How Margins are Set and Affect Asset Prices

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Abstract

I examine how margin requirements are set and affect prices in futures markets. Analyzing a data set covering the margins for 16 commodity futures, I find that the primary factors determining margins are contract-specific price volatility and the overall market volatility as captured by the VIX index. Contract-specific price volatility alone is found to explain 95% of the cross-sectional variation in margins. Furthermore, I find that margins affect liquidity and prices as predicted by theories of financial constraints. High margins reduce volume, increase price impact costs, and decrease open interest. In addition, an increase in the margins of futures in which speculators hold long positions reduces the futures price of long-term contracts.

1 Introduction

Traders must post performance bonds, also known as margin payments, in over-the-counter derivatives markets, repo markets, and futures markets to assure the fulfillment of their contract obligations, as the trading profits and losses are marked to market. Liquidity crises arise when traders hit their margin constraints due to capital shortfall and increased margin requirements. As higher margins tie up capital for banks, broker-dealers, and hedge funds, their ability to intermediate is restricted. A key empirical challenge in investigating the

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effects of margins is that most margin requirements are set in opaque markets in which public data on margins do not exist. The commodity futures market is a unique setting where historical margins are available, allowing a study of how margins are set and how they affect prices.

This analysis is also motivated by the renewed interest in margin setting for commodities, as expressed by both market participants and policy makers: Traders in commodity futures often state that margin increases squeeze out speculators and drive down prices,[1] and members of Congress, concerned that high commodity prices negatively affect the economy, have requested that the U.S. Commodity Futures Trading Commission (CFTC) increase margins on certain commodities to prevent excess speculation and deflate prices (Nelson, 2011). The Dodd–Frank Wall Street Reform and Consumer Protection Act (known as the Dodd–Frank Bill), signed into law on July 21, 2010, gives the CFTC the power to set margin requirements on futures contracts, something that 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.

This paper uses data on margin requirements for 16 commodity futures contracts over the period 2003–2011 to explore empirically how margins are set, and test the existing theories on the implications of changing margin levels. The empirical analysis yields three main results: *i)* Margin requirements are determined by volatility, *ii)* high margins result in low market liquidity, and *iii)* margin changes impact the futures price of long-term contracts. More specifically, my findings are as follows: First, analyzing the determinants of margins, I find that *i.a)* margins are primarily determined by contract-specific volatility, *i.b)* the best fit is achieved using range-based volatility estimators, while other risk measures such as tail exponents have no incremental influence on margins, and *i.c)* market-wide volatility as measured by the VIX index has some additional explanatory power in the time series. Second, analyzing the effect of margins on liquidity, I find that in periods with high margins *ii.a)* volume is lower, *ii.b)* market impact measured by Amihud's illiquidity measure (Amihud, 2002) is higher, and *ii.c)* growth in open interest is lower. Third, analyzing the effects of changes in margin requirements on futures prices, I find that *iii.a)* the futures prices of front-month contracts are not significantly affected by margin changes, but that *iii.b)* the slope of

[1] An example is Joe Cusick, senior market analyst at Chicago-based online brokerage optionsXpress, who stated on May 5th, 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).

the futures curve[2] changes, and the direction of the change depends on whether speculators are long or short in aggregate.

In explaining the average margin requirement over time for a futures contract, I find that the average percentage margin is set as a multiple of the volatility of the particular contract and that the percentage margin requirement is, on average, 2.5 times the daily standard deviation of returns. For instance, gold, which has had an annualized volatility of 21% and thus a daily standard deviation of 1.3%, has had an average percentage margin requirement of $3.4\% \approx 2.5 \times 1.3\%$. Crude oil has had an average volatility of 41%, corresponding to a daily standard deviation of 2.6% and an average percentage margin requirement of $6.4\% \approx 2.5 \times 2.6\%$. Measured by the R^2 of the regression, the average volatility of a contract explains 95% of the variation in the average percentage margin requirements across contracts. I also estimate the margin requirements predicted by extreme value theory, but they do not have any explanatory power beyond volatility. In addition, I show that aggregate volatility measured by the VIX is statistically significant at the 1% level in a multi-variate panel data regression with the daily percentage margin over time.

Turning to my findings on margins and liquidity, higher margins are associated with lower trading volume and higher price impact, controlling for contract-specific volatility and market-wide volatility. When margins increase by 1 percentage point (e.g., 6% instead of 5% of the futures price), weekly volume decreases by 6% of a standard deviation, price impact, as measured by Amihud's illiquidity measure, increases by 4% of a standard deviation, and the growth in open interest decreases by 5% of a standard deviation. All three effects are statistically significant at the 1% level.

Finally, I consider the effect of margin changes on futures prices. Margin changes can impact futures prices due to either selling pressure as traders are forced to reduce their positions or a change in equilibrium returns. As futures contracts are in zero net supply—for every long position, there is an identical short position—these channels require that traders holding long positions are different from traders holding short positions. The prediction that margin changes lower futures prices thus requires that speculators are long and are more constrained than hedgers. In general, there is no reason to believe this should be true. I show that when hedgers are short and speculators long in aggregate, a margin increase

[2]Futures contracts on the same commodity are available with different times to expiry: For example, for gold, it is always possible to trade in contracts for delivery during the current calendar month and the next two calendar months, and contracts exist for select months, up to six years in the future. The contract for the shortest expiry (excluding the current calendar month) is called the front-month contract. The slope of the futures curve is the difference between the futures price of long-term contracts and the futures price of the front-month contract.

decreases the futures price of *long-term* contracts, and vice versa when hedgers are long and speculators short. Again, the results are statistically significant at the 1% level. Margin changes do not seem to significantly impact the futures price of front-month contracts. These findings are consistent with a model in which speculators are more constrained than hedgers, or have a higher shadow cost of capital on their margin requirement.

The economic magnitude of my findings is modest, but that is to be expected. First, margin requirements in futures markets are purposefully set low to not impose unnecessary costs on traders. Second, traders holding long positions are as a group similar to traders holding short positions, and a pricing impact of margin changes only occurs because of a small *difference* in these two groups.

This paper 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, starting with Figlewski (1984). Early research assumed returns are normally distributed, whereas later research has relaxed the distributional assumption on returns and bases the optimal margin level on extreme value analysis.[3] I find that margins on commodity futures are primarily determined by the volatility of the individual contracts and that aggregate volatility measured by the VIX is also important but that tail risk does not help explain margin levels.

