DO FUTURES PRICES FOR COMMODITIES EMBODY RISK PREMIUMS?

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INTRODUCTION

The issue of whether commodity futures prices embody risk premiums continues to elicit interest and research—in no small part due to the fact that it remains unresolved. Keynes (1930) argued that normal backwardation—namely, the expectation that futures prices will rise over contract life as a reward to risk-assuming speculators which is paid for by risk-averse net short hedgers—should prevail for commodity futures. Cootner (1960) pointed out that contango—the expectation that futures prices will decline over contract life—was similarly appropriate when hedgers were net long. Synthesizing the two, one can say that commodity futures conform to *risk premium theory* if backwardation holds when hedgers are net short, and contango when they are net long.[1] In terms

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[1]From here on, the term backwardation is used in place of the more cumbersome normal backwardation. It should be noted that backwardation sometimes refers to the situation where futures prices at a given moment are below the corresponding *current* cash price—a sense not intended here. See Kolb (1991).

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of ex ante futures returns, backwardation/contango implies that they are positive/negative.

Subsequent theoretical innovations in finance have led to several complications. Risk is viewed as meaningful today only if it is nondiversifiable and hence priced. Thus, competitive speculators are able to demand a premium only if their positions are correlated with the return on a *properly defined* market portfolio. Dusak (1973) found, for grains, that mean futures returns and betas are both zero—a finding which conforms to CAPM. Bodie and Rosansky (1980) provided contrary evidence. Looking at 23 commodity futures during 1949–1976, they found all but one with mean positive returns—despite the fact that the betas were mostly negative. Their evidence provides strong support for Keynes' view that backwardation is the norm, and calls into question modern asset pricing theory in explaining futures prices.[2]

Another issue relates to the fact that it is now recognized that risk premiums may be time-variant. This can be due to such factors as changes in risk aversion and market volatility, shifts in the balance between long and short hedging demand, and seasonality (perhaps revealed by the basis).[3] Fama and French (1987) explored this issue by investigating whether the basis embodies some predictive power for ex post premiums (i.e., futures returns). Using data ending at 1984, they found some evidence that this is so for seven out of 21 commodities. As for *unconditional* ex post premiums (or, simply, average returns), they found only four/one cases of significant backwardation/contango—arguing that the tests have little power because of the high degree of price variability.[4]

In theory, backwardation commodities should have mean daily returns that are positive; prices should fall below the futures price at expiry more often than not; and the magnitude of the latter gap should increase the farther one is from contract maturity. Kolb (1992) studied 29 commodities for a sample period extending from 1959 and concluded

[2]The debate concerning the applicability of asset pricing theory was continued by Carter et al. (1983) who argued that an appropriate market portfolio should include a substantial weighting for an index of commodities and, on this basis, found significantly positive betas for commodity futures. Black (1976) argued that a market portfolio already incorporates the value of commodities since firms own commodities outright. Marcus (1984) and Baxter et al. (1985) countered that any weighting for a commodity index in the market portfolio should be fairly small and, in line with this view, found commodity betas insignificantly different from zero. Note that others (Breeden (1980) and Hazuka (1984)) worked in terms of consumption-based CAPM.

[3]One approach, as in the ARCH-M of Engle et al. (1987), is to investigate whether high recent volatility induces higher ex ante returns. See Deaves and Krinsky (1992) for some evidence.

[4]When continuously compounded returns were used, there was only one significant case—and it was for contango.

that only seven unequivocally exhibited evidence of a risk premium based on a battery of tests.[5] The three contango commodities were heating oil, crude oil, and lumber; while the four backwardation commodities were live cattle, feeder cattle, live hogs, and orange juice.

This article revisits the above-listed seven commodities included in Kolb's study to see whether, given five years of additional data, these commodities have remained backwardation or contango commodities. It is found that this is not generally so, though the livestock (i.e., live cattle, feeder cattle, and live hogs) commodities are salient exceptions. This study suggests why some commodity futures may for extended periods appear to embody risk premiums. It is argued that this is due to the fact that the backwardation/contango commodities have tended to have *real* spot price trends that are positive/negative. To the extent that some of this was unanticipated by financial markets, what may be coming through is not a risk premium but persistent forecast error. The implication is that market participants would not go far wrong by viewing futures prices as reflective of the markets expectations of eventual spot prices. This finding enhances the price discovery role of futures.

