Informed Futures Market Speculation:
An Analysis of the Commitments of Traders Reports
for the New York 'C' Coffee Contract

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Abstract

Informed speculators receive signals which are informative about future cash prices. Hedgers observe only the futures price. They attempt to infer the information content of the signals but only do so imperfectly because of the presence of noise traders. The consequence is that speculators bid positions away from the hedgers. In general, one is not able to observe asymmetrically-held information, but this is possible over the period 1993-95 when there was an influx of speculative capital from non-traditional sources into physical commodity markets. We attempt to substantiate this claim by estimating models for futures positions on the New York coffee market over that period.

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1. Introduction

Futures markets perform the twin functions of risk transfer and price discovery. These two functions have tended to be analyzed in separate literatures. In this paper, we try to bring the two strands of the literature together and to test them in a specific context.

Risk transfer involves agents with exposure to changes in the price of the underlying asset (so-called "commercials") taking positions which will offset their exposure, with any net position being covered by agents with no exposure ("non-commercials"). If the risk associated with the underlying asset were entirely diversifiable, non-commercials would not require any compensation for taking this on in their portfolios. However, if this risk is only partially diversifiable, the non-commercials will require a risk premium in order to take up the net commercial position. Chang (1985) and Bessembinder (1992) report evidence that non-commercial traders on futures markets in which the underlying asset is a physical commodity do earn risk premia. Both Chang and Bessembinder use data reported to the US Commodity Futures Trading Commission (CFTC) and published in *Commitments of Traders in Futures* (henceforth CTF).Chang's study was confined to agricultural futures, but Bessembinder, who also investigated financial futures, failed to find evidence for risk premia rewarding non-commercial positions in financial futures markets.

Price discovery is the process by which, as the result of trades initiated by informed agents, prices come to incorporate this information. The problem for an informed trader is that, if she is recognized as being informed, she will fail to find a counterparty with whom to trade. If the informed trader cannot trade on her information, she will have no incentive to acquire information (Grossman and Stiglitz, 1980). Price discovery therefore requires a market structure in which equilibrium will be less than fully-revealing. The standard framework in which this problem is analyzed is the model proposed by Kyle (1985) of a continuous auction market in which informed traders are able to hide their intentions behind the trades of so-called "noise" or "liquidity" traders. Prices are set by a risk-neutral market maker, which we may think of as a computer algorithm in an automated exchange. There is either a single informed trader, or the finite number of traders share the same information. The market maker sets the futures price on the basis of the observed net market position. Since the net position is positively correlated with the signal received by the informed trader(s), the futures price partially reflects that signal. The market-maker sets prices such that losses to the informed trader(s) are counterbalanced by profits made at the expense of the uninformed traders. Kyle shows that in a model with repeated trading, the information is

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asymptotically fully incorporated in the price. With multiple informed traders, the speed with which information is incorporated rises with the number of informed traders. In models of this class, there will therefore be a risk premium associated with positions of informed traders.

Shalen (1993) proposed a somewhat different price discovery model. Her model consists of informed agents ("speculators") and uninformed agents ("hedgers") trading a single futures contract through what is implicitly a Walrasian tatonnement process. Speculators have diverse beliefs about the future cash price of the underlying asset, while hedgers are myopic - ie they correspond to Kyle's noise traders. In the most simple case, the futures price becomes a weighted average of speculators' expectations of the future cash price.

This paper is concerned with developing a testable model, and we therefore need to worry about the relationship of the theoretical distinction between informed and uninformed traders and the actual data classification adopted by the CFTC in their CTF reports. A number of studies have analyzed the these data, but largely in relation to the question of who makes money on futures markets.[1] Our interest is in investigation of the price discovery process rather than with investigation of normal backwardation theory, so we are not directly concerned with *ex post* profitability.[2] Instead, we need to worry about which traders know which elements of the information set. Commercial traders are conventionally regarded as hedgers, while the non-commercials are seen as pure speculators - see Edwards and Ma (1992, pp.463-6). In commodity futures markets, there are typically a relatively small number of reporting positions and the CTF makes a three-way distinction between the positions of commercial traders, those of large non-commercial traders, and non-reportable positions. Non-reporting positions correspond to small traders. The practical difficulty in empirically implementing either the Kyle or the Shalen models is that the distinction between informed and uninformed traders fails to correspond directly with the commercial-noncommercial distinction used by the CFTC.[3]

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[1] See Houthakker (1957), Rockwell (1977), Hartzmark (1987) and Yoo and Maddala (1991). In related work, Phillips and Weiner (1994) report profitability calculations for Brent oil forward trading based on detailed trading account data.

[2] Gilbert and Brunetti (1997) report estimated profitability bounds for the coffee market over the period discussed in this paper.

[3] Economists typically regard a position as speculative to the extent that it leaves the agent's profits or utility exposed to price movement, and consequently any discretionary hedging policy would involve a speculative component. From this standpoint, many positions which the CFTC reports as hedging may be in part speculative. Equally, some positions reported as speculative may be hedging options positions, not

The model we develop below starts from the premiss that all traders with large positions, whether commercial or non-commercial are likely to be informed about market data and will take this information into account in deciding their positions. Commercial traders will be well-informed about the markets in which they operate but may have little special knowledge about broader financial markets. Large non-commercial traders, by contrast, who are free to invest across the range of markets, may have less information about the specific features of the underlying markets than the commercials, but are likely to be better informed about financial markets in general. While we would not wish to claim any degree of generality for these information assumptions, we choose to look at a particular market in a particular period in which this information partition appears plausible.

The model combines features of the Kyle's (1985) and Shalen's (1993) models. It uses the Walrasian structure adopted by Shalen, but follows Kyle in imposing uniformity on speculators' beliefs. But whereas in Shalen, hedgers behave myopically, we allow hedgers to form rational expectations about the future cash price in the same way as does Kyle's market maker. The futures price turns out to be a weighted average of speculators' and hedgers' expectations, as in Shalen's model with two groups of speculators. To ensure that the equilibrium is not fully revealing, we introduce a third class of noise traders which we identify with the CTF non-reporting positions. We suppose that noise traders lack information on both the specific commodity market and on financial markets more generally. However, they do observe past prices and may attempt to make inferences on this basis. In particular, they may attempt either to identify trends by extrapolating past price movements, or to make inferences from recent CTF data which is easily available. If they do forms expectations extrapolatively, it is possible that these could become self-fulfilling (De Long *et al*, 1990, 1991).