Second, this paper is related to a newer literature on the theoretical implications of margins. Brunnermeier and Pedersen (2009) develop a model in which shocks to speculators can cause liquidity spirals and they distinguish between two types of liquidity: market liquidity and funding liquidity. Funding liquidity is the ease with which traders can obtain funding, and market liquidity is the ease with which an asset is traded. The authors show that market liquidity and funding liquidity are linked and that a shock to either can cause 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. Consistent with Brunnermeier and Pedersen (2009), I find that higher margins (lower funding liquidity) are associated with lower market liquidity as measured by trading volume, Amihud's measure of price impact, and growth in open interest. The model also shows how a shock to liquidity or volatility in one market can impact liquidity in other markets (because speculator funding affects all markets), and provides a theoretical foundation for my finding that in the time series the

[3]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.

VIX is important for margin requirements on commodity futures.

Gârleanu and Pedersen (2011) develop a model in which traders have heterogeneous risk aversion and face margin constraints, see also Geanakoplos (1997) and Gromb and Vayanos (2002). The authors show that a security's required return depends on its margin requirement. Higher margin requirements lead to a higher required return, thus providing the theoretical foundation for the idea that margin increases should lower prices. Moreover, futures contracts on the same underlying commodity are traded with different times to expiry and, according to the authors' model, a change in required return should affect the futures price of long-term contracts more than that of short-term contracts, and the *slope* of the futures curve should change, with the direction depending on whether constrained investors are long or short. I show that margin changes do affect the futures prices of long-term contracts and that, controlling for speculator positions, the direction of the change is consistent with speculators being more constrained than hedgers.

Third, contemporaneous research by Dudley and Nimalendran (2011) shows that margin increases on Standard & Poor's 500 futures, USD/JPY currency futures, and Eurodollar futures increase the probability of contagion among hedge funds. My study complements theirs in analyzing a large cross-section of margin requirements for commodity futures and considering the effects on the commodity futures contracts themselves instead of hedge fund returns.

Finally, my paper relates to a number of other studies of the commodity futures market, such as those of Keynes (1927), Bessembinder and Seguin (1993), Hong (2000), Erb and Harvey (2005), Gorton and Rouwenhorst (2006), Acharya et al. (2010), and Hong and Yogo (2011), and studies by the CFTC on excess speculation and price bubbles, such as the Interagency Task Force on Commodity Markets (2008).

In summary, this paper sheds light on how margins have been set in futures markets, documenting that higher margins reduce volume, increase price impact, and decrease open interest, and that margin changes impact the futures price of long-term contracts. These findings provide evidence consistent with recent theories and imply that the regulation of margins can adversely affect liquidity.

The rest of the paper is organized as follows. Section 2 develops the predictions to be tested and links them to existing theory, Section 3 describes the data used for the study, Section 4 considers how margins are set, and Section 5 tests how margins affect liquidity and asset prices. Section 6 concludes the paper. I describe the details of daily settlements in futures markets in Appendix A.

2 Predictions

This section develops the set of predictions to be tested in the remainder of the paper.

2.1 Margin Setting

The theoretical literature on margin setting considers the tradeoffs faced by the exchange when setting margins:[4] If margins are too low, the exchange 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 exchange is unknown, assuming returns are normally distributed, it can be shown that there exists a linear relation between optimal margin levels and volatility, such that the optimal margin–volatility ratio is constant across contracts and across time. See, for example, Figlewski (1984) and Fenn and Kupiec (1993).

Relaxing the distributional assumptions on the return process and employing extreme value theory to derive the optimal margin level, Longin (1999) shows that for a given probability p of a margin violation, the exchange must set the margin M as

$$M = -\beta + \frac{\alpha}{\xi}\big(1 - (-\log(1-p))^{\xi}\big), \tag{1}$$

where β, α, and ξ are, respectively, the position parameter, scale parameter and tail parameter of the distribution of extreme returns. Return distributions with fatter tails have smaller (or more negative) values of the tail parameter ξ, resulting in a higher margin requirement. Similarly, distributions with a higher value of the scale parameter α have higher margin requirements. I estimate the three parameters of the distribution of extreme returns for each contract in my data set, calculate the implied margins, and test whether they help explain the observed margins.

Finally, the model of liquidity spirals in Brunnermeier and Pedersen (2009) predicts that there is commonality in market and funding liquidity across markets and that shocks to one market can propagate to other markets. To test this, I include the VIX as a measure of market-wide volatility and test for the significance of the VIX in a panel data regression.

This leads to the following predictions on margin setting.

[4]Appendix B briefly reviews the theoretical literature on margin setting.

Predictions on Margin Setting:

1.a Margins are linear in contract-specific volatility.

1.b Margins are based on contract-specific tail risk.

1.c Margins are based on aggregate volatility.

These predictions are not mutually exclusive, and each variable can potentially explain part of the variation in observed margins.

2.2 Margins and Liquidity

The model of liquidity spirals in Brunnermeier and Pedersen (2009) predicts that shocks to funding liquidity impact market liquidity. The implication of the model is that unexpected margin increases should be followed by a decrease in market liquidity. This prediction is also consistent with the idea that higher margins are detrimental to trading activity. I thus consider the following

Liquidity Predictions: *High margins are associated with low market liquidity; specifically,*

2.a Volume is lower.

2.b Price impact is higher.

2.c Open interest is lower.

2.3 Margins and Prices

A popular view, often in the media, is that margin changes affect futures prices and that speculation can be curbed by increasing margins. Journalists and traders attribute price changes to recent changes in performance bond requirements; for example,

> "I've seen them kill bubbles many times this way before, and the silver example is certainly very fresh in our minds," said John Kilduff, Founding Partner of Again Capital, referring to the 5 margin hikes in the silver markets in recent weeks, causing silver prices to dive 20 percent, (CNBC, 2011).

This quote expresses a common story: Margin increases force out speculators, which in turn decreases futures prices.

Traders in futures contracts are divided into two broad groups, commonly referred to as 'hedgers' and 'speculators.' The CME Group glossary defines hedgers as 'an individual or firm who uses the futures market to offset price risk when intending to sell or buy the actual commodity,' and speculators as 'an individual who accepts market risk in an attempt to profit from buying and selling futures and/or options contracts by correctly anticipating future price movements.' The logic that margin changes lead to a drop in the futures price critically relies on the implicit assumption that speculators are long and are more constrained than hedgers, and, a priori, there is no reason why speculators should be long in aggregate.