RECENT EVIDENCE ON BACKWARDATION VERSUS CONTANGO

Risk premium theory relates futures prices at t for delivery at $T(F_{t,T})$ to spot prices anticipated at t for $T(E_tS_T)$, as follows:

$$F_{t,T} + RP_t = E_tS_T \tag{1}$$

where RP_t is an unobservable, possibly time-varying positive or negative risk premium.[6] It is termed a risk premium since, if positive/negative, it is the average reward for a speculator going long/short in futures at t and closing out the position just prior to delivery (at T).[7]

[5]All seven were *pure* commodities—that is, there were no financial, precious metal, or foreign exchange futures. Such pure commodities made up 19 out of the 29 in the sample.

[6]One should view futures and spot prices as being in natural logs for the risk premium to be in percentage terms.

[7]To see that the gap is a risk premium, one should note that the futures price for a commodity with virtually no time until delivery will be equal to the cash price, or $S_T = F_{T,T}$ and $E_tS_T = E_tF_{T,T}$. (Were this not so, there would exist obvious arbitrage opportunities.) This means that the ex ante risk premium is $E_tF_{T,T} - F_{t,T}$, which is the same as the expected return on a long futures position initiated at t and closed out just prior to delivery (E_tR_T).

Realized futures returns from t to $T(R_T)$ also include forecasting errors (u_T), as follows:

$$R_T = RP_t + u_T \tag{2}$$

Of course since the risk premium is never observable, the futures return can never with any certainty be decomposed as above.

One should expect the risk premium to be positive if hedgers are net short, since, to insulate themselves from price fluctuations, they must sell futures contracts. Since net long speculators are needed to supply price insurance, they must be induced to do so by the expectation of futures price increases, or synonymously, positive risk premiums, which implies backwardation. On the other hand, contango implies hedgers are net long, speculators net short, declines in futures prices are expected, and risk premiums are negative.

The data in Tables I and II provide information on mean one-, two-, four-, and six-month (log difference) returns—and associated t-statistics—for the four backwardation and three contango commodities of interest [from Kolb (1992)] over a number of different sample periods. The full sample information is shown in the first column of numbers. The samples for each commodity run from close to contract inception to February 1994.[8] The next two columns provide mean returns for subperiods that comprise roughly equal halves of the relevant full samples. The final two columns allow for a different sample break, with the first subperiod running to the end of 1988 (to coincide with Kolb's sample period) and the second subperiod going from that point to February 1994.

Before discussing the results, a couple of econometric issues should be discussed. First, the standard errors for all overlapping returns—over two months for all but the energy futures, where it is over one month—are estimated using the asymptotic covariance matrix suggested by Hansen and Hodrick (1980), which accounts for the moving average nature of the error terms.[9] Second, where the evidence

[8]The data are from Technical Tools of Los Altos, California. The first contract year included is 1973 for lumber; 1979 for heating oil; 1983 for crude oil; 1973 for orange juice; 1970 for live hogs; 1976 for live cattle; and 1977 for feeder cattle. (Kolb used a different data source, so his starting points differ somewhat.) The two energy futures have 12 contracts per year; orange juice, lumber, and live cattle have six contracts per year at two month increments; while live hogs and feeder cattle have seven and eight, respectively. In the latter cases, one and two contracts per year are dropped (July for live hogs; and April and October for feeder cattle) to facilitate estimation, which assumes observations at regular frequencies (though this is still only approximately true for feeder cattle).

[9]Not to do so can often falsely imply statistical significance, examples of which are given below in the text.

