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# Default Premiums in Commodity Markets: Theory and Evidence

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**ABSTRACT**

We model the effect of nonperformance risk on forward and futures pricing and look for evidence of nonperformance risk in precious metals futures prices from the "Hunt Brothers" episode. Changes in default premiums are measured and related to the sequence of events in the metals markets during this period. Results suggest first that ex ante costs of nonperformance can be a significant, priced factor in commodity markets and second that the arrival of new information is often associated with changes in these costs. The evidence has implications for both theoretical and empirical research on commodity markets.

ORGANIZED COMMODITY MARKETS OFFER traders an efficient medium in which to execute their hedging and speculative strategies. In particular, the markets have developed mechanisms that reduce the costs of nonperformance, which would be substantial in the absence of an organized exchange. Devices such as margin requirements, position limits, daily marking-to-market, price limit moves, and the clearinghouse reduce the expected costs of distress and default in commodity markets.[1]

While organized exchanges greatly reduce expected costs of nonperformance, they do not eliminate such costs. Throughout the history of organized futures trading, there have been many instances of markets collapsing, or coming to the brink of collapse, after a period of unusual trading activity. The most prominent example in recent times is the near-collapse of the New York City Commodity Exchange (COMEX) silver futures market in 1980 after a period of heavy buying activity by members of the Hunt family of Texas. More recently, the palm oil futures market in Malaysia (1984), the tin market in London (1985), stock index futures markets in Hong Kong (1987) and Brazil (1989), the soybean market in Chicago (1989), the bond futures

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[1]See Anderson (1984), Brennan (1986b), and Forster (1988) for a discussion of commodity market features.

market in New Zealand (1989), and the silk futures market in Japan (1990) have experienced episodes which threatened the solvency of traders, brokers, financial institutions, clearing members of the exchange, or the exchange clearinghouse itself. In some cases, these episodes resulted in temporary or permanent market closings along with massive bailouts of distressed traders or institutions by banks or government agencies. Sometimes nonperformance costs resulted not from the demise of the entire market but from the insolvency of a particular member firm of the exchange. Examples include the Maine potatoes case (1976) and the Volume Investors case (1985) where a single customer's default on a large margin call led to the seizure of all accounts of the approximately 100 investors trading COMEX gold futures through the firm. In each such instance of futures market distress, investors, exchange members, and other parties faced potential costs of revoked contracts, litigation, unpaid margin calls, and the inability to continue to trade or close out existing positions. Legal remedies have not always compensated innocent parties fully.[2]

While instances of commodity market failure are uncommon, the potential for nonperformance exists in all commodity exchanges. In an efficient market, a premium incorporated into the prices at which contracts trade compensates for the expected costs of nonperformance. For example, a forward contract on which the buyer might default will change hands with a premium added to the default-free forward price to compensate the seller for default risk. A forward contract on which the seller might default will change hands with a premium subtracted from the default-free forward price to compensate the buyer for default risk. Determining the sign of the premium is more complex if there is a chance that either side of the contract will default. In the case of an organized market, the nonperformance risk associated with brokers, clearing members of the exchange, and the exchange clearinghouse itself is affected by the actions of large traders. Changes in the default premium occur as information arrives and market participants update their beliefs about expected costs of nonperformance.

A time-varying premium for nonperformance risk can be significant for both theoretical and empirical research on forward and futures markets. Cox, Ingersoll, and Ross (1981) and Richard and Sundaresan (1981) value commodity contracts in general equilibrium settings with utility-maximizing economic agents while Rolfo (1980), Marcus and Modest (1984), and Hirshleifer (1988) examine optimal hedging and production decisions. The conclusions of these authors can change if their models are altered to include imperfect performance guarantees and economic agents who may rationally decide to default on contracts. Numerous authors present empirical tests of

[2] In the Hunt brothers episode, some creditors were obliged to settle for oil and gas properties, rather than the cash they were owed. In the London tin case, a U.K. court upheld the exchange's decision to settle outstanding contracts at prices considerably lower than the transacted price. In the Maine potatoes case, a delivery default was settled in cash almost a year after the incident. In the Volume Investors case, it was many months before frozen assets of nondefaulting investors were released.

the ability of storage, forecast, or equilibrium risk-return models to explain futures prices.[3] Evidence from such tests may be affected by the presence of a time-varying default premium in some observed futures prices.

This paper uses option pricing principles and data from the "Hunt Brothers" period in U.S. metals futures markets (1979 to 1980) to examine the impact of ex ante nonperformance costs on commodity contract prices. First, we present a model that shows how nonperformance risk can cause commodity contract prices to differ from equilibrium default-free prices. We find that relatively large nonperformance risk on the long (short) side of a contract induces a positive (negative) default premium in the contract price. We also find that periodic resettlement of a futures contract does not reduce its nonperformance risk to that of a one period forward contract. Second, we develop a method for measuring changes in default premiums impounded in futures prices. Series of default premium changes are estimated for the period when the Hunt brothers were active in the COMEX silver market. Following the event study methodology common in corporate finance studies, these changes are related to the sequence of information events during the period.

Our results contribute to the literature on the valuation of commodity contracts and the efficiency of commodity markets in several respects.[4] Furthermore, the study of cataclysmic events in futures markets serves the same purpose as the "October 1987" stock market literature in increasing understanding of how markets for risky assets function.[5] Above all, the paper highlights the previously unexplored default premium component of the commodity contract basis, an unusual but significant factor in commodity contract markets. The paper is organized as follows. Section 1 presents a model of commodity contract pricing under default risk. Section 2 details the empirical methodology and the dataset, then presents and interprets empirical evidence. Section 3 is a summary and conclusion.

## 1. A Model of the Default Premium

Kane (1980) suggests that a forward contract price can be thought of as equaling the default-free contract price plus the value of the purchaser's option to default on the contract minus the value of the seller's option to default on the contract. Johnson and Stulz (1987) employ option-pricing techniques to value what they call a "vulnerable" option, that is, an option on which the writer might default. This section presents a simple model

[3]See, for example, Dusak (1973), Bodie and Rosansky (1980), Jagannathan (1985), Hansen and Hodrick (1980), Hsieh and Kulatilaka (1982), Brennan (1986a), and Fama and French (1987). Brennan (1986a) notes that his empirical analysis of silver futures prices may be confounded by "the very real risk of default . . . occasioned by the Hunt brothers incident . . ."

[4]Several authors have studied the efficiency with which commodity markets incorporate new information. See Draper (1984), Roll (1984), Bhattacharya (1986), and Cornell and French (1986).

