Review of Economic Studies (1984) LI, 33–52 0034-6527/84/00030033$00.50

Considering an Informational Role for a Futures Market

PAMELA P. BRANNEN
Citizens and Southern Georgia Corporation

and

EDWIN F. ULVELING
Georgia State University

This study compares how well current spot prices predict future spot prices for a variety of commodities in a non-futures market environment and examines how the predictive power of the price system is altered after the initiation of futures trading. The results indicate a positive association between the inability of a non-futures market price system to predict the future spot price and the subsequent development of a futures market. The claim that traders can earn a return on information collection after the introduction of a futures price into the pricing system is supported for some, but not all, commodities.

1. INTRODUCTION

Traditional models of a "perfect market" have assumed all traders are equally endowed with knowledge and the ability to analyse that knowledge. This assumption eliminates differences of opinion as a viable reason for trading. Even allowing for homogeneous analytical ability, the amount of potentially relevant information available to traders is sufficient to imply that all traders cannot collect and analyse all information. Therefore, as Holbrook Working (1958: 37–39) noted, it is reasonable to assume that an "informal division of labour" occurs. Different traders, due to circumstance and taste, concentrate on acquiring particular information. If useful information were being neglected, some traders would soon recognize the profitability of its collection and use.

Because of the cost associated with information collection and analysis, traders invest in information expecting to earn a return on that investment. These traders, making profits on expectational differentials arising from information differences, suggest a function for futures markets in addition to the traditional insurance, or risk reallocation, function. The futures market provides a place where, through information exchange, traders can earn a return on their investment in information.

Postulate a group of traders in a spot market making demand decisions based on their beliefs about a random environmental variable. The random equilibrium price variable will be a function of these beliefs. Then allow a trader or group of traders to be given (random) superior information about the distribution of the environmental variable. Their revised beliefs will lead to new demands and to an adjusted equilibrium price reflecting this new information. Can uninformed traders determine this new information by noting the new equilibrium price? Or, more importantly, can they determine the price expected by the informed trader conditional on the new information? If so, there will be no price expectation differences among traders. Will there then be any incentive for the private collection of information?

The incentive depends on how much information is conveyed through prices. Equilibrium prices will be affected by the trading activity of those who have invested in information, and, therefore, these prices will be functions of that information. So prices may be viewed as statistics freely revealing costly information to those with no investment in information collection. But prices are also affected by other factors which add "noise" to the system of information transmission.

If the current spot price reveals all information to the uninformed, a futures market could serve no informational role. If there is "noise" in the current spot price, so that not all information is conveyed, there would be an incentive for people to collect information and for a futures market to develop for information exchange. These informed traders could expect to earn a return on their investment in information in the futures market as long as their expectations of the future spot price differ from the expectations of uninformed traders.

However, the establishment of the futures market will provide a new statistic to the uninformed. Now the relevant price system includes both the current spot price and the futures price. Uninformed traders form their future spot price expectations conditional on both prices in the price system. Informed traders form their expectations conditional on their information. If the addition of the futures price to the system eliminates the "noise" in the system, then information known to the informed is again revealed without cost to the uninformed. The expectations of the future spot price for the two groups will be the same, and no return to information can be expected by the informed. The information exchange role of the futures market would cease. There will be no private incentive to collect information. As long as noise remains in the system, a difference in expectations will persist, providing an incentive for private information collection and providing an information exchange role for the futures market.

Grossman (1975, 1977) has suggested that such information differentials may be one reason why futures markets have developed for some commodities and not for others.[1] This paper examines that claim for a specific set of commodities. Based on Grossman's model, differences in expectations due to information differences among traders are compared for a set of commodities over a time interval when none are traded in an organized futures market. Subsequently, futures markets do develop for a subset of these commodities. The evidence is examined to see if there is an association between the information-related expectation differences and market development.

According to Grossman's claims if "noisy" prices do "leak" information, then the addition of the futures price to the price system after futures markets development will reduce expectation differences among traders. This paper continues to investigate Grossman's claims by examining, for a specific set of commodities, the change in expectation differences among traders before and after futures trading evolves.

Specifically, this paper examines the following claims:

1. Do information-induced differences in price expectations help explain why futures markets develop for some commodities and not for others.

2. Does the development of a futures market reduce the information and expected price differences among traders?

2. THE MODEL

Using the Grossman model developed in (1975, 1977), consider a commodity that is produced (harvested) only at certain times of the year but is storable and may be consumed throughout the year. Once the planting decision has been made, the relevant decision becomes how much of the harvest (or expected harvest) to sell immediately and how much to carry forward in inventory. The planting decision has been made, but the harvest has a random component. Uncertainty enters the model via random factors in both present and future consumption.

Initially

$$p_2 = D_2(I, w_2) \tag{1}$$

and

$$D_1(p_1) = w_1 - I \tag{2}$$

where I represents inventories, w_1 is the realized value of a random variable representing the harvest, and w_2 is the realization of a (vector) random demand variable. Demand in the harvest period, period 1, is a function of the first period price, p_1. Period 2 involves no new production and D_2 represents demand for the stored inventory or carry-over. There is no carry-over into the next harvest period. Therefore, the model analyses intertemporal allocation of a single harvest.

Assume that the realization of the joint distribution of $(\tilde{w}_1, \tilde{w}_2)$ is unknown.[2] Traders will be comprised of two groups, those who invest to learn about $(\tilde{w}_1, \tilde{w}_2)$ and those who do not. Grossman demonstrates that in equilibrium w_1 will be revealed to informed traders. Therefore they employ no resources to study the distribution of w_1 and devote all resources to the study of $\tilde{w}_2$. Let μ be a (vector) random variable joint normally distributed with $\tilde{w}_2$ and with the covariance not identically equal to the zero matrix. Prior to trading informed traders pay to learn the true value of μ. During trading these informed traders use μ in forming expectations about the future price, p_2. Uninformed traders will form expectations of p_2 using the observable current spot price, p_1, and $\theta(\mu)$, a measure of their prior beliefs about μ. Therefore informed traders will

$$\max_I E(((\tilde{p}_2 - p_1)I - C(I))|w_1, \mu) \tag{3}$$

and uninformed traders will

$$\max_I\ (((\tilde{p}_2 - p_1)I - C(I))|\tilde{p}_1 = p_1) \tag{4}$$

where $C(I)$ is a non-negative storage cost function with $C'(x) > 0$ for some $x > 0$ and $C''(I) > 0$ for all non-negative I. Equilibrium conditions are discussed in Grossman.