If speculators are indeed long in aggregate, a price impact can be due to either short-term selling pressure or changes in the equilibrium-required returns. 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 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:

$$E(r^i) = r^f + \beta^i \times \text{covariance risk premium} + m^i \times \text{margin premium}, \tag{2}$$

where m^i is the margin requirement on asset i and the margin premium is the investor's shadow cost of capital.

The M-CAPM and possible short-term selling pressure have different implications for short-term versus long-term futures contracts. According to the M-CAPM, a margin increase leads to a given increase in the required return on the asset for which the margin is used. If the asset pays off in one year from the time of the investment, the required *price* change is larger than if the asset pays off in one month. Hence, the equilibrium futures price of short-term contracts should change less than that of long-term contracts, and the *slope* of the futures curve should change. In addition, the futures price of short-term commodity contracts is closely linked to the spot price of the underlying commodity, but for long-term contracts this link is weaker. Thus, long-term contracts should be affected more than short-term contracts by selling pressure. Again, I emphasize that the direction of the change depends on speculators being long or short and speculators being more constrained than hedgers.

This discussion leads me to test the following predictions.

Asset Pricing Predictions:

3.a The futures price of short-term contracts is less affected by margin changes than that of long-term contracts, and thus the slope of the futures curve changes.

3.b The direction of the change depends on net speculator positions.

3 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 live stock contracts, 2003–2011 for agricultural contracts, and 2004–2011 for energy and metal contracts. Table 1 lists the different contracts together with the contract symbol, the size of the contract, the settlement type, and the date of the first margin observation in my data set.

I obtain data on margins from both the CME Group and the CFTC. The data from the CME Group cover metal contracts over 2008–2011, energy contracts over 2008-2011, agriculture contracts over 2003–2011, and live stock contracts over 2000–2011. The data are available directly from the CME Group online.[5] I also obtain data from the CFTC on margins for energy and metals over 2004–2011.[6] For the periods where the two data sets overlap, the margin levels and dates of margin changes are identical. Unfortunately, I have not been able to obtain margins on gold or silver for the period October 2006 to August 2008. I obtain daily data on futures prices, open interest, and volume from Datastream.

The CME Group sets different margins for hedgers and speculators. For hedgers, the initial and maintenance margins are identical. For speculators, the initial margin is higher, and the maintenance margin is the same as the margin for hedgers. My data set contains both initial and maintenance margins for all 16 futures contracts.[7]

When the CME Group changes margins, they do so by issuing an advisory notice, as described in Appendix C. My data on margins are not the actual advisory notices but, rather, historical records of the days of margin changes and the new margin levels. Advisory notices dating back to 2008 are available online and, after matching them to the margin changes in my data set, almost all advisory notices are found to announce the margin change the day prior to the effective date. Hence, when performing event studies to investigate the effect

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

[6]I obtain the data using the Freedom of Information Act.

[7]My findings do not rely on margins being different for hedgers and speculators, but are driven by the *level* of margins and the *changes* in margin requirements.

of margin changes, I assume that margin changes are announced at the close on the day before they take effect. If any margin changes were announced several days prior to their implementation, this would bias *against* me finding any effect of margin changes.

Futures contracts on the same commodity are available with different times to expiry. The contracts are divided into different tiers, depending on the time to expiry, and contracts in different tiers can have different margin requirements. Most often, but not always, the margins for different tiers are changed in lock step, but I do not have data on margins for all tiers for all contracts, or for the specification of different tiers (which varies over time). Hence, my analysis is based on margin changes for front-month contracts. I have data on margins for front-month contracts for all commodities.

I also obtain data on speculator and hedger positions through the Commitments of Traders (COT) report, published weekly by the CFTC and showing the aggregate positions of speculators and hedgers, divided into five categories: producers and merchants, swap dealers, money managers, others, and non-reportables. Producers and merchants as well as swap dealers are hedgers, whereas money managers and others are speculators. An example of a COT report for crude oil is given in Appendix D.

3.1 Margin Levels

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. Figure 1 shows the time series of the maintenance margins for the contracts in my data set. Clearly, the exchange actively manages margins. The CME Group kept the ratio of the maintenance margin to the initial margin fixed over time for all contracts in my data set. For all contracts except platinum, the maintenance margin is always 74.1% of the initial margin. For platinum, the maintenance margin is 90.9% of the initial margin.

3.2 Margin Changes

Figure 2 shows separate histograms of the percentage changes in margins for metal, energy, agricultural, and live-stock contracts. There is a large variation in the magnitude of the changes, from less than 5% to more than 100% in one extreme case (for gold in September

2008). However, most changes are less than 30%.

Table 2 lists the different futures contracts in my data set, the average maintenance margin, the number of margin changes, the number of increases and decreases, the average time between changes, and the average percentage increase and decrease. My data set contains 597 margin changes, of which 350 are increases and 247 are decreases. Margin changes are typically between 15% and 20%, with margin changes for energy contracts being smaller and more frequent than for other sectors.

Margins are changed infrequently. Across all contracts, the average time between margin changes is 82 days. Margins for energy contracts are changed more frequently, with an average time of 56 days between changes.

3.3 Net Speculator Positions

I calculate net speculator positions as

$$\text{SP}_t = \frac{\text{Long Speculator Positions} - \text{Short Speculator Positions}}{\text{Total Open Interest}}. \tag{3}$$

This is a measure of the extent to which speculators are long or short in aggregate. Table 3 shows summary statistics for the net speculator positions for different contracts. For most contracts, speculators are net long in aggregate. However, as seen from the standard deviations, minima, and maxima, net speculator positions fluctuate over time, with speculators sometimes being short in aggregate. The only exception is gasoline for which speculators have always been long.

My measure of net speculator positions is highly correlated with the measure of hedging pressure used by de Roon et al. (2000), which is defined as

$$\frac{\text{Short Hedger Positions} - \text{Long Hedger Positions}}{\text{Short Hedger Positions} + \text{Long Hedger Positions}}, \tag{4}$$

and my results are qualitatively robust to using either measure.