[5]See, for example, Harris (1989) and Blume, MacKinlay, and Terker (1989).

which illustrates the effect of default risk on forward and futures prices. The model indicates that the periodic resettlement feature of futures contracts reduces the default risk of a futures contract relative to an otherwise identical forward contract. However, the model also shows that the default risk of a futures contract exceeds that of a short maturity forward contract.

We adopt the binomial model and notation of Cox, Ross, and Rubinstein (1979). The underlying state variable is the price of a risky asset which, for simplicity, is assumed to pay no dividend or convenience yield.[6] Time is divided into subperiods during each of which the price $S$ of the risky asset may either grow at the rate $u$ or decline at the rate $d = 1/u$. Letting $r$ represent one plus the riskless rate of interest, the assumed stochastic process for $S$ implies an equivalent risk neutral probability measure in which the probability $p$ of an increase in $S$ over one period equals $r - d/u - d$.

We solve for prices of forward and futures contracts which mature in one and three time periods.[7] In pricing a particular type of contract, it is assumed that exactly one contract is outstanding, the long side of the contract has finite wealth $W$, and the short side has infinite wealth.[8] With a forward contract, default occurs if, at maturity, the contract payoff is less than minus the wealth of the long trader. With a three period futures contract, we assume that the contract is resettled to changes in the *cash* price at the end of the first and second periods.[9] Thus, long-side wealth changes as variation margin is added or subtracted over the life of the contract. Default occurs when the long side cannot meet variation margin calls at the end of the first or second period or defaults on the terminal payment due at the end of the third period. In case of either forward or futures default, we assume the long side transfers its wealth to the short side. To solve for the initial forward or futures price, we note that such contracts require no initial cash flow.

[6]The convenience yield is the certainty-equivalent of the stream of benefits earned by the owner of a spot inventory of a commodity but not earned by the owner of a forward (or futures) contract written on the commodity. The convenience yield is affected by output, price, inventories, and the equilibrium risk-return relationship in the economy. If, for example, output declines, then price rises, inventories decline, and the benefit from owning an inventory (the convenience yield) rises. See Brennan (1958), Brennan and Schwartz (1985), and Brennan (1986). The convenience yield also reflects the value of a cash inventory given a "squeeze" in the futures market.

[7]In this model, periodic resettlement of futures implies that the *path* of $S$ is important because it determines the path of a trader's wealth and, thus, the likelihood of default on a variation margin call. We restrict the analysis to a small number of time periods because the number of branches in a path-dependent binomial tree increases exponentially with the number of time periods.

[8]It is straightforward to extend the model to finite wealth on both sides of the contract. Also, note that the economic setting can be modified such that finite wealth does not preclude classical no-arbitrage valuation solutions. See Heath and Jarrow (1987). We may also think of the wealth of clearing members, the clearinghouse, and other guarantors as supplementing the wealths of traders and thus affecting the likelihood and cost of a default.

[9]Given only two traders and one contract, our model admits a variety of noncompetitive solutions in which the path of the futures price and the path of $W$ are jointly determined. Our simple resettlement procedure allows us to examine the risk reduction which periodic resettlement achieves relative to the single terminal settlement of a forward contract.

Therefore, the initial contract price must be set so that the value of the contract payoffs is zero.

Because we use a numerical valuation procedure, we cannot solve explicitly for the equilibrium initial contract price, but we search iteratively for the price which equates the value of the contract payoffs to zero. For example, the initial value $\nu$ of the long position in a default-vulnerable forward contract is:

$$\nu = \left[ p \cdot \max\{u \cdot S - f, -W\} + (1-p) \cdot \max\{d \cdot S - f, -W\} \right] / r \quad (1)$$

where $f$ is the forward price. We solve for the value of $f$ which sets $\nu$ to zero. In addition to pricing default-vulnerable one and three period forward contracts and three period futures contracts, we compute prices for corresponding default-free contracts. The default premium for a particular contract is measured as the contract price minus the price for the otherwise identical default-free contract. Though we cannot obtain explicit comparative statics given the numerical solution technique, we vary parameter values to get a sense of how the default premium responds to changes in long side wealth and spot price volatility.

Figure 1 plots some of the resulting default premium values. The figure indicates that default premiums for forward contracts increase as the wealth of the buyer decreases. The premium is uniformly larger for the longer

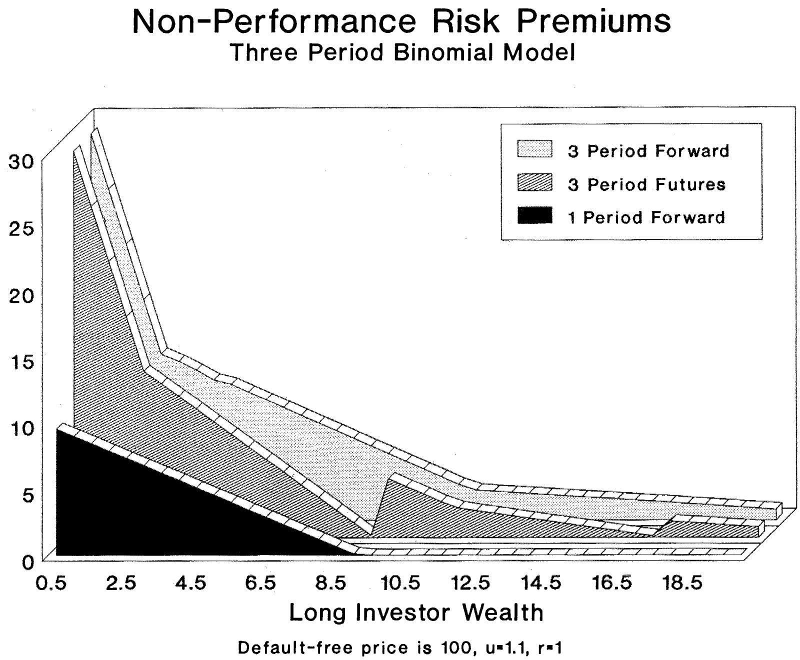


**Figure 1. Comparison of default premiums on forward and futures contracts.** Default premium equals contract price minus price of an otherwise identical default-free contract. Long side transfers its wealth to short side when it is insufficient to meet margin calls or terminal payoff. Short side is assumed to have infinite wealth.

maturity contract. In comparing the premiums for forward contracts to those for the three period futures contract, we see that the futures default premium is always bounded above by the three period forward default premium, yet it is also substantially larger than the one period forward default premium. Thus, futures resettlement does not reduce default exposure to that of a one period forward contract. The intuition is that the seller of the three period futures contract has granted the buyer a *sequence* of default options.[10] The buyer may survive a loss in one period only to default in a subsequent period.