This model shares with Shalen's (1993) model the view that different market participants may have access to different information. In particular, we distinguish between information on the market in the underlying physical commodity and information on more general financial markets. We use weekly CTF data, but information on commodity market fundamentals is available at best on a quarterly basis. In order to implement my model we therefore consider a period in which it was widely believed in the commodities industries that financial market developments were more than usually important in commodity futures markets. Specifically, we consider the CSCE coffee

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covered in these reports.

market over the period 1993-95.

1994 is the central year of the sample. In that year, concerns about the re-emergence of inflation and the announced Fed policy or raising interest rates led many investors to diversify portfolios away from equities and bonds, seen as both more risky and less likely to generate high returns than in normal years. Because commodity prices were at historically low levels, they benefited from relatively low risk-return ratios at a time when other assets appeared unattractive. This influx of what was seen as "fund" investments puzzled the commercial (hedging) community who were suspicious of the sustainability of higher price levels that this buying pressure was seen to generate. This resulted in a situation in mid-1994 in which commercials had large short positions while non-commercials had large long positions. At this point, the coffee market was hit by the impact of a double frost in the main Brazilian coffee-growing region which sharply changed market fundamentals giving large profits to the non-commercials at the expense of the commercials. The price changes generated a substantial unwinding of the previous positions, and these large movements make it possible to identify the effects of information disparity more clearly than in other markets.

The structure of the paper is as follows. In section 2 we develop a simple two period market microstructure model which traces the price impact of information received by informed speculators. In section 3, we describe developments on the coffee futures market over our three year sample. Section 4 sets out the econometric model, estimation results from which are reported in section 5. Section 6 contains brief conclusions.

2. A Model of Informed Futures Market Speculation

We consider a stylized two period model which provides a metaphor for understanding the effects of speculation in a commodity futures market. In period 1 trading takes place in a futures contract which specifies period 2 delivery. The futures price is f. In the second period, production and consumption take place with the cash market clearing at p.[4] Seen from period 1, the period 2 spot price is random. This randomness may be thought of as arising from randomness in production or consumption; or, if the commodity is storable, from randomness in the convenience yield. We shall be interested in the period 1 futures price f. We distinguish three groups of traders in the period 1 futures market:

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[4] In a fuller notation, p_2 and f_{21}, but we omit all time subscripts since the notation is unambiguous.

Noise Traders: Noise traders have aggregate position Z which is stochastic and is not known by other market participants.

Speculators: Speculators are "non-commercial", ie they will not be involved in period 2 production, consumption or storage. In period 1 they receive a signal e which is correlated with, and therefore informative about, the period 2 spot price p. The aggregate speculative position is S.

Hedgers: Hedgers are "commercials". In period 1 they expect to have a net physical position of X in period 2 which they hedge in period 1. They do not observe the signal e but are aware that speculation may be informed and attempt to the signal from the futures price f. They are, however, unable to distinguish trades resulting from informed speculation from noise trades. Their aggregate position is H.

After these preliminaries, we may turn to the period 1 futures market. Consider first the representative hedger who wishes to protect an anticipated physical position of x in period 2, where x is measured as long. The hedger purchases a period 1 futures position of h, again measured as long. The resulting period 2 cashflow c is

$$c = xp - h(f - p) \qquad (1)$$

Hedgers maximize a mean-variance utility function

$$U(h) = Ec - \frac{1}{2}aV(c) \quad \text{where } V(c) = E(c - Ec)^2 \qquad (2)$$

and where a is the hedger's coefficient of absolute risk aversion. All expectations are relative to the period 1 information set. The hedger's optimal hedge h is then

$$h = -x + \frac{E^h p - f}{aV^h(p)} \quad \text{where } V^h(p) = E^h(p - E^h p)^2 \qquad (3)$$

where the superfix h indicates that expectations are relative to the hedger's information set. Equation (3) gives the familiar decomposition of the optimal hedge into a pure hedge component, in this simple case equal and opposite to the physical position, and a speculative component. If there are n hedgers, the aggregate hedge H is

$$H = -X + \frac{E^h p - f}{A V^h(p)} \quad where \ X = nx \tag{4}$$

where aggregate risk aversion $A = a/n$. I take the aggregate physical position X to be common knowledge to all market participants in period 1.

The same analysis applies to the representative speculator, except that she will have no physical position. Hence the aggregate speculative position is

$$S = \frac{E^s p - f}{A V^s(p)} \tag{5}$$

where, for simplicity, I have assumed that the number of speculators is also equal to n.[5] Finally, the aggregate position Z of the noise traders is random. The model is closed by the futures market clearing condition

$$S + Z + H = 0 \tag{6}$$

Solving equations (4) and (5) into (6), we obtain the period 1 futures price as

$$f = \delta E^h p + (1-\delta) E^s p + \psi(Z - X) = \delta E^h p + (1-\delta) E^s p + \zeta - \xi$$

$$where \ \delta = \frac{V^s(p)}{V^h(p) + V^s(p)} \quad \psi = \frac{A V^h(p) V^s(p)}{V^h(p) + V^s(p)} \quad \zeta = \psi Z \ and \ \xi = \psi X \tag{7}$$

In order to proceed further, we need to evaluate the price expectations and variances. I have assumed that speculators receive a signal e in period 1 which is informative about the period 2 price p. Without loss of generality, we may take the signal variance to be equal to the variance σ^2 of the price disturbance. The crucial parameter is the correlation $\rho \ (\geq 0)$ of the signal and the price disturbance. Specifically, I assume

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[5] It is trivial to relax this assumption. The substantive element of the assumption is that the number of speculators is fixed.

$$\begin{pmatrix} p \\ e \\ \zeta \end{pmatrix} \sim N\left(\begin{pmatrix} \bar{p} \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma^2 & \rho\sigma^2 & 0 \\ \rho\sigma^2 & \sigma^2 & 0 \\ 0 & 0 & \omega^2 \end{pmatrix} \right) \tag{8}$$

It follows that speculators' period 1 expectations of the period 2 cash price are

$$E^s p = \bar{p} + \rho e \tag{9}$$

and
$$V^s(p) = \left(1 - \rho^2\right)\sigma^2 \tag{10}$$

The hedgers do not receive the signal e but attempt to infer it from the futures price f. By joint normality (8), their price expectation is given by the conditional expectation

$$E^h p = E(p|f) = \bar{p} + \beta(f - Ef) \quad \text{where} \quad \beta = \frac{Cov(f,p)}{V(f)} \tag{11}$$

Solving equations (9) and (11) into equation (7) one finds

$$f = \bar{p} + \frac{1}{1 - \beta\delta}(\varepsilon - \xi) \quad \text{where} \quad \varepsilon = \zeta + (1 - \delta)\rho e \tag{12}$$

where we have combined the noise disturbance ζ and the signal e into a single disturbance ε. The period 1 futures price is therefore seen as being raised by

- the imbalance ξ between short and long hedging,
- the combined effects of noise trading ζ and
- the signal e received by speculators.