4 How Margins Are Set

This section analyzes the predictions on how margins are set: Margins are *i.a)* linear in contract-specific volatility, *i.b)* based on contract-specific tail risk, *i.c)* based on aggregate volatility. These predictions are not mutually exclusive, and each variable can potentially explain part of the variation in observed margins. To test this, I consider the panel data system

$$m_{n,t} = \beta' x_{n,t} + \varepsilon_{n,t} \qquad n = 1, \ldots, 16,\ t = 1, \ldots, T, \tag{5}$$

where $m_{n,t}$ is the percentage margin, $x_{n,t}$ is a vector of potential explanatory variables, n denotes the particular contract in my data set, and t denotes the day of observation.

As explanatory variables I use measures of volatility and tail risk. Theory predicts that if futures returns are normally distributed, percentage margins should be linear in volatility, and I thus include *i)* realized volatility based on daily returns, and *ii)* realized volatility based on the daily range, $\sqrt{1/(4\log(2))}[\log(\text{Daily High}) - \log(\text{Daily Low})]$, motivated by Parkinson (1980) and Alizadeh et al. (2002). The distribution of futures returns is neither normal nor symmetric but margins are nevertheless the same for short and long positions, and I thus also include *iii)* skewness of returns. Since the CME Group states that they set margins to cover 99% of price moves,[8] I also include *iv)* the 99% quantile of the distribution of absolute returns. Based on extreme value theory, some models propose setting margins according to tail risk, and to test this I include *v)* the margin requirement predicted by extreme value analysis.[9] I am also interested in whether the exchange considers market wide volatility when setting margins, and I thus include *vi)* the VIX.

4.1 Average Margin Requirements

Table 4 shows summary statistics for the 16 contracts, where I average each variable over time: The first column shows the contract name, and the second the average maintenance margin as a percentage of the futures price. The third and fourth columns show the two measures of volatility, annualized assuming 250 trading days in a year. The two measures of volatility (standard deviation of daily returns and volatility based on range) have a correlation of 0.92 across contracts. The data on daily highs and lows for platinum seem stale and thus unreliable, since the values are repeated for extended periods. For this reason, I

[8]According to Kim Taylor, president of CME Clearing, on Open Markets, a blog presented by the CME Group, on May 4, 2011.

[9]I use the extreme value distribution of the extreme absolute returns, since the margins are identical for long and short positions. Parameters of the extreme value distribution are hard to estimate because their value depends on what is defined to be the tail. I estimate the parameters based on the generalized Pareto distribution, and although the specific values of the margins implied by extreme value analysis depend on the threshold used, the *relative* values of the margin requirements across contracts are very stable, which is what matters in the regression analysis.

exclude platinum for every analysis where range is included as an explanatory variable. The average margin is then highest for natural gas, which also has the highest volatility (using both daily returns and daily ranges). Feeder cattle has the lowest average margin, as well as the lowest average volatility. The correlation between the average margin and the standard deviation of returns is 0.92, and the correlation between margins and the range-based measure of volatility is 0.95. The fifth column of Table 4 shows the margin as predicted by the extreme value analysis in, for example, Longin (1999). The correlation between the predicted margin and the average margin is 0.79. The 99%-quantile is highly correlated with volatility (0.97) but only has a correlation of 0.86 with the average margins. There is some variation in skewness, which ranges from −0.89 for soybean meal to 1.28 for natural gas.

To analyze how margins are set on average, I collapse the time dimension in equation (5) by taking the average across all t, resulting in the regression

$$\bar{m}_n = \beta' \bar{x}_n + \nu_n, \quad n = 1, \ldots, 16, \tag{6}$$

where $\bar{m}_n$ is the average percentage margin over the entire sample period, and similarly for $\bar{x}_n$. Averaging over time removes any correlation issues in the panel data set, and the ordinary least squares (OLS) standard errors are consistent.

Table 5 shows the results (with the explanatory variables measured in daily values; that is, volatility is not annualized). I do not include the VIX in this analysis, since this variable is the same for all contracts. Individually, the two measures of volatility are highly significant, and both are significant at the 5% level when combined. The margin level predicted by extreme value analysis is significant on its own but is driven out when combined with the measures of volatility. The 99%-quantile is also significant on its own but, when combined with the other measures of volatility, it enters significantly with the wrong sign, since it is highly co-linear with the volatility measures. Skewness is not significant. Table 5 shows regression results without a constant term. When including a constant the estimate is statistically insignificant and economically unimportant.

The magnitudes of the coefficients are economically sensible: the percentage maintenance margin requirement is, on average, 2.5 times the daily standard deviation of returns. For instance, gold, which has had an annualized volatility of 21% and thus a daily standard deviation of 1.3%, has had an average percentage maintenance margin requirement of $3.4\% \approx 2.5 \times 1.3\%$. Crude oil has had an average volatility of 41%, corresponding to a daily standard deviation of 2.6%, and an average percentage maintenance margin requirement of $6.4\% \approx 2.5 \times 2.6\%$. The range-based measure of volatility has the highest explanatory power and, measured by the adjusted R^2 of the regression, explains 95% of the cross-sectional variation in average margins. The left plot in Figure 3 shows the average percentage margin as a function of the average range-based volatility measure for the commodity futures (platinum excluded), and the right plot shows the average percentage margin as a function of the daily standard deviation. This figure clearly shows the importance of volatility for the average margin. It is also evident that, on average, margins are set the same way for different contracts, which is important to keep in mind when policy makers suggest raising margins on specific commodity futures.

4.2 Margin Setting over Time

Kim Taylor, president of CME Clearing, explains the objective of their margin levels on Open Markets 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. Changes are often made when the volatility environment experiences a sustained change. We mark positions to market twice a day to prevent losses from accumulating over time."

Table 6 shows the percentage of days with margin violations, that is, days where price moves were larger than the margin requirement, using close-to-close price changes (rather than intraday price changes). If the exchange marks to market twice a day, the fraction of settlements with margin violations would be half that shown in the table, provided returns are independent over time. Kim Taylor's statement seems in line with observations: The fraction of days where the initial margin did not cover the price moves is 0.5%, and the fraction of days where the maintenance margin did not cover the price moves is 1.4% There is not much variation over time in the violation rate; however, there is some variation across contracts, especially corn, wheat, and lean hogs having a higher margin violation rate.

Above I show that, on average, over time margins are set as a multiple of the volatility of the individual contracts. For a visual impression of the extend that this is also the case in the time series, Figure 4 shows the maintenance margins as a percentage of the futures price (the top line in each plot), together with the conditional volatility estimate from a GARCH(1,1) model (the bottom line in each plot). The estimation of GARCH(1,1) does not converge for lean hogs, so I use the unconditional volatility. The percentage margins vary a lot over time and are particularly high in 2009 for most commodities. Clearly there is strong co-movement of the percentage margins and volatility.