TABLE I

Mean Futures Returns for Backwardation Commodities

Return Interval	*Full Sample*	*First Half*	*Second Half*	*Up to 1988*	*Post 1988*
Feeder cattle					
1 month	0.0103	0.0071	0.0171	0.0099	0.0146
	(2.1052)	(0.7756)	(4.1562)	(1.4376)	(3.4762)
2 month	0.0157	0.0177	0.0208	0.0165	0.0191
	(2.4179)	(1.5535)	(3.0325)	(1.8060)	(3.6091)
4 month	0.0247	0.0203	0.0419	0.0216	0.0363
	(1.9576)	(0.9246)	(4.0832)	(1.2397)	(2.8183)
6 month	0.0292	0.0215	0.0525	0.0238	0.0470
	(1.5883)	(0.6898)	(3.3179)	(0.9363)	(2.6299)
Live cattle					
1 month	0.0146	0.0187	0.0157	0.0169	0.0045
	(2.9676)	(2.1993)	(2.8921)	(2.6124)	(0.6538)
2 month	0.0198	0.0174	0.0296	0.0198	0.0190
	(2.8848)	(1.4502)	(4.2778)	(2.1634)	(2.1607)
2 month—ARCH	0.0233	0.0145	—	0.0232	0.0213
	(3.8160)	(1.4487)		(2.7314)	(2.0111)
4 month	0.0314	0.0271	0.0473	0.0306	0.0338
	(2.3716)	(1.1767)	(3.9582)	(1.7074)	(2.2319)
6 month	0.0372	0.0311	0.0553	0.0351	0.0441
	(2.1467)	(1.0429)	(3.3757)	(1.5012)	(2.1326)
Live hogs					
1 month	0.0223	0.0293	0.0168	0.0274	−0.0025
	(3.4566)	(3.0499)	(1.8989)	(3.6277)	(0.2128)
2 month	0.0353	0.0361	0.0333	0.0365	0.0282
	(3.6515)	(2.3096)	(2.8872)	(3.1121)	(2.0218)
2 month—ARCH	0.0341	0.0358	—	0.0352	—
	(3.4315)	(2.1096)		(2.8797)	
4 month	0.0502	0.0545	0.0468	0.0507	0.0504
	(2.7846)	(1.8124)	(2.3508)	(2.2752)	(2.6612)
6 month	0.0623	0.0689	0.0575	0.0615	0.0748
	(2.6063)	(1.7034)	(2.2503)	(2.0969)	(2.5964)
Orange juice					
1 month	0.0134	0.0164	0.0054	0.0145	0.0183
	(1.5633)	(1.2358)	(0.4601)	(1.5130)	(0.8255)
2 month	0.0121	0.60690	0.0037	0.0183	−0.0024
	(1.0353)	(0.7323)	(0.2243)	(1.4548)	(0.0747)
4 month	0.0183	0.0201	0.0084	0.0292	−0.0091
	(0.7866)	(0.5913)	(0.2532)	(1.1252)	(0.1518)
6 month	0.0274	0.0314	0.0171	0.0424	−0.0103
	(0.7947)	(0.6060)	(0.3624)	(1.0437)	(0.1294)

merits, the longest horizon nonoverlapping return is estimated using the ARCH (autoregressive conditional heteroskedasticity) model of Engle (1982), which takes into account the possibility that the variance is conditional on recent volatility.[10] In particular, the following model is

[10]The problem with OLS, on which basis the standard means and *t*-statistics are calculated, is that it assumes a constant variance.

TABLE II
Mean Futures Returns for Contango Commodities

Return Interval	*Full Sample*	*First Half*	*Second Half*	*Up to 1988*	*Post 1988*
Crude oil					
1 month	0.0007	−0.0006	0.0047	−0.0053	−0.0063
	(0.0794)	(0.0468)	(0.3801)	(0.4455)	(0.5161)
1 month—ARCH	0.0079	0.0170	0.0021	0.0094	−0.0066
	(1.1237)	(1.3608)	(0.2139)	(0.8013)	(0.5870)
2 month	0.0026	−0.0042	0.0100	−0.0092	−0.0067
	(0.1395)	(0.1505)	(0.3818)	(0.3793)	(0.2550)
4 month	0.0021	−0.0134	0.0176	−0.0241	0.0016
	(0.0631)	(0.2494)	(0.4082)	(0.5159)	(0.0400)
6 month	0.0020	−0.0277	0.0314	−0.0410	0.0176
	(0.0471)	(0.3364)	(0.6899)	(0.5924)	(0.4070)
Heating oil					
1 month	0.0063	0.0004	0.0117	0.0029	0.0096
	(0.8665)	(0.0486)	(0.9990)	(0.3664)	(0.6018)
1 month—ARCH	−0.0010	—	−0.0034	—	−0.0023
	(0.2226)		(0.4129)		(0.2603)
2 month	0.0052	−0.0052	0.0164	−0.0020	0.0096
	(0.3808)	(0.2883)	(0.7540)	(0.1351)	(0.3306)
4 month	0.0011	−0.0304	0.0264	−0.0187	0.0177
	(0.0474)	(1.0483)	(0.7545)	(0.7758)	(0.3822)
6 month	−0.0037	−0.0594	0.0421	−0.0381	0.0350
	(0.1250)	(1.6650)	(1.1114)	(1.1344)	(0.7463)
Lumber					
1 month	−0.0088	−0.0166	0.0119	−0.0158	0.0154
	(0.9219)	(1.5701)	(0.7588)	(1.5487)	(0.5604)
2 month	−0.0054	−0.0159	0.0228	−0.0155	0.0320
	(0.3950)	(0.9928)	(1.0551)	(1.0936)	(0.7663)
2 month—ARCH	−0.0040	—	0.0256	—	0.0336
	(0.3191)		(1.7252)		(0.9347)
4 month	−0.0094	−0.0256	0.0275	−0.0257	0.0499
	(0.3994)	(0.8413)	(0.8284)	(0.9845)	(0.8279)
6 month	−0.0158	−0.0367	0.0298	−0.0381	0.0642
	(0.5188)	(0.8176)	(0.8446)	(1.0334)	(1.2704)