It follows from equations (8) and (12) that

$$V(f) = \frac{\omega^2 + (1-\delta)^2\rho^2\sigma^2}{(1 - \beta\delta)^2} \tag{13}$$

and
$$Cov(p,f) = \frac{(1-\delta)\rho^2\sigma^2}{1 - \beta\delta} \tag{14}$$

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implying
$$\frac{\beta}{1-\beta\delta} = \frac{(1-\delta)\rho^2\sigma^2}{\omega^2+(1-\delta)^2\rho^2\sigma^2} \tag{15}$$

Equation (15) may in principle be solved to give an explicit expression for β. However, direct substitution from equations (12) and (15) into equation (11) gives the anticipated capital gain from holding period 1 futures, as seen by the hedgers, as

$$E^h p - f = -\frac{1-\beta}{1-\beta\delta}(\varepsilon - \xi) \tag{16}$$

giving the aggregate hedge, through equation (4), as[6]

$$H = -\frac{1-\delta}{1-\beta\delta}X - \frac{(1-\beta)\varepsilon}{AV^h(p)} \tag{17}$$

$$E^s p - f = \rho e - \frac{1}{1-\beta\delta}(\varepsilon - \xi) \tag{18}$$

Similarly,

giving the aggregate speculative position as[7]

$$S = \frac{1-\delta}{1-\beta\delta}X + \frac{(1-\beta)\delta\rho e - \zeta}{AV^s(p)} \tag{19}$$

It is straightforward to check that equations (17) and (19) satisfy the market clearing identity (6). Note that

- A bullish signal leads hedgers to shorten their positions in an apparently perverse manner. This arises because the signal raises the futures price f by more than it raises their expectation of the future spot price. The signal, which the hedgers do not observe directly,

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[6] This derivation uses the result $\xi/AV^h = \delta X$ which follows from the definitions associated with equation (7).

[7] $\xi/AV^s = (1-\delta)X$ - see equation (7).

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leads hedgers to become more bullish (in proportion to β), but they regard the futures price as over-reacting, and therefore shorten their positions. In the face of a change in futures prices, hedgers regard the direction of movement as justified by fundamentals, but see the extent of the change as excessive.

- An increase in short hedging pressure (positive X) results in an increase in long speculative positions as the hedge-selling forces down the futures price relative to the expected spot price. This also results in hedgers taking less fully hedged positions.

- An increase in perceived volatility reduces the size of the speculative elements of both hedging and speculative positions. This is a standard result.

- Speculative and hedge positions are negatively correlated. Noise positions are negatively correlated with speculative positions but uncorrelated with hedge positions.

The econometric model, estimates of which I report in Section 4, is based on equations (4) and (19). Equation (4) shows the net hedge position H as depending negatively on the futures price f, and positively on the price volatility σ - recall that the net hedge is typically negative, so that an increase in the futures price will increase the absolute size of the net hedge, while an increase in volatility will decrease its absolute size. Because of lack of information, I suppose the net underlying physical position X to be constant.[8] Equation (19) shows the net large speculative position as depending positively on the signal e, negatively on the net noise trader position Z, and negatively on the price volatility σ. The informational assumptions have the implication that the speculators can infer the net noise trading position through the market clearing condition (6) and calculation of the net hedge position using equation (17). The proximity of large speculators to the market makes this assumption reasonable on other grounds. The consequence is that the futures price f does not provide speculators with any information, and it follows that speculative positions should be independent of prices.

3. The Coffee Futures Market, 1993-95

Figure 1 graphs the New York Coffee, Sugar and Cocoa Exchange (CSCE) nearby coffee

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[8] Hedging is primarily related to export and import of coffee and to stockholding. Coffee consumption ("disappearances") showed a fairly steady negative trend over the three years 1993-95 (International Coffee Organization, 1999, Table III-13A). Although coffee production is seasonal, developed country imports show little seasonal variation, and are close to a linear trend (*ibid*, Table III-3C). This might be taken as implying the presence of a similar trend in the futures market positions, but our sample is too short to distinguish trend from cyclical movements.

price (the 'C' contract) in ¢/lb on a weekly basis over 1993-95.[9] The choice of Tuesdays matches the price series with the *CTF* reports which, starting from the end of September 1992, were published weekly on Fridays and relate to closing positions on the preceding Tuesdays.

The coffee price was fairly flat in the range of 50-70 ¢/lb through the first half of 1993. In historical terms, this was a very low price and reflects abundant supply plus the transfer of stocks from producers to consumers in the aftermath of the 1989 lapse of the International Coffee Agreement export controls - see Gilbert and Brunetti (1997). The September 1993 decision of the coffee producers to limit exports (the so-called Coffee Retention Scheme) lifted the price towards 80 ¢/lb and the price again rose steadily through the first half of 1994, allegedly because of speculative buying. It again rose sharply in late June and early July as the result of two sharp frosts in the Brazilian coffee-growing states. These had no immediate effect on the availability of coffee but were seen as likely to reduce the Brazilian 1995-96 crop by as much as 30%. Subsequently, coffee prices trended down from their summer 1994 peaks as it became clear that coffee supplies would remain in line with static consumer demand, and by the end of 1995, they were only 10% above their January 1993 level.

A feature of all commodity markets over the first half of 1994 was the build-up of speculative positions. The commonality of this development suggests that speculators were investing in commodities as an asset class rather than picking specific commodities. A number of commercial studies had suggested portfolio diversification benefits from a move into commodities (Wadhwani and Shah, 1993; Satyanarayan and Varangis, 1994). However, portfolio diversification arguments as such do not demonstrate why the move into commodities took place specifically in the spring of 1994, nor why the diversification was into long rather than short commodity futures positions. We argue that the diversification decisions made by a number of fund managers were prompted by the shift in the term structure of dollar interest rates in February 1994 which opened

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[9] We identify the cash price *p* as the price of the first future position, provided this has more than 15 days to maturity, and otherwise the second position. We identify the future price *f* as that of the second position, provided that the first position has more than 15 days to maturity, and otherwise the third position . We adopt the convention that contracts are rolled on the 16th day of the delivery month prior to delivery (or the first trading day thereafter). Thus the Sep contract is the first position and the Dec the second position until 16 August when the Dec becomes the first and the Mar becomes the second. This reflects pricing practices in the coffee industry where physical prices are quoted basis the future contract most closely corresponding to expected delivery. We ignore the possible delivery option in these prices. Weekly differences, $\Delta \ln F_t$ and $\Delta \ln P_t$, use lagged values F_{t-1} and P_{t-1} from the same contract as the current quotation F_t and P_t.

the possibility that interest rates would rise further through the year generating low or negative returns on equities and bonds. This was indeed the outcome. We use this insight to motivate inclusion of variables relating to prospective portfolio returns in the speculative information set in the empirical model developed in section 4.