When informed traders[3] observe w_1 and μ they form an equilibrium expected price, p_2. The equilibrium inventory supply depends on the w_1 and the μ they observe. This means that the equilibrium p_1 depends on w_1 and μ also. With $p_1^e = p_1(w_1, \mu)$, this price becomes a statistic that uninformed traders can use to get information about μ. As long as there are differences in price expectations, $E(\tilde{p}_2|w_1, \mu) - E(\tilde{p}_2|\tilde{p}_1^e(w_1, \mu)) \neq 0$, traders will have incentives to trade.[4]

With random supply the uninformed cannot, in general, separate the effects of μ and w_1 and cannot determine the optimal inventory level of the informed. Therefore, they cannot discover the price expected by the informed. $\tilde{w}_1$ adds noise; p_1 does not fully disseminate $E(p_2|w_1, \mu)$; and differences in expectations persist.

The incentive to invest in information is related to how well the current spot price predicts the future price expected by the informed. Var $(E(\tilde{p}_2|w_1, \mu)|p_1)$ is a measure of how well the current spot price predicts (for the uninformed) the average future spot price based on all available information. Hence, a (relatively) large variance, suggesting that p_1 is a (relatively) poor predictor, would indicate greater private incentive for information gathering. Since greater differences in profits indicate greater differences in price expectations, this result would also suggest incentives for a futures market to develop. Different price expectations would imply that traders have incentives to hold opposite positions in a futures market.

Therefore, the existence of a futures market can be expected to depend on how well p_1 predicts p_2 in terms of mean square prediction error conditional on all available information. The analogous expression after market development is var$(E(\tilde{p}_2|z)|p_1, p_f)$ where $z=(w_1, \mu)$. This measures the size of expected differences in prices on average or the average (squared) difference in beliefs between the informed and the uninformed.[5] However, both var $(E(\tilde{p}_2|z)|p_1)$ and var $(E(\tilde{p}_2|z)|p_1, p_f)$ are unobservable. Therefore, the following identity will prove useful in making the model operational:

$$\text{var}\,(p_2|p_1, p_f) = \text{var}\,(E(\tilde{p}_2|z)|p_1, p_f) + E(\text{var}\,(\tilde{p}_2|z)|p_1, p_f). \tag{5}$$

This follows from the fact that p_1 and p_f are functions of z and from $E(E(\tilde{p}_2\gamma z)|p_1, p_f) = E(\tilde{p}_2|p_1, p_f)$.[6]

Equation (5) is used to test whether differences in information among traders help to explain why futures markets develop for some commodities and not for others. Note that var $(\tilde{p}_2|z)$ does not depend on z but only the moments of $\tilde{z}$ and $\tilde{w}_2$. Hence E(var $(\tilde{p}_2|z\,|p_1, p_f)$ = var $(\tilde{p}_2|z)$ so that equation (5) may be re-written,

$$\text{var}\,(\tilde{p}_2|p_1, p_f) = \text{var}\,(E(\tilde{p}_2|z\,|p_1, p_f) + \text{var}\,(\tilde{p}_2|z). \tag{6}$$

Provided that there are no changes over time in the joint distribution of $\tilde{z}$ and $\tilde{w}_2$ so that var $(\tilde{p}_2|z)$ is constant it is then possible to use changes in var $(\tilde{p}_2|p_1, p_f)$ to estimate changes in var $(E(\tilde{p}_2|z)|p_1, p_f)$. In the period with no futures market the analogous expression for (6) is:

$$\text{var}\,(\tilde{p}_2|\,p_1) = \text{var}\,(E(\tilde{p}_2|z)|\,p_1) + \text{var}\,(\tilde{p}_2|z). \tag{7}$$

Assume that $(\tilde{z}, \tilde{w}_2)$ is multivariate normal, that $\tilde{z}$ is correlated with $\tilde{w}_2$ and that the logs of prices are linear in their arguments. For notational convenience, logs of prices are denoted with upper case letters.

$$\tilde{P}_2 = h_2 \cdot \tilde{z} + \tilde{w}_2 \tag{8}$$

$$\tilde{P}_1 = h_1 \cdot \tilde{z} \tag{9}$$

and

$$\tilde{P}_f = h_f \cdot \tilde{z}, \tag{10}$$

where h_2, h_1, and h_f are each vectors and $\tilde{z}$ is a vector of exogenous variables. It follows that both $(\tilde{P}_1, \tilde{P}_2, \tilde{P}_f)$ and $(\tilde{P}_2, \tilde{z})$ are joint normal. Since prices can never be negative the log normal distribution seems to be a better assumption than the normal distribution for prices. Var $(\tilde{P}_2|P_1, P_f)$ can be estimated by regressing P_2 on P_1 and P_f:

$$\tilde{P}_{2t} = a + bP_{1t} + cP_{ft} + \tilde{e}_t. \tag{11}$$

The standard error of the estimate, SEE, in (11) provides the estimate of $\sqrt{\text{var}\,(\tilde{P}_2|P_1, P_f)}$. In a period with no futures market the appropriate regression equation becomes:

$$\tilde{P}_{2t} = a + bP_{1t} + \tilde{e}_t \tag{12}$$

and $\sqrt{\text{var}\,(\tilde{P}_2|P_1)}$ is estimated by SEE in (12).

Estimates of var $(\tilde{P}_2|P_1)$ were determined for various commodities using equation (12). No futures markets exist for the selected commodities over the estimation period. However, futures markets do develop subsequently in a subset of the chosen commodities. If information induced differences in expectations among traders do help explain why futures markets develop for some commodities and not for others, a positive correlation will exist between the variance and the development of a futures market for the commodity. The reasoning is that if var $(E(\tilde{P}_2|z)|P_1)$ is large, P_1 is not revealing a great deal about $E(\tilde{P}_2|z)$. The potential for a return on information encourages futures market development. The hypothesis that the variance is not correlated with the subsequent development of a futures market against the alternative that higher variances are associated with such market development is tested, and the results are detailed in Section 4.