The sawtooth pattern in the binomial futures default premium also highlights the sequence of default options the long side holds. At certain levels of $W$, an increase in long wealth *increases*, rather than decreases, the potential cost of default. The intuition for this result is as follows. With a small amount of wealth, a long side default is limited to the amount that can be lost in one time period. Given enough wealth to last beyond one period, however, the long side may default for a greater amount in the next period.

The results point out the significant default premium which can arise in commodity contract prices and highlight the limit to the risk reduction which can be achieved with periodic resettlement. The complete set of prices we have generated indicate that the default premium increases with volatility and time to maturity and (aside from the sawtooth effect) decreases with long side wealth. Similar effects of opposite sign are observed when it is the short side of the contract which has finite wealth. As is the case with any option value, a critical determinant of the size of the default premium is the ex ante volatility of the underlying asset price. Ex ante price volatility during distress episodes is likley to be particularly large. For example, Figure 2 plots the cash silver price during the "Hunt Brothers" period in that market. Daily price changes of several dollars per ounce (approaching twenty percent on some days) are frequently observed. Such an environment can cause market participants to estimate volatility at a level which yields very significant default premiums.

## 2. Empirical Evidence

### 2.1 Methodology

The model presented in the previous section does not include such elements as active trading strategies for market participants, objective functions which govern their behavior, changes in margins or position limits, or other realistic factors. Nonetheless, the model motivates the basic idea that nonperformance risk can induce a premium which varies through time as the wealth of market participants changes. We use this idea as the basis for our empirical tests. The cash-futures basis can be thought of as a function of the interest rate, the cost of storage, the convenience yield, and the default premium:

$$\frac{F(T,t) - P(t)}{P(t)} = f\{r, s, c, \pi, T, t\} \tag{2}$$

[10] See Carr (1988) for a treatment of sequences of options in a Black and Scholes (1973) setting.

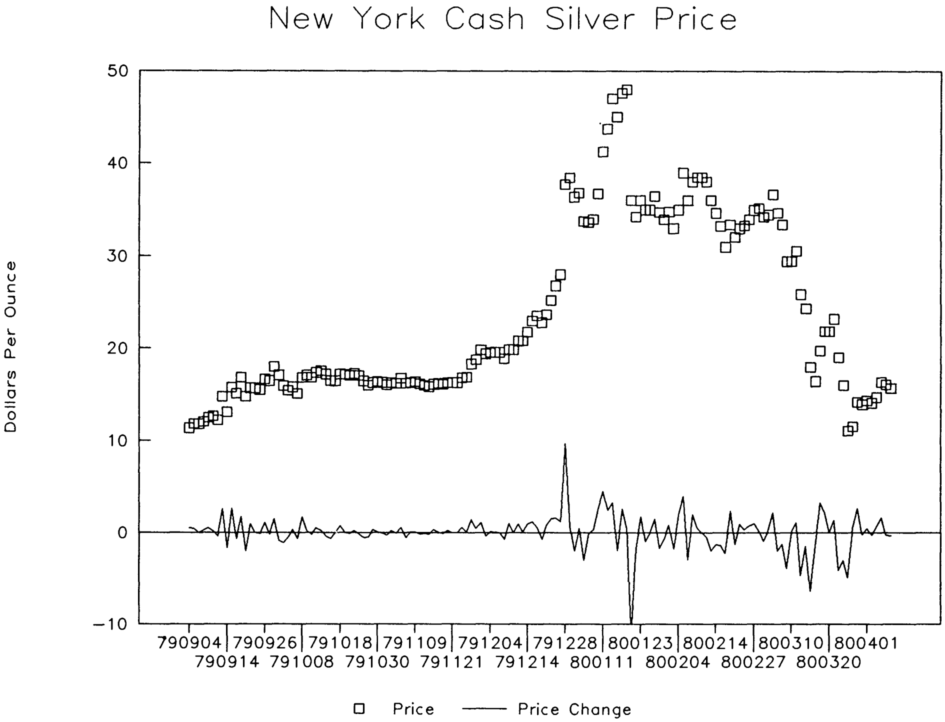


**Figure 2. Handy and Harman base price for cash silver.** Data source is Reuters.

where $r$, $s$, $c$, and $\pi$ represent the risk-free interest rate, the cost of storage, the convenience yield, and the default premium, all expressed as annualized rates. The cost of storage and convenience yield can be time-varying, due perhaps to seasonals in production or consumption. The default premium changes as the contract's maturity decays and as traders update their beliefs about the expected costs of nonperformance. The premium increases (decreases) as the probability of default by buyers increases (decreases).

We begin by estimating a time series of changes in the default premium. We use a regression approach adapted from Brennan (1958), Brennan (1986a), and Fama and French (1987) to produce a series of estimated default premium changes as a residual. We regress the annualized basis on the interest rate and cash price as follows:[11]

$$\Delta \frac{F(T,t) - P(t)}{P(t) \cdot (T - t)} = \beta_0 + \beta_1 \Delta r + \beta_2 \Delta P(t) + \xi(t). \tag{3}$$

[11]Fama and French (1987) estimate the monthly cost of storage for precious metals (as a percentage of spot price) is small, about 0.06% for silver and 0.03% for gold. Brennan (1986a) uses the cash price to proxy for the level of inventories and capture the convenience yield. We collected data on inventories of deliverable silver and gold in exchange vaults but regression results (available on request) indicate that the explanatory power of this variable is poorer than that of the cash price.

The interest rate term is intended to capture the time value of money element of the cost of storage, while the cash price term proxies for the convenience yield. The $\beta_i$ terms are regression coefficients. The estimate of $\beta_2$ should be negative: as spot price rises and inventories decline, the convenience yield rises and causes the futures price to fall relative to the spot price. The regression residual $\xi(t)$ equals the sum of the default premium, regression error in the conventional sense, and those parts of the convenience yield and cost of storage which $\Delta r$ and $\Delta P(t)$ do not capture. The regression is estimated in simple first-differenced form for two reasons. First, this specification helps alleviate serial correlation in the regression residuals. Second, the differencing yields a residual series which reflects the *change* in the default premium, thus facilitating our empirical tests.

The computation and analysis of the series of default premium changes is patterned after the "event study" methodology common to much finance research. First, the coefficients of regression 3 are estimated with observations from prior to the "Hunt Brothers" episode in the silver market. Second, the estimated parameters are used to generate a series of residuals for the episode itself, just as an estimated "market model" is used to produce stock return residuals for an event study. Third, cumulative residuals from the episode are plotted. Finally, residuals from several days surrounding information events in the period are summed, then divided by the standard error of the sum to produce a test statistic (Chen and Merville 1986):[12]

$$\tau(t) = \frac{\sum_{i=t-n}^{t+n} \xi(i)}{\widehat{\sigma(\xi)}\sqrt{2n+1}} \tag{4}$$

where $\sigma(\xi)$ is the estimated standard deviation of residuals, [13] and $(2n + 1)$ is the length, in trading days, of the time period used to examine each event and also equals the degrees of freedom of the test statistic.[14] The test statistic is computed for windows of five trading days surrounding the information

[12]Typical event studies aggregate cross-sectional residuals from many realizations of the same type of event. Such tests are more powerful than those of this paper, which examine the significance of a single realization of an information event for a single time series of residuals. Nonetheless, there is some precedent for conducting an event study with a single residual series or small cross section of residual series. See Ruback (1982), Hill and Schneeweis (1983), Chen and Merville (1986), Dann and DeAngelo (1988), and Ryngaert (1988) for studies of stock prices and Draper (1984) and Bhattacharya (1986) for studies of commodity prices.

