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# Margin Requirements, Price Fluctuations, and Market Participation in Metal Futures

THE OCTOBER 1987 STOCK MARKET CRASH renewed interest among regulators and economists in using margin requirements as a tool of controlling excessive speculation in cash and futures markets. For example, the 1988 Brady Report's recommendations of consistent margin requirements across related markets led to a heated debate on the desirability of permanently higher margins in futures contracts. Permanently higher margins would be desirable only if they enhance the efficiency of the price mechanism by reducing mispricing and excess volatility. However, economic theory does not make unambiguous predictions on the consequences of higher margins. Economists who believe that financial markets are often dominated by irrational speculators would tend to favor a permanent margin increase, whereas economists who believe that financial markets are dominated by rational investors would view a permanent increase in margins as harmful. Empirical analysis is needed.

Empirical work in cash markets has not reached unanimous conclusions. Hardouvelis (1990) reports a negative association between margins and volatility, excess volatility, and deviations of stock prices from fundamentals in the United States

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over the period 1935–1987. Moreover, Hardouvelis and Peristiani (1992) show that margins have a clear price-stabilizing influence in the post–World War II Japanese stock market. On the other hand, others, including Salinger (1989) and Hsieh and Miller (1990), argue that the U.S. evidence is not strong enough to support either view.

Empirical work on the effects of futures margins is voluminous. Examples are Nathan (1967), Tomek (1985), Breeden (1985), Hartzmark (1986), Fishe and Golberg (1986), Fishe et al. (1990), or Ma, Kao, and Frohlich (1993). This literature finds a negative correlation between margins and market participation (open interest), but an ambiguous correlation with volatility. However, in futures markets, unlike cash markets, it is extremely difficult to use volatility in order to discriminate between the two alternative hypotheses. The difficulty originates from the decision rules that futures exchanges follow. Unlike cash markets, where volatility has not historically influenced the decision to change margin requirements, in futures markets, the exchanges systematically raise (lower) margins in anticipation of higher (lower) future volatility. Thus, even if there is a negative causal effect from margins to volatility, it would be hard to uncover it because it would probably be swamped by the volatility trend that the exchange is (correctly) forecasting.

The sample selection difficulty does not deter us from taking another look at futures margins in the present article. The article's main innovation lies on the use of a benchmark set of contracts. For each target contract we examine, we use a benchmark sample of other related contracts that do not undergo a similar margin change and, by comparing the behavior of target and benchmark metals, we assess more precisely the presence or absence of true causality from the change in margin requirements to the target contract. To our knowledge, this is the first study that uses a benchmark sample to explore the causal influence of futures margins. The approach is partially successful. It does reveal, for example, that the observed negative relation between margins and market participation is *causal* running from the former variable to the latter, something the previous literature was unable to show. For reasons we explain later (footnote 7), our approach is less successful at discriminating between the rational and irrational investor stories.

## 1. DATA, VARIABLE DEFINITIONS, AND SUMMARY STATISTICS

The article examines eight metal contracts from the early 1970s, or from the initiation of the contract, to October 1990: the Chicago Board of Trade (CBT) gold and silver, the New York Commodity Exchange (COMEX) gold, silver, copper and aluminum, and the New York Merchantile Exchange (NYM) platinum and palladium.[1]

1. Some contract peculiarities are noteworthy: First, two contracts are currently traded in CBT gold: a kilo and an 100-ounce contract. Our data series refer to the kilo contract. Margin levels are standardized to reflect an 100-ounce contract, the same-size contract traded in the COMEX. Second, two CBT silver contracts are currently traded: the older 5,000-ounce and the newer 1,000-ounce. Our data series reflect the 5,000-ounce contract until 01/24/1982 and the 1,000-ounce contract thereafter. The margin level is adjusted to reflect a 5,000-ounce contract, the same-size contract traded in the COMEX. Third, the

TABLE 1

SUMMARY STATISTICS

| $N$ | $\Delta \ln M$ | $\Delta \ln \sigma_1$ | $\Delta \ln \sigma_2$ | $\Delta \ln V$ | $\Delta \ln OI$ | $\Delta gOI$ |
|---|---|---|---|---|---|---|
| | | | Positive Day-Zero Changes in Margin Requirements | | | |
| 226 | 0.303 | 0.115 | 0.089 | −0.014 | −0.020 | −0.116 |
| | 0.426 | 0.331 | 0.318 | 0.407 | 0.306 | 0.325 |
| | | | Negative Day-Zero Changes in Margin Requirements | | | |
| 274 | −0.198 | −0.054 | −0.073 | −0.022 | −0.026 | 0.070 |
| | 0.284 | 0.285 | 0.302 | 0.351 | 0.262 | 0.391 |

NOTES: The first number denotes the sample mean and the second number the sample standard deviation. $N$ denotes the number of margin changes across all eight commodities. $\Delta \ln M \equiv \ln(M_{[0,43]}/M_{[-43,-1]})$ is the continuously compounded percentage change in the average margin from interval $[-43, -1]$ to interval $[0, 43]$, with business day 0 denoting the day of the margin change. $\Delta \ln \sigma_1 \equiv \ln(S_{[0,43]}/S_{[-43,-1]})$ is the continuously compounded percentage change in the average Garman-Klass (1980) measure of daily volatility, $S$, from $[-43, -1]$ to $[0, 43]$; $\Delta \ln \sigma_2 \equiv \ln(\sigma_{[0,43]}/\sigma_{[-43,-1]})$ is the continuously compounded percentage change in the standard deviation of residuals generated form separate AR(2) models of daily returns $r_t \equiv \ln(P_t/P_{t-1})$; $\Delta \ln V$ and $\Delta \ln OI$ are defined similarly as the continuously compounded percentage changes in trading volume and open interest; $\Delta gOI \equiv \ln(OI_{[32,43]}/OI_{[-2,2]}) - \ln(OI_{[-2,2]}/OI_{[-43,-32]})$ is the change in the growth rate of open interest. The data for the two silver markets exclude the period 9/79–4/80.