estimated:[11]

$$R_T = RP + u_T$$

$$\sigma_T^2(u_T) = \delta_0 + \sum_{i=1}^{q} \delta_i u_{T-i}^2 + w_T \tag{3}$$

where δ_0 and δ_i are parameters to be estimated; w_T is white noise; and the risk premium is assumed constant (and hence not time-subscripted).

[11]To test for an ARCH effect of order q, the procedure is to regress the OLS squared residuals on q lags of themselves. The Lagrange Multiplier (LM) test statistic, calculated as nR^2 (where n is the sample size), is asymptotically distributed as $\chi^2(q)$. In all but one case it is found to be of order one. (The one exception is crude oil after 1988, where it is of order two.)

The results listed in column five of the tables show that by and large this study corroborates Kolb's results, showing strong evidence of a risk premium.[12] All returns for his four backwardation commodities (feeder cattle, live cattle, live hogs, and orange juice) are positive, though feeder cattle has only one that is significant at 10%, and orange juice has none in this category. As for contango, his three relevant commodities (crude oil, heating oil and lumber) all exhibit returns that are negative (except for a couple of one-month returns). None, however, is statistically significant.[13]

Given five additional years of data, do the same commodities continue to exhibit backwardation or contango as before? In the majority of cases, the answer is a firm negative. Focusing on the last column in each table, one can see that in four cases, namely for all the contango commodities and, in addition, for orange juice, most of the returns now have the *wrong sign*.[14] In the case of the other three commodities, which are all livestock futures, backwardation continues to prevail for all but the shortest term price changes. Based on these findings, one is forced to question whether any commodity futures, perhaps with the exception of those associated with livestock, are characterized by consistent risk premiums.

ARE *REAL* PRICE TRENDS RESPONSIBLE?

A simple explanation is offered as to why certain commodities may appear to be backwardation/contango commodities over fairly long samples. If one again refers to eq. (2), which decomposes a realized return into a risk premium and a forecast error, it should be clear that, under a time-invariant risk premium and rational expectations (which implies that forecast errors are mean-zero and uncorrelated), a sample mean is an unbiased estimator of this risk premium.

It is increasingly common for one to question the strict validity of the assumption of rational expectations. Some have argued, in the context of other securities, that markets may have in the past made a

[12]While Kolb used daily settlement prices, this study uses monthly data. Monthly observations are taken from daily series by selecting the date from each month when the nearby contract expires. For commodities where contracts do not exist for every month, the date of the last expiry (or, failing this, the next available date) is used.

[13]Here, the importance of using appropriate standard errors comes into play. For example, the six-month mean return for heating oil/lumber is significantly positive at 5%/10% if the OLS standard error is used.