[13]The standard deviation is computed with the regression residuals. The regression is computed with data from prior to the Hunt Brothers period. Brown and Warner (1985) suggest that significance tests be based on an estimate of the residual standard deviation, conditional on being in the time period when unusual information is arriving. However, they also note that it is not possible to derive an estimate of this conditional variance if time-series (not cross-sectional) data are being used, as is the case in this study.

[14]It is necessary to sum residuals over several days (rather than examining a single day's residual) because only a single time-series of residuals is being studied. Parametric test statistics cannot be computed based on a single residual.

events which we have identified in the Hunt Brothers period in the silver market.

Several complications arise in implementing our procedure. First, we find that the first-differencing of regression 3 does not eliminate autocorrelation in the regression residuals.[15] Second, futures contracts are available for several maturities on any given day. Therefore, regressions are estimated for each of three maturity ranges and results are reported for each. Third, spot prices are not available from the futures markets. Following Fama and French (1987), we use the price of the maturing futures contract as a proxy for the spot price.[16] Fourth, most information events are too closely spaced for separate 5-day windows and are grouped within windows. Fifth, we correct for measurement error induced by limit moves in the futures markets as follows. On days when the futures price change reaches the limit, the observed futures price does not equal the equilibrium futures price. The observed basis is biased and causes the expected value of the regression residual to differ from zero. We correct for this by assuming that the ratio of futures to spot price on the first day prior to the limit move can proxy for the ratio of the true futures price to the spot price on the limit day.[17]

A final issue is whether it is reasonable to attribute the regression residuals largely to changes in the default premium. We attempt to control for convenience yield and storage cost changes by including the cash price change in the regression. However, if some element of the convenience yield or storage cost is not captured by our explanatory variables, it will appear in the residuals. If certain events or time periods are associated with significant residuals, we may erroneously conclude that the evidence supports our default premium story, though the true cause may be unexplained changes in the convenience yield or storage cost.

We take two approaches to remedy this potential problem. First, we examine data from the silver futures market of the Chicago Board of Trade (CBT), in addition to data from the COMEX market. Actions taken by the CBT early in the Hunt Brothers episode greatly reduced the Hunt presence in the CBT silver market, thus insulating it from the costs of a default by the Hunts. Changes in the silver convenience yield are common to both the COMEX and CBT price series,[18] while default risk affects COMEX much more significantly. Therefore, we extend our study to regression residuals for the CBT silver basis and changes in the difference between the COMEX silver basis and the CBT silver basis.

[15]However, we found that results based on this specification are similar to those produced with more elaborate time series modeling of the residuals.

[16]Spot price quotes from commodity dealers may not be contemporaneous with corresponding futures prices and may be subject to other biases and errors. At the same time, the short maturity futures price may be a biased estimate of the spot price if it reflects a default premium.

[17]Empirical results are similar when repeated without the price limit correction.

[18]Note that a squeeze in one futures market affects the convenience yield in the basis of *both* markets because of their common underlying cash commodity.

Second, we note that a default threatening the COMEX silver market may affect all the contracts COMEX offers due to their common clearinghouse. On the other hand, the contractual arrangements of futures markets may contain the default risk within the silver market. Edwards (1983), Bernanke (1990), and Jordan and Morgan (1990) note that the responsibility of the clearinghouse is limited to paying *net* margins to clearing member firms. There is no responsibility to individual traders. Thus, the default of a large customer within a firm or set of firms could impose costs on other traders with accounts at those firms without requiring the clearinghouse to make good the losses, as was the case in the Volume Investors incident. Therefore, we also examine regression residuals for the COMEX gold futures basis for "spillover" from the COMEX silver market. Lack of reaction in the gold market will suggest that the consequences of a Hunt Brothers default were expected to be confined to silver market participants.

### *2.2 Data*

COMEX and CBT silver futures contracts are written on 5000 troy ounces of silver while COMEX gold contracts represent 100 troy ounces of gold. All three markets offer maturities in the current month, next 2 months, and other months out to 2 years.[19] Delivery occurs at any time in the maturity month, but, following Fama and French (1987), empirical results assume delivery on the first day of the month. Daily closing futures prices are obtained for the period January 3, 1977 to April 2, 1980 from yearbooks published by the exchanges.[20] Daily Treasury bill yields with maturity closest to the maturity of each futures contract in the sample were obtained from *The Wall Street Journal*. A chronology of events in the Hunt Brothers episode (September 1979 through March 1980) was constructed from U.S. C.F.T.C. (1980), Fay (1982), *The Wall Street Journal*, and *The New York Times*. The limit move history of the markets was obtained from the exchanges and from U.S. C.F.T.C. (1980).

### *2.3 Results*

Throughout this section, we look for evidence consistent with our model. Specifically, we predict that positive (negative) residuals are associated with events which increase (decrease) the likelihood of a Hunt Brothers default. This should be evident not only in the COMEX silver residuals but in the COMEX-CBT silver spread as well. The degree to which there is also a reaction in the COMEX gold market will indicate whether a potential Hunt default was expected to contaminate the entire COMEX market.

Table I presents results of the estimation of equation 3 for three maturity ranges of the silver and gold futures in the sample. Most of the silver

[19] Beyond 2 months, the available COMEX and CBT silver maturities always differ so that a perfect comparison is never possible.

[20] At some times in our sample period, COMEX and CBT closing hours have differed by as much as 10 minutes.