Figure 5 repeats the plot of average margins as a function of volatility shown in Figure 3, now grouping the observations by year. It shows regression lines relating the percentage margin to volatility, separately for each of the six years from 2006 to 2011, where volatility is the standard deviation of daily returns. The relation between volatility and margins is very stable over time, with the exception of 2009, where the intercept is clearly unusually high.

To more formally investigate how margins are set over time, I consider the original panel data system in equation (5) with daily observations. Since margins are highly persistent, I estimate the system both with and without the lagged margin level on the right-hand side, the latter leading to the system

$$m_{n,t} = \alpha m_{n,t-1} + \beta' x_{n,t-1} + \varepsilon_{n,t} \qquad n = 1, \ldots, 16,\, t = 1, \ldots, T. \tag{7}$$

As explanatory variables I include a GARCH(1,1) estimate of conditional volatility, the 95% quantile of absolute returns over the previous 20 days, and the VIX.

Hardouvelis and Theodossiou (2002), studying how stock market margins influence stock market volatility, consider a similar regression model with margins and volatility, and they determine the analysis should be carried out in levels (rather than changes) as neither the percentage margin nor volatility contains a unit root.[10]

Table 7 shows the results of the panel data regression with contract fixed effects: Panel A does not include m_{t-1} as a regressor, whereas Panel B does. Standard errors are clustered by time and contract using the method described by Cameron et al. (2009). As advocated by Petersen (2009), I perform several robustness checks and confirm that the statistical significance is not changed when clustering by contract or by time alone.[11] All variables are

[10]Hardouvelis and Theodossiou (2002) first argue that the percentage margin cannot contain a unit root because it is bounded by zero and one and thus has a finite variance. They also test for the presence of a unit root in the percentage margin and volatility and reject both tests. The authors conclude that the lack of a unit root in both series suggests that the specification relating the two in levels is the proper one. However, since the variables are highly persistent, the near–unit–root behavior of the percentage margin together with the high persistence of volatility can result in a spurious regression, leading to biased coefficient estimates. Investigating this carefully by bootstrapping methods shows that the bias of the point estimates is neither economically nor statistically significant, but that OLS standard errors are biased due to serial correlation in the residuals or model misspecification.

[11]Mitchell A. Petersen has kindly provided code online for the double-clustering of standard errors. The MATLAB routine I use was written by Ian Gow, Gaizka Ormazabal, and Daniel Taylor and is available online through Petersen's web page. When including fixed effects, I first absorb the means, then calculate clustered standard errors, and finally adjust the standard errors to take into account the (unknown) absorbed means.

measured in percentage points. The contract fixed effects simply demean the variables, and the results in Panel A show that when volatility is 1 percentage point higher than average, the percentage margin is 2.55 percentage points higher than average. This point estimate is very close to the point estimate of 2.53 found when averaging margins and volatility over time. When combining realized volatility with quantiles and the VIX, all three measures are statistically significant at the 1% level.

Turning to Panel B of Table 7, the lagged percentage margin is, of course, highly significant in all specifications since the percentage margin is very persistent. The coefficients in Panel B have a different interpretation from those in Panel A: When including the lagged margin level from the previous day, Panel B addresses what variables lead to *changes* in the percentage margin. The quantitative magnitude of the coefficients is hard to interpret: The coefficient 0.04 on the GARCH estimate of volatility shows that if the measure of conditional volatility increases by 1% from one day to the next, margins increase by 0.04% on average. The qualitative impact is, however, unambiguous: Increases in contract-specific volatility and the VIX are both associated with higher margins.

As robustness checks, I first run the regression with observations averaged by week. In the specification with lagged margins, the point estimates on the explanatory variables increase (except for the coefficient of the lagged margin) as changes become larger on a weekly basis, but the economic and statistical significance remains unchanged.

In summary, this section provides evidence that the main factor determining the percentage margin level is the volatility of the futures prices for the individual contracts and that the relation between margins and volatility has been very stable, except for the year 2009. In the time series, both the volatility of the individual contracts and the VIX have explanatory power for margin changes.

5 How Margins Affect Asset Prices

5.1 How Margins Affect Liquidity

This section investigates the predictions on the impact of margins on liquidity. The predictions are that in periods with high margins *ii.a)* volume is lower, *ii.b)* price impact according to Amihud's measure is higher, and *ii.c)* open interest is lower.

Specifically, I construct the different liquidity measures as follows: First, I use the logarithm of the daily dollar volume traded (the dollar volume is highly skewed). Second, I use Amihud's illiquidity measure as a measure of price impact (Amihud, 2002). Amihud's illiquidity measure is given by the absolute return over the dollar volume: $\text{illiq}^i = \frac{1}{T}\sum_{t=1}^{T}|r_t^i|/(V_t^i \cdot p_t^i)$, where r_t^i is the return on asset i on day t, V_t^i is the trading volume of asset i on day t, and p_t^i is the price of asset i on day t, such that $V_t^i \cdot p_t^i$ is the dollar volume traded. Illiquidity is also highly skewed, and I thus work with $\log(1+\text{illiq}^i)$ ensuring that the transformed values are positive and changes are measured with the correct sign. Finally, I use the growth in the dollar value of open interest. The dollar volume and Amihud's measure are closely related, but Amihud's measure also depends on the size of the absolute returns and thus on volatility. Since margins are set based on volatility, I examine both measures.

To test for the impact of margin levels on liquidity, I estimate the panel data regression

$$y_{n,t} = \alpha m_{n,t} + \beta' x_{n,t} + \varepsilon_{n,t} \qquad n = 1, \ldots, 16,\ t = 1, \ldots, T, \tag{8}$$

where $y_{n,t}$ is the given measure of liquidity, $m_{n,t}$ is the percentage margin, $x_{n,t}$ is a vector of other potential explanatory variables, n denotes the futures contract, and t denotes the day of observation. The previous section shows that margins depend on the volatility of the futures price as well as the VIX, and I thus include a GARCH(1,1) estimate of conditional volatility and the VIX on the right–hand side of equation (8). My interest is in whether higher margins are contemporaneously associated with lower liquidity, and I thus estimate (8) using weekly averages, with contemporary variables on the right–hand side. That is, I estimate the panel

$$\bar{y}_{n,s} = \alpha \bar{m}_{n,s} + \beta' \bar{x}_{n,s} + \nu_{n,s} \qquad n = 1, \ldots, 16, s = 1, \ldots, S, \tag{9}$$

where $\bar{y}_{n,s}$ denotes the average over $y_{n,t}$ for the days t in week s, and similarly for $\bar{m}_{n,s}$ and $\bar{x}_{n,s}$.