These metals provide a lengthy sample of five hundred discrete margin changes, enabling us to conduct powerful tests of many interesting hypotheses. The analysis excludes the sample observations of the two silver contracts from September 1979 through April 1980, a time when the Hunt brothers cornered the silver market, and thus avoids a possible contamination of the evidence by the frequent intervention of the exchanges during that period.

The margin data were provided by the individual exchanges. The empirical analysis uses maintenance margins—the official-per-contract dollar amounts of investor's capital, which trigger a margin call whenever violated—because their definition is similar across the different types of investors (hedgers and speculators) and contracts. Table 1 provides summary statistics on the variables used in the later regression analysis. $\Delta \ln M \equiv \ln(M_{[0,43]}/M_{[-43,-1]})$, the independent variable of the later regressions, is the continuously compounded percentage change in the average margin requirement from the two-month period $[-43, -1]$ to the two-month period $[0, 43]$, where day 0 denotes the day of the margin change. Observe that there is a larger number of negative margin changes, but their average size is smaller (−19.8 percent as opposed to 30.3 percent for positive margin changes). The large standard deviation of, particularly positive, $\Delta \ln M$ is primarily due to ocassional drastic changes (more than 100 percent) in margin requirements.[2]

The data on trading volume, open interest, and prices come from Technical Tools, Inc. Open interest and trading volume represent total volume and total open interest

COMEX silver contract was a 10,000-ounce contract until September 26, 1974, and then it changed to a 5,000-ounce contract. We standardized the dollar level of the margin requirement to reflect a 5,000-ounce contract. Fourth, our COMEX copper data series switches from the old 25,000-pound contract to the new 25,000-pound high grade contract on November 27, 1989. Currently, only high grade copper is trading.

2. These outliers are spread across most of the commodities and do not affect our results in any discernible way. We have repeated the entire analysis excluding all such outliers in margin changes and the results continue to hold (see also Table 3 below).

of all outstanding contracts of a given commodity. Afterall, the margin changes are not specific to a particular delivery date but affect all delivery dates of each metal. Moreover, aggregate trading volume and open interest avoid the abrupt fluctuations in individual contracts during or before the delivery months. Table 1 presents summary statistics on $\Delta \ln V \equiv \ln(V_{[0,43]}/V_{[-43,-1]})$, the continuously compounded percentage change in the average trading volume, and $\Delta \ln OI \equiv \ln(OI_{[0,43]}/OI_{[-43,-1]})$, the continuously compounded percentage change in average open interest. Because open interest is a nonstationary variable, we also present the change in the growth rate of open interest, $\Delta gOI \equiv \ln(OI_{[32,43]}/OI_{[-2,2]}) - \ln(OI_{[-2,2]}/OI_{[-43,-32]})$. The table shows a consistent negative relation only between changes in margins and changes in the growth of open interest, $\Delta gOI$. Specifically, following a decrease in margin requirements, the average trading volume and average open interest do not seem to move in the opposite direction. Later, however, Table 3 shows that the absence of a complete reversal is due to autonomous downward trends in these variables that overwhelm the influence of margins.

For robustness, we use two measures of volatility. The first is an average of independent daily measures. Each daily measure, $S_t$, is the square root of the Garman-Klass (1980) variance estimator, which is based on the day's opening, settlement, highest, and lowest price. We average $S_t$ over the two intervals $[-43, -1]$ and $[0, 43]$ creating $S_{[-43,-1]}$ and $S_{[0,43]}$, and we then compute the continuously compounded percentage change in volatility as follows: $\Delta\sigma_1 \equiv \ln(S_{[-43,-1]}/S_{[0,43]})$.[3]

The second measure of volatility is the standard deviation, $SD$, of the residuals $e_t$ from second-order autoregressive models of daily returns, run separately for each bimonthly interval around each margin change: $r_t = \alpha_0 + \alpha_1 r_{t-1} + \alpha_2 r_{t-2} + e_t$, where $r_t$ is the continuously compounded return based on the daily settlement price. The AR(2) models eliminate the serial correlation in daily returns, which exist around the days of margin changes: metal prices follow an upward (downward) trend prior to a margin increase (decrease). The continuously compounded percentage change in the residual standard deviation is then computed as follows: $\Delta\sigma_2 \equiv \ln(SD_{[-43,-1]}/SD_{[0,43]})$. Table 1 shows that both measures of volatility increase (decrease) following a rise (reduction) in margins.