Evidence for the build-up of speculative positions in New York coffee futures may be seen in Figure 2.[10] Speculators established significant large positions through the summer of 1993 in response to the announcement of the Coffee Retention Scheme, but these were subsequently run down and they entered 1994 with a slightly negative net position. Their positions then climbed to a peak of around 20,000 contracts in April 1994, an investment of around $600m. After the frosts, these positions gradually worked back down to zero at the year-end but built up again through the spring of 1995 against the possibility of a second successive southern hemisphere winter of frosts. These are significant sums of money in relation to the coffee market, but very small in relation to overall equity and bond markets. What was therefore a relatively small diversification out of those markets amounted to a very large diversification into coffee futures.

4. The Econometric Model

We specify equations for the three futures market positions (large speculators, hedgers and noise traders). The futures price equation is inferred through the market clearing identity (6) on the futures positions resulting in a four equation system.

Consider first the positions equations. As noted in section 2, these follow directly from equations (4) and (19) together with random noise traders positions. However, the theoretical model considers only a single sequence of trades, while my data consist of time series relating to a sequence of position realizations. This has four sets of implications.

i)   It is apparent from Figure 2 that positions exhibit positive serial correlation. This can be rationalized in terms of at least some agents adjusting their futures positions less rapidly than the weekly frequency of our data. It suggests that we regard the theoretical position relationships as targets to which actual positions adjust over time.

ii)   Hedgers tend to view the futures price in relation to their perceptions of likely prices in the future which they will necessarily judge from past prices. I model the net hedge in relation to the current period futures price relative to its previous value.

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[10] The units are contracts of 36,500 lbs.

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iii)   The CFTC positions data attract widespread interest and comment in brokers' circulars
         to their clients and there is evidence in the data that noise traders do imitate the large
         speculators. I attempt to capture this behaviour.

iv)   The theoretical model supposes that coffee prices are efficient relative to each agent's
         information set, but the data exhibit mild evidence of inefficiency (see below).

The model consists of the following positions equations:

$$\alpha_0(L)S_t = \alpha_1' I_t - \alpha_2 Z_t \qquad\qquad\qquad + u_t^S$$

$$\beta_0(L)H_t = \qquad\qquad - \beta_3 \Delta \ln F_t \qquad\qquad + u_t^H \qquad\qquad (20)$$

$$\gamma_0(L)Z_t = \qquad\qquad\qquad\qquad\qquad \gamma_4 \Delta S_{t-1} + u_t^Z$$

L is the lag operator and lag distributions are all second order. Here, F_t is the second position
futures price (corresponding to f in the theoretical model[11]) and I_t is a vector of informational
variables ($\alpha_1 ' I_t$ corresponds to e in the theoretical model). All coefficients (except α_1) are written
so that parameters will be positive. Each equation in (20) also contains an intercept and two
dummy variables associated with the two frost weeks in 1994, which would otherwise exert
excessive leverage .[12]

Model identification follows from standard exclusion restrictions. The net speculative
equation is identified through exclusion of the lagged hedge positions H_{t-1} and H_{t-2} while the hedge
equation is identified by exclusion of the informational variables I_t and the lagged speculative
positions S_{t-1} and S_{t-2}. The noise equation is inferred from the futures market identity (6).

The crucial variables are those appertaining to speculative information, denoted by I_t in
equations (20). As outlined in section 3, we see speculators in the CSCE coffee market over this
particular period as being informed about likely developments in the financial markets generally
rather than on coffee market fundamentals. We attempt to capture this information through
including a set of variables which are relevant to forecasting short term holding gains on equity
and bond portfolios. The three variables we include measure respectively equity returns, bond

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[11] See footnote 9.

[12] An earlier draft of this paper reported a version of the model augmented by an additional
equation for volatility. The estimates showed volatility as reducing the absolute size of both speculative
and hedge positions, but both coefficients were highly insignificant.

market returns and bond market volatility, as a measure of the riskiness. Precise definitions are

$I_{1t} = \Delta_3 \ln S\&P_t$ the change in the Standard and Poors Composite Index over the previous three weeks;

$I_{2t} = \Delta YGAP_t - \Delta YGAP_{t-3}$ the change in the yield gap between the redemption yields on 30 and 10 year US government bonds over the preceding week relative to the same change two weeks earlier; and

$I_{3t} = \Delta BVOL_{t-1} - \Delta BVOL_{t-3}$ the change in the implied volatility of CBT Treasury bond futures the preceding week relative to the same change two weeks earlier.[13]

The precise measures (ie difference and lag structures) were suggested by preliminary regressions. Note that, because only exogenous variables are differences, these transformations do not in any way contaminate the equation disturbances.

Stacking the three position variables so that $y_t = (S_t, H_t, Z_t)'$ and writing the remaining variables as v_t, the three position equations (20) may be written as

$$A(L)y_t = \Lambda I_t - \beta \Delta \ln F_t + u_t \quad where \ \beta = \begin{pmatrix} 0 \\ \beta_3 \\ 0 \end{pmatrix} \quad \Lambda = \begin{pmatrix} \alpha_1' \\ 0' \\ 0' \end{pmatrix}$$

$$A_0 = \begin{pmatrix} 1 & 0 & \alpha_2 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \quad A_1 = \begin{pmatrix} \alpha_{01} & 0 & 0 \\ 0 & \beta_{01} & 0 \\ -\gamma_4 & 0 & \gamma_{01} \end{pmatrix} \quad and \ A_2 = \begin{pmatrix} \alpha_{02} & 0 & 0 \\ 0 & \beta_{02} & 0 \\ \gamma_4 & 0 & \gamma_{02} \end{pmatrix}$$

       (21)

The identity (6) implies $\iota' y_t = 0$ where ι is the vector of units allowing us to infer the solved futures price equation as

$$\Delta \ln F_t = \frac{1}{\beta_3}\left[\sum_{j=1}^{2} \iota' B_j y_{t-j} - \iota' \Lambda I_t - \iota' u_t\right]$$

$$where \ B_j = A_0^{-1} A_j \ (j=1,2) \quad and \ v_t = A_0^{-1} u_t$$

       (22)

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[13] I am grateful to the Chicago Board of Trade for providing implied volatility data. I have taken volatilities from bond futures contracts with maturity closest to six months.