The three measures of liquidity all trend over time: Volume and open interest increase dramatically over my sample period, and price impact falls (as volume increases). Furthermore, each series contains some predictable variation due to systematic variation in trading activity over trading cycles. To ensure my results are not spurious, I perform the analysis two ways.

First, I use the percentage changes in each series, measured over weekly intervals (since volume and price impact fluctuate wildly on a day-to-day basis). Since the changes have different volatilities for different contracts, I standardize them by their unconditional volatility for each contract. Since all series have persistent trends, I include five lags of the dependent variable on the right–hand side of the regression (coefficient estimates on the lags are not reported).

Second, I remove any systematic trading cycle variation in the three series by standardizing them as follows: For each contract, I look up the contract months and the last trading day on the CME Group website. Each observation day is assigned an index, describing its distance to the nearest last trading date. For instance, if the contract is traded monthly, different days will get an index between (approximately) -11 and 11. Here, -11 indicates that the day is 11 days prior to the next last trading date, and 11 indicates that the day is 11 days after the previous last trading date. Next, I use a two–year rolling window and standardize each observation using all days with the same index. Finally, to account for time-varying volatility, I standardize each daily observation with the volatility calculated over a ±10–day window, ensuring that the resulting series are homoskedastic with a volatility of one. Thus, if open interest always drops prior to the last trading day, this will not be considered an abnormal innovation after this normalization. The resulting series can be interpreted as the daily abnormal level of volume, abnormal level of pricing impact, and abnormal growth in open interest. I consider weekly averages of these standardized series and normalize the weekly averages to have volatility one. Again, I include five lags of the dependent variable on the right–hand side of the regression (coefficient estimates on the lags are not reported).

Considering the estimation results based on weekly averages of abnormal levels shown in Table 9, Panel A shows how changes in volume are correlated with the margin level. Columns one and two, considering the effects of margin levels and volatility separately, show that higher margins are associated with lower volume, and likewise for higher volatility. However, when including both volatility and margin levels in the third column, the margin level drives out volatility, and only the margin level remains significant. Columns four to six exclude the VIX and include time fixed effects instead. Individually, both higher margins and higher volatility are associated with lower volume. However, when combining the two, higher volatility is associated with *higher* volume, and higher margins are associated with *lower* volume, and both measures are significant at the 1% level. With contract and time fixed effects, the contract fixed effects first remove the average level of volume over time, for each contract. After this normalization, we can think of all contracts as having an average (normalized) level of volume of zero. Volume for a given contract still fluctuates from week to week, and some periods have a positive average volume across all contracts while others have a negative average volume. Including time fixed effects shows that, for a given week, the contracts with higher than average volume are those with lower than average margin requirements, and vice versa. While correlation does not imply causation, it is very plausible that higher margins decrease trading volume, since the cost of trading is higher.

This is consistent with the model of liquidity spirals in Brunnermeier and Pedersen (2009), as well as the tradeoff between higher margins and lower trading activity noted by Figlewski (1984), Gay et al. (1986), and Brennan (1986).

Panel B in Table 8 shows the estimation results with changes in Amihud's illiquidity measure as the dependent variable. With contract and time fixed effect, column six shows that higher volatility is associated with *lower* price impact, and *higher margins increase price impact*. Recall that the absolute return directly enters into the nominator of the Amihud illiquidity measure, such that higher volatility mechanically increases price impact. I find that price impact is *lower* in periods with high volatility, which is due to the increase in volume documented in Panel A. As with volume, the effects are consistent with the theoretical literature mentioned in the above paragraph.

Finally, Panel C in Table 8 shows the estimation results with changes in the dollar value of open interest as the dependent variable. With contract and time fixed effects, higher margins are associated with *lower* growth in the dollar value of open interest. Again, the result that higher margins lead to lower growth in open interest is consistent with the fact that higher margins are costly for traders.

The economic effect of margin levels is small, which is to be expected. Futures markets are extremely liquid, and exchanges set margins to balance the tradeoff between lower counterparty risk and lower liquidity. The results in Table 9 show that 1% higher margins—for example, 6% instead of 5%—are associated with a 6% of one standard deviation drop in volume, a 4% of one standard deviation increase in price impact, and a 5% of one standard deviation decrease in the growth of open interest. All effects are statistically significant at the 1% level.

5.2 How Margins Affect Prices

This section investigates the predictions on the pricing impact of margin increases. The predictions are that *iii.a)* the futures price of short-term contracts is less affected than that of long-term contracts by margin changes, such that the slope of the futures curve changes, and *iii.b)* the direction of the change depends on whether speculators are net long or short in aggregate.

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. The prediction of the M-CAPM is that equilibrium returns are determined as

$$E(r^i) = r^f + \beta^i \times \text{covariance risk premium} + m^i \times \text{margin premium}. \tag{10}$$

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. Luckett (1982) argues that as long as investors are risk averse, they will not borrow infinitely much, even if this were possible. Thus, investors impose a margin constraint on themselves. In my data set, the average margin on futures contracts is about 5% of the price, and thus the margin may not be binding for most investors, such that the shadow cost of capital is zero. Furthermore, as described in Appendix A, traders can post a variety of assets, such as T-Bills and gold, as collateral for margin requirements. If the investor willingly holds these in their 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. If margin posting were costless, or if traders have an adequate credit reputation that allows them to not be required to post margins at all, one can expect traders to move to a forward market thereby avoiding the complications of daily settlements. I show that higher margins have a highly significant impact on volume, price impact, and open interest, clearly showing 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%, thus increasing the margin from 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 stronger.

Finally, holders of long positions must be different from holders of short positions for margin changes to have an impact on the futures price. Table 3 shows the average net speculator positions for the different contracts in my data set, based on weekly COT reports. For most contracts net speculator positions fluctuate around zero over time such that holders of short positions as a group are similar to holders of long positions. In conclusion, I do not expect to find large economic effects of margin changes.