Table I

**Regressions of the Cash/Futures Basis on Intercept, Interest Rate, and Cash Price Proxy Terms, January 1977 to August 1979**

$$\Delta \frac{F(T,t) - P(t)}{P(t) \cdot (T-t)} = \beta_0 + \beta_1 \Delta r + \beta_2 \Delta P(t) + \xi(t)$$

Regressions are estimated with daily data for each of three maturity ranges. $T$-statistic testing the difference from zero is reported below each coefficient estimate. Critical values of the $T$-statistics for significance at the 10%, 5%, and 1% levels are 1.645, 1.960, and 2.576, respectively. Correction for measurement error due to limit moves is detailed in Section II of the paper. Shorter maturities (zero to 2 months) are not included since the price of the currently-maturing contract is used to proxy for the spot price of the commodity.

| Contract | $\beta_0$ | $\beta_1$ | $\beta_2$ | $\bar{R}^2$ | Durbin-Watson | Standard Deviation of Residuals | Number of Observations | Observations Corrected for Limit Move |
|---|---|---|---|---|---|---|---|---|
| COMEX Silver, 2–4 Months | 1.747 E-6 | 1.140 E-2 | 3.775 E-6 | 0.00 | 2.74 | 7.71 E-3 | 668 | 34 |
| | (.01) | (.29) | (1.06) | | | | | |
| COMEX Silver, 5–7 Months | −2.531 E-5 | −1.390 E-2 | 6.157 E-6 | 0.00 | 2.94 | 1.30 E-2 | 668 | 33 |
| | (−.05) | (−.21) | (1.02) | | | | | |
| COMEX Silver, 8–10 Months | 5.968 E-5 | 1.349 E-2 | −7.255 E-7 | 0.00 | 2.73 | 7.58 E-3 | 668 | 33 |
| | (.20) | (.36) | (−.21) | | | | | |
| CBT Silver, 2–4 Months | 1.209 E-4 | 1.712 E-2 | −0.980 E-5 | 0.01 | 2.77 | 7.22 E-3 | 672 | 77 |
| | (.43) | (.50) | (−3.01) | | | | | |
| CBT Silver, 5–7 Months | 3.087 E-5 | 1.149 E-2 | −3.280 E-6 | 0.00 | 2.95 | 1.32 E-2 | 672 | 77 |
| | (.06) | (.19) | (−.05) | | | | | |
| CBT Silver, 8–10 Months | 2.205 E-4 | 2.728 E-2 | −1.918 E-4 | 0.09 | 2.48 | 5.09 E-3 | 672 | 77 |
| | (1.11) | (1.16) | (−8.19) | | | | | |
| COMEX Gold, 2–4 Months | 5.983 E-4 | −1.187 E-1 | −1.988 E-3 | 0.12 | 2.73 | 1.39 E-2 | 669 | 34 |
| | (1.10) | (−1.68) | (−9.59) | | | | | |
| COMEX Gold, 5–7 Months | 4.978 E-4 | −1.320 E-1 | −1.603 E-3 | 0.04 | 2.89 | 2.22 E-2 | 669 | 34 |
| | (.57) | (−1.20) | (−4.85) | | | | | |
| COMEX Gold, 8–10 Months | 7.216 E-4 | −1.157 E-1 | −2.270 E-3 | 0.19 | 2.60 | 1.22 E-2 | 669 | 34 |
| | (1.51) | (−1.93) | (−12.49) | | | | | |

regressions are insignificant while the gold regressions show some explanatory power, particularly for the longer maturity ranges. For those regressions (8–10 month CBT, all gold) with some explanatory power, the estimates of the slope coefficient $\beta_2$ on the convenience yield proxy are significantly negative and, thus, consistent with the negative effect of a dividend or convenience yield on the basis. Given the poor explanatory power of most of the regressions, we produced an alternative set of results based on raw basis changes. This is analogous to using the "mean returns" approach instead of the market model approach in an event study. These alternative results are almost identical to those produced with the regression residuals and discussed below.

In comparing our regression results to those of Fama and French (1987), it is useful to recall that Fama and French study a longer time period and employ monthly observations, unlike the 32 months of daily data we use. Furthermore, our regression data span a period of relatively significant macroeconomic fluctuations. Though the cost-of-carry model of forward prices leads us to expect the coefficient $\beta_1$ on the interest rate to equal one, other estimates may be consistent with correlation between macroeconomic variables, risk premiums, and the interest rate.[21]

Figure 3 plots cumulative residuals for the Hunt Brothers period for the 2–4 month maturity class for the three markets while Figure 4 plots the corresponding cross-market spread, the COMEX silver basis minus the CBT silver basis.[22] Both the residuals and spread changes represent daily changes normalized by the maturity of the contracts. They must be adjusted for the maturity of the contract to yield economic meaning. For example, a residual of 0.12 implies a change of 0.02, or 2%, in the basis of a 2-month contract.

In examining the figures, we note a generally-increasing sum of residuals for COMEX silver during the second half of the Hunt Brothers episode. This is consistent with the market repeatedly revising upward its estimate of the ex ante cost of nonperformance on the Hunts' long positions. However, the CBT residuals exhibit a broadly similar pattern, suggesting that the COMEX residuals reflect changes in the silver convenience yield which are common to both markets. The plot of the COMEX-CBT silver spread maintains the increasing pattern during the second half of the episode. What this means is that something occurring in the COMEX silver market was not occurring in the CBT market. Furthermore, the generally positive and increasing sum of changes through the climax of the episode is consistent with an increasing likelihood of default by long COMEX silver investors. Turning to the plot of the cumulative COMEX gold residuals, we note a pattern which does not resemble those in the silver markets. This hints at subsequent results which indicate little expected spillover of a COMEX silver default into other COMEX markets.

[21] See Fama and French (1988) and Bailey and Chan (1990) for discussions of general equilibrium effects in observed futures prices.

[22] Plots for the 5–7 and 8–10 month maturity ranges are similar to those for the 2–4 month maturity range. Copies are available from the authors.