(since $A_0^{-1}\Lambda = \Lambda$). It is natural to require that the current period futures price should not be predictable from lagged speculative and hedge positions - a market efficiency condition. This requires

$$B_j^{'}\iota = b_j\iota \quad (j=1,2) \tag{23}$$

ie the column sums of the reduced form adjustment distributed lag matrices should be identical. The futures price equation would then become

$$\Delta \ln F_t = -\frac{1}{\beta_3}\left(\iota'\Lambda I_t + \iota'v_t\right) \tag{24}$$

The most simple way that equation (24) might be satisfied is if each of the two matrices B_j were proportional to the identity matrix. However, model fit is improved by permitting noise traders to imitate speculative positions with a one week lag; and conditioning speculative positions on the noise positions introduces further off-diagonal elements. One may evaluate

$$B_1 = \begin{pmatrix} \alpha_{01} + \alpha_2\gamma_4 & 0 & -\alpha_2\gamma_{01} \\ 0 & \beta_{01} & 0 \\ -\gamma_4 & 0 & \gamma_{01} \end{pmatrix} \quad and \quad B_2 = \begin{pmatrix} \alpha_{02} - \alpha_2\gamma_4 & 0 & -\alpha_2\gamma_{02} \\ 0 & \beta_{02} & 0 \\ \gamma_4 & 0 & \gamma_{02} \end{pmatrix} \tag{25}$$

Noting that the second columns of both B_1 and B_2 each contain a single element, the column sum restrictions (23) may be written as

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\begin{aligned}
\alpha_{01} &= b_1 - (1-\alpha_2)\gamma_4 & \alpha_{02} &= b_2 + (1-\alpha_2)\gamma_4 \\
\beta_{01} &= b_1 & and \quad \beta_{02} &= b_2 \\
\gamma_{01} &= \frac{b_1}{1-\alpha_2} & \gamma_{02} &= \frac{b_2}{1-\alpha_2}
\end{aligned}
\tag{26}
$$

However, there is also some evidence that lagged positions do have some effect on the futures price, implying a degree of semi-strong inefficiency. This may be accounted for by inclusion of the

lagged change in the noise position in equation (24) which becomes[14]

$$\Delta \ln F_t = -\frac{1}{\beta_3}\left(\iota'\Lambda I_t + \phi\Delta Z_{t-1} + \iota'v_t\right)$$ (27)

so that (26) is modified such that

$$\gamma_{01} = \frac{b_1}{1-\alpha_2} + \phi \quad and \quad \gamma_{02} = \frac{b_2}{1-\alpha_2} - \phi$$ (28)

Notice that, with this modification, equations (26) only impose the single restriction

$$\alpha_{01} + \alpha_{02} = \beta_{01} + \beta_{02}$$ (29)

since the noise equation is dropped in estimation and hence γ_4 must be inferred from the estimated speculative and hedge equations.

5. Results

The model was estimated on data from the CSCE for the 'C' contract covering the 156 week period from January 1993 to December 1995. Table 1 summarizes the position data. Note

- Large speculators were generally but not invariably net long, while hedgers were generally but not invariably net short. Small speculators were net long throughout the period.

- The net hedge positions showed the greatest variability and the net small speculative position the least variability. The net hedge and large speculative positions were strongly negatively correlated, while the small speculative position was positively correlated with the large speculative position. These correlations confirm the visual impression given by Figure 2.

- Turning to the number of reporting traders,[15] large speculators were predominantly long while hedgers were much more evenly balanced. The greatest variability was in the number

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[14] Because the lagged positions sum to zero, I cannot identify which of the lagged positions affect the futures price. The specification in (27) is one of many possibilities.

[15] The CFTC reports only the positions and not the numbers of small speculators. Table 1 omits the generally small number of non-commercial traders reported as spreading.

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of long large speculators.

These numbers are consistent with a characterization of the CSCE markets as operating with a relatively small and consistent group of traders but which experienced an influx of non-traditional large speculators taking predominantly long positions.

Model estimation results are reported in Tables 2-4. Tables 2 reports single equation (OLS or IV) estimation of the position equations together with the implied futures price equation, while Table 3 reports FIML system estimates of the same equations. The estimates reported in Table 2 impose only the intra-equation restrictions while those reported in Table 3 impose both intra- and inter-equation restrictions. Table 4 reports the correlation matrices of the single equation residuals and the structural residuals from the system estimates.

Considering first the estimated equations for the net large speculative positions (Tables 2 and 3, column 1), the coefficients α_{1j} on the three informational variables I_{jt} ($j=1,2,3$) are well-determined and differ little between the two estimation procedures. These estimates provide strong support for the contention that speculators were motivated to invest in coffee by consideration of financial rather than coffee fundamentals in this period. The coefficient α_2 on the noise positions Z_t is incorrectly signed in the single equation estimates, but correctly signed, although insignificant, in the system estimates.

Turning to the estimated net hedge equations (Tables 2 and 3, column 2), note that it is necessary to reverse the signs on the estimated coefficients when interpreting effects on the size of the hedge position in view of the fact hedgers are almost invariably net short. The effects of changes in the futures price on the hedge position are clear and in line with the theoretical model developed in section 2. A rise in the futures price $\ln F_t$ results in an increase in the net short position.

For completeness, the coefficients in the noise (small speculators) equation implied by the FIML estimates are also tabulated together with OLS estimates for purposes of comparison (Tables 2 and 3, column 3). The coefficient estimates are fairly similar, but there is in this case a substantial deterioration in fit in moving from the single equation to the system estimates. As might be expected from market efficiency considerations, the single equation estimates of the futures price equation (Table 2, column 4) are very poorly determined. The FIML estimates of the same equation (Table 3, column 4) derive almost entirely from the imposition of cross-equation restrictions.