For a given commodity future, the COT report does not show which expiries are held as long positions by hedgers and speculators and which are held as short positions. For instance, although the COT report in Appendix D shows that speculators are long crude oil in aggregate, spread positions account for a large fraction of the open interest held by speculators.[12] In general, there is no way of knowing whether speculators are long short-term oil contracts and short long-term contracts or vice versa, and a change in speculators' required returns would have the opposite prediction for the change in the slope of the futures curve. The CFTC has access to detailed information on hedger and speculator positions, not published in the weekly COT reports. Chief Economist Jeff Harris (2008) of the CFTC, testifying before the U.S. Senate Committee on Energy and Natural Resources, shows that in 2007 speculators in crude oil were in aggregate long most expiration dates of crude oil futures, with the exception of front-month contracts. There is thus reason to believe that speculators are either systematically long or systematically short in aggregate across expiries. If this is not the case for some commodity futures, or for certain periods, this would bias me *against* finding any effects of margin changes.

5.2.1 Effect on Front-Month Prices

This section considers whether margin changes have any effect on the futures price of front-month contracts. Futures prices have time-varying volatility, and to avoid my results being driven by large returns in periods with high volatility, I consider standardized returns from a GARCH(1,1) model. 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

$$r_{t+1} = \varepsilon_{t+1}\sigma_{t+1}, \tag{11}$$

$$\sigma^2_{t+1} = \mu + \alpha r^2_t + \beta\sigma^2_t, \tag{12}$$

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

$$\tilde{r}_t = \frac{r_t}{\hat{\sigma}_t}. \tag{13}$$

The autocorrelation of $\tilde{r}^2_t$ 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

[12]Spread positions are where the trader goes long a futures contract with one expiration date and short another futures contract for the same commodity with another expiration date; that is, the trader is speculating that the slope of the futures curve will change.

set.

I first perform an event study and consider the average change in the futures price of front-month contracts after margin changes. This study does not account for the magnitude of the margin change or for the exact net speculator position at the time of the margin change; it only addresses the question of whether there is, on average, a directional effect of margin increases and decreases. The left column of plots in Figure 6 shows the average cumulative change in the front-month futures price over the first four days after margin increases, considering all contracts together in the top plot and contracts by sector in the plots below. The blue lines show the sum of standardized log-returns, and the red solid and dashed lines show 95% and 99% confidence intervals based on a t-test.[13] Day zero denotes the day of the margin change. There is no evidence of an average change in the futures price after margin increases. Similarly, the right column of plots shows the cumulative change in the futures price after margin decreases. Again, there is no evidence of an average change in the futures price after margin decreases.

In the above event study, I do not account for the size of the margin change or the exact net speculator position at the time of the margin change. The hypothesis that the change in the futures price should depend on the size of the margin change as well as net speculator positions can be formalized by estimating the model

$$\begin{aligned}\tilde{r}_t^i &= \alpha \Delta m_t^i + \beta \mathrm{SP}_t^i + \gamma \Delta m_t^i \times \mathrm{SP}_t^i + \varepsilon_t, \qquad (14)\\ i &= 1, \ldots, 16, \\ t &\in \{\text{Days with margin changes}\},\end{aligned}$$

where $\tilde{r}_t^i$ is the standardized return on day t for commodity i, Δm_t^i is the margin change on day t for commodity i, and SP_t^i is the net speculator position for commodity i on day t. If margin changes matter in combination with net speculator positions, the coefficient γ of the interaction term should be negative and significant, whereas α and β should be insignificant. On some days, several contracts have their margins changed, and the changes

[13] The t-test relies on asymptotic theory, assuming the test statistic converges in distribution as the number of observations increases. I therefore also consider the median change in price, and test whether the median change is zero using a sign test. If prices are equally likely to go up or down (and the price change thus has median zero) and the price changes X_i are assumed to be independent, then the total number of price increases $S = \sum_{i=1}^{n} 1_{(X_i>0)} \sim \mathrm{Bin}(n, 0.5)$. One can now construct confidence intervals based on the binomial distribution and compare these to the actual number of price increases. I also construct confidence intervals by bootstrapping historical returns. The results of the sign tests and bootstrapping confidence intervals are always in line with those of the t-tests.

in futures prices may be correlated across contracts. I therefore cluster standard errors by time. However, on a given day only one or a few contracts have their margins changed, and clustering by contract, or simply using OLS standard errors, does not change the significance of the coefficient estimates.

Table 10 shows the estimation results for the system (14), as well as the results of only including the percentage margin change on the right-hand-side, without interacting it with net speculator positions, and only including the interaction term. Columns 1-3 include all observations for all margin changes (583 observations). None of the coefficients are significant. To avoid that the results are weakened by observations with small margin changes or small net speculator positions, column 4-6 only include margin changes larger than 10% for which net speculator positions were also larger than 10% (272 observations). Again, none of the coefficients are significant. Finally, the effect of margin increases may be different from the effect of margin decreases, since increases may force traders to de-leverage. Columns 7-9 thus only include margin increases, but again, none of the coefficients are significant. I conclude that there is no evidence that margin changes, increases or decreases, affect the front-month futures price in any economically or statistically significant way.

5.2.2 Effect on the Slope of the Futures Curve

I now turn to the impact of margin changes on the slope of the futures curve. Let $P^i_{t,k}$ denote the price at time t of a futures contract on commodity i with expiration k months later. So $P^{\text{Gold}}_{t,12}$ is the price of a 12–month gold futures contract at time t. The futures curve is described by the vector of prices $P^i_{t,1}, P^i_{t,2}, \ldots, P^i_{t,n}$, and the slope is described by the vector of price differences between the long-term contracts and the front-month contract: $s^i_{t,k} = P^i_{t,k} - P^i_{t,1}$. Typically the futures prices of long-term contracts are less volatile than that of the front-month contract. I therefore calculate the β of the returns on long-term contracts with respect to the returns on the front-month contract using my entire sample: Letting $r^i_{t,k}$ be the return on day t of a futures contract on commodity i with expiration k months later, $r^i_{t,k} = P^i_{t,k}/P^i_{t-1,k} - 1$, I estimate β^i_k as $r^i_{t,k} = \beta^i_k r_{t,1} + \varepsilon^i_{t,k}$. The abnormal change in slope is then $\Delta s^i_{t,k} = r^i_{t,k} - \beta^i_k r^i_{t,1}$. For example, I find that the return on the 36–month crude oil contract has a β of 0.43 with respect to the front-month contract, with a standard error of 0.0074. Thus, the abnormal change in the three year slope is $\Delta s^{\text{Crude}}_{t,36} = r^{\text{Crude}}_{t,36} - 0.43 r^{\text{Crude}}_{t,1}$. The volatility of these changes in the slope of the futures curve is time varying, and I hence finally standardize the changes using a GARCH(1,1) model. In the following, I refer to the resulting standardized GARCH residuals as $\Delta \tilde{s}^i_{t,k}$.