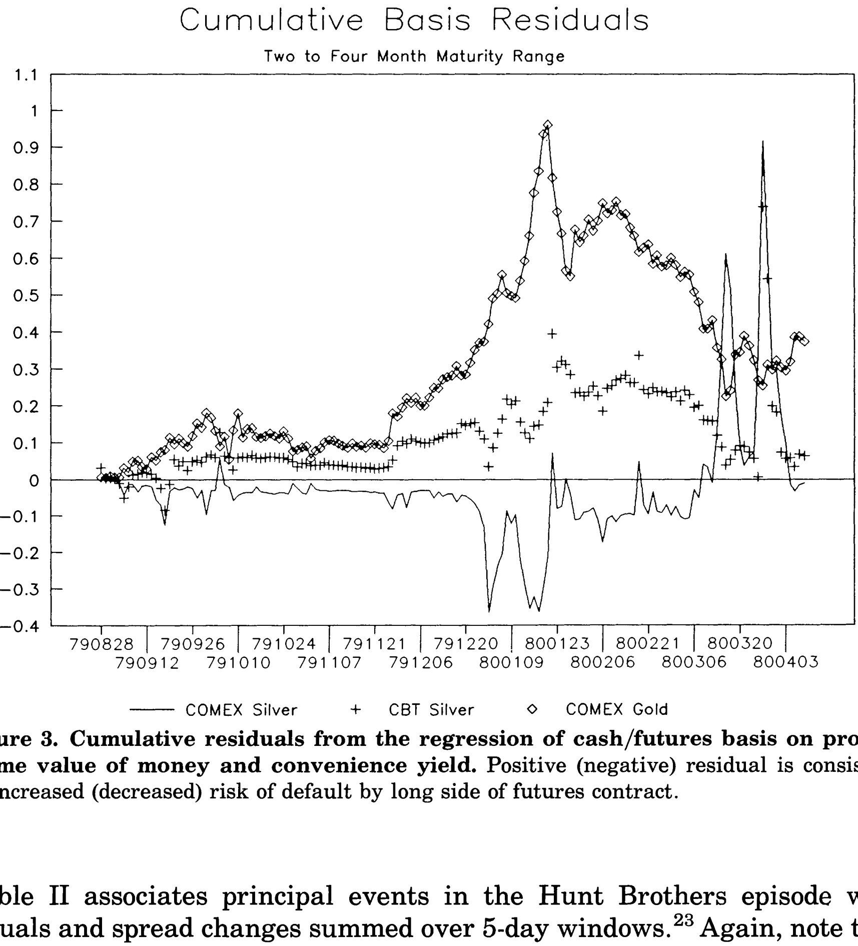


**Figure 3. Cumulative residuals from the regression of cash/futures basis on proxies for time value of money and convenience yield.** Positive (negative) residual is consistent with increased (decreased) risk of default by long side of futures contract.

Table II associates principal events in the Hunt Brothers episode with residuals and spread changes summed over 5-day windows.[23] Again, note that the regression residuals are intended to control for convenience yield effects and highlight the effect of the Hunt presence in the COMEX market. Given the measurement error in our explanatory variables, we can expect some convenience yield changes to appear in the residuals. The raw changes in the COMEX-CBT spread are intended to correct for this problem and provide an alternative measure of the idiosyncratic element of the COMEX silver basis.

In examining events early in the episode, we note one case (September 17 to 18) where there is little evidence of a significant impact in the COMEX and CBT residuals. However, marginally significant increases in the COMEX-CBT spread are consistent with an increased default premium in the COMEX silver market. In the next period (September 24), there is an apparently larger reaction in the CBT market but the change in the spread

[23]In one case (January 14th), a window of only 3-trading-days' length is used to avoid overlapping other event windows. The sample standard deviation of the change in the COMEX-CBT silver spread is computed with data from the 1/77 to 8/79 period, resulting in estimates of 1.052 E-2, 8.214 E-3, and 8/096 E-3 for maturity ranges of 2–4, 5–7, and 8–10 months, respectively.

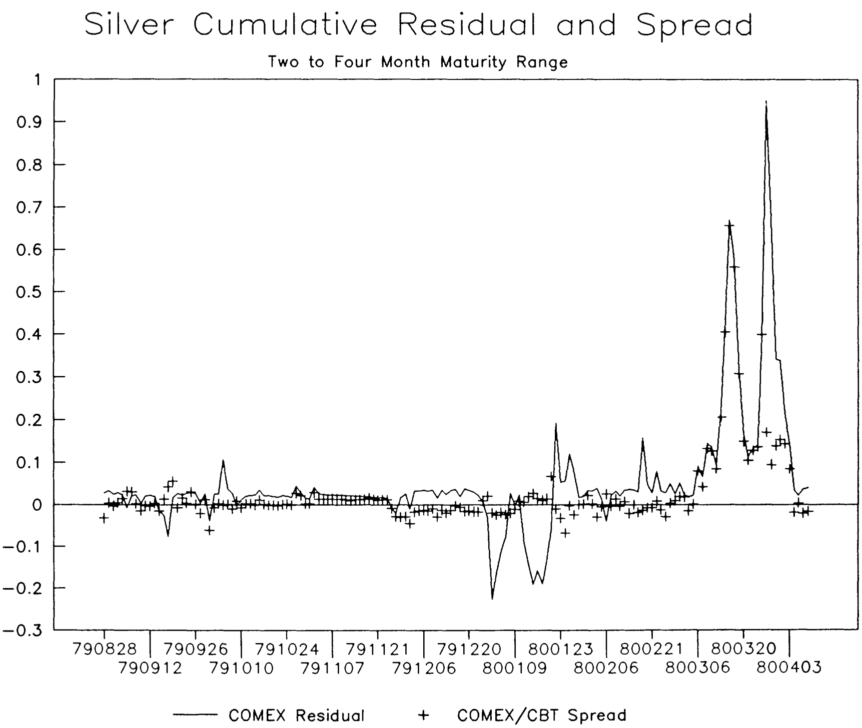


**Figure 4. The COMEX silver cumulative residual versus the COMEX/CBT silver futures spread.** Positive (negative) spread is consistent with relatively larger (smaller) COMEX default risk or relatively smaller (larger) COMEX convenience yield.

points out the true differential effect across the two markets. For January 2, the expression of concern by the Fed appears to affect both markets, but, once again, the change in the spread indicates a positive differential effect for COMEX, suggesting relatively increased default risk in the market.

Throughout the tableau of events, comparison of the individual silver market residuals to the change in the spread is instructive. The cancellation of Hunt contracts due to an exchange of futures for physicals on January 14 should reduce long default risk and is, indeed, associated with negative COMEX silver residuals. However, the CBT silver residuals are, for two of three maturities, similarly negative while the change in the spread is insignificant. This suggests that the January 14 event caused a change in the convenience yield common to both markets. On the other hand, when the Hunts obtain new financing (February 23) it is apparent that there is a strong differential effect for the COMEX market. The negative change in the spread is consistent with the decreased risk of Hunt default which the new financing implies. Both of these events highlight the importance of benchmarking the COMEX residuals with the CBT residuals and the COMEX-CBT spread changes.

Towards the end of the episode, we observe increasingly large residuals and spread changes. Evidence of increasing Hunt distress is matched with positive changes in the COMEX silver basis, consistent with an increasing premium for default by those holding long positions. The beginning of the resolution of the crisis (March 27) is associated with negative changes in the COMEX basis, consistent with decreased default risk at this point in the episode. Throughout Table II it is notable that similar residuals are usually observed across maturities. Furthermore, the significance of residuals is sometimes so large that, even if the conditional residual variance in the distress period is several times larger than $\widehat{\sigma(\xi)}$, the residuals remain statistically significant.

