# Causes and Consequences of Margin Levels in Futures Markets

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**Abstract**

This paper examines how margin requirements in futures markets are set and how they affect prices and liquidity. Margin increases cause both hedgers and speculators to reduce their open positions, and a margin increase for one contract causes funding liquidity spillovers that affect price impact for all contracts. I do not find a significant effect of margin changes on the futures price level. However, realized variance increases by 50% on average on the day of a margin increase and remains high in the following weeks. The findings imply that imposing higher margins adversely affects liquidity and volatility, and that regulation of margins can make trading more costly for all market participants.

I use a novel data set on margin requirements, obtained through a Freedom of Information Act request, for 16 commodity futures contracts over the period 2000–2011 to explore how margins are set and to test the existing theories on the implications of changing margin levels. Margins are important for investors because they tie up part of the investors' capital, and they are important for the financial system because they reduce counterparty risk. The futures market provides an ideal venue for exploring the effect of funding constraints on financial markets, since historical margin requirements are available for multiple contracts.

Previous studies show that margin increases are followed by a drop in open interest,[1] however, these studies do not consider which trader groups reduce their positions.[2] Further, there is disagreement on the impact of margin changes on price volatility.[3] If margin increases lower volatility or change trader composition, margins may be used as a policy tool to stabilize markets, and the Dodd-Frank bill gives the U.S. Commodity Futures Trading Commission (CFTC) the power to set margin requirements on futures contracts.

The empirical analysis yields three main results: First, margin requirements are determined by contract-specific volatility and contract-specific tail risk. Second, margins impact liquidity. Margin increases are followed by a decrease in the open interest held by both hedgers and speculators, and speculators reduce their open positions more than hedgers. There are funding liquidity spillovers, where price impact increases for both the contract that has its margin increased, and for the remaining contracts. This provides new evidence on the link between funding liquidity and market liquidity. Third, while margin changes do not significantly impact the level of futures prices, margin increases are followed by a rise in the realized variance of the futures price process. These results imply that regulating margins may reduce participation of both hedgers and speculators, and increase trading costs

[1] See, e.g., Fishe and Goldberg (1986), Hartzmark (1986), Hardouvelis and Kim (1995).

[2] An exception is Chatrath et al. (2001), who consider margin changes for gold and silver futures.

[3] See, e.g., Ferris and Chance (1988), Fishe et al. (1990), Goldberg and Hachey (1992), Hardouvelis and Kim (1995), Hardouvelis and Kim (1996).

and position risk for all market participants.

In explaining the average margin requirement over time for a futures contract, I find that the main determinant of margin levels is contract-specific price volatility. The average percentage margin is set as a multiple of the volatility of the particular contract and the percentage margin requirement is, on average, 2.5 times the daily standard deviation of returns. For instance, gold, which has an annualized volatility of 21% and thus a daily standard deviation of 1.3%, has an average percentage margin requirement of $3.4\% \approx 2.5 \times 1.3\%$. Crude oil has an average volatility of 41%, corresponding to a daily standard deviation of 2.6%, and an average percentage margin requirement of $6.4\% \approx 2.5 \times 2.6\%$.

I confirm the finding in previous research that open interest declines after margin increases, and additionally I show that the decline is caused by both hedgers and speculators reducing their positions. Following a margin increase, hedgers reduce their positions by about 3% on average over the next 8 weeks, and speculators reduce their positions by about 5% on average. Margin increases cause funding liquidity spillovers, where the price impact of trading increases for both the affected contract and for the remaining contracts in the market. On average, a margin increase leads to a 15% rise in the price impact of trading for the affected contract, and an average increase in price impact of 6% for *all* contracts considered, both economically large effects. Whereas previous studies report mixed findings on the impact of margin increases on trading volume, I show that these findings can be explained by different event windows, and that the long-term effect of higher margins is lower trading volume.

Finally, I test the popular claim that margin increases cause a drop in the futures price level, but I find no evidence supporting this claim. However, although margin increases do not affect the level of futures prices, they do affect the distribution of returns. I use high-frequency data to compute the realized variance of the futures price process, and I document a rise in realized variance of 50% on average on the day of a margin increase, after which realized variance slowly mean-reverts. Margin changes are of course endogenous as they are set by the clearing house primarily based on volatility, and I address this endogeneity problem throughout the paper.

Traders in commodity futures often state that margin increases squeeze out speculators and drive down prices.[4] Members of Congress, concerned that high commodity prices negatively affect the economy, have requested that the CFTC increase margins on certain commodities to prevent excessive speculation and to deflate prices (Nelson, 2011).[5] The argument that margin increases reduce futures prices relies on the idea that margin increases drive out speculators, who are assumed to have a higher cost of margin capital than hedgers. The prediction that this lowers futures prices further requires that speculators close out more long positions than short positions. I confirm the conjecture that speculators reduce their positions more than hedgers, however, I do not find evidence that they reduce their long position more than their short positions immediately after a margin increase. Also, I do not find evidence supporting the claim that margin increases lead to a change in the level of futures prices.

The Dodd–Frank Wall Street Reform and Consumer Protection Act, signed into law on July 21, 2010, gives the CFTC the power to set margin requirements on futures contracts, something that the private sector exchanges previously have had sovereign power to do. Understanding how margins have been set historically, as well as the implications of changing them, is important for public policy if the CFTC wishes to regulate the margins set by futures exchanges. Furthermore, section 804 of the Dodd-Frank bill provides the Financial Stability Oversight Council with the authority to designate a financial market utility, such as

[4]An example is Joe Cusick, senior market analyst at Chicago-based online brokerage optionsXpress, who stated on May 5, 2011, "The catalyst for the silver move could be the margin requirement hikes, squeezing out the pure short-term speculators that were playing a hot segment." (Frankel, 2011).

[5]Part of the letter to the CFTC reads: "We urge you to restore integrity to our energy markets by exercising the CFTC's authority to require higher margin levels for speculative oil futures contracts...For the same reason we don't let pharmaceutical companies approve their own drugs, we shouldn't let futures exchanges self-regulate by setting their own margin requirements." (Nelson, 2011)

a clearinghouse, as systemically important. On July 18, 2012, several exchanges, including the CME Group, were deemed to be systemically important.[6] As such, they will have access to emergency lending from the Federal Reserve Board.