A second test considers whether the existence of a futures market reduces the informational differential among traders. Equations (11) and (12) are used to estimate var $(\tilde{P}_2|P_1)$ and var $(\tilde{P}_2|P_1, P_f)$ for commodities during periods prior to and after futures market development. If the second claim is valid, the futures trading period, providing the additional price statistic, should have the smaller variance, implying that the addition of the futures price statistic reduces the expected price deviation term in equation (5). The hypothesis that the pre-trading variance is the same as the post-trading variance against the alternative that the post-trading variance is smaller is tested with the results reported in Section 4.

3. DATA DESCRIPTION

The study required a set of commodities that meets the following conditions:

1. The commodities must fit the demands of the model as well as possible. The model considers intertemporal allocation over a single crop year assuming no inventory carryover from past or into future years. Therefore, the selected commodities could not be readily storable but should be perishable or semi-perishable. This eliminated such "crops" as cotton, the metals, and most of the grains, which have large end-of-year carryover.

2. Since the data required would include both a pre-(futures) trading and post-trading period, commodities that began trading early in futures market history were eliminated from consideration. Data for the pre-trading period would be unavailable or unreliable. In addition to cotton (1870), corn (1877) and wheat (1877), this condition excludes such commodities as eggs (1919) and butter (1919). Very recently traded commodities, such as frozen boneless beef and sunflower seeds do not have sufficiently long post-trading periods to warrant consideration.

The commodities finally selected, commodities with relatively small carryovers and available price data for pre- and post-trading periods, are Maine potatoes, onions, wool, frozen pork bellies, and frozen concentrated orange juice. This selection includes as wide a variety of commodities as possible subject to the constraints noted above. The price data required was:

p_1 = Cash price representing harvest time (period 1)
p_2 = Cash price representing the time during the crop year when inventories held at harvest began to move into markets (period 2).
p_f = The futures price in period 1 for the period 2 contract.

The New York Mercantile Exchange began trading Maine potatoes in 1941. The pre-trading period for the study is 1924–1939. Post-trading price data is collected for 1947–1976. The crop year for Maine potatoes begins in the Fall. Cash prices are New York wholesale in ¢/cwt. For the purposes of this study, p_1 is the November cash price, p_2 is the March cash price, and p_f is the November price of the March futures contract.[7] Although there was some government intervention in the markets from 1947–1950, it was not a major influence.

Most commercial onions are late onions harvested in the Fall with stores depleted in early Spring. January is a primary hedge month with some hedges rolled into February and March. Cash prices are Chicago wholesale in dollars per 50 pound sack. p_1 and p_2 are November and January prices respectively. The futures price, p_f, is the November price of the January contract. Onion trading began at the Chicago Mercantile Exchange in September 1942, was declared illegal by the government, and ceased on November 6, 1959. Onions are the only commodity whose trading is suppressed by the government. This allows for a pre-trading period (1929–1941), a post-trading period (1945–1958), and an additional post-nontrading period (1959–1978).

The Wool Association of the New York Cotton Exchange began trading grease wool in 1941. Domestic wool is produced in Texas, Wyoming, Montana and California, with the world's largest central market in Boston. Shorn wool is available (harvested) from February to July with inventories peaking in May or June. Cash prices are Boston average raw wool prices in ¢/lb. April and December prices are used for p_1 and p_2, respectively. Therefore, p_f is the April price of the December contract. The pre-trading period used is 1929–1940. During the war years the government bought large quantities of wool with the Commodity Credit Corporation providing price floors from 1944 to 1947. In 1954 the Wool Act abandoned price supports in favour of market pricing with "incentive payments" possible. The post period used in the study is 1955–1970. Since 1970, wool has become a thin market and data would be unreliable. These years are excluded from the study.

Pork Bellies have been a very actively traded commodity on the Chicago Mercantile Exchange since 1961. The pre-trading period is 1949–1960, and the post-trading period is 1963–1977. The commodity traded is a 12–14 pound frozen pork belly, a semi-perishable. A "crop year" can be identified for bellies from the corresponding "crop year" for pigs. Spring pigs are generally marketed in August through December with bellies, therefore, available with a slight lag. Inventories usually increase until May, and then fall until October as stores make their way into the market place. December and July ¢/lb. Chicago prices are p_1 and p_2 respectively. p_f is the December price of the July contract.

Of the commodities selected for the study, frozen concentrated orange juice (FCOJ) has the shortest trading history. It is traded through the Citrus Association of the New York Cotton Exchange where trading began in 1966. Therefore, the post-trading period is quite brief, extending from 1968 to 1976. The pre-trading period is 1957–1966.

The FCOJ contract is for 15,000 pounds solid (pounds of pure orange solids or bulk concentrate) delivered to licensed Florida warehouses. Therefore, pricing data for futures is in ¢/lb. solid. This is not a cash price commonly quoted prior to futures trading, and even today the cash price quoted in the *Wall Street Journal* is inappropriate because it is a New York price for pounds solid. Appropriate cash prices, p_1 and p_2, were computed from suggestions and data provided by the Florida Citrus Mutual and the Florida Citrus Processors Association. (See Appendix A.)

The crop year begins in December with over one-half of the crop harvested by the first of March and the Valencia orange harvested somewhat later. Seventy-five percent of U.S. oranges are grown in Florida and seventy-five percent of these are used for FCOJ. February and July are the respective cash periods for p_1 and p_2. The February price of the July contract determines p_f.

In addition to the commodities described above, a second set of commodities which do not develop futures markets was required. These commodities must also satisfy the conditions of the model in that the crop is basically a one-year crop without substantial across-crop-year carryovers. Further, these crops should have no specific characteristics that would prohibit futures market development. Characteristics of commodities adaptable to futures trading include homogeneity and gradeability. The units of the commodity must be interchangeable and the commodity must be susceptible to standardization of grades. (Gradeability was a problem with wool overcome with the help of the USDA. Tea is another example of a commodity difficult to grade.) A large and uncertain supply and demand is another necessary characteristic. This is necessary to assure sufficient price volatility to support a market. Further, the flow of supply should be free and unimpeded.[8]

The commodities chosen were frozen shrimp (1956–1979), turpentine (1929–1972), rice (1930–1977), peanuts (1930–1977), peanut oil (1929–1976), and lard (1946–1976). Two of these require further comments. Peanuts were chosen although this violates the above adaptability conditions. Government intervention severely restricts price volatility. Peanuts were chosen to see if such an unlikely candidate for futures market development would be revealed as such by the study. Peanut oil has somewhat more pricing flexibility and, therefore, is also included.