We summarize our default risk interpretation of the evidence as follows. First, the effect of rules changes by the exchange or expressions of concern by regulatory authorities does not appear to increase confidence. Our results either show no reaction, or positive changes in the COMEX silver basis which are consistent with an increasing ex ante cost of default. Second, events which clearly threaten the Hunts' ability to continue to post initial or variation margins are associated with positive basis changes, while events which enhance their ability to pay margin or reduce their COMEX position are associated with negative basis changes. Again, this is consistent with our default premium story. Third, the evidence on the COMEX-CBT spread confirms that we are capturing effects in the COMEX market which are not common to other silver markets.

While there is much evidence to support our default risk interpretation of the Hunt Brothers episode, some questions remain. First, there is some evidence that basis changes differ across contract maturities. While this may be explained by a time-varying Hunt presence at different points on the COMEX silver "term structure," we have not been able to find records on exact Hunt holdings to back up such an interpretation. Second, we find no evidence that the COMEX gold market was affected by events in the COMEX silver market. As discussed earlier, this may be due to the contractual arrangements between clearinghouse, clearing members, and traders, but there may be alternative explanations unrelated to our default risk story. Third, we have not considered the possibility that default by *short* investors in the silver market may have been significant. Faced with huge price increases and seemingly infinite Hunt wealth through much of the episode, default by contract sellers may have been a possibility. Finally, we note throughout the paper how we have checked our results for errors that may be induced by our methodology. Nonetheless, other interpretations of the Hunt Brothers episode may emerge if a substantially different methodology is employed.

## 3. Summary and Conclusion

Imperfections in mechanisms which serve to reduce the costs of nonperformance in commodity markets can lead to default. The mere possibility of

**Table II**

**Principal Clusters of Events in the Silver Market During the Hunt Brothers Period and Corresponding Cumulative Residuals, September 1979 to March 1980**

All cumulative residuals and test statistics (in parentheses) are based on nonoverlapping 5-trading-day periods except for January 14, which is based on a nonoverlapping 3-trading-day period. Critical values of the $T$-statistics (reported in parentheses beneath each cumulative residual) for significance at the 10%, 5%, and 1% levels are 1.796, 2.201, and 3.106, respectively. For the 3-day period surrounding January 14, critical values are 1.895, 2.365, and 3.499.

| | | Cumulative Residuals | | | | | | | | | Cumulative Changes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | COMEX Silver Basis Maturity Range (Months) | | | CBT Silver Basis Maturity Range (Months) | | | COMEX Gold Basis Maturity Range (Months) | | | COMEX/CBT Spread Maturity Range (Months) | | |
| Date | Event | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 |
| September 4, 1979 | COMEX raises margin from $2000 to $3000 per contract | −.0006 (−.02) | −.0112 (−.26) | −.0197 (−.78) | −.0189 (−.79) | −.0027 (−.06) | 0.0008 (.05) | 0.0389 (.84) | 0.0544 (.74) | 0.0228 (.56) | 0.0053 (.15) | 0.0000 (.00) | 0.0082 (.31) |
| September 6, 1979 | COMEX raises margin to $5000 per contract. | | | | | | | | | | | | |
| September 17, 1979 | COMEX raises margin to $7500. | −.0162 (−.63) | −.0259 (−.60) | −.0046 (−.18) | −0.0306 (−1.28) | −.0675 (−1.54) | −.0061 (−.36) | 0.0848 (1.84) | 0.0738 (1.00) | 0.0942 (2.33) | 0.0565 (1.62) | 0.0609 (2.24) | 0.0593 (2.21) |
| September 18, 1979 | COMEX raises margin to $20000. | | | | | | | | | | | | |
| September 24, 1979 | Shearson asks Hunts for all trading profits to be left as collateral. Hunts remove accounts from | | | | | | | | | | | | |

**Table II**—*Continued*

| Date | Event | Cumulative Residuals: COMEX Silver Basis Maturity Range (Months) 2–4 | 5–7 | 8–10 | CBT Silver Basis Maturity Range (Months) 2–4 | 5–7 | 8–10 | COMEX Gold Basis Maturity Range (Months) 2–4 | 5–7 | 8–10 | Cumulative Changes: COMEX/CBT Spread Maturity Range (Months) 2–4 | 5–7 | 8–10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Shearson. Merrill Lynch asks Hunts for additional margin. E. F. Hutton suspends trading for Hunts. | 0.0074<br>(.29) | 0.0192<br>(.45) | 0.0223<br>(.89) | 0.0617<br>(2.58) | 0.0772<br>(1.76) | 0.0844<br>(5.03) | 0.0046<br>(.10) | 0.0045<br>(.06) | 0.0245<br>(.61) | −.0531<br>(−1.52) | −.0556<br>(−2.04) | −.0628<br>(−2.34) |
| October 26, 1979 | Chicago Board of Trade imposes position limit of 600 in its silver market, with compliance required by April 1. | −0.0025<br>(−.10) | −0.0019<br>(−.04) | −0.0113<br>(−.45) | −0.160<br>(−.67) | −0.0074<br>(−.17) | −0.0240<br>(−1.43) | −0.398<br>(−.86) | −.0361<br>(−.49) | −.0481<br>(−1.19) | 0.0012<br>(.03) | 0.0001<br>(.00) | −.0042<br>(−.18) |
| October 29, 1979 | COMEX raises margin to $30000 for traders with more than 251 contracts. CFTC estimates Hunts control about 250 million ounces of cash and futures silver. | | | | | | | | | | | | |
| January 2, 1980 | Fed expresses concern about recent events in the silver market | −.2402<br>(−9.39) | −.2652<br>(−6.15) | −.1845<br>(−7.34) | −.0675<br>(−2.82) | −.1651<br>(−3.77) | 0.0226<br>(1.35) | 0.1378<br>(2.99) | 0.1102<br>(1.50) | 0.1680<br>(4.15) | 0.0603<br>(1.73) | 0.0582<br>(2.14) | 0.1324<br>(4.93) |
| January 7, 1980 | COMEX imposes position limit of | | | | | | | | | | | | |