This study is related to several areas of research: First, there exists a long history of research on how futures margins should be set for risk management purposes. I briefly review this in Appendix A.[7] Gay et al. (1986), Fishe et al. (1990), Goldberg and Hachey (1992), and Fenn and Kupiec (1993) consider how margins are set empirically. Second, the effect of margin changes is studied by Fishe and Goldberg (1986), Hartzmark (1986), Ferris and Chance (1988), Fishe et al. (1990), Goldberg and Hachey (1992), Hardouvelis and Kim (1995), Hardouvelis and Kim (1996), and Chatrath et al. (2001). Third, this study is related to recent literature on the theoretical implications of margins. Brunnermeier and Pedersen (2009) develop a model in which market liquidity and funding liquidity are linked, and a shock to either causes liquidity spirals where market liquidity and funding liquidity are mutually reinforcing. A change in margin requirements is a shock to *funding* liquidity, since it changes the size of the position a trader can take with a given amount of capital. I find that an increase in the margin for one contract increases the price impact for all other contracts as well, providing new evidence in support of the model in Brunnermeier and Pedersen (2009).

The rest of the paper is organized as follows. Section 1 describes the data used for the study, Section 2 considers how margins are set, and Section 3 tests how margins affect liquidity, price levels and realized variance. I describe the details of daily settlements in futures markets in Appendix B.

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[6]http://www.treasury.gov/initiatives/fsoc/Documents/2012%20Appendix%20A%20Designation%20of %20Systemically%20Important%20Market%20Utilities.pdf%20Market%20Utilities.pdf

[7]Figlewski (1984), Gay et al. (1986), and Fenn and Kupiec (1993) discuss optimal margin setting when returns are normally distributed. Brennan (1986) analyzes the interaction between margins and price limits in futures markets. Dewachter and Gielens (1999), Longin (1999), Cotter (2001), Broussard (2001), and Cutter and Dowd (2006) use extreme value analysis to determine optimal margin levels.

# 1 Data and Summary Statistics

My data on margins consist of margins on the 16 commodity futures contracts listed in Table 1. The data cover 2000–2011 for livestock contracts, 2003–2011 for agricultural contracts, and 2004–2011 for energy and metal contracts, with a total of 597 margin changes. I obtained data on margins from both the CME Group and the CFTC. The data from the CME Group are available online.[8] I obtained data from the CFTC via a Freedom of Information Act request.[9] For the periods where the two data sets overlap, the margin levels and dates of margin changes are identical. I obtained daily data on futures prices, open interest, and volume from DataStream. I use tick data from the CME Group to calculate the realized variance of the futures prices process based on 5-minute returns.

[Table 1 about here.]

Margins are set as a dollar amount per futures contract. For instance, one gold futures contract is for the physical delivery of 100 troy ounces of a minimum of 995 fineness, and on November 16, 2011, the futures price for December delivery was $177,430 per contract. The initial margin was $11,475 and the maintenance margin was $8,500, corresponding to 6.47% and 4.79% of the futures price, respectively.[10] The average margin by contract, along with average margin changes and other summary statistics, can be seen in Table 1. Of the 597 margin changes, 350 are increases and 247 are decreases. The average margin increase is around 20%, while the average margin decrease is slightly lower at around 17%, with margin changes for energy contracts being smaller and more frequent than for other sectors. However, there is a large variation in the magnitude of the changes, from less than 5% to

[8] See www.cmegroup.com/clearing/risk-management/historical-margins.html

[9] Neither the CME Group nor the CFTC was able to provide data on margins prior to 2001.

[10] When a trader enters into a futures contract, the exchange requires the trader to deposit the initial margin amount in the trader's margin account. If the value of the margin account later falls below the maintenance margin, set below the initial margin, the trader must transfer funds to bring the value of the account back up to the initial margin. The ratio of maintenance-to-initial margin is the same across contracts and time in my data.

more than 100% in one extreme case (for gold in September 2008). Across all contracts, the average time between margin changes is 82 trading days. Margins for energy contracts are changed more frequently, with an average time of 56 trading days between changes.

I also obtained data on speculator and hedger positions from the Commitments of Traders (COT) report, which is published weekly by the CFTC and shows the aggregate positions of speculators and hedgers, divided into five categories: producers and merchants, swap dealers, money managers, others, and non-reporters. Producers and merchants, as well as swap dealers, are hedgers, whereas money managers and others are speculators. The CFTC now uses the term 'commercial traders' instead of hedgers, and 'non-commercial traders' instead of speculators. However, I continue to use the hedger-speculator terms as this is common in the literature.

# 2 How Margins Are Set

It is widely recognized that clearing houses set margins based on volatility.[11] I confirm this finding for the CME Group for the recent post-2000 period, and additionally show that commodity futures margins are also set based on contract-specific tail risk. The theoretical literature on margin setting considers the tradeoffs faced by the clearinghouse when setting margins:[12] If margins are too low, the clearinghouse is exposed to too high a level of counterparty risk. If margins are too high, the funding costs imposed on market participants will reduce participation and liquidity. Even though the exact objective of the clearinghouse is unknown, Figlewski (1984) and Fenn and Kupiec (1993) show that if returns are normally distributed there exists a linear relation between the optimal margin level and volatility, such

[11] The CME Group and many other exchanges use the SPAN system (Standard Portfolio Analysis) to calculate margins on portfolios and options. SPAN determines the total margin requirement by analysing the possible losses over 16 different scenarios, which are set by the exchange (the SPAN risk array). SPAN does not determine margins on individual futures contracts. Margins on individual contracts, as well as the SPAN risk array, are set by the exchange.

[12] Appendix A briefly reviews the theoretical literature on margin setting.

that the optimal margin-to-volatility ratio is constant across contracts and across time. If futures returns are not normally distributed, Longin (1999) shows that the optimal margin level depends on the tail parameter of the distribution of extreme returns, such that return distributions with fatter tails have higher margin requirements.

Only a few studies have explored how margins have been set in practice, possibly due to the lack of readily available data on historical margins. Gay et al. (1986) and Fishe et al. (1990), who consider commodity futures, and Goldberg and Hachey (1992), who consider foreign exchange futures, find that margin levels are primarily determined by price volatility. Fenn and Kupiec (1993) find a large variation in the margin-to-volatility ratio across contracts and time and conclude that the clearinghouse generally does *not* set margins in accordance with any of the theoretical models developed.

Kim Taylor, president of CME Clearing, explains the objective of their margin levels on Open Markets (a CME Group blog) on May 4, 2011:

> "The CME Clearing approach is to ensure that margins are set to cover 99 percent of the potential price moves. Margins then are lower in less volatile periods and higher in more volatile periods."

I first consider how margins depend on volatility, since the simplest prediction is that if returns are normally distributed, margins should be linear in volatility. Figure 1 shows in the left plot the average percentage margin as a function of the average volatility for the commodity futures contract. The average margin is linear in the average volatility, which clearly shows the importance of volatility for margin setting and confirms the findings of previous research. The right plot in Figure 1 shows the time-series of the average percentage margin across contracts together with the average conditional volatility across contracts. The conditional volatility is calculated from a daily GARCH(1,1) model and both series are standardized to have mean zero and variance 1. The two series move closely together, showing again the strong relation between margin requirements and volatility.