## 2. EMPIRICAL EVIDENCE

We now analyze the behavior in each metal market relative to the behavior of each metal's benchmark group. A metal's benchmark group consists of the remaining metals which did not undergo a margin change over the four-month interval $[-43, 43]$ of the $k$th margin change of the target metal. Thus for a given margin change, the number of commodities in the benchmark group can vary from zero to

3. A simple high-low spread measure of daily volatility provides similar results. All required price data are of the first maturing contract, switching to the next maturing contract on the nineteenth calendar day of the month preceding the expiration month, except for copper and CBT silver which switch six days later, on the twenty-fifth calendar day.

seven. Some margin changes are associated with more than one benchmark commodity and some are not associated with any commodity. The cross-sectional benchmark regressions treat each benchmark commodity as a separate sample observation. The sum of all benchmark commodities over all the margin changes represents the total number of observations of a benchmark group.[4]

It should be emphasized that we do not view the benchmark group as a true *control* group. If, say, two metals are substitutes in investors' optimal portfolios and a margin increase causes a reduction in the open interest and trading volume of the target metal, then we may well observe a simultaneous rise in the open interest and trading volume of the substitute metal as investors move to that metal. Substitutability would allows us to uncover differences in the open interest and trading volume behavior between a target metal and its benchmark relatively easily, but would hinder our effort to uncover differences in the behavior of prices and volatility. Complementarity would have the opposite effects.

Our entire analysis treats the change in margin requirements as unanticipated. If the change is partly anticipated either because it was announced earlier or because it was inferred by market participants, then prices, volume, and other variables of interest would have reacted before the date of the margin change, reducing the power of our methodology in detecting causal effects of margin changes on prices and quantities.

### *2.1 Regression Analysis over Bimonthly Intervals*

Table 2 presents the cross-sectional regression results of each variable of interest on $\Delta \ln M$, the percentage change in the average margin requirement. The *average* margin over each interval [−43, −1] and [0, 43]—instead of the margin on business days −1 and 0—overcomes partly the problem of data overlapping and the mixing of different margin changes within the period [−43, 43]. This problem is particularly pronounced in metals with frequent margin changes, like COMEX silver.[5]

There is a clear causal negative margin effect on trading volume and open interest. Trading activity moves away from (toward) the metal with the higher (lower) margins. In the first column of Table 2, which presents the stacked regression results of all five hundred margin changes, a 10 percent increase in margins is associated with a drop in average trading volume of 1.38 percent, a drop in average open interest of 1.51 percent, and a drop in the growth rate of open interest of 2.96 percent. At the same time, trading volume and open interest in the benchmark metals increase by 1.77 and 0.69 percent, respectively. The differences between target and benchmark metals are statistically significant.

4. In the cases of gold and silver for which we analyze two separate contracts, the benchmark group excludes the second gold or silver contract. This exclusion, however, did not affect the results in any discernible way.

5. The overlapping of margin changes does not bias our estimates. We have repeated the entire analysis using the business day interval [−21, 21], which ensures very little overlapping, and the results remain approximately the same.