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Overall, the system estimates impose a total of 12 over-identifying restrictions. A likelihood ratio test indicates that the set of restrictions is acceptable at the 5% level.[16] The residual correlations reported in Table 4 (single equation estimates on the sub-diagonal and system estimates on the super-diagonal) should be compared with the correlations of the raw variables in Table 1. The residuals from the speculative and hedge positions are near independent, while the raw variables are strongly negatively correlated. Note also the high correlation of the residuals from the futures price equation with the position residuals. High residual cross-equation correlations are consistent with the theoretical model in which the futures price disturbances are a linear combination of the position disturbances - see equations (20) and (21). Overall, therefore, we regard the systems estimates, reported in Table 3 as providing a satisfactory representation of the econometric model elaborated in section 4, and as representing the theoretical model developed in section 2.

This view may be corroborated by reconstruction of the convenience yield signal e_t, estimated as α_1'I_t. The correlation of this estimated signal does indeed turn out to be positively correlated with the return to holding a long futures position over the following weeks. The correlation is maximized for a three week holding period with a value of $r = 0.168$ - see Figure 3 for the scatter plot. This correlation is significantly different from zero at conventional significance levels. And although this particular correlation is reduced if the frost period in mid-1994 is excluded from the sample, it remains positive, and is actually higher than the value quoted for slightly longer holding periods. At least with regard to coffee, therefore, speculators were correct in judging that possibly poor returns and increased riskiness of equity and bond investments made diversification into physical commodities attractive.

6. Conclusions

A general difficulty with models which rely on asymmetry of information is that it is

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[16] One might consider imposing the restrictions in sequence testing each set in turn. The problem with this approach is that the acceptability of a given set of restrictions is not independent of the sequence order and no "natural" ordering suggests itself in the current context. In practice it was found that any given subset of restrictions was less acceptable the later in the sequence it was imposed. The most problematic restrictions were the cross equation restrictions on the futures price equation implied by equation (30) and the restriction that the bottom left hand elements of the polynomial distributed lag matrices A_1 and A_2 in (30) be equal and opposite. The equation diagnostics suggest significant departures from normality on all equations, and this indicates caution with regard to reported t values and χ^2 statistics.

difficult to work out who knew what and when they know this. This in turn makes it difficult to test these models econometrically. We have sought to overcome this problem by looking at a short historical period in which an influx of non-traditional traders entered the physical commodity markets. 1994 saw a large movement of speculative money into commodities, motivated by portfolio diversification considerations in the face of likely poor equity and bond returns in the face of the probability of rising interest rates. Although this information was available to traditional traders in these markets, and in particular to hedgers, it was not information which they had come to regard as relevant. This implies a degree of informational segmentation in the market.

Within this context we have developed a model in which informed speculators receive signals relating to price developments, and establish futures positions on the basis of these signals. A bullish signal results in speculators establishing a long position thereby bidding up the futures price. Hedgers, observing the price rise but not the information which generated it, are unsure as to whether it is due to informed speculation or to random noise trading. The consequence is that, even though the rise in the futures price raises their expectation of the future cash price, this is not by so much as the rise in the futures price, and they shorten their futures positions.

This was the observed sequence of events in the New York coffee futures market during 1994. We have reported estimates of an econometric model of the coffee futures market which provide support for the segmentation hypothesis. This model is relatively successful in accounting for the comovement of the speculative and hedge positions. Furthermore, we have been able to reconstruct an estimate of the signal received by speculators and demonstrate that this is positively correlated with futures holding returns. This does not demonstrate the profitability of ant actual speculative behaviour, but does establish that any speculators who took notice of this information would have been able to partially anticipate subsequent price movements.

Our estimates relate to a particular market in a particular time period. We do not claim any generality for the informational partition which we have been able to exploit in this particular instance.[17] Rather, this should be taken as a cast study, in which we have been able to use the modern theory of price discovery in financial markets to explain a set of events which market contemporary market participants found hard to understand. This theory does have general

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[17] Phillips and Weiner (1994) find that speculators in the Brent oil forward market have no informational advantage. However, all traders in this market are either large national or international oil refining companies or major international banks and it seems entirely plausible, in that context, that all would have access to and be familiar with the same information.

application, and the general structure of the argument, although not the particular model, will be relevant in a number of contexts. Examples might include learning from central bank support operations in foreign exchange markets and leaning about possible manipulative trades in commodity futures markets.

Appendix: Variable Definitions and Sources

BVOL   Implied volatilities of CBT options on Treasury bond futures with approximately six months to maturity (CBT).

F   Second position price, CSCE, ¢/lb, Tuesdays (FDI).See footnote 9 on rolling.

H   Net long reportable positions of commercial traders on the CSCE, Tuesdays, contracts of 36,500 lbs (CFTC).

P   First position price, CSCE, ¢/lb, Tuesdays (FDI). See footnote 9 on rolling.

S   Net long reportable positions of non-commercial traders on the CSCE, Tuesdays, contracts of 36,500 lbs (CFTC).

S&P   Standard and Poors Composite Index (DS).

YGAP   Redemption yield on 30 year US Treasury bond less redemption yield on 10 year US Treasury bond, Tuesdays, (constructed; bond yields: DS).

Z   Net long non-reportable positions of non-commercial traders on the CSCE, Tuesdays, contracts of 36,500 lbs (CFTC).

CBT   Chicago Board of Trade

CFTC   Commodity Futures Trading Commission, *Commitments of Traders in Futures*, Washington, DC

DS   Datastream Ltd, London.

FDI   Futures Data Institute, Washington, DC

The data used in this study are available from the author on request.

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Table 1 Descriptive Statistics and Correlations			
Positions (contracts)	*S*	*H*	*Z*
Mean	4,577	- 10,132	5,555
Standard deviation	5,593	7,664	2,932
Minimum	- 4,961	- 27,173	322
Maximum	19,333	3,594	12,229
Position correlations	*S*	*H*	*Z*
Correlation with *S*	1.000		
Correlation with *H*	- 0.952	1.000	
Correlation with *Z*	0.592	- 0.810	1.000
Numbers of Traders	**long, short**	**long, short**	
Mean	43 , 22	56 , 41	
Standard deviation	18 , 9	8 , 5	
Minimum	17 , 5	41 , 27	
Maximum	80 , 43	78 , 54	