[Figure 1 about here.]

To analyze how margins depend on volatility as well as tail risk, I estimate the regression

$$\bar{m}_n = \beta' \bar{x}_n + \nu_n, \quad n = 1, \ldots, 16, \tag{1}$$

where $\bar{m}_n$ is the average percentage margin over the entire sample period, and similarly $\bar{x}_n$ is the average of the explanatory variables over the entire sample period. I include the realized volatility based on daily returns as well as the tail parameter describing the distribution of extreme returns.[13] Table 2 shows the results (with volatility measured as a daily value). Volatility is clearly an important determinant for margin levels, and the tail parameter is significant at the 10% level. Note that a small (or more negative) value of the tail parameter indicates fatter tails. The sign on the tail parameter in column 4 is thus what one would expect; after controlling for volatility, contracts with fatter tails have higher margins.

[Table 2 about here.]

The magnitudes of the coefficients are economically sensible: the percentage margin requirement is, on average, 2.5 times the daily standard deviation of returns (when omitting the intercept). For instance, gold, which has an annualized volatility of 21% and thus a daily standard deviation of 1.3%, has an average percentage maintenance margin requirement of $3.4\% \approx 2.5 \times 1.3\%$. If returns were normally distributed, this would cover roughly 98.8% of the daily price moves.

I also consider how margins are changed over time. While Figure 1 show that on average, margins are set the same way for different contracts, the clearing house does not seem to follow the same rule for changing margins for different contracts. When regressing margin changes on changes in volatility since the previous margin change, the test of equal coefficients

[13] I use the extreme value distribution of the extreme absolute returns, since the margins are identical for long and short positions, and estimate the parameters based on the generalized Pareto distribution.

across contracts is strongly rejected with a $p$-value of less than 1%. In summary, this section shows that margins are set based on measures of both volatility and tail risk. The average level of the margin requirement for a given contract is very well explained by the average volatility of that contract. However, the exchange does not seem to follow the same rule when adjusting margins for different contracts, and margin changes are hard to predict due to the varying size of the changes.[14]

# 3 How Margins Affect Futures Markets

## 3.1 How Margins Affect Liquidity

This section investigates the impact of margins on liquidity. While margins vary across contracts with different maturities, when margins are changed they are changed by the same percentage amount for all contract maturities. I therefore aggregate open interest and volume across all available contract months to study the effect of margin changes on these variables.

Fishe and Goldberg (1986) and Hartzmark (1986) find that margin increases are associated with a decline in open interest. However, their results on trading volume are inconclusive. Hardouvelis and Kim (1995) find a negative effect of margins on both volume and open interest, and Dutt and Wein (2003) also conclude that higher margins are associated with lower volume. Chatrath et al. (2001) consider the relation between margins and trader composition for gold and silver and show that small traders and speculators are especially sensitive to margin changes.

This study contributes in several ways: First, I show that following margin increases both hedgers and speculators reduce their open positions, and speculators reduce their positions

[14] As mentioned in footnote 11, the CME Group uses SPAN to calculate margins on portfolios and options. While the SPAN system mechanically calculates the total margin requirement for a portfolio based on the SPAN risk array, the SPAN risk array and the margin on individual futures contracts are inputs to SPAN and are set by the clearing house. Thus, there is no deterministic link from past price history to individual margin requirements.

more than hedgers. Second, I study hedger- and speculator pressure, and show that while hedgers reduce short positions more than long positions, there is no evidence that speculators change the ratio of long to short positions. Third, I document that a margin increase for one contract affects the price impact across all contracts. In other words, there are significant liquidity spillovers.

I construct the different liquidity measures as follows: I first consider the daily percentage change in open interest as well as the percentage change in the dollar value of open interest. Next, I use the daily volume, measured as the number of contracts traded. Third, I use Amihud's illiquidity measure as a measure of price impact (Amihud, 2002), as advocated for commodity futures markets by Marshall et al. (2012). However, instead of using daily observations I use returns and volume over 5-minute intervals, and average over each day to construct a daily measure of illiquidity. Amihud's illiquidity measure is given by the absolute return over the dollar volume: $\text{illiq}_t^i = \sum_{n=1}^{N} |r_{t,n}^i| / (V_{t,n}^i \cdot p_{t,n}^i)$, where $N$ is the number of 5-minute trading intervals on day $t$, $r_{t,n}^i$ is the return on asset $i$ for the $n$'th 5-minute interval on day $t$, $V_{t,n}^i$ is the trading volume, and $p_{t,n}^i$ is the price, such that $V_{t,n}^i \cdot p_{t,n}^i$ is the dollar volume traded.[15]

### 3.1.1 Event Studies

Margin changes are not exogenous but are set by the clearing house in response to changing market conditions. To address this this problem I use a control group of contracts that do not experience a margin change. That is, if the margin for gold is increased, I compare the change in trading activity for gold with the change in trading activity for the contracts that do not have their margin changed within 10 days before or after the same day.

Figure 2 shows the event study for the impact of margin increases on open interest

[15] The average correlation across contracts between the price impact calculated based on daily observations and the price impact calculated based on 5-minute data is 0.3, and increases to 0.62 when averaging to monthly values. My results are quantitatively robust to using either measure, but the results based on 5-minute returns are much less noisy.

(number of outstanding contracts), separated into open interest held by hedgers and open interest held by speculators. To address the concern that margin changes are not exogenous, I compare the change in open interest for the "treatment" group of contracts that have their margin increased to the change in open interest for a "control group" of contracts that do not have their margin changed.[16] Since changes in open interest are highly correlated across contracts, looking at the differences between the two groups helps identify the effect of margin changes. The left plot in Figure 2 shows the growth in open interest held by hedgers for the two groups, and the right plot shows a similar study for the open interest held by speculators. Each figure is constructed such that the lines show the cumulative change in open interest normalized to be zero on the day of the margin change, which is day 0.

[Figure 2 about here.]

The control groups in both plots in Figure 2 show that open interest increases over the sample period. Open interest held by hedgers increases by about 7% over a 100 day period, and open interest held by speculators increases by about 12% over the same period. This simply reflects the dramatic increase in open interest for commodity futures over the sample period. For the contracts that have their margin increased, hedgers reduce their positions by about 3% in the first 40 days following a margin increase, and the difference relative to the control group is about 6%. The decline in open interest starts precisely on the day of the margin change, showing that margin increases impose significant costs on hedgers and force them to reduce their holdings.