Lard plays a somewhat different role in the study than the other commodities listed above. It was traded quite actively by the Chicago Board of Trade throughout the fifties. However, trading had fallen off considerably by the early sixties and was suspended by the Board of Trade in 1963. Therefore, there are two periods available for lard—a post-nontrading period (1963–1976) and a trading period (1946–1961).

Detail on data sources is included in Appendix A.

4. EMPIRICAL RESULTS

Two types of empirical tests were undertaken. The first was designed to determine whether differences in information among traders helped to explain the development of a futures market for some commodities. The second examined the reduction in informational differences due to the addition of the futures price statistic.

Logarithms of price were used for all regressions. This "standardized" the SEEs and made comparison easier.[9] However, some of the estimated equations suffer from serially correlated residuals. This was the case for peanuts in the nontrading period and pork bellies in the trading period. The Durbin–Watson statistic was inconclusive for peanut oil and onions in the nontrading period and lard and real wool in the trading period. The presence of serially correlated residuals presents two problems.

1. Since it is assumed that commodities cannot be stored beyond period 2 the essentially static model has no explanation for serial correlation and
2. What form of misspecification of the model is causing the serial correlation?

In an attempt to gain some information relevant to the second problem the following models were estimated:[10]

$$P_{2_t} = \alpha + \beta_1 P_{2_{t-1}} + \gamma_0 P_{1_t} + \gamma_1 p_{1_{t-1}} + v_t \tag{13}$$

where $|\beta_1| < 1$, v_t has a zero mean and constant variance σ^2, and

$$P_{2_t} = \alpha' + \beta'_1 P_{2_{t-1}} + \gamma'_0 P_{1_t} + \gamma'_1 P_{1_{t-1}} + \delta_0 P_{f_t} + \delta_1 P_{f_{t-1}} + v'_t. \tag{14}$$

With these models it is possible to test the static models (12) and (11) against the dynamic models (13) and (14). In doing this H_0: $\beta_1 = \gamma_1 = 0$ and H_0: $\beta'_1 = \gamma'_1 = \delta_1 = 0$ were tested respectively—see Table I. The hypothesis was rejected only for pork bellies and real wool in the trading period, suggesting that the dynamic forms are more appropriate for these two commodities. For peanuts, peanut oil, onions, and lard the static model is apparently more appropriate. Ordinary least squares results are reported for these commodities in tests 1 and 2.[11] For pork bellies and real wool in the trading period it is then possible to test whether the dynamics is well represented by a first order autoregressive error and process, i.e. test the common factor restrictions—see Hendry and Mizon (1978). This was done using a likelihood ratio test to compare the results for (13) and (14) with the corresponding results for the static models with autoregressive errors (implemented using the Hildreth–Lu algorithm). As Table I shows the autoregressive restrictions are not rejected for pork bellies, though they are rejected for real wool.

TABLE I

Tests for variables with possibly serially correlated residuals
Results for H_0: $\beta_1 = \gamma_1 = 0$ and H_0: $\beta'_1 = \gamma'_1 = \delta_1 = 0$

	F-Statistic:		
Commodity	Nominal	Real	Critical
Pre-trading			
Peanuts	2·4076	1·0620	F2, 36 = 3·27
Peanut oil	0·9943	1·0133	F2, 36 = 3·27
Onions	3·9644	2·5226	F2, 8 = 4·46
Trading			
Pork bellies	5·4155[1]	6·6621[1]	F2, 10 = 4·10
Lard	3·5433	2·7931	F2, 10 = 4·10
Wool	—	8·3965[1]	F2, 10 = 4·10

Likelihood ratio test results

Commodity	$-2 \log \lambda \sim \chi^2$
Pork bellies	
nominal	4·66502
real	4·65787
Wool	
real	6·25944[1]

[1] Significant at 0·05 level.

However, since the data for these two commodities appear to be inconsistent with the static theory we must treat the results for both very carefully. In Table IV the Hildreth–Lu estimates are reported for pork bellies, and for real wool the OLS estimates are given since these are deemed to be the most conservative as far as the informational tests are concerned.

Test 1: Information in futures market development

The first test regressed P_2 on P_1[12] for a set of eleven commodities: Maine potatoes, onions, wool, pork bellies, FCOJ, rice, turpentine, peanuts, peanut oil, frozen shrimp, and lard. The first five commodities developed a futures market subsequent to the estimation period for test 1. The next five did not develop futures markets.[13] Lard had traded actively prior to the estimation period, but all trading had been suspended by the time of the estimation period.

Table II ranks the commodities by standard error of the estimate. Results for both nominal prices and real prices (adjusted using the consumer price index) are included. The commodities which later develop futures markets are starred. Detailed regression results are presented in Appendix B.

TABLE II

Results of Test 1

Nominal		Real	
Commodity	SEE	Commodity	SEE
*Lard	0·288329	*Lard	0·283189
*FCOJ	0·254035	*Wool	0·256681
*Wool	0·235816	*FCOJ	0·248617
*Pork bellies	0·226711	*Pork bellies	0·236326
Turpentine	0·189170	*Onions	0·184395
*Onions	0·186715	Turpentine	0·182092
*Maine potatoes	0·167073	*Maine potatoes	0·168561
Peanut oil	0·155240	Peanut oil	0·146961
Shrimp	0·136691	Shrimp	0·130685
Peanuts	0·105328	Peanuts	0·097409
Rice	0·105016	Rice	0·083150

Notes:
1. SEE = standard error of the estimate.
2. * = commodities that later develop futures markets.
3. Results of Mann Whitney U test: Probability of observing the nominal ranking above if there were no difference in trading and nontrading groups is 0·009. For the real ranking the probability is 0·004. Therefore, reject the hypothesis that there is no difference between the two groups.

The rankings by standard errors are quite similar for real and nominal prices. All commodities associated with futures market development have larger coefficients of variation than those commodities that do not develop futures markets with the exception of turpentine which exceeds onions and Maine potatoes. The rankings seem to suggest that for those commodities for which p_1 reveals little about $E(\tilde{p}_2|z)$ futures markets are more likely to develop. A Mann–Whitney U statistic was employed to test the null hypothesis that the coefficients of variation are not associated with the subsequent development of futures markets against the alternative hypothesis that the coefficients of variation are positively associated with such market developments. Computed U statistics are 2 for the nominal ranking (probability value $=0{\cdot}009$) and 1 for the real ranking (probability value $=0{\cdot}004$). The critical U value for $N_1=5$ and $N_2=6$ is 5. The null hypothesis was rejected in favour of a positive association between (higher) variation and the subsequent development of futures markets.