	S_t (IV)	H_t (IV)	Z_t (OLS)	$\Delta n F_t$ (OLS)
Table 2 **Single Equation Estimates**				
S_{t-1}	1.0282 (12.9)		0.0716 (2.23)	
S_{t-2}	-0.1448 (1.90)		-0.0716 (*)	
H_{t-1}		1.2116 (10.1)		
H_{t-2}		-0.3379 (2.31)		
Z_t	0.1330 (2.01)			
Z_{t-1}			0.7143 (9.36)	-0.0033 (0.58)
Z_{t-2}			0.2528 (3.31)	0.0033 (*)
$\Delta\ln F_t$		-69.052 (1.42)		
$I_{1,t}$	- 18.434 (2.04)			-0.4195 (1.50)
$I_{2,t}$	- 4.531 (1.79)			0.0309 (0.27)
$I_{3,t}$	0.7689 (2.32)			0.0007 (0.07)
R^2 (OLS) standard error serial correlation heteroscedasticity normality	1.877 $\chi^2_4 = 3.94$ $\chi^2_{14} = 9.14$ $\chi^2_2 = 15.5$	3.254 $\chi^2_4 = 1.33$ $\chi^2_8 = 123$ $\chi^2_2 = 31.9$	0.928 0.801 $\chi^2_4 = 5.92$ $\chi^2_8 = 6.76$ $\chi^2_2 = 1.81$	0.068 0.060 $\chi^2_4 = 6.54$ $\chi^2_{10} = 10.8$ $\chi^2_2 = 18.4$
Restrictions	$\chi^2_1 = 3.30$	$\chi^2_4 = 4.00$		

Notes: Equations also contain constant and two frost dummies; see appendix for variable definitions; asymptotic t statistics in parentheses; * indicates a restricted coefficient; italicized χ^2 values are significant at the 95% level.

	S_t	H_t	Z_t	$\Delta \mathrm{n} F_t$
Table 3 **FIML System Estimates**				
S_{t-1}	1.1067 (17.7)		0.0836 (*)	
S_{t-2}	- 0.1855 (2.94)		- 0.0836 (*)	
H_{t-1}		1.1884 (17.6)		
H_{t-2}		- 0.2672 (*)		
Z_t	- 0.0227 (0.95)			
Z_{t-1}			0.7841 (*)	- 0.00647 (1.98)
Z_{t-2}			- 0.2734 (*)	0.00648 (*)
$\Delta \ln F_t$		- 81.302 (2.11)		
$I_{1,t}$	- 20.535 (2.33)			- 0.2526 (*)
$I_{2,t}$	- 4.912 (1.97)			- 0.0604 (*)
$I_{3,t}$	0.8683 (2.64)			0.01068 (*)
standard error serial correlation heteroscedasticity normality	1.911 $\chi^2_4 = 1.40$ $\chi^2_{14} = 12.4$ $\chi^2_2 = 13.2$	3.919 $\chi^2_4 = 6.29$ $\chi^2_{14} = 9.92$ $\chi^2_2 = 13.7$	4.562 $\chi^2_4 = 4.90$ n.a. $\chi^2_2 = 22.9$	0.0601 $\chi^2_4 = 5.36$ $\chi^2_{14} = 16.8$ $\chi^2_2 = 23.1$
Restrictions	$\chi^2_{12} = 19.2$			

Notes: See Table 2.

<table>
<thead>
<tr><th colspan="5">Table 4
Residual Correlations
(Single Equation \ System)</th></tr>
</thead>
<tbody>
<tr><td></td><td>S_t</td><td>H_t</td><td>Z_t</td><td>$\Delta \ln F_t$</td></tr>
<tr><td>Correlation with S_t</td><td>1.000</td><td>0.176</td><td>- 0.559</td><td>0.563</td></tr>
<tr><td>Correlation with H_t</td><td>0.094</td><td>1.000</td><td>- 0.915</td><td>0.898</td></tr>
<tr><td>Correlation with Z_t</td><td>0.106</td><td>0.126</td><td>1.000</td><td>- 0.988</td></tr>
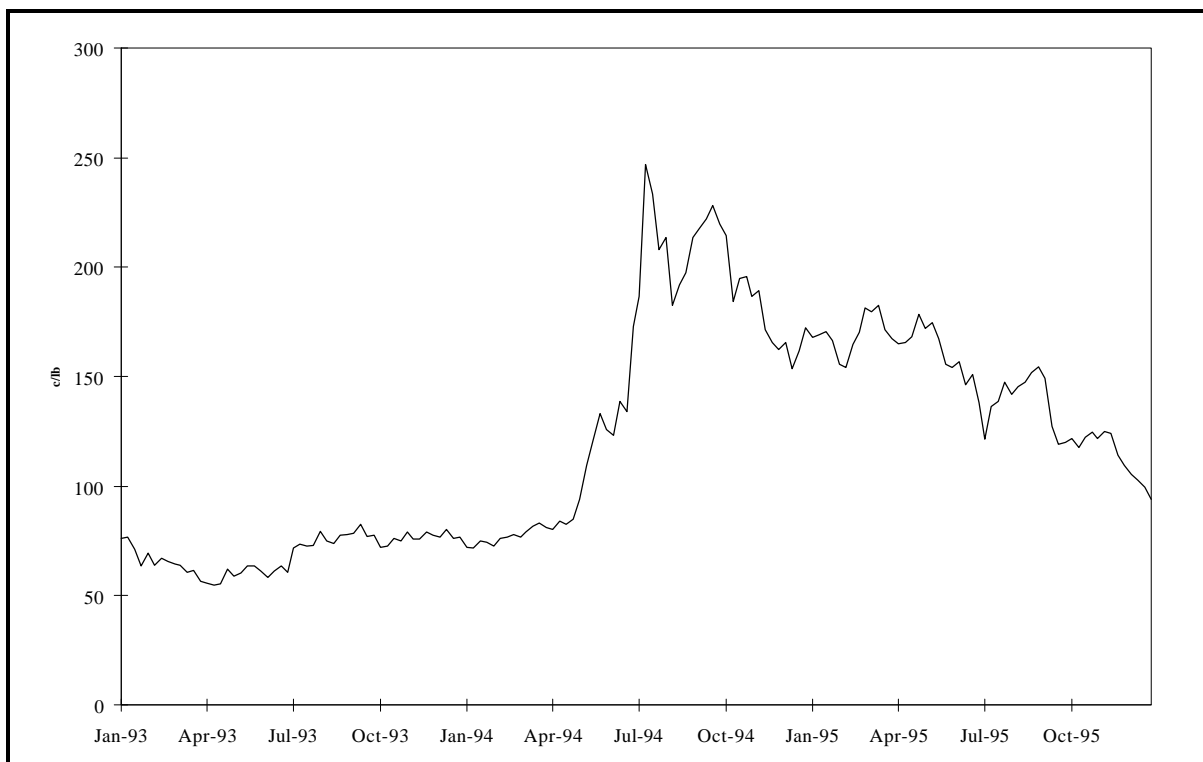<tr><td>Correlation with $\Delta \ln F_t$</td><td>0.538</td><td>0.838</td><td>0.359</td><td>1.000</td></tr>
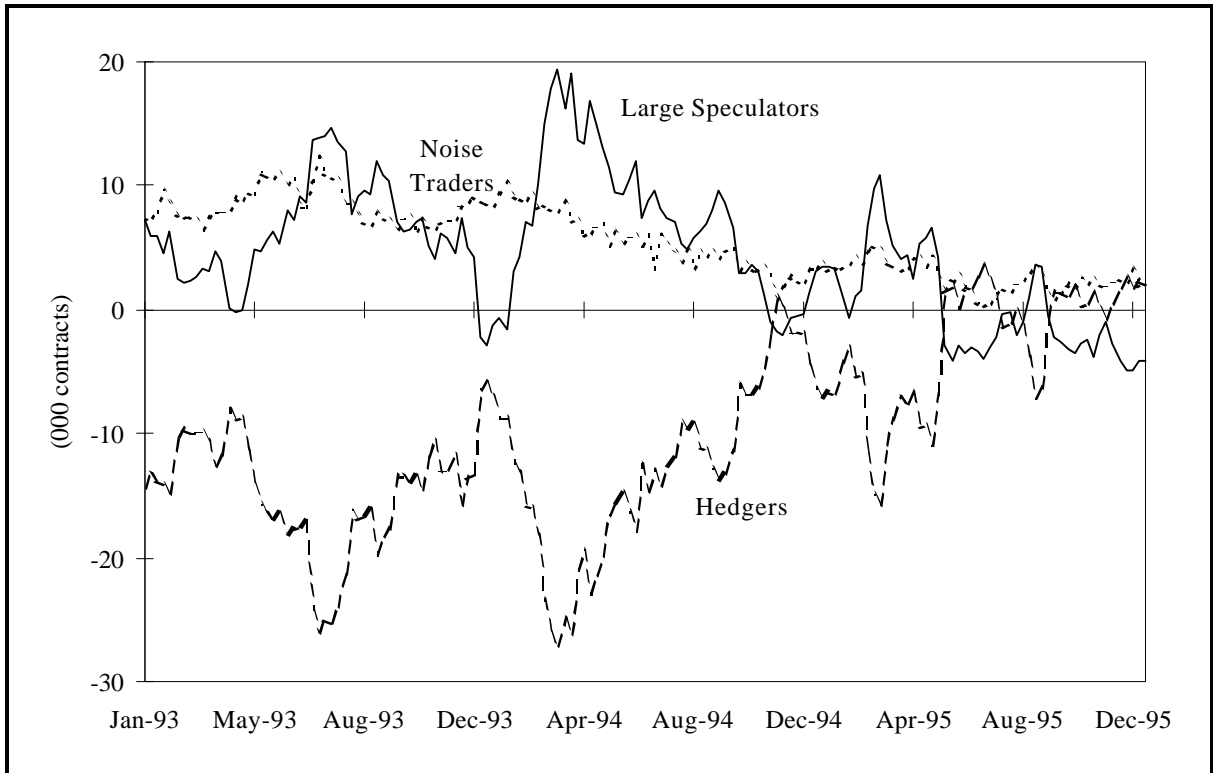</tbody>
</table>