Speculators also reduce their open positions for the contracts that have their margin increased, and they reduce their positions more than hedgers. For speculators, the drop in open interest starts prior to the margin increase, and the total drop in open interest is about 7% (9% relative to the control group). Looking at the *dollar value* of open interest (not

[16]See Hardouvelis and Kim (1995) for a similar approach.

reported), calculated as the closing price of the futures contract times the number of open positions, reveals that the decline in the dollar value of open interest held by speculators coincide exactly with the margin increase. The reason for the difference between the change in the number of outstanding contracts and the dollar value of open interest is that margin increases tend to follow price increases (Since margins are set as a dollar amount, if the futures price increases and the percentage volatility is constant, a higher dollar margin is needed). If speculators allocate a certain fraction of their capital to each asset, this shows that the higher margin requirement leads speculators to exit their positions.

Table 3 at the end of this section reports the coefficient estimates and standard errors from an event study, comparing the treatment group to the control group. For both the growth in open interest held by hedgers and the growth in open interest held by speculators, the difference between the two groups—from before to after the margin increase—is significant at the 1% level, and there is thus clear evidence that margin increases do reduce the growth in open interest for both hedgers and speculators.

Since the prediction that margin increases lower futures prices further requires that speculators close out more long positions than short positions, I look at hedger pressure and speculator pressure, defined by de Roon et al. (2000) as

$$\text{Hedger Pressure} = \frac{\text{Short Hedger Positions} - \text{Long Hedger Positions}}{\text{Short Hedger Positions} + \text{Long Hedger Positions}} \tag{2}$$

$$\text{Speculator Pressure} = \frac{\text{Long Speculator Positions} - \text{Short Speculator Positions}}{\text{Long Speculator Positions} + \text{Short Speculator Positions}}. \tag{3}$$

Table 3 shows that hedger pressure is reduced following margin increases, i.e., that hedgers reduce their short positions more than their long positions. Further, the difference between the treatment group and control group is significant at the 1% level. However, there is no evidence that speculators reduce their long positions more than their short positions in response to margin increases. Of course, the total number of long positions must equal the total number of short positions at all times, but some traders are "non-reporters" and are neither classified as hedgers nor speculators.

[Figure 3 about here.]

Finally, I consider the effect of margin increases on volume and price impact in Figure 3. For each event, volume is standardized to have mean zero over the period $(-50, -5)$ days before the margin increase, such that the percentage change in the variables is gauged easily. As seen in the left plot of Figure 3, volume grows about 10% for the control group over the event window which is simply due to the average growth in volume over my sample period. For the contracts that have their margin increased, volume is about 10% higher than for the control group around the day of the margin change and then drops. Expanding the event window reveals that over longer periods, volume for the contracts that have their margin increased drops below the volume for the control group.

The right plot in Figure 3 repeats the analysis for price impact, again normalized to have mean zero over the −50- to −5-day interval for both groups. Margin increases are followed by higher price impact for both the contracts that have their margin increased, as well as for the remaining contracts in the control group. Both increases in price impact are significant at the 1% level (see Table 3). Clearly, price impact increases more for the contract that has its margin raised, and the increase in price impact is about 15% on average. Table 3 shows that the difference to the control group is significant at the 1% level. This provides new evidence supporting the model in Brunnermeier and Pedersen (2009), where a shock to funding liquidity for one asset affects market liquidity for other assets. Here, the reduced funding liquidity for one futures contract makes the entire futures market less liquid. If financial intermediaries have positions in several contracts, a margin increase for one contract ties up more capital and lowers the amount of liquidity that the intermediary can provide in other markets.

Table 3 shows the estimates from the event study regression

$$\Delta y_i = \mu + \alpha \Delta m_i 1_{(\text{Contract has margin increase})} + \beta \Delta m_i 1_{(\text{Control Group})} + \varepsilon_i. \quad (4)$$

Here, $\Delta y_i$ measures the change in the variable of interest from before to after the margin increase, averaging over 50 days before/after the margin increase. For instance, for open interest, $\Delta y_i$ measures the difference between the average daily growth of open interest during the 50 days before the margin increase and the average daily growth of open interest during the 50 days after the margin increase. For volume, $\Delta y_i$ measures the change in average volume from before to after the margin increase. The constant captures the average change for all contracts—for instance open interest and volume grow over time. $\alpha$ captures the effect of a margin change on the contract that has its margin changed, and $\beta$ captures the effect of the margin change on the remaining contracts. The coefficients are scaled to show the effect of a typical 20% margin change (say, from 5% to 6% of the futures price).

[Table 3 about here.]

As seen in Panel A of Table 3, a 20% margin increase results in a change in the daily growth of open interest held by hedgers of −0.09% per day, relative to the control group. Over 50 days, this adds up to about 4.5% which closely corresponds to the difference seen in the left plot in Figure 2. For speculators, a 20% margin increase leads to a change in the growth of open interest of −0.1% per day, which adds up to 5% over a 50 day periods. This slightly underestimates the effect seen in the right plot of Figure 2 since the drop in open interest held by speculators starts prior to the margin increase. Hedger pressure drops by about 1.25% relative to the control group, whereas there is no effect of margin increases on speculator pressure. There is no significant effect on volume, but there is an increase in price impact of about 15% for contracts that have their margin raised. Further, margin increases are followed by an increase in price impact of about 6% for contracts that did not have their margin raised, and the difference between the two groups is about 9%. These numbers closely correspond to the findings in the right plot of Figure 3. Margin increases thus lead to an increase in price impact across all contracts and make the entire futures market less liquid.

Panel B of Table 3 shows the average effect of a 20% decrease in margins. Margin decreases have no effect on the growth of open interest for either hedgers or speculators. Margin decreases have a significant effect on volume, leading to an increase in volume for both groups of contracts. Margin decreases also have a significant effect on price impact: A 20% margin decrease is followed by a 6% decrease in price impact for the contract that has its margin decreased (significant at the 5% level), and the change in price impact relative to the control group is significant at the 10% level. Thus, margin decreases increase liquidity in the futures market.

## 3.2 How Margins Affect Futures Returns

### 3.2.1 Margins and Price Levels

The claim that margin increases lead to lower futures prices is based on the reasoning that margin increases force out speculators, which in turn decreases futures prices when speculators are long. Masters (2008) argues that increased participation of speculators has increased commodity futures prices, and while numerous academic papers have generally failed to find support for the belief set forth by Masters (2008) (see, e.g., Irwin and Sanders (2012) and Hamilton and Wu (2012)), the question of whether margins in particular affect commodity futures prices has not been examined rigorously. As noted above, I found strong evidence that speculators do exit the market in response to margin increases, and that they reduce their positions more than hedgers.