Test 2: *Information differentials in the post market environment*

In Section 2 it was noted that the use of var $(\tilde{p}_2|p_1)$ and var $(\tilde{p}_2|p_1, p_f)$ to estimate changes in var $(E(\tilde{p}_2|z)|p_1)$ and var $(E(\tilde{p}_2|z)|p_1, p_f)$, respectively, depended on an unchanging stochastic structure for the exogenous variables, z and w_2.[14] If a shift in the distribution of z increases var $(E(\tilde{p}_2|z)|p_1, p_f)$, then futures trading becomes more likely for any given level of information that p_1 reveals about $E(\tilde{p}_2|z)$. Grossman notes the possibility of distribution changes *between* trading and nontrading periods. This would hamper the second test suggested here; the model could not be tested by merely comparing the standard error of the estimate for a pre-trading and post-trading period. However, it seems more likely that a shift in the distribution of z would occur *prior to* formation of the market and reaction to the change would eventually lead to market development.[15] To examine the pre-trading period for evidence of such a shift, the pre-trading period data of each selected commodity was divided into two subsets, the second subset including the last few years prior to the initiation of trading. A Chow test was performed to test equality between the coefficients in the subsets.[16] The null hypothesis that the two subgroups belonged to the same regression model could not be rejected for any of the selected commodities. This suggests that structural changes prior to market development were not the cause of futures market initiation. Results are shown in Table III.

TABLE III

H_0: *The groups belong to the same regression model*

Commodity	Sample sizes[1] N_1	N_2	F	Result at 0·05 level
Maine potatoes	10	5	2·80	not significant
Onions	8	5	0·008	not significant
FCOJ	6	4	0·124	not significant
Pork bellies	7	5	0·047	not significant
Wool	7	5	2·00	not significant

[1] Subsets of the pre-trading sample.

The second test compares information transfer in trading and non-trading periods by comparing the standard errors of each period for each of the six futures market commodities (including lard). These SEEs for var $(\tilde{p}_2|p_1)$ and var $(\tilde{p}_2|p_1, p_f)$ are determined by ordinary least squares regression of P_2 on P_1 and P_1, P_f respectively. As in test 1, SEEs are reported for real and nominal prices. Table IV summarizes these results. As discussed above, onions have an estimation period prior to futures trading, during trading, and after the cessation of trading. Lard has a trading period and a non-trading period after market suspension. Detailed regression results are included in Appendix B.

For four of the six commodities reported the SEE falls considerably during the period of the existence of the futures market implying that the additional price statistic reduces the differences in prices. For test 2, the hypothesis that σ^2 is unchanged from the pre-trading to the trading period is tested against the alternative that σ^2 is greater in the pre-trading period. The results are noted in Table IV. Wool, lard, and real pork bellies are significantly smaller in the trading period.

SEEs for onions and Maine potatoes show no decline in the trading period. These two commodities are similar. Particularly, they are the two perishable, rather than semi-perishable, commodities. Legislation has often been introduced to prohibit futures trading in onions and Maine potatoes. Legislation was eventually passed prohibiting futures trading in onions.

The results for onions are nearly unchanged over the three periods, suggesting that the futures price added very little information and may have increased the differences in expected prices. This is particularly interesting in that Grossman suggests that onions

TABLE IV

Results of Test 2

Commodity	Nominal SEE	Real SEE
Pork bellies[3]		
pre-trading	0·226711	0·236326*
trading	0·154418	0·140922
Wool		
pre-trading	0·235816*	0·256681*
trading	0·113451	0·112564
Lard		
trading	0·161984*	0·16552*
post-trading	0·288329	0·283189
FCOJ		
pre-trading	0·254035	0·248617
trading	0·137008	0·145370
Maine potatoes		
pre-trading	0·167073	0·168561
trading	0·179740	0·176608
Onions		
pre-trading	0·186715	0·184395
trading	0·221518	0·221274
post-trading	0·206221	0·206481

Notes:
1. SEE = standard error of the estimate.
2. * = pre-trading and trading periods are significantly different at the 0·05 level.
3. Hildreth–Lu estimates are reported for pork bellies in the trading period.

may be a good commodity to test since the suspension of trading by the government would lead one to believe that no stochastic change in exogenous variables led to market demise. In fact, these results may support the government contention that the futures market had destabilizing influence. Further these results support those reported by Cox (1976) using an autoregressive model to examine the effect of market information on the relationship between current and past prices.[17] Cox calculated a coefficient of variation for onions that fell in the trading period and fell further in the post-trading period. He also reported a declining coefficient for Maine potatoes in the post-trading period.

5. CONCLUSIONS

The claim that a futures market affords an investor an opportunity to earn a return on resources expended to collect information is supported for some, but not for all, of the commodities tested. The evidence supports such a function for the lard, wool, pork bellies, and perhaps FCOJ markets. For onions and Maine potatoes, however, it cannot be argued that information differentials result in sufficient price expectation differences to support information collection by traders. For those markets in which the claim is supported, it is not clear whether information collection is viewed as a separate activity by the informed or whether information collection is viewed as a complement to risk reduction.

For pork bellies, test 1 indicates that the cash price conveys relatively little information about the future cash price, suggesting potential for futures market development to capitalize on information differences. The second test shows that the addition of the futures price statistic to the price system reduces expected price deviations among traders.

Results for lard, wool, and FCOJ are consistently similar throughout the study. As with pork bellies the results tend to support the claim of an information function. The cash price appears to convey sufficiently little about future cash prices to offer incentives for future market development for the purpose of information exchange. The addition of the futures price does reduce differences in price expectations.

The onion evidence indicates that P_f does not alter price expectation differences from those based on P_1 alone. This result, in conjunction with the result of the first test, indicates that although the current spot price is not a particularly good predictor of future spot prices, little if anything is gained through observation of the futures price. Therefore it appears that the cash price conveys available information well. The onion market, therefore, does not offer an arena for a return to information collection.[18]

The results for Maine potatoes are unclear. Test 1 suggests that for the commodities examined which develop futures markets, Maine potatoes are least likely to have developed a futures market to exploit a potential return to information. The addition of P_f does not appear to substantially change price expectations from those based on knowledge of P_1 alone, and, indeed, the addition of P_f to the pricing system may even increase expected differences in prices.