[14]Notice as well that the highest t-statistic for the contango commodities is for the two-month ARCH-estimated lumber return during the second half of the full sample, but the return is significantly *positive*.

series of one-sided forecast errors. For example, it is sometimes said that the persistent extremely low and sometimes negative realized real rates of interest experienced in the late 1970s were due to the market's consistent underestimation of the rising inflation of the period.[15] Analogously, one can further make the argument that the high realized real rates of interest for much of the 1980s occurred due to the opposite type of forecast error. Moreover, it is now recognized that there are reasonable scenarios such that errors can be persistently one-sided while markets remain rational. Two possibilities are the peso problem, where there is a very low probability of a major price change that is never witnessed within sample; or the situation in which a learning period is required after a regime change.[16]

Could it be that the backwardation/contango commodities have witnessed a preponderance of positive/negative forecast errors? No one can say for certain, but an indirect way of exploring this possibility is suggested here. When a price changes, this event may be anticipated, unanticipated, or it may incur a mix of these two.[17] It seems logical that price changes that move in tandem with changes in a general price level should be largely anticipated, while *real* price changes have *on average* an unexpected component of the same sign.[18] To explore this, for each individual commodity, each month's nominal spot price (as proxied by the price of the future nearest delivery) is deflated by dividing it by the Commodities Research Bureau Index of Commodity Spot Prices for the corresponding month to arrive at *real* commodity prices.[19]

Figures 1 and 2 show the paths of real commodity prices up to 1988 for the backwardation and contango commodities, respectively.[20] To juxtapose the price paths meaningfully, they are scaled by assigning a base of 1.00 to the point where each series begins. Notice that all contango commodities experience real price declines, while three of the four backwardation commodities experience real price increases. Remarkably, if one ranks all commodities by real price levels as of the

[15]For example, see Spiro (1989).

[16]See Frankel and Froot (1987) for a discussion.

[17]Of course, the unanticipated and the anticipated components of a quantifiable event sometimes have different signs.

[18]Note that this argument only requires that some component of real price changes be unanticipated. This need not be a large component.

[19]Nominal commodity spot prices are proxied by nearby futures prices. The CRB index, which is obtained from Knight Ridder, is a weighted average of 23 commodity (primarily of an agricultural or industrial nature) prices in the cash market. A similar CRB index, based on 21 commodity futures prices, yields very similar results—not surprisingly, since the correlation between the two indices is 0.95.

[20]To make the backwardation graph less cluttered, live cattle, which begins at about the same time as feeder cattle and is highly correlated with the latter, is dropped.

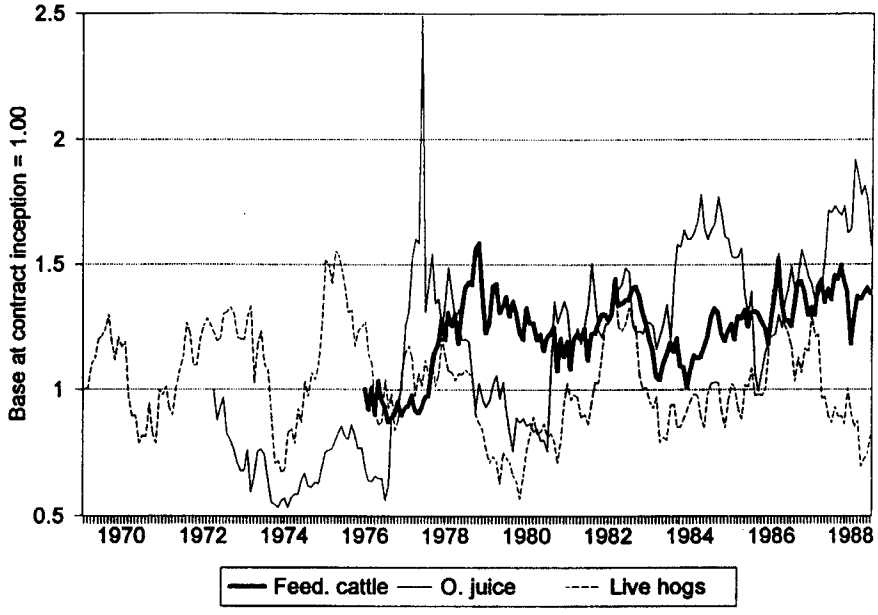

FIGURE 1
Real price trends for backwardation group.