Gârleanu and Pedersen (2011) develop the theoretical underpinnings of the view that required returns should increase when margins are increased (and thus prices should fall). In their margin-based capital asset pricing model (M-CAPM), equilibrium-expected returns are a function of the risk-free rate, the usual risk premium that arises from the CAPM, and the margin requirement times the margin premium:

$$E(r^i) = r^f + \beta^i \times \text{covariance risk premium} + m^i \times \text{margin premium}, \quad (5)$$

where $m^i$ is the margin requirement on asset $i$ and the margin premium is the shadow cost of funding for the average agent. The margin premium is positive when margin constraints are binding for at least one investor, and zero otherwise. Although the M-CAPM, combined with assumptions on speculator positions, predicts that equilibrium prices should change after margin changes, it is not clear if this effect should be economically large. Indeed, there is reason to believe that the quantitative effect of margin changes on prices should be very small. Gârleanu and Pedersen (2011) note that the margin premium is determined by the investor's shadow cost of capital, the fraction of constrained investors, and their risk aversion.

On the one hand, the shadow cost of capital for margin requirements is likely very small. The average margin on futures contracts is about 5% of the futures price, and traders can post a variety of assets, such as T-bills and gold, as collateral for margin requirements. If the investor willingly holds these assets in his portfolio, the shadow cost of margin requirements is zero. On the other hand, Brennan (1986) argues that posting margins must be costly for some market participants for the futures market to exist. Above, I found that higher margins affect both open interest and price impact, clearly illustrating that margins do matter for liquidity. Assuming margin requirements are costly to some market participants, the impact of margin changes on prices depends on the magnitude of the margin change. In my sample a typical margin change is around 20% in the dollar amount, thus increasing the margin from, e.g., 5% to 6% or decreasing it from 5% to 4% of the futures price. According to the M-CAPM, the change in required return is determined by the change in the percentage margin, which is just 1% of the price. Were the typical margin 50% of the futures price, the theoretical predictions of a 20% increase, from 50% to 60% of the futures price, would be much larger. Finally, holders of long positions must react differently to margin changes than holders of short positions for margin changes to have an impact on the futures price, since every futures contract is a contract between two parties, one having a long position and one having a short position.

To analyze the effect of margin changes on futures prices, I consider standardized returns from a GARCH(1,1) model to avoid my results being driven by large returns in periods with high volatility.[17] I first perform an event study and consider the average change in the futures price after margin increases, but find no evidence of abnormal returns following margin increases.

In the above event study, I do not account for the size of the margin change or the exact speculator pressure at the time of the margin change. I measure speculator pressure relative to total open interest to capture the potential effect of speculators being long or short. Thus, I define the relative speculator pressure as

$$\text{RSP}_t = \frac{\text{Long Speculator Positions} - \text{Short Speculator Positions}}{\text{Total Open Interest}}. \tag{8}$$

[17]First, I calculate log-returns as $r_t = \log(P_{t+1}) - \log(P_t)$, and second I estimate a GARCH(1,1) model based on the log-returns. The GARCH(1,1) model is

$$r_{t+1} = \varepsilon_{t+1}\sigma_{t+1}, \tag{6}$$
$$\sigma_{t+1}^2 = \mu + \alpha r_t^2 + \beta \sigma_t^2, \tag{7}$$

where $\varepsilon_1, \varepsilon_2, \ldots$ are independent and identically distributed, with $E_t(\varepsilon_{t+1}) = 0$ and $V_t(\varepsilon_{t+1}) = 1$. The model having been estimated, the standardized returns are calculated as $\tilde{r}_t = \frac{r_t}{\hat{\sigma}_t}$. The autocorrelation of the standardized returns shows that there is no volatility clustering left in the standardized residuals from the GARCH model, and thus the model has done a nice job of removing the volatility clustering present in the return series. This is true for all 16 contracts in my data set.

The hypothesis that the change in the futures price should depend on the size of the margin change as well as speculator pressure is formalized by estimating the model

$$\tilde{r}_t^i = \alpha \Delta m_t^i + \beta \mathrm{RSP}_t^i + \gamma \Delta m_t^i \times \mathrm{RSP}_t^i + \varepsilon_t, \tag{9}$$
$$i = 1, \ldots, 16, \quad t \in \{\text{Days with margin changes}\},$$

where $\tilde{r}_t^i$ is the standardized return on day $t$ for commodity $i$, $\Delta m_t^i$ is the margin change on day $t$ for commodity $i$, and $\mathrm{RSP}_t^i$ is the relative speculator pressure for commodity $i$ on day $t$. If margin changes matter in combination with the relative speculator pressure, the coefficient $\gamma$ of the interaction term should be negative and significant, whereas $\alpha$ and $\beta$ should be insignificant. However, I find no evidence that margin changes and speculator positions result in a change in futures prices. These findings are consistent with my findings above on the effect of margin changes on hedger and speculator positions, which showed that while both hedgers and speculators exit the market following margin increases, speculators do not change the ratio of long positions to short positions.

To see if the lack of significant results stems from a lack of power, I simulate from the model $\tilde{r}_t^i = \gamma \Delta m_t^i \times \mathrm{RSP}_t^i + \varepsilon_t$, where I use the actual margin changes and speculator positions, but randomly draw standardized returns from the entire sample. I vary gamma such that the average shock, defined as $\gamma E\left(|\Delta m_t^i \times \mathrm{RSP}_t^i|\right)$, is a given fraction of the daily standard deviation of returns, and I calculate the power of the test $\gamma = 0$ for different alternative average shock sizes. The power is about 46% when the average shock is 5% of one daily standard deviation and 95% when the average shock is 10% of one daily standard deviation. Thus, the power of the test is reasonably high.

### 3.2.2 Margins and Volatility

Even if margin changes do not have a directional effect on the futures price level, they may still affect the distribution of returns. A particularly important question is whether margins affect volatility, and it has been suggested that margin increases can be used to lower volatility in both stock markets and futures markets. Ferris and Chance (1988) and Goldberg and Hachey (1992) fail to find evidence that margin changes affect volatility in the futures market, whereas Hardouvelis and Kim (1996) find weak evidence that volatility decreases due to mean reversion after margin increases. A large literature looks at the effect of margin requirements on volatility in the stock market, see, e.g., Hardouvelis and Theodossiou (2002) for a recent account, and the evidence here is also mixed.

Analyzing the long-term effect of margins on volatility in the futures market is an intractable problem since margins are set based on volatility, so instead I focus on the short term effects using high-frequency data. Using tick-data, I calculate 5-minute returns and construct the realized variance for a given day as

$$RV_t = \sum_{i=1}^{N} r_{t,i}^2, \tag{10}$$

where $r_{t,i}$ is the $i$'th 5-minute return on day $t$ (see Andersen et al. (2003)).

[Figure 4 about here.]