**Table II**—*Continued*

| Date | Event | Cumulative Residuals | | | | | | | | | Cumulative Changes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | COMEX Silver Basis Maturity Range (Months) | | | CBT Silver Basis Maturity Range (Months) | | | COMEX Gold Basis Maturity Range (Months) | | | COMEX/CBT Spread Maturity Range (Months) | | |
| | | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 |
| | 500 contracts, effective February 18. | 0.1986<br>(7.74) | 0.2100<br>(4.87) | 0.1875<br>(7.46) | 0.1266<br>(5.29) | 0.1590<br>(3.63) | 0.1102<br>(6.57) | 0.0022<br>(.05) | 0.0097<br>(.13) | −.0132<br>(−.33) | −.0303<br>(−.87) | −.0314<br>(−1.15) | −.0319<br>(−1.19) |
| January 9, 1980 | COMEX limits purchases to 50 new contracts, raises margin to $75000 per contract, $40000 for investors with more than 251 contracts. | | | | | | | | | | | | |
| January 14, 1980 | 3800 COMEX contracts are cancelled by an exchange of futures for physicals (EFP) between Hunts and Englehard Minerals. | −.2597<br>(−8.10) | −.2967<br>(−5.49) | −.2138<br>(−6.78) | −.1015<br>(−3.38) | −.2361<br>(−4.30) | 0.0049<br>(.23) | 0.1690<br>(2.92) | 0.1328<br>(1.44) | 0.1831<br>(3.61) | −.0429<br>(−.98) | −.0455<br>(−1.33) | −0.0469<br>(−1.39) |
| January 21, 1980 | COMEX delays opening, restricts trading to offsetting existing positions only, raises margins. | 0.4275<br>(16.72) | 0.4642<br>(10.77) | 0.3822<br>(15.20) | 0.2846<br>(11.89) | 0.4227<br>(9.66) | 0.1754<br>(10.45) | 0.1574<br>(3.41) | 0.1664<br>(2.26) | 0.2143<br>(5.30) | 0.3437<br>(9.85) | 0.3531<br>(12.96) | 0.3573<br>(13.31) |
| January 22, 1980 | Chicago Board of Trade adopts similar rules. | | | | | | | | | | | | |

**Table II**—*Continued*

| | | Cumulative Residuals | | | | | | | | | Cumulative Changes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | COMEX Silver Basis Maturity Range (Months) | | | CBT Silver Basis Maturity Range (Months) | | | COMEX Gold Basis Maturity Range (Months) | | | COMEX/CBT Spread Maturity Range (Months) | | |
| Date | Event | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 |
| February 23, 1980 | Hunts succeed in mortgaging $250 million in oil and gas properties. | −.1384 (−5.41) | −.1458 (−3.38) | −.1316 (−5.23) | −.0907 (−4.05) | −.1114 (−2.54) | −.0740 (−4.41) | −.0391 (−.85) | −.0351 (−.48) | −.0427 (−1.06) | −.1246 (−3.57) | −.1274 (−4.68) | −.1323 (−4.93) |
| March 14, 1980 | Fed announces credit restraint program; loans to gold and silver traders cease. | | | | | | | | | | | | |
| March 17, 1980 | Hunts cease to meet margin calls with immediate telex of funds. | 0.2557 (10.00) | 0.2970 (6.89) | 0.2481 (9.87) | −.0805 (−3.36) | 0.1295 (2.96) | −.0137 (−.82) | −.1900 (−4.12) | −.0730 (−.99) | −.1179 (−2.91) | 0.2162 (6.20) | −.1334 (−4.90) | 0.1547 (5.76) |
| March 18, 1980 | Hunts cease buying shares of Bache, their broker | | | | | | | | | | | | |
| March 19, 1980 | Hunts meet large margin call with bullion, not cash. | | | | | | | | | | | | |
| March 25, 1980 | Hunts advise Bache that they cannot meet a $135 million margin call. | 0.0907 (3.79) | 0.1297 (3.01) | 0.1077 (4.28) | −.0712 (−2.97) | 0.0701 (1.60) | −.0252 (−1.50) | −.0686 (−1.49) | −.0531 (−.72) | −.0631 (−1.56) | 0.0906 (2.60) | 0.5187 (19.04) | 0.5330 (19.85) |
| March 26, 1980 | Hunts and Saudi investors announce | | | | | | | | | | | | |

**Table II**—*Continued*

| | | Cumulative Residuals | | | | | | | | | Cumulative Changes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | COMEX Silver Basis Maturity Range (Months) | | | CBT Silver Basis Maturity Range (Months) | | | COMEX Gold Basis Maturity Range (Months) | | | COMEX/CBT Spread Maturity Range (Months) | | |
| Date | Event | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 | 2–4 | 5–7 | 8–10 |
| | multibillion dollar issue of silver-backed bonds. Bache asks CFTC and Fed to close COMEX so Hunt contracts can be settled without bankruptcy. COMEX drops margin to $25000. | | | | | | | | | | | | |
| March 27, 1980 "Silver Thursday" | Hunts inform CFTC they will not sell unsecured silver to meet a margin call or pay $233 million owed Bache ($800 million total due). Bache begins liquidating Hunts' 4070 contracts. | | | | | | | | | | | | |
| March 28, 1980 | Bache completes sale of Hunt contracts and avoids bankruptcy. | −.1752 (−6.85) | −.2131 (−4.94) | −.2171 (−8.64) | 0.0667 (2.79) | −0.2093 (−4.78) | −0.2265 (−13.50) | 0.0334 (.72) | −.0002 (−.00) | −.0081 (−.20) | −.3613 (−10.36) | −.3406 (−12.50) | −.3449 (−12.84) |
| March 31, 1980 | Hunts give oil and gas properties to Englehard Minerals to settle a $605 million silver forward contract. | | | | | | | | | | | | |

nonperformance should be reflected ex ante in the prices at which contracts change hands. Default premiums reflected in market prices should be particularly pronounced in markets undergoing a period of distress. Furthermore, these premiums should, in an efficient market, change as new information concerning the probability of default arrives.

Borrowing from the corporate finance literature, we have developed a method for estimating changes in commodity contract default premiums. Plots of cumulative estimated premium changes are consistent with our default risk interpretation of the sequence of events in the silver market in 1979 and 1980. We also find statistically significant default premium changes associated with many individual events during the episode. Interestingly, many significant events are not anticipated by the market and result in significant changes in the measured default premium. Observing changes in the COMEX-CBT silver spread helps confirm out default risk interpretation of the behavior of the COMEX silver basis during the Hunt Brother episode. The evidence offers new insights into the effects of the actions of traders, exchanges, and regulators on the expected costs of nonperformance in asset markets. Furthermore, the results confirm the simple notion that markets are quick to incorporate new information into the prices at which risky claims trade.

Our results are of importance to several areas of research in asset pricing. By definition, the identical-economic-agents models presented in many theoretical papers preclude default: forward and futures contract volume and open interest are zero in such models. However, the model presented in this paper indicates that default-vulnerable commodity contract prices can differ from default-free prices. The empirical evidence of the paper is consistent with costly contracting resulting in imperfect nonperformance guarantees in actual commodity markets. Commodity contract pricing and hedging models which do not incorporate the possibility of nonperformance are likely to produce errors when applied to markets which are experiencing high volatility, unusual price trends, or heavy trading activity by large investors. While episodes like the silver market of 1979–1980 are not common, our results suggest that ex ante costs of nonperformance should be viewed as potentially important factors for theoretical, empirical, and applied research into the pricing of commodity contracts and their use by utility-maximizing hedgers and speculators.

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