Figure 1: CSCE Coffee Price, 1993-95.

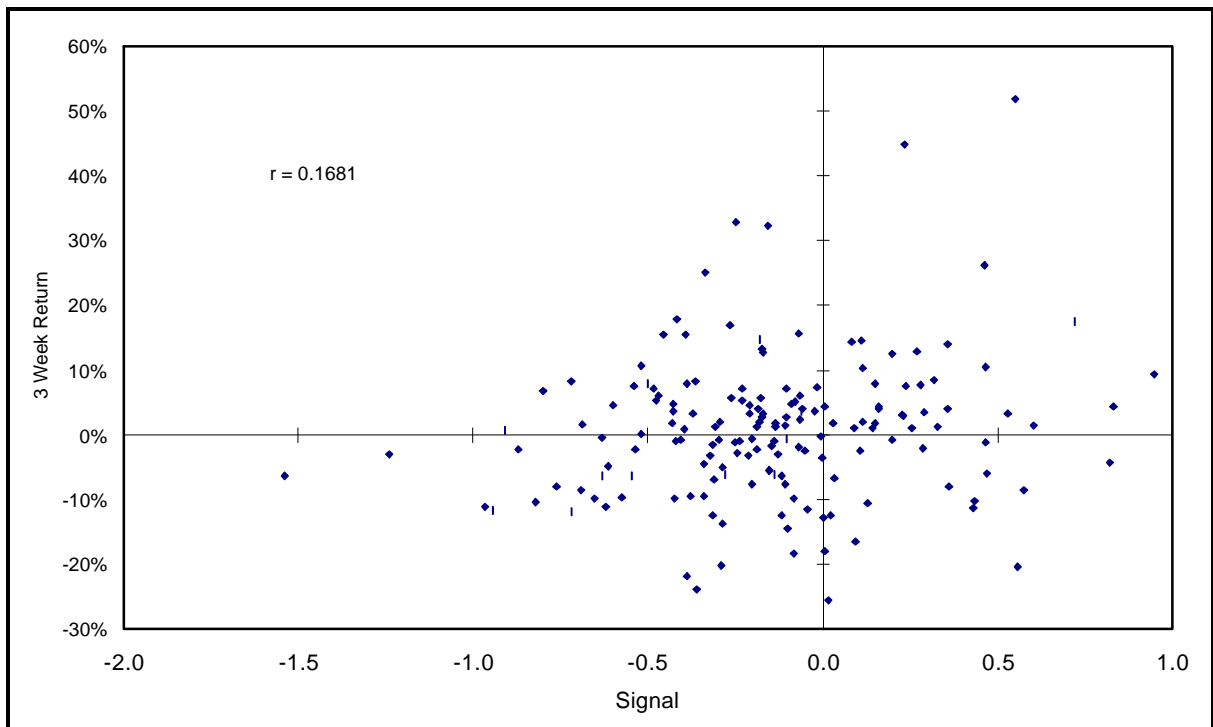**Figure 2: CSCE Coffee Market Net Positions**

Figure 3 Scatter Plot, 3 Week Long Future Holding Return Against the Estimated Convenience Yield Signal