Grossman's theoretical development also allows for the empirical examination of noise reduction as additional information (including prices) becomes available. Brannen (1981) has made an initial attempt at introducing proxies for the z vector of available market information and examining the reduction in the differences in expected prices between informed and uninformed traders.

APPENDIX A

DATA SOURCES

Finding consistent price series was a difficult and less-than-straightforward exercise. Prices are in all possible cases the monthly average of daily prices. An exception is onions, where daily prices were not consistently available. Mid-month prices were used in this case. Sources for individual commodities are cited below.

Maine Potatoes

Cash Prices:

N.Y. wholesale (less than carlot) in ¢/cwt:
1924–1937 *Agricultural Statistics*, United States Department of Agriculture
1937–1961, *Commodity Year Book*, Commodity Research Bureau
Eastern N.Y. wholesale in ¢/cwt:
1961–1976, *Commodity Year Book*, Commodity Research Bureau

Futures Prices—in ¢/cwt:

1947–1972, *Commodity Futures Statistics*, United States Commodity Exchange Authority
1972–1980, *Wall Street Journal*

Onions

Cash Prices:

Chicago wholesale in \$/50 lb. sacks:
1929–1956, *Onion Statistics*, United States Commodity Exchange Authority
1957–1980, *Wholesale Prices*, Bureau of Labour Statistics

Futures Prices—Chicago wholesale in \$/50 lb. sacks:

1944–1947, Estimated from Jan. high and low prices, *Onion Statistics*, and
1947–1955, *Onion Statistics*, United States Commodity Exchange Authority
1955–1959, *Commodity Futures Statistics*, United States Commodity Exchange Authority

Wool

Cash Prices:

Boston average raw wool in ¢/lb.
Commodity Year Book, Commodity Research Bureau

Futures Prices—in ¢/lb.,

Commodity Futures Statistics, United States Commodity Exchange Authority

Pork Bellies

Cash Prices:

in ¢/lb:
1949–1967, Chicago monthly average of high and low prices, *Yearbook*, Chicago Mercantile Exchange
1968–1979, Chicago monthly average of cash pork bellies, *Yearbook*, Chicago Mercantile Exchange

Futures Prices—in ¢/lb.

Yearbook, Chicago Mercantile Exchange

FCOJ

Cash Prices:

in ¢/pounds solid "delivered in" price paid for Florida oranges for concentrate (*Annual Statistical Report*, Florida Citrus Mutual) adjusted by a "bulk" processing cost using an average cost of processing, warehousing, and selling. Florida FCOJ statistic compiled by Kilmer and Hooks, Institute of Fruit and Agricultural Sciences, University of Florida (transmitted by Kilmer via phone) and adjusted from 42–45 degree brix to the 51 degree brix of the futures contract

Futures Prices—in ¢/lb. solid

Wall Street Journal

APPENDIX B

REGRESSION RESULTS

TABLE B1

Ordinary least squares results
Test 1, pre-trading
$P_{2t} = a + bP_{1t} + e_2$

Commodity	$\hat{a}$	$\hat{b}$	$\bar{R}^2$	SEE	n	D.W.
Onions						
Pre 1						
Nominal	0·326	1·275 (0·135)	0·890	0·18672	13	2·80
Real	1·444	1·285 (0·134)	0·894	0·18440	13	2·81
Pre 2						
Nominal	0·016	1·033 (0·114)	0·813	0·20622	21	1·95
Real	0·184	1·034 (0·174)	0·650	0·20648	21	1·94
Pork bellies						
Nominal	2·448	0·321 (0·260)	0·132	0·22671	12	2·15
Real	−0·549	0·390 (0·261)	0·183	0·23633	12	2·04
Wool						
Nominal	2·452	0·446 (0·268)	0·218	0·23582	12	1·74
Real	0·246	0·539 (0·322)	0·219	0·25668	12	1·65
FCOJ						
Nominal	2·207	0·422 (0·231)	0·295	0·25404	10	2·22
Real	−0·503	0·389 (0·233)	0·258	0·24862	10	2·29
Shrimp						
Nominal	−0·018	0·872 (0·046)	0·948	0·13669	22	1·89
Real	−1·19	0·749 (0·078)	0·823	0·13069	22	1·87
Turpentine						
Nominal	0·491	0·885 (0·068)	0·828	0·18917	37	1·77
Real	−0·053	0·814 (0·077)	0·762	0·18209	37	1·92

TABLE B1 (*cont.*)

Commodity	$\hat{a}$	$\hat{b}$	$\bar{R}^2$	SEE	n	D.W.
Peanut oil						
Nominal	0·302	0·892 (0·56)	0·867	0·15524	41	2·56
Real	−0·391	0·762 (0·081)	0·700	0·14696	41	2·55
Peanuts						
Nominal	−0·226	1·095 (0·026)	0·978	0·10533	41	1·15
Real	0·643	1·280 (0·061)	0·920	0·09800	41	1·25
Rice						
Nominal	0·054	0·953 (0·029)	0·963	0·10501	42	1·17
Real	−0·613	0·769 (0·044)	0·885	0·08315	42	1·58
Lard						
Nominal	0·151	0·977 (0·167)	0·741	0·28833	14	1·65
Real	−0·266	0·852 (0·219)	0·56	0·28319	14	1·50
Maine potatoes						
Nominal	0·122	0·943 (0·099)	0·866	0·16707	16	2·55
Real	−0·016	0·969 (0·113)	0·840	0·1686	16	2·43

Note: Standard errors are in parentheses in all tables.

