for wheat and corn futures are apparently profitable—but the important question for this study is whether there is a difference in profits that is consistent with the evidence on information.

The returns to one trading rule are examined here to see if the predicted change does occur. These returns are gross returns because the calculations do not include some costs such as the cost of transacting. Furthermore, this is a special test because an unlimited number of trading rules could be devised. The trading system considered is the following: Estimate an autoregression like those in table 2 for the first half of each sample period and use that equation to forecast the price 1 week hence for each observation in the last half of the sample. If the forecast is above the current price, buy one unit of the commodity and sell it at the market price 1 week hence. If the forecast is below the current price, sell one unit of the commodity and replace it at the market price 1 week hence. The return is measured as the difference between the selling and buying price.

Table 5 contains the statistics pertinent to this analysis. First, consider the average returns from the trading system. In the absence of futures trading, the average return is positive for all six commodities, but it is negative for three of the commodities when there is futures trading. The trading system is risky in every case—none of the mean returns is as much as 25 percent of the standard deviation—however, the variability of returns increases in periods of futures trading for five of the six commodities. In order to compare magnitudes, the averages are expressed as annual rates of return on the mean price for each trading period. This is approximately the rate of return on investment for a chartist using the trading system. With no futures trading, the rates of return range from 11 to 389 percent; with futures trading the range is from -13 to 25 percent. The results for onions and potatoes are remarkable. Prior to the time of futures trading, the rule yields an annual return of 389 and 108 percent for onions and potatoes, respectively. When there is futures trading in these commodities, the returns fall to -1 and 15 percent. Notice, too, that when onion futures are prohibited, the return increases substantially to 25 percent. Only one of the seven comparisons (FCOJ) shows a greater rate of return with than without futures trading. Overall, the difference in returns to the trading rule is consistent with the prediction that spot markets are more efficient because of futures trading. This result is additional support for the hypothesis that traders are more fully informed when there is organized futures trading in a commodity.

Could the markets be so imperfect that chartists would not learn of 300, 100, or even 25 percent rates of return, enter the markets, and thereby reduce the returns to more "normal" levels? The answer to this question requires a knowledge of more than the sequence of market prices. The cost of transacting in the spot markets was ignored in calculating the returns; yet costs of identifying potential traders, searching for the best price, and negotiating other terms of the exchange would lower the net returns in every case. Also, it is likely that the cost of transacting per unit of commodity traded declines enough that more than one unit would have

TABLE 5

RETURNS TO A TRADING RULE BASED ON THE HISTORY OF PRICES

Commodity and Period	Average Return per Trade	SD of Returns	Annual Rate of Return	Number of Trades
Onions:				
Sept. 1935–Apr. 1942	.0607	0.261	389.886	240
Mar. 1954–Oct. 1959	−.0005	0.368	−1.782	184
Oct. 1965–Apr. 1971	.0113	0.303	25.610	191
Potatoes:				
Apr. 1933–July 1941	.0297	0.251	108.658	313
Mar. 1960–July 1971	.0106	0.421	15.652	407
Pork bellies:				
Oct. 1955–Sept. 1961	.0942	1.838	17.644	313
Oct. 1966–Sept. 1971	−.0843	1.863	−13.380	261
Hogs:				
Dec. 1957–Feb. 1966	.0385	0.607	11.216	430
Apr. 1968–May 1970	.0203	0.732	4.494	111
Cattle:				
Feb. 1957–Nov. 1964	.0864	0.581	18.188	408
Apr. 1968–July 1971	−.0187	0.634	−3.321	174
FCOJ:				
Dec. 1961–Oct. 1966	.1408	1.988	17.986	257
Apr. 1969–Aug. 1971	.1769	1.013	25.889	126

to be traded to make the system worthwhile. If so, it is important to know about the breadth of the market, that is, whether an optimum size purchase or sale would change the market price enough to eliminate any potential profits. For these reasons, the returns in table 5 do not seem unreasonably high.

III. Conclusion

The empirical evidence on price behavior clearly shows an information effect of futures trading. Both week-to-week price analysis and returns to a trading system based on the history of prices yield results consistent with increased information from futures trading. So market prices provide more accurate signals for resource allocation when there is futures trading in a commodity. Previous work on price effects of futures trading has not investigated the relation between futures trading and market information. Yet the strength and consistency of the evidence reported here suggest that price effects of futures trading result mainly from more fully informed traders.

The results in this study are directly relevant to public policy because they contradict the main argument made in behalf of legislation that prohibits trading in onion futures and regulates futures trading in other commodities. The data do not support the claim that price effects of futures trading impose costs on producers, consumers, and others who handle the physical commodity. On the contrary, spot markets seem to work more efficiently because of futures trading. The prohibition of futures trading reduces market efficiency. The other restrictions on futures trading may or may not benefit the public—we do not know the effects of this regulation—but the argument for those restrictions is incorrect.

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