Figure 4 shows the effect of margin increases on realized variance. The level of realized variance for both groups of contracts is normalized to zero in the −50- to −5-day window prior to the margin increase, such that the plot shows the percentage change in realized variance. Realized variance naturally increases before the margin is raised (the increase in volatility causes the margin increase) and then spikes on the day the margin hike, increasing by more than 50% on average.[18] Further, realized variance stays higher than for the control

[18]The event study is based on 350 margin increases. The probability of randomly picking 350 day-contract

group after the margin increase, and it remains between 50% and 80% higher in the first two weeks after a margin increase than in the period before the margin increase. The fact that realized variance is higher than for the control group after the margin increase could be due to the clearing house correctly anticipating an increase in volatility, and increasing the margin in response to this. However, the large spike in realized variance on the day of the margin increase and the days immediately after clearly suggests that margin increases lead to an increase in volatility in the short term. There is no abnormal change in realized variance around margin decreases.

# 4 Conclusion

The financial crisis of 2007-2009 has resulted in increased focus on speculator behavior and financial constraints. The Dodd-Frank bill gives the CFTC the power to set margin requirements for futures contracts for the first time, and Congress has suggested that the CFTC uses this power to increase margins to drive out speculators and cool down commodity prices. I find that margins have been set systematically by the CME Group based on the volatility of the individual contracts, and that, on average, margins are set as 2.5 times the daily volatility of a given contract. In addition, the exchange also considers contract-specific tail risk.

Margins are important for liquidity, and margin increases result in funding liquidity spillovers where price impact increases for all futures contracts. Further, margin increases are followed by a drop in open interest, and both hedgers and speculators reduce their positions. The drop in open interest held by hedgers coincide with the day of the margin increase, suggesting that margin increases force hedgers to reduce their open positions. Contrary to the view often expressed in the popular press, as well as in Nelson (2011), I fail to find evidence

observations with an average increase in realized variance of 50% or more is 0—it did not happen once in 10,000 random draws.

that margin changes affect futures prices, even when controlling for speculator positions. This is consistent with the finding that speculators hold both long and short positions, and that they do not alter the ratio of long-short positions following margin changes. However, margin increases do affect realized volatility, which increases by about 50% on average on the day of a margin increase.

These findings imply that imposing higher margins drives both hedgers and speculators from the market, adversely affects liquidity and volatility, and that regulation of margins can make trading more costly for all market participants.

# A Margin Setting

Several studies have addressed how futures margins should be set from a theoretical point of view, starting with Figlewski (1984). Figlewski (1984) assumes returns are normally distributed and suggests that the optimal margin level should be set such that the probability of a loss large enough to deplete margin before it is replenished is less than some acceptable level. The simplest setting used by Figlewski (1984) assumes daily returns are normally distributed with mean zero and volatility $\sigma$. For a given target probability of a margin violation $p$, the margin level $M$ satisfies

$$p = P(r_t < M) = \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{M} e^{-\frac{x^2}{2\sigma^2}}\, dx \tag{11}$$

where $r_t$ is the return such that $M/\sigma = \Phi^{-1}(p)$, where $\Phi^{-1}$ is the inverse of the cumulative normal distribution function.

Common to the above studies is that there's a one-to-one relationship between margins and volatility, which comes from the normality assumption. Later studies by Dewachter and Gielens (1999) and Longin (1999) relax the distributional assumptions on the return process and employ extreme value theory to derive the optimal margin level.

# B Commodity Futures and Margin Requirements

When entering a futures contract on an exchange, the clearinghouse for that exchange becomes the legal counterparty to every contract. The purpose of the futures exchange institution is to act as intermediary and minimize the risk of default by either party. Thus the exchange requires both parties to put up an initial amount of cash, the performance bond, which is set by the clearinghouse. Performance bond requirements are good faith deposits to guarantee performance on open positions and are often referred to as "margin." At the end of every trading day (or twice a day on many exchanges), the exchange checks the futures price. For a trader with a long positions, if the value has gone up during the course of the day the exchange credits the counterparty's margin account the amount of that increase; if it has gone down the exchange debits the amount of the decrease. This process is known as marking to market. Whenever the balance exceeds the initial margin level the counterparty has the right to withdraw any excess credit amount above the initial margin from the account. On the other hand, whenever the balance drops below the maintenance margin level, a fixed level that is less than or equal to the initial margin amount, he must bring the balance back up to the initial margin level again. At the expiration of the contract he may close the account and withdraw all remaining funds. Thus on the delivery date, the amount exchanged is not the specified price on the contract but the spot value (since any gain or loss has already been previously settled by marking to market).

Note that the exchange does not necessarily lose money when a daily price move is larger than the margin requirement. If a daily price move is larger than the margin requirement and the amount in a client's margin account does not cover the loss, the client will receive a margin call asking the client to replenish the margin by the following morning. Usually the client simply transfers the amount owed to the exchange, as the client will otherwise default and will not be allowed to continue trading, and the exchange will liquidate the position the next day.

Clearing members to CME Clearing may meet performance bond requirements using a wide variety of collateral (subject to haircuts—that is, a percentage of the market value), including cash (USD and selected foreign currency), U.S. Treasury securities, letters of credit, stocks selected from the S&P 500 index, selected sovereign debt, selected U.S. government agencies and mortgage backed securities, selected money market mutual funds, and physical gold.

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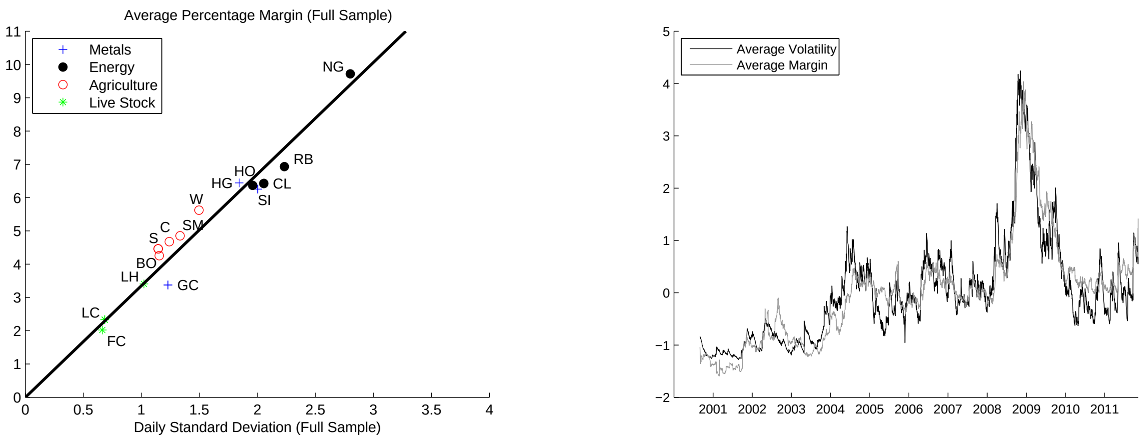


Figure 1: Margins and Volatility

The left plot shows the average percentage margin as a function of the average futures price volatility, both calculated over the full sample period. The right plot shows the average conditional volatility for all contracts together with the average percentage margin, calculated daily. The conditional volatility is estimated individually for each contract using a daily GARCH(1,1) model, and the conditional volatilities are then averaged. Both series are standardized to have mean zero and variance 1.