TABLE B2

Test 1, *pre-trading*
Autoregressive model without common root restrictions
$P_{2_t} = \alpha + \beta_1 P_{2_{t-1}} + \gamma_0 P_{1_t} + \gamma_1 P_{1_{t-1}} + v_t$

Commodity	α	β_1	γ_0	γ_1	$\bar{R}^2$	SEE	n
Onions							
Nominal	0·270	−0·460	1·124	0·209	0·969	0·11606	12
	(0·100)	(0·188)	(0·097)	(0·262)			
Real	−0·135	−0·458	1·134	0·215	0·969	0·11710	12
	(0·814)	(0·195)	(0·096)	(0·276)			
Peanuts							
Nominal	−0·016	0·363	1·200	−0·521	0·983	0·09500	40
	(0·066)	(0·151)	(0·077)	(0·165)			
Real	0·317	0·301	1·271	−0·431	0·928	0·09378	40
	(0·192)	(0·162)	(0·093)	(0·186)			
Peanut oil							
Nominal	0·169	−0·146	0·794	0·292	0·886	0·14736	40
	(0·169)	(0·256)	(0·140)	(0·164)			
Real	−0·297	−0·256	0·761	0·315	0·740	0·14150	40
	(0·145)	(0·253)	(0·136)	(0·156)			

Hildreth–Lu results
$P_{2_t} = a + bP_{1_t} + e_t$

Commodity	$\hat{a}$	$\hat{b}$	$\bar{R}^2$	SEE	n	$\hat{\rho}$	$t(\hat{\rho})$
Onions							
Nominal	0·234	0·991	0·951	0·12841	11	−0·80	−4·42
	(0·047)	(0·107)					
Real	0·069	0·929	0·949	0·12537	11	−0·85	−5·35
	(0·443)	(0·103)					
Peanuts							
Nominal	0·2085	1·088	0·982	0·9605	40	0·40	2·76
	(0·087)	(0·038)					
Real	0·614	1·267	0·928	0·09139	40	0·35	2·36
	(0·192)	(0·081)					
Peanut oil							
Nominal	0·155	0·945	0·882	0·14638	40	−0·39	−2·68
	(0·119)	(0·041)					
Real	0·233	0·858	0·740	0·13949	40	−0·41	−2·80
	(0·096)	(0·059)					

TABLE B3

Ordinary least squares results
Test 2, Trading
$P_{2t} = a + bP_{1t} + cP_{ft} + e_t$

Commodity	$\hat{a}$	$\hat{b}$	$\hat{c}$	$\bar{R}^2$	SEE	n	D.W.
Maine potatoes							
Nominal	−0·411	0·167 (0·243)	0·757 (0·188)	0·784	0·17974	30	2·55
Real	−0·198	0·132 (0·215)	0·720 (0·180)	0·690	0·17661	30	2·61
Onions							
Nominal	0·084	0·919 (0·301)	0·076 (0·282)	0·812	0·22152	14	1·77
Real	0·006	0·901 (0·311)	0·077 (0·280)	0·818	0·22127	14	1·77
Pork bellies							
Nominal	−0·134	0·171 (0·505)	0·394 (0·578)	0·806	0·18475	15	2·99
Real	0·346	−0·054 (0·663)	1·27 (0·942)	0·656	0·18302	15	3·14
Wool							
Nominal	0·412	0·393 (0·533)	0·520 (0·598)	0·437	0·11345	16	2·21
Real	0·020	0·411 (0·530)	0·677 (0·548)	0·777	0·11256	16	2·62
FCOJ							
Nominal	2·00	−0·245 (0·652)	0·749 (0·641)	0·346	0·13701	9	2·51
Real	−0·280	−0·094 (0·673)	0·787 (0·680)	0·560	0·14537	9	2·23
Lard							
Nominal	0·550	0·072 (0·320)	0·688 (0·412)	0·694	0·16120	16	2·70
Real	−0·394	0·024 (0·321)	0·810 (0·389)	0·793	0·16555	16	2·68

TABLE B4

Test 2, Trading
Autoregressive model without common root restrictions
$P_{2_t} = \alpha' + \beta_1' P_{2_{t-1}} + \gamma_0' P_{1_t} + \gamma_1' P_{1_{t-1}} + \sigma_0 P_{f_t} + \sigma_1 P_{f_{t-1}} + v_t'$

Commodity	α'	β_1	γ_0	γ_1	σ_0	σ_1	$\bar{R}^2$	SEE	n
Pork bellies									
Nominal	0·188	−0·861	0·791	−0·175	0·453	0·908	0·910	0·13751	14
	(0·534)	(0·298)	(0·447)	(0·491)	(0 537)	(0·603)			
Real	1·032	−0·832	0·139	−0·808	1·329	1·930	0·890	0·11871	14
	(0·431)	(0·247)	(0·525)	(0·537)	(0·687)	(0·777)			
Wool									
Real	−0·005	−1·86	2·06	0·763	−0·028	0·421	0·945	0·06574	15
	(0·027)	(0·411)	(0·486)	(0·353)	(0·364)	(0·354)			
Lard									
Nominal	1·251	−0·863	0·472	0·279	0·591	0·005	0·793	0·14646	15
	(0·542)	(0·348)	(0·391)	(0·363)	(0·437)	(0·460)			
Real	−0·760	−0·855	0·390	0·229	0·766	0·124	0·853	0·15811	15
	(0·323)	(0·383)	(0·419)	(0·395)	(0·445)	(0·485)			

Hildreth–Lu results
$P_{2_t} = a + bP_{1_t} + cP_{f_t} + e_t$

Commodity	$\hat{a}$	$\hat{b}$	$\hat{c}$	$\bar{R}^2$	SEE	n	$\hat{\rho}$	$t(\hat{\rho})$
Pork bellies								
Nominal	−0·068	0·312	0·740	0·843	0·15442	14	−0·55	−2·46
	(0·381)	(0·385)	(0·421)					
Real	0·567	−0·335	1·756	0·787	0·14092	14	−0·65	−3·20
	(0·258)	(0·533)	(0·746)					
Wool								
Real	0·026	0·856	0·352	0·876	0·08512	15	−0·060	−2·90
	(0·020)	(0·341)	(0·348)					
Lard								
Nominal	0·592	0·210	0·537	0·706	0·15130	15	−0·45	−1·95
	(0·333)	(0·363)	(0·437)					
Real	−0·404	0·157	0·668	0·809	0·15609	15	−0·45	−1·95
	(0·1897)	(0·370)	(0·425)					

First version received December 1981; *Final version accepted May* 1983 (*Eds.*)

We gratefully acknowledge invaluable comments and assistance from Martin D. Fraser. Comments from referees greatly improved the paper

NOTES

1. Grossman also notes that the inclusion of additional markets by providing additional prices and, therefore, additional informational sources, may explain why we don't see markets for all commodities contingent on all states (an Arrow–Debreu world). The price system would be so refined that there would be very little investment in information collection and very little incentive for speculators to trade in a futures market.
2. Random variables will be denoted with tildes throughout.
3. Grossman assumes one informed trader and one uninformed trader for notational convenience. See Grossman (1977, pp. 434, 448). Brannen (1981) includes a discussion of the generalized model with n_1 informed and n_2 uninformed traders.
4. All traders are assumed risk neutral to focus on the effects of information.
5. Var $[E(\tilde{p}_2|z)|p_1, p_f] = E[(E(\tilde{p}_2|z) - E(\tilde{p}_2|p_1))^2|p_1, p_f]$
6. See Grossman (1975, p 64).