TABLE 2

THE RELATIONSHIP BETWEEN MARGIN REQUIREMENTS AND VOLATILITY, VOLUME, AND OPEN INTEREST OVER BI-MONTHLY HORIZONS

| $\Delta Y_k = \alpha + \beta\, \Delta \ln M_k + \epsilon_k$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\Delta Y_k$ | All Metals | Gold (COMEX) | Gold (CBT) | Silver (COMEX) | Silver (CBT) | Copper (COMEX) | Aluminum (COMEX) | Platinum (NYM) | Palladium (NYM) |
| Target Obs. | 500 | 93 | 8 | 200 | 24 | 103 | 27 | 26 | 19 |
| Benchmark Obs. | 620 | 146 | 13 | 175 | 28 | 125 | 72 | 34 | 27 |
| Sample period | | (741231–901031) | (840412–901113) | (710729–901031) | (740907–901031) | (720822–901118) | (831208–901113) | (791015–890630) | (821101–901113) |
| (−0.00) | | | | | | | | | |
| $\Delta \ln OI$ | −1.51* | −0.11 | −0.75 | −3.49* | −3.95* | 0.08 | 1.16 | 1.04 | 1.13 |
| | (−5.30) | (−0.34) | (−0.27) | (−6.07) | (−2.67) | (0.19) | (1.02) | (1.45) | (1.22) |
| | 0.05 | 0.00 | 0.01 | 0.12 | 0.24 | 0.00 | 0.04 | 0.08 | 0.08 |
| Benchmark | 0.69* | 0.61 | −3.82 | 0.63 | 1.11 | −0.30 | 0.46 | 1.74* | 2.14 |
| | (2.68) | (1.23) | (−2.01) | (1.22) | (0.90) | (−0.35) | (0.95) | (2.91) | (1.69) |
| | [−5.74] | [−1.16] | [0.94] | [−5.07] | [−2.50] | [0.27] | [0.69] | [−0.72] | [−0.58] |
| $\Delta g\ OI$ | −2.96* | −2.42* | −4.95 | −2.10* | −3.88* | −3.82* | −2.15 | −8.02* | −1.86 |
| | (−8.16) | (−5.89) | (−1.04) | (−2.98) | (−2.36) | (−5.05) | (−1.29) | (−5.22) | (−1.25) |
| | 0.12 | 0.28 | 0.15 | 0.04 | 0.20 | 0.20 | 0.06 | 0.53 | 0.08 |
| Benchmark | −1.27* | −0.63 | −3.99 | −1.96* | −2.27 | 0.20 | −2.65* | −1.51 | 2.13 |
| | (−3.66) | (−1.04) | (−1.97) | (−2.96) | (−1.30) | (0.18) | (−2.68) | (−1.09) | (1.42) |
| | [−3.39] | [−2.33] | [−0.21] | [−0.13] | [−0.65] | [−3.00] | [0.27] | [−3.01] | [−0.78] |
| $\Delta \ln V$ | −1.38* | −2.43 | −1.04 | −3.51* | −4.56 | 1.72* | −1.50 | 1.28 | 2.83 |
| | (−3.58) | (−0.49) | (−0.25) | (−5.04) | (−1.80) | (3.85) | (−0.66) | (1.08) | (1.15) |
| | 0.03 | 0.01 | 0.01 | 0.11 | 0.13 | 0.13 | 0.02 | 0.05 | 0.07 |
| Benchmark | 1.77* | 1.97* | −5.59 | 2.76* | 1.52 | 1.45 | 1.28 | 2.92* | −0.53 |
| | (4.66) | (2.63) | (−1.49) | (4.61) | (0.90) | (1.12) | (1.19) | (2.61) | (−0.24) |
| | [−5.83] | [−2.55] | [0.78] | [−6.46] | [−1.87] | [0.21] | [−1.28] | [−0.95] | [1.00] |
| $\Delta \ln \sigma_1$ | 3.53* | 3.01* | −2.66 | 3.60* | 2.81* | 4.77* | 5.91 | 1.98* | 1.85 |
| | (12.48) | (6.24) | (−0.85) | (10.60) | (2.73) | (11.00) | (1.77) | (2.08) | (0.53) |
| | 0.24 | 0.30 | 0.11 | 0.36 | 0.25 | 0.55 | 0.11 | 0.15 | 0.02 |
| Benchmark | 1.49* | 1.32* | −1.13 | 3.02* | 0.54 | 0.25 | 0.95 | 1.38 | 0.21 |
| | (4.42) | (2.60) | (−0.43) | (5.00) | (0.51) | (0.19) | (1.17) | (1.26) | (0.08) |
| | [4.64] | [2.38] | [−0.37] | [0.88] | [1.50] | [3.49] | [2.05] | [−0.37] | [0.39] |
| $\Delta \ln \sigma_2$ | 3.41* | 3.00* | −3.32 | 3.29* | 3.57* | 4.32* | 3.32* | 3.23* | 3.76 |
| | (11.64) | (4.84) | (−1.64) | (7.00) | (2.74) | (7.66) | (2.05) | (3.18) | (1.23) |
| | 0.22 | 0.21 | 0.31 | 0.20 | 0.25 | 0.37 | 0.14 | 0.30 | 0.08 |
| Benchmark | 1.52* | 1.58* | −1.66 | 2.53* | 0.08 | 2.84* | 1.05 | −0.04 | 1.20 |
| | (4.54) | (2.52) | (−1.06) | (4.02) | (0.07) | (2.50) | (1.10) | (−0.04) | (0.70) |
| | [4.27] | [1.61] | [−0.65] | [0.98] | [1.93] | [1.21] | [1.28] | [2.03] | [0.78] |

NOTES: Variable definitions are in Table 1. The table presents coefficient $\beta$ multiplied by a factor of 10 with its $t$-statistic in parentheses and the regression $R^2$ below the $t$-statistic. The benchmark regressions utilize metals for which no margin change ocuurs during the interval [−43, 43]. Numbers in brackets are $t$-statistics of the hypothesis that the coefficient $\beta$ is the same in the target commodity and its benchmark group. All metals refers to a stacked regression that restricts $\alpha$ and $\beta$ to be the same across all metal (or all benchmark) contracts.

*Statistically significant at the 5 percent level.

Both measures of volatility have a positive association with margins.[6] Benchmark volatility has a positive association with margins as well, but its regression coefficients are significantly smaller. The stronger positive relation of margins with the volatility of a target metal supports the sample selection hypothesis: The exchanges

6. The positive association between margins and volatility is robust. It remains after controlling for the change in open interest, trading volume, and average daily returns in the regressions of Table 2. Moreover, we have repeated the analysis replacing the daily standardized Garman-Klass estimator with residuals from a vector autoregression of daily volatility and the results do not change much. We have also estimated GARCH models based on the daily settlement prices, which also show a positive relation between margins and volatility.

increase (decrease) the margins of those metals that are expected to show the largest future increase in volatility. Nevertheless, the stronger positive response of a target metal's volatility is also consistent with the hypothesis that margins restrict rational investors, thus causing a comparatively larger increase in the volatility of a target metal. Our evidence cannot discriminate between the two hypotheses.

Panel A of Table 3 separates the positive from the negative margin changes. Although the regression $R^2$s are larger in the case of positive margin changes, the slope coefficients $\beta$ are very similar across the two groups. Observe that in the case of volatility, the earlier Table 2 sharp distinction between target and benchmark metals is due primarily to the influence of positive margin changes. Also observe that in the cases of $\Delta\ln V$ and $\Delta\ln OI$, the constant terms $\alpha$ very substantially across positive and negative margin changes. Specifically, $\alpha$ is positive for positive margin changes, suggesting a positive autonomous trend, and negative for negative margin changes, suggesting a negative autonomous trend. Thus if margins were to change very little, they would be unable to counteract the autonomous trend in market participation. Apparently, this is the reason why the summary statistics for $\Delta\ln V$ and $\Delta\ln OI$ in Table 1 did not reveal the opposing influence of lower margins on market participation that Table 2 or the present table uncover.