I am interested in the standardized changes in slope, $\Delta\tilde{s}^i_{t,k}$, for different expiration dates. The hypothesis is that the futures price of long-term contracts should react more than that of short term contracts to margin changes, and thus $\Delta\tilde{s}^i_{t,24}$ should be larger than $\Delta\tilde{s}^i_{t,12}$ following a margin change and both should be unusually large relative to their conditional volatility. I exclude live-stock contracts (live cattle, feeder cattle, and lean hogs), since futures contracts on live-stock are generally not traded with more than six months' maturity, and I thus have 13 contracts in my analysis. As mentioned above, I base my analysis on margin changes for front-month contracts only. If margins for long-term contracts are not changed at the same time as margins for front-month contracts, this would bias me *against* finding any results of margin changes.

First, I perform an event study considering the average standardized change in the slope of the futures curve on the day of the margin change implementation. Figure 7 shows the average standardized change in slope for maturities varying from six to 48 months: The horizontal axis shows the expiry of the contracts considered and the vertical axis the average standardized change. The average change is shown in blue, and the numbers above the line show the number of observations available for each point of the futures curve. As the expiry increases, the number of observations drops, since not all commodities have long-term futures contracts traded on them. The left column of plots shows the effect of margin increases, and the right column of plots shows the effect of margin decreases. For instance, considering the average effect of a margin increase on all contracts, the slope of the two year point of the curve shows an average change of -0.2 standard deviations, which is based on 215 observations. The dashed and dotted red lines are the 95% and 99% confidence intervals, respectively, based on bootstrapping. The confidence intervals are pointwise by expiry.

Visually, the reaction of the futures curve to margin increases and decreases is clearly different for metals. The point estimates of the changes in slope are all negative after a margin increase, consistent with the fact that, on average, speculators are net long metals.[14] On the contrary, after margin decreases, all point estimates of the changes in slope are positive. For energy contracts, which have, on average, small net speculators positions, there is no abnormal change after margin increases but the slope declines after margin decreases. The effect of margin changes on energy contracts is thus different from the effect on metal contracts, consistent with the observed differences in net speculator positions. For agricultural contracts, the net speculator positions in soybeans, soybean meal, and soybean

[14] The estimates for different expiries are highly correlated, and the fact that they are *all* negative only increases the statistical significance slightly.

oil are positive, on average, and consistent with this finding, the slope declines after margin increases and does not seem to change after margin decreases. Simply aggregating across all sectors, as in the two top plots, reveals no systematic pattern in the change in slope after margin increases or any difference in the reaction to margin increases and decreases, because the net speculator positions are different for different contracts and sectors.

To give a visual impression of the importance of net speculator positions, Figure 8 groups the observations depending on the sign of the margin change and the sign of net speculator positions. If speculators are net long, and the margin is increased, my prediction is that the slope should decline. The prediction is the same if speculators are net short and the margin is decreased. I group these observations, and the solid blue line shows the average change in the slope of the futures curve for these observations. As predicted, the slope declines. On the other hand, if speculators are net short and margins are increased, or if speculators are net long and margins are decreased, the prediction is that the slope of the futures curve should increase. I therefore also group these observations, and the dotted red line shows the average change in the slope of the futures curve for these observations. Although the slope does not seems to increase for these observations, the effect for this group is different from the effect for the first group. As opposed to the top plots in Figure 7, where I did not condition on net speculator positions, Figure 8 shows a clear difference in the change in the slope of the futures curve, depending on whether the margin is increased or decreased, and whether speculators are net long or short.

To formally test for the effect of margin changes and net speculator positions on the slope of the futures curve, I estimate the model

$$\begin{aligned} \Delta\tilde{s}^i_{t,k} &= \alpha m^i_t + \beta \mathrm{SP}^i_t + \gamma m^i_t \times \mathrm{SP}^i_t + \varepsilon_t, \\ i &= 1, \ldots, 13, \\ t &\in \{\text{Days with margin changes}\}, \\ k &= 12, 18, 24, 30, 36, 42, 48, \end{aligned} \tag{15}$$

where $\Delta\tilde{s}^i_{t,k}$ is the standardized change in slope on day t for commodity i with k months to expiry, Δm^i_t is the margin change, and SP^i_t is the net speculator position. As mentioned above, I exclude live-stock because futures contracts on live-stock are generally not traded with more than six months' maturity, and I thus have 13 contracts. I have 174 unique days with margin changes, and consider expiries from 12 to 48 months.

For a given contract on a given day, the changes in slope as measured by different expiries are highly correlated. In addition, on some days, margins are changed for several different contracts, and the change in slope is likely to be correlated across contracts on a given day. For this reason, I cluster standard errors by event date. This way, a cluster contains the different contracts and different expiries that are likely to be highly correlated. I also cluster by event date $\times$ contract, which only allows for correlation across expiries but not across contracts on a given day, but this does not change the statistical significance of the results. Table 11 shows the estimation results for equation (15), only including margin changes for which $|\Delta m_t^i| > 10\%$ and $|\mathrm{SP}_t^i| > 10\%$. I estimate (15) both for the day the new margin requirement takes effect, as well as the day before and the day after. Table 11 shows that on the day the margin change takes effect, the interaction term of margin changes with net speculator positions has a negative and highly significant point estimate, consistent with the predictions. Next, re-estimating the system for the day before the margin change and the day after, none of the coefficients are significant. This provides support for my hypothesis that the change in slope is driven by the margin change, and is not caused by other changes in market conditions such as changes in volatility. It also alleviates concerns that the significant findings on the day of the margin change are a spurious result of the correlation structure of the data. Finally, note that the adjusted R^2 for the regression is 3% on the day of the margin change, 0% on the day before, and 1% on the day after, showing that margin changes and net speculator positions have some explanatory power for the change in the slope of the futures curve on the day of the margin change, but no explanatory power before or after.

The point estimate is $\hat{\alpha} = -4.8$. Hence, a margin increase of 20%, combined with a hedging pressure of 0.4, which is typical for gold