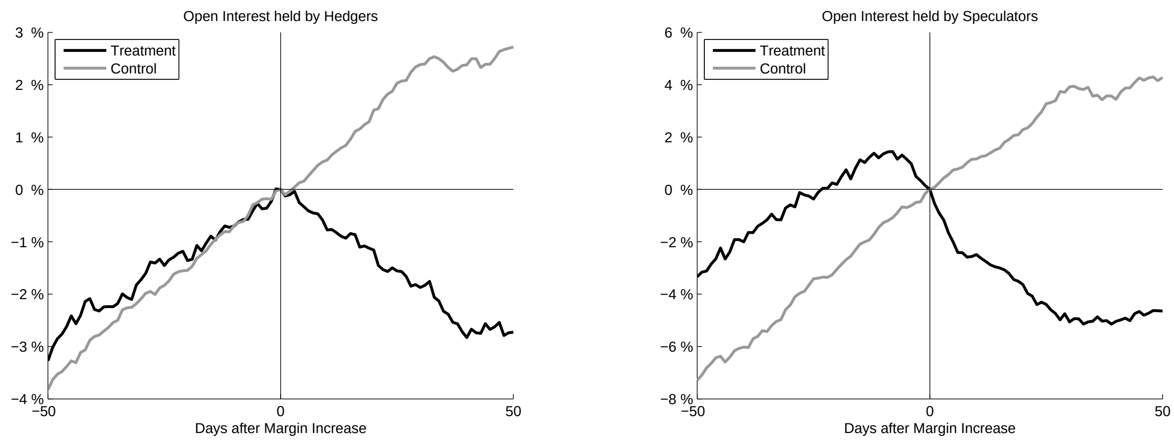


Figure 2: Effect of Margin Increases on Open Interest held by Hedgers and Speculators
The figure uses the percentage change in open interest held by hedgers (left plot) and speculators (right plot). The figure shows event studies, comparing the change in open interest for a "treatment group" of contracts that have their margin increased to a "control group" of contracts that do not have their margin changed. The treatment group consists of all margin increases. The control group is based on contracts that did not have their margin increased 10 days before or after the same day. The event study shows that hedgers reduce their positions in contracts that have their margin increased, and that the reduction in open interest coincides exactly with the margin increase. Speculators reduce their positions before and after the margin increase—however, the dollar value of open interest held by speculators starts declining exactly when margins are increased. Number of observations: 350 margin increases, 3933 in the control group.

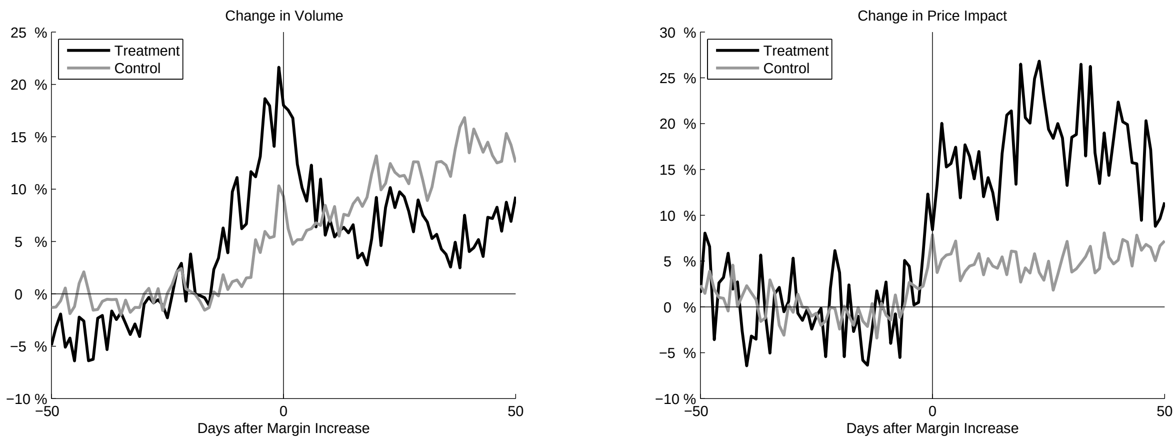


Figure 3: Effect of Margin Increases on Volume and Price Impact

The left plot shows the change in volume around margin increases, normalized to be zero in the window prior to the margin increase. The right plot shows the change in price impact around margin changes, again normalized to be zero in the window prior to the margin increase. The figure shows event studies, comparing the change in volume and price impact for a "treatment group" of contracts that have their margin increased to a "control group" of contracts that do not have their margin changed. The treatment group consists of all margin increases. The control group is based on contracts that did not have their margin increased 10 days before or after the same day. Volume increases over the sample period as seen in the growth for the control group, and for the contracts that have their margin increased volume is abnormally high around the margin increase. For price impact, margin increases are followed by higher price impact for both groups of contracts, but the increase in price impact is higher for the contracts that have their margin increased. Number of observations: 350 margin increases, 3933 in the control group.

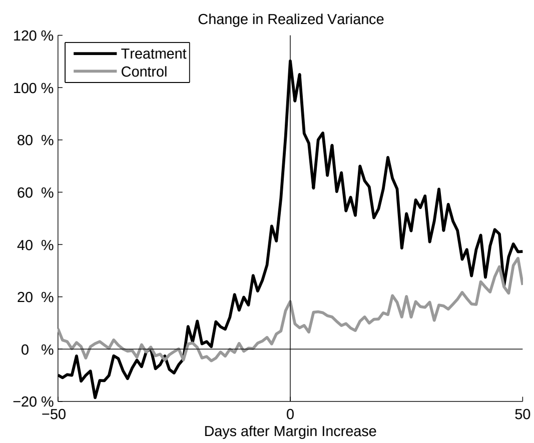


Figure 4: Effect of Margin Increases on Realized Variance

The figure shows changes in realized variance around margin increases. The event study compares the change in realized variance for a "treatment group" of contracts that have their margin increased to a "control group" of contracts that do not have their margin changed. The treatment group consists of all margin increases. The control group is based on contracts that did not have their margin increased 10 days before or after the same day. Realized variance increases before margins are raised, and jumps by about 50% on the day of the margin increase after which it remains higher in the weeks following the margin increase. Number of observations: 350 margin increases, 3933 in the control group.