Panel B of Table 3 examines whether our results are driven by a few large margin changes. Nathan (1967) finds that very large margin changes in grain futures have a stronger adverse effect on prices. Similarly, Bear (1972) and Tomek (1985) find that the distribution of futures returns is less leptokurtic when margins are very high. Here we partition the sample of margin changes into three groups with equal number of observations, low, medium, and high, according to the absolute size of the percentage margin change of Tables 1 and 2. Panel B shows that although large margin changes provide the most precise $\beta$ estimates, the sizes of the slope coefficients $\beta$ are very similar across the three ranked groups. Moreover, the null hypothesis that they are the same cannot be rejected at any conventional level of significance. However, the differences between target and benchmark metals are statistically significant only in the largest one third of the margin changes. It is the large margin changes that give us statistical power to distinguish between the two groups and assess whether the relations are causal.

## 2.2 *Daily Behavior*

The previous regressions characterize the overall magnitudes of correlations at bimonthly intervals, but are unable to provide more detailed information at the daily level. This information is provided by Figures 1a and 1b for open interest, and 2a and 2b for volatility. Figures 1a and 1b plot the ratio of open interest at business day $t$, $t = -43, \ldots, -1, 0, 1, \ldots, 43$, over the average open interest of business day interval $[-52, -44]$. For each margin change, say the $k$th margin change, we first construct the time series of relative open interests over the interval $[-43, 43]$, and then we compute a cross-sectional weighted average (across the 226 margin increases in Figure 1a, and 274 margin decreases in Figure 1b) of these time series.

TABLE 3

POSITIVE VERSUS NEGATIVE, AND LARGE VERSUS SMALL CHANGES IN MARGIN REQUIREMENTS

| | Panel A: $\Delta Y_k = \alpha_j + \beta_j \Delta \ln M_k + \epsilon_k, j =$ POS, NEG | | | | | | Panel B: $\Delta Y_k = \alpha_j + \beta_j \Delta \ln M_k + \epsilon_k, j = S, M, L$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Positive Change | | | Negative Change | | | Small Change | | Medium Change | | Large Change | | $\beta_S = \beta_M = \beta_L$ & | |
| $\Delta Y_k$ | $\alpha_{POS}$ | $\beta_{POS}$ | $R^2$ | $\alpha_{NEG}$ | $\beta_{NEG}$ | $R^2$ | $\alpha_S$ | $\beta_S$ | $\alpha_M$ | $\beta_M$ | $\alpha_L$ | $\beta_L$ | $\alpha_S = \alpha_M = \alpha_L$ | $\beta_S = \beta_M = \beta_L$ |
| $\Delta \ln OI$ | 0.57* | −2.55* | 0.13 | −0.63* | −1.86* | 0.04 | −0.25* | 0.45 | −0.61* | −1.57* | 0.35 | −1.75* | 1.87 | 0.30 |
| | (2.45) | (−5.70) | | (−3.31) | (−3.38) | | (−2.04) | (0.35) | (−3.21) | (−2.13) | (1.19) | (−4.10) | {0.084} | {0.826} |
| Benchmark | −0.29 | 1.17* | 0.03 | −0.30* | −0.09 | 0.00 | −0.35 | −2.93 | −0.54* | −0.70 | 0.19 | 0.80* | 2.85* | 2.20 |
| | (−1.37) | (2.49) | | (−2.00) | (−0.18) | | (−1.81) | (−1.46) | (−3.22) | (−0.87) | (1.38) | (3.10) | {0.010} | {0.087} |
| | [2.73] | [−5.66] | | [−1.38] | [−2.32] | | [0.46] | [1.42] | [−0.27] | [−0.80] | [0.53] | [−5.24] | | |
| $\Delta g\ OI$ | −0.40 | −2.52* | 0.11 | 0.17 | −2.71* | 0.04 | −0.63* | −1.32 | 0.21 | −2.78* | 0.31 | −3.13* | −1.31 | 0.15 |
| | (−1.58) | (−5.24) | | (0.59) | (−3.31) | | (−3.14) | (−0.61) | (0.68) | (−2.32) | (1.02) | (−7.05) | {0.250} | {0.932} |
| Benchmark | −0.22 | −1.16 | 0.02 | 0.28 | −0.44 | 0.00 | 0.27 | −1.30 | −0.19 | −2.60* | −0.04 | −1.07* | 0.62 | 0.67 |
| | (−0.62) | (−1.86) | | (1.29) | (−0.57) | | (0.93) | (−0.43) | (−0.92) | (−2.58) | (−0.23) | (−3.08) | {0.713} | {0.573} |
| | [−0.50] | [−1.95] | | [−0.33] | [−2.05] | | [−2.56] | [−0.00] | [1.12] | [−0.11] | [1.04] | [−3.72] | | |
| $\Delta \ln V$ | 0.45 | −1.94* | 0.04 | −0.72* | −2.51* | 0.04 | −0.58* | 0.74 | −0.45 | −1.01 | 0.70 | −1.79* | 2.17* | 0.33 |
| | (1.38) | (−3.11) | | (−2.83) | (−3.41) | | (−2.70) | (0.32) | (−1.77) | (−1.04) | (1.83) | (−3.25) | {0.044} | {0.801} |
| Benchmark | −0.90* | 3.23* | 0.10 | 0.07 | 1.71* | 0.01 | −0.69* | −2.92 | −0.31 | −1.33 | 0.16 | 2.16* | 2.57* | 3.72* |
| | (−3.22) | (5.25) | | (0.28) | (2.04) | | (−2.58) | (−1.06) | (−1.36) | (−1.22) | (0.67) | (4.99) | {0.018} | {0.011} |
| | [3.13] | [−5.79] | | [−2.25] | [−3.78] | | [0.33] | [1.02] | [−0.39] | [0.22] | [1.27] | [−5.72] | | |
| $\Delta \ln \sigma_1$ | −0.09 | 3.83* | 0.25 | 0.14 | 3.43* | 0.12 | −0.44* | 3.63 | 0.34 | 4.04* | 0.42 | 3.35* | 1.72 | 0.20 |
| | (−0.40) | (8.70) | | (0.72) | (5.99) | | (−2.11) | (1.60) | (1.74) | (5.41) | (1.76) | (9.70) | {0.115} | {0.898} |
| Benchmark | −0.15 | 1.33* | 0.03 | −0.15 | 1.75* | 0.01 | −0.95* | 7.31* | 0.88* | 1.61 | −0.51* | 1.50* | 9.65* | 1.73 |
| | (−0.64) | (2.52) | | (−0.69) | (2.30) | | (−3.70) | (2.75) | (4.08) | (1.56) | (−3.04) | (3.93) | {0.000} | {0.159} |
| | [0.19] | [3.62] | | [0.97] | [1.76] | | [1.53] | [−1.06] | [−1.82] | [1.89] | [3.28] | [4.05] | | |
| $\Delta \ln \sigma_2$ | −0.24 | 3.72* | 0.25 | −0.12 | 3.10* | 0.08 | −0.45* | 1.17 | 0.19 | 3.05* | −0.12 | 3.53* | 0.84 | 0.38 |
| | (−1.04) | (8.60) | | (−0.57) | (5.01) | | (−2.02) | (0.49) | (0.86) | (3.57) | (−0.50) | (10.69) | {0.541} | {0.767} |
| Benchmark | 0.22 | 0.70 | 0.01 | 0.18 | 2.71* | 0.03 | −0.72* | 3.99 | 1.35* | 3.16* | −0.74* | 1.55* | 13.06* | 1.14 |
| | (0.88) | (1.29) | | (0.83) | (3.67) | | (−3.03) | (1.64) | (6.98) | (3.42) | (−3.84) | (4.44) | {0.000} | {0.331} |
| | [−1.36] | [4.34] | | [−0.98] | [0.40] | | [0.83] | [−0.83] | [−3.94] | [−0.08] | [2.07] | [4.10] | | |

NOTES: Variable definitions are in Table 1. The table presents the regression coefficient estimates α and β of the stacked regression multiplied by 10. Numbers in parentheses are $t$-statistics of the hypothesis that a coefficient is equal to zero. Numbers in brackets are $t$-statistics of the hypothesis that a coefficient is equal across the target and benchmark groups. In Panel A, there are 226 positive and 274 negative margin changes; the corresponding sample size in the benchmark groups are 241 and 379. In Panel B, small, medium, and large margin change regimes have 166, 166, and 168 observations, respectively, and are defined by ranking all 500 metal margin changes according to the absolute size of the percentage margin change, $|\Delta M_k|$. The number of benchmark contracts in each of the regimes is 169, 220, and 231. The last two columns present the $F$-statistics for the tabulated null hypothesis with the probability values in angles.

*Statistically significant at the 5 percent level.

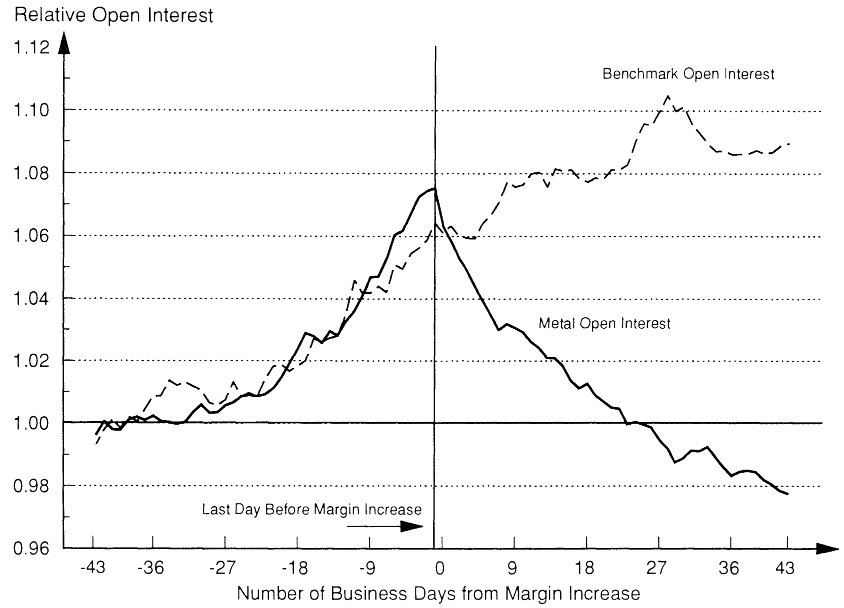


FIG. 1a. Metal Open Interest. Figure 1a refers to margin increases and Figure 1b to margin decreases. The open interest of business day $t$ is divided by the average open interest of days $-52$ through $-44$, and a cross-sectional weighted average of relative open interests in computed with weights proportional to the rank of the percentage increase (Figure 1a) or decrease (Figure 1b) in the average margin over intervals $[-43,-1]$ and $[0,43]$. Benchmark open interest is a similar measure for metals that do not undergo a margin change over the interval $[-43,43]$.

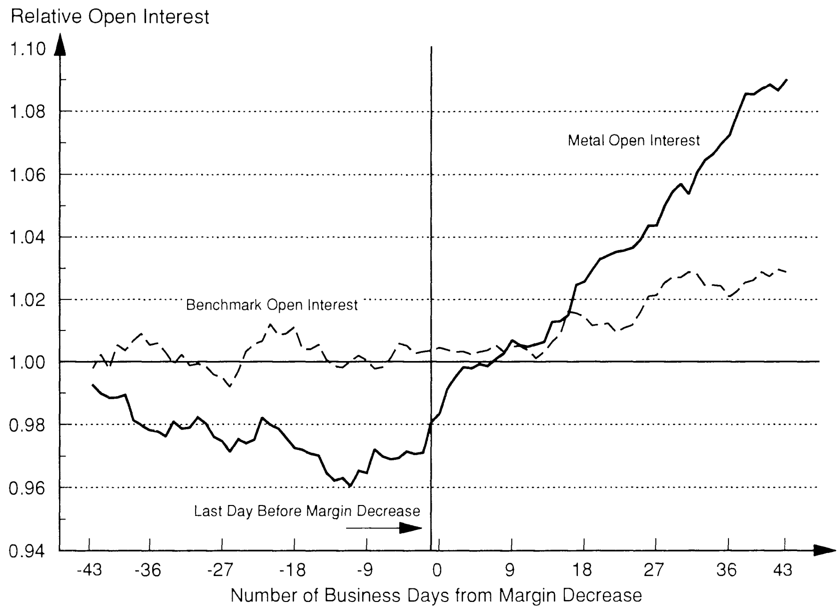


FIG. 1b. Metal Open Interest

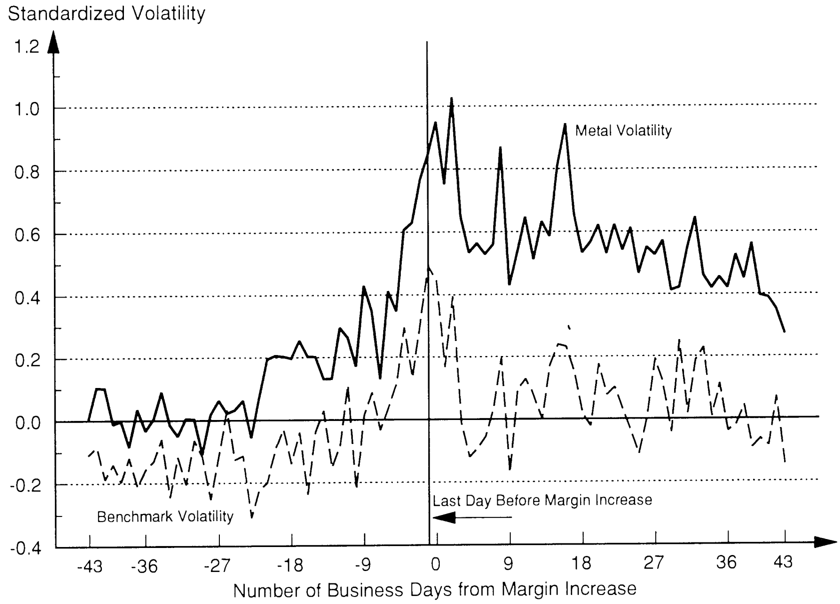


FIG. 2a. Metal Volatility. Figure 1a refers to margin increases and Figure 1b to margin decreases. The daily Garman-Klass volatility is standardized using the full sample mean and standard deviation, and a cross-sectional weighted average is subsequently computed as in Figure 1. Benchmark volatility is a similar standardized measure for metals that do not undergo a margin change over the interval [−43,43].

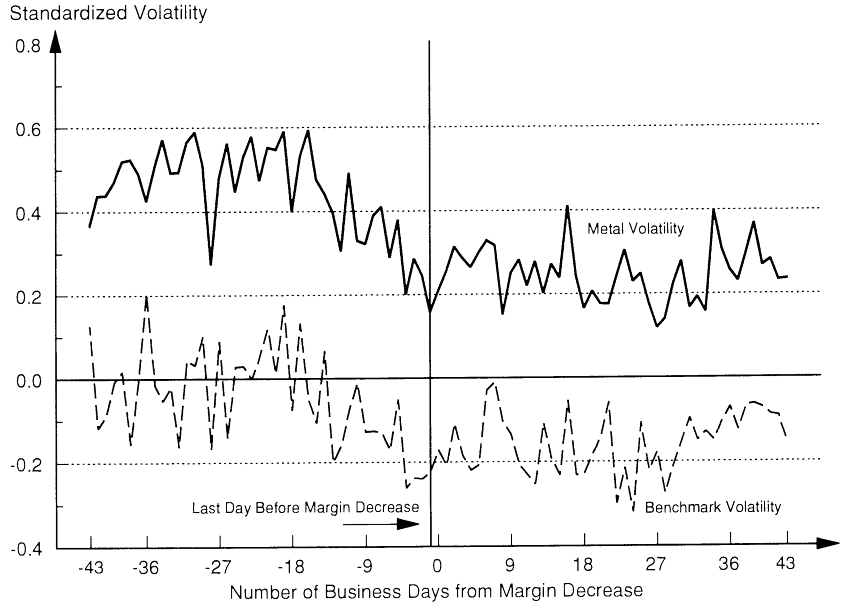


FIG. 2b. Metal Volatility

The weights sum up to unity and are proportional to the rank of each percentage margin change, $\Delta M_k$. For example, in Figure 1a, the largest positive $\Delta M_k$ receives the highest rank, 226, and the largest negative $\Delta M_k$ receives the lowest rank, 1 (because of interval overlapping, some of the $\Delta M_k$ in Figure 1a are negative). The purpose of the weighting scheme is to adjust for the fact that the margin changes differ in size and, therefore, more weight should be given to the larger margin changes. Also, using the rank instead of the size of the margin change in constructing the weights avoids placing undue emphasis on a few outliers. Construction of the aggregate benchmark open interest follows a similar procedure. The volatility Figures 2a and 2b are slightly different: They reflect standardized instead of relative volatility. (Relative volatility is an awkward measure because in some commodities the base volatility of the interval $[-55, -44]$ is zero or very close to zero.) We first calculate the overall historical sample mean and sample standard deviation of each commodity's $S_t$—the square root of Garman-Klass daily variance estimator, and then standardize each daily volatility measure, that is, we calculate the number of standard deviations away from the mean. Subsequently, for each business day $t$, $t = -43, -42, \ldots, -1, 0, 1, \ldots, 43$, we calculate the cross-sectional weighted average of the standardized volatility.

Figure 1a shows a very striking difference between the behavior of metal open interest and its benchmark. The open interest of both the target metal and its benchmark group follow upward trends from business day $-43$ to business day $-1$. The target metal open interest rises to a level that is 7.5 percent higher than two months earlier. The benchmark open interest rises to a level that is 6 percent higher. *The similarity stops on the day of the margin increase.* On the day of the margin increase, the target metals switch to a negative trend and two months later open interest falls to a level that is two percent lower than the original base. On the other hand, benchmark open interest continues to rise reaching a level that is 9 percent higher than its base. Figure 1b, which refers to margin decreases, also shows a substantial difference between the behavior of metal open interest and its benchmark group. Benchmark open interest remains essentially flat, rising by only 2 percent from day $-1$ to day 43, whereas the open interest of the target metals increases by 11 percent from day $-1$ to day 43. The discrepancy between target and benchmark behavior after day $-1$ in the two figures is not only economically important but statistically significant as well [see Hardouvelis and Kim (1992) for the tests statistics]. These large discrepancies provide strong support for the hypothesis of causality from margin requirements to market participation.

Figures 2a and 2b show the evolution of standardized volatility. In Figure 2a, the level of volatility remains high after the margin increase. A comparison with the benchmark group shows that the positive discrepancy between the two volatilities gets larger after business day $-1$ and this increase is statistically significant (19 out of the 44 business days have $t$-statistics larger than 1.96). Thus Figure 2a confirms the earlier regression results. In Figure 2b, standardized volatility is higher than benchmark volatility at the time of the margin decrease. This evidence is surprising. It suggests that the exchanges are anxious to decrease margins after an earlier rise, and they do so very quickly, even though the volatility of the target metal relative to the other metals may be higher. In Figure 2b, the relative discrepancy between the target and benchmark groups does not reveal any special pattern after business day −1, a result consistent with our earlier findings in Table 3, Panel A.

## A. CONCLUSION

There is a clear causal negative influence from margin requirements to market participation documented both in our bimonthly regressions and in the figures. As margin requirements increase, market participants leave the metal market affected by the margin increase and apparently move into similar metal markets unaffected by the increase. The behavioral differences between target and benchmark metals are not only economically important but also strongly statistically significant.

While the costs of higher margins are clear, the potential benefits from reduced excess volatility are less clear. The data on futures price volatility do not allow us to determine with confidence the type of investors who are primarily restricted by margin changes. Benchmark metal volatility shows a weaker positive association with margins than target metal volatility and allows two alternative interpretations of the evidence: The first interpretation is that the exchanges raise margin requirements in those metals for which they expect a comparatively larger future increase in volatility. The second interpretation is that rational investors are the ones who are primarily affected by the increase in margin requirements.[7]

Distinguishing between the hypotheses of rational and irrational investors using data exclusively from futures markets remains an open challenge. As long as this question is unanswered, and as long as there is disagreement about the evidence from the cash markets, the desirability of permanently higher margins in futures contracts would remain an open issue.

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7. Had the positive association between benchmark metal volatility being stronger than the corresponding positive association of target metal volatility, the behavioral rules of the exchanges would have been ruled out as a potential explanation, and one would have concluded that irrational investors were affected by the change in margin requirements.

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