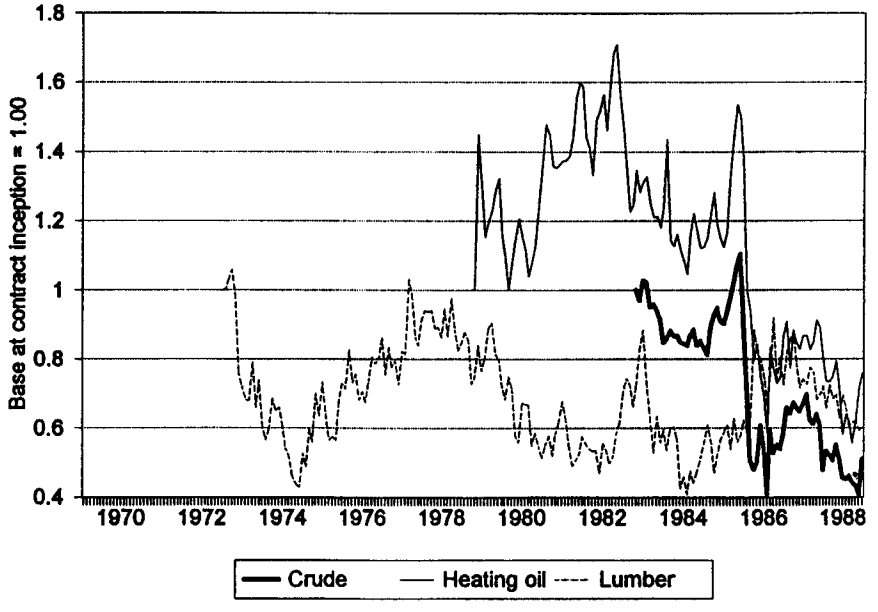

FIGURE 2
Real price trends for contango group.

end of 1988, the four backwardation commodities hold the first through fourth positions and the contango commodities hold the fifth through seventh.[21]

A reasonable inference is that the backwardation commodities experienced more positive forecast errors than negative; hence, the finding of positive mean returns. On the other hand, the contango commodities witness a preponderance of negative forecast errors, leading to the finding of negative mean returns. As for the fact that the livestock commodities continue to reflect backwardation price movements after 1988, all three of them have positive real price trends *over this time as well.*[22]

One is left to wonder whether any commodities—perhaps with the exception of the livestock commodities—show consistent evidence of a risk premium. This could be because short hedging demand and long hedging demand tend usually to be in balance. It could also be that most of the risk associated with commodity futures is diversifiable in the context of a broad portfolio and, therefore, requires no reward. These questions will likely remain open for some time, the first because of insufficient information, and the second because of the ongoing debate about what constitutes the best proxy for the market portfolio.

Nevertheless, it is fair to say that, if there do exist candidates that seem to fit the backwardation mold, the livestock commodities are the prime ones. The finding of significantly positive returns is fairly consistent over a number of different subperiods.[23] Others have noted the persistent tendency for livestock futures to be downward biased estimates of eventual spot prices.[24] In this context it is interesting to note that Breeden (1980) found significantly positive consumption betas for futures in this category; as did Carter et al. (1983) and Elam and Vaught (1988) using a standard CAPM framework with the market proxied by a weighted average of the S&P 500 and the Dow Jones Commodity Index.[25] There are some theories about why these commodities may be different. For example, Koppenhaver (1983) notes that "one possible explanation of the risk premiums... is that

[21]This event has a p-value of 2.86%, given randomness.

[22]Lumber also has a (major) positive real price trend, and its returns are also positive (though insignificantly so). The price of lumber seems to have been influenced by several major events (such as Hurricane Andrew), which caused such volatility that it is difficult to find statistically significant mean returns.

[23]Referring to Table I, notice that 12 out of 15 mean two-month returns are significantly positive.

[24]For example, see Leuthold (1974) and Koppenhaver (1983).

[25]This is not to diminish the importance of the debate on the relevant definition of the market portfolio. See footnote 2 for details.

the nonstorable characteristics of live cattle eliminate intertemporal arbitrage as a factor linking futures prices of different maturities." He further remarks on the preponderance of short hedging activity relative to long.[26] Therefore, the ingredients may be there *for this one group*. As always, further research is needed.

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[26] He states that in 1978 "short positions by large reporting hedgers averaged 45.6% of the monthly open interest while long positions by reporting hedgers averaged 6.6%." Thus long speculators were required to balance the market.

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