Table 1: Margin Changes by Contract

| Contract | Avg. Maint. Margin (%) | Changes | Increases/ Decreases | Avg. Days btw. Change | Avg. % Increase | Avg. % Decrease |
|---|---|---|---|---|---|---|
| | | | Metal | | | |
| Gold | 3.3 | 28 | 18/10 | 86 | 24.42 | −16.17 |
| Silver | 6.1 | 38 | 27/11 | 65 | 16.13 | −15.91 |
| Platinum | 5.6 | 22 | 13/9 | 118 | 26.34 | −21.31 |
| Copper | 6.5 | 27 | 18/9 | 96 | 16.13 | −15.91 |
| | | | Energy | | | |
| Crude Oil | 6.4 | 31 | 18/13 | 80 | 15.54 | −13.32 |
| Natural Gas | 9.8 | 72 | 34/38 | 36 | 16.53 | −13.26 |
| RBOB Gasoline | 7.2 | 39 | 24/15 | 50 | 11.12 | −14.43 |
| Heating Oil | 6.4 | 44 | 25/19 | 59 | 14.24 | −13.40 |
| | | | Agriculture | | | |
| Soybeans | 4.5 | 42 | 24/18 | 67 | 19.76 | −16.13 |
| Soybean Meal | 4.8 | 34 | 21/13 | 82 | 22.65 | −21.48 |
| Soybean Oil | 4.3 | 28 | 17/11 | 100 | 21.75 | −19.44 |
| Wheat | 5.3 | 38 | 24/14 | 70 | 23.05 | −20.21 |
| Corn | 4.6 | 39 | 24/15 | 69 | 21.33 | −17.98 |
| | | | Livestock | | | |
| Live Cattle | 2.3 | 43 | 25/18 | 95 | 19.74 | −17.23 |
| Feeder Cattle | 2.0 | 45 | 24/21 | 91 | 23.87 | −16.87 |
| Lean Hogs | 3.4 | 27 | 14/13 | 151 | 16.71 | −11.90 |
| | | | All Sectors | | | |
| All | 5.2 | 597 | 350/247 | 82 | 19.33 | −16.56 |

The table shows the average maintenance margin for each contract as a percentage of the futures price (that is, dollar margin divided by dollar futures price, averaged over the full sample period), the number of margin changes, the number of margin increases and decreases, the average number of days between margin changes, and the average increase and decrease.

Table 2: Determinants of Margins

Dependent Variable: Average Percentage Margin

| | 1 | 2 |
|---|---|---|
| Constant | $-0.38$ | $-0.08$ |
| | (0.65) | (0.60) |
| Standard Deviation | $2.70^{***}$ | $2.74^{***}$ |
| | (0.30) | (0.27) |
| EVA Tail | | $-2.51^{*}$ |
| | | (1.18) |
| $R^2$ | 0.85 | 0.89 |

The table shows the results of regressions of the average percentage margin on explanatory variables:

$$\bar{m}_n^{\%} = \beta' \bar{x}_n + \varepsilon_n, \quad n = 1, \ldots, 16$$

Standard errors are reported in parentheses. For each of the 16 futures contracts analyzed, I calculate the average percentage margin over the sample period and regress that on the average volatility measured by the standard deviation of returns, and the estimated tail parameters of the distribution of extreme returns. Note that a smaller (or more negative) value of the tail parameter indicates fatter tails, such that the tail parameter enters with the correct sign in column 2.

$^{***}$,$^{**}$, and $^{*}$ indicate significance at the 1%, 5%, and 10% levels, respectively.

Table 3: Effect of a 20% Margin Change (±50 Day Event Window)

| | Constant | Margin Change | Control Group | Difference |
|---|---|---|---|---|
| Panel A: Margin Increases—Percentage Change in Dependent Variable | | | | |
| Daily Growth in Open Interest held by Hedgers | −0.05*** | −0.06*** | 0.03** | −0.09*** |
| | (0.01) | (0.02) | (0.01) | (0.02) |
| Daily Growth in Open Interest held by Speculators | −0.04** | −0.12*** | −0.02 | −0.10*** |
| | (0.02) | (0.03) | (0.02) | (0.03) |
| Hedger Pressure | −0.53* | −0.98** | 0.27 | −1.25*** |
| | (0.28) | (0.49) | (0.25) | (0.46) |
| Speculator Pressure | −0.59 | 0.11 | 0.09 | 0.02 |
| | (0.53) | (1.00) | (0.49) | (0.95) |
| Volume | 9.91*** | −1.25 | −0.24 | −1.01 |
| | (1.28) | (2.81) | (1.09) | (2.63) |
| Price Impact | −0.10 | 14.57*** | 5.56** | 9.01*** |
| | (2.07) | (2.59) | (2.19) | (2.38) |
| Panel B: Margin Decreases—Percentage Change in Dependent Variable | | | | |
| Daily Growth in Open Interest held by Hedgers | 0.05** | −0.01 | −0.06** | 0.05 |
| | (0.02) | (0.04) | (0.02) | (0.03) |
| Daily Growth in Open Interest held by Speculators | 0.06* | −0.07 | −0.11*** | 0.04 |
| | (0.03) | (0.06) | (0.04) | (0.05) |
| Hedger Pressure | −0.22 | −0.68 | 0.51 | −1.19 |
| | (0.39) | (0.84) | (0.47) | (0.75) |
| Speculator Pressure | −0.64 | −2.47 | 1.01 | −3.48** |
| | (0.82) | (1.78) | (0.96) | (1.56) |
| Volume | 2.77*** | 4.27** | 2.85*** | 1.41 |
| | (0.85) | (1.95) | (0.91) | (1.75) |
| Price Impact | 1.73 | −5.85** | −1.09 | −4.76* |
| | (1.85) | (2.93) | (1.96) | (2.64) |

The table shows estimates from the event study

$$\Delta y_i = \mu + \alpha \Delta m_i 1_{(\text{Contract has margin increase})} + \beta \Delta m_i 1_{(\text{Control Group})} + \varepsilon_i.$$

Here, $\Delta y_i$ measures the change in the variable of interest, e.g., the change in daily growth in open interest, or the change in volume, from before to after the margin increase. The event window is 50 days before/after the margin increase. The coefficients are scaled to show the effect of a typical 20% margin change (say, from 5% to 6% of the futures price), and White's heteroscedasticity robust standard errors are reported in parentheses. A 20% increase in margin results in a decrease in the daily growth of open interest of −0.09% per day relative to the control group, and an increase in price impact of 9% relative to the control group. There are 350 observations with margin increases and 3,933 observations in the control group for margin increases. There are 247 observations with margin decreases and 2,836 observations in the control group for margin decreases.

***,**, and * indicate significance at the 1%, 5%, and 10% levels, respectively.