7. Appropriate price data was determined for each crop based on growing and trading characteristics for that crop. For example, the November and March dates were chosen based on information in the Commodity Exchange Authority survey of potatoes futures trading.

8. This does not mean that government intervention prevents futures market success. It depends on the effectiveness of the control. There are active markets in coffee, wheat, sugar, cotton, corn, and cocoa, all of which are influenced by government intervention. For a more detailed discussion of adaptability conditions for commodities see Baer and Saxon, *Commodity Exchanges*, Chapter 6, pp. 110–125.

9. Additionally using logarithms provided a significance test for the difference in the SEEs in the nontrading and trading period in test 2. Without logarithms, comparisons could have been made using the coefficient of variation. However, there is no test statistic for testing the difference in the coefficients of variation in the nontrading and trading periods.

10. For these models the expressions in (6) and (7) become

$$\text{Var}\ (\tilde{P}_{2_t}|P_{2_{t-1}}, P_{1_t}, P_{1_{t-1}})$$

and

$$\text{var}\ (\tilde{P}_2|P_{2_{t-1}}, P_{1_t}, P_{1_{t-1}}, P_{f_t}, P_{f_{t-1}}).$$

11. Except for peanuts, the commodities involved appeared to exhibit evidence of *negative* serial correlation. Therefore, the OLS estimate of σ is most likely an overestimate. The OLS estimate reported for lard in Table IV and for peanut oil in Table II are then more likely to be conservative in terms of the conclusion reached. On the other hand, the estimate for peanuts may be understated and the estimate for onions overstated in Table II. However, because of their relative positions in the ranking, the results of test 1 would not appear to be in doubt.

12. All regressions in both tests 1 and 2 were on log prices. Therefore, P_t implies log p_t throughout.

13. In 1963 a frozen shrimp contract was traded on the Chicago Mercantile Exchange, and in 1964 rice was traded on the New York Mercantile Exchange. Neither market developed substantial activity, and each existed only briefly. See Richard L. Sandor (1973), 122–123.

14. z represents all exogenous information variables. If the model were extended to address, for instance, risk aversion among traders, the risk parameter of the informed would be part of z. Any change in risk preferences of these traders would, then, constitute a change in the structure of z.

15. For example, the higher inflationary environment of the late 1960s and early 1970s may have resulted in a shift in z inducing the initiation of financial futures markets in the second half of the 1970s.

16 This test developed by Rao is usually referred to as the Chow test See C. R. Rao (1952) and Gregory C. Chow (1960).

17. Cox (1976), pp. 1215–1237. It should be noted that Cox's major conclusion with respect to onion trading is based on the results of a returns-to-a-trading-rule test. He concludes that the data do not support arguments made in behalf of legislation to prohibit onion trading.

18. This conclusion appears to support the characterization of traders cited by the Senate Committee on Agriculture and Forestry of the 85th Congress in its recommendation to prohibit onion futures trading. See Peck (1977*b*). It is, however, a different matter to assume that the lack of an information function supports prohibition of trading. This study offers no evidence on cash price fluctuations or additional costs incurred by handlers of the physical crop in the post-trading environment. These issues are addressed in detail elsewhere.

REFERENCES

BAER, J. B. and SAXON, O. G. (1949) *Commodity Exchanges and Futures Trading* (Harper and Brothers).

BLALOCK, H. M. (1972) *Social Statistics* (New York: McGraw-Hill).

BRANNEN, P. P. (1981), "An Examination of the Claim for an Information Function of a Futures Market" (Ph.D. Dissertation, Georgia State University).

CHOW, G. C. (1960), "Test of Equality Between Sets of Coefficients in Two Linear Regressions", *Econometrica*, **28**, 591–605.

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

GROSSMAN, S. J. (1975), "Essays on Rational Expectations, the Informational Role of Futures Markets, and Equilibrium Bayesian Experimentation" (Ph.D. Dissertation, University of Chicago).

GROSSMAN, S. J. (1977), "The Existence of Futures Markets, Noisy Rational Expectations and Informational Externalities", *Review of Economic Studies*, **44**, 431–449.

HENDRY, D. F. and MIZON, G. E. (1978), "Serial Correlation as a Convenient Simplification, Not a Nuisance: A Comment on a Study of the Demand for Money by the Bank of England", *The Economic Journal*, **88**, 549–563.

LABYS, W. C. and GRANGER, C. W. J. (1970) *Speculation, Hedging and Commodity Price Forecasts* (Lexington, Massachusetts: Heath Lexington Books).

LITNER, J. (1969), "The Aggregation of Investor's Diverse Judgments and Preferences in Purely Competitive Security Markets", *Journal of Financial and Quantitative Analysis*, **4**, 347–400.

PECK, E. (ed.) (1977*a*) *Selected Writings on Futures Markets.* Vol. 2. (Chicago: Board of Trade of the City of Chicago.)

PECK, A. E. (1977*b*) *Selected Writings of Holbrook Working* (Chicago: Board of Trade of the City of Chicago).

RAO, C. R. (1952) *Advanced Statistical Methods in Biometric Research* (New York: John Wiley).

SANDOR, R. L. (1973), "Innovation by an Exchange: a Case of the Plywood Futures Contract", *Journal of Law and Economics* **16**, 119–136.

TELSER, L. G. (1958), "Futures Trading and the Storage of Cotton and Wheat", *Journal of Political Economy* **66**.

WARD, R. W. and DASSE, F. A. (1977), "Empirical Contributions to Basis Theory: The Case of Citrus Futures", *American Journal of Agricultural Economics* **59**, 71–80.

WARD, R. W. and JAMES, A. N. (1975), *Hedging Strategies in FCOJ Futures* (Lakeland, Florida: Florida Department of Citrus).

WORKING, H. (1949), "The Theory of Price of Storage", *American Economic Review*, 1254–1262.

WORKING, H. (1953), "Futures Trading and Hedging", *American Economic Review*, 314–343.

WORKING, H. (1958), "A Theory of Anticipatory Prices", *American Economic Review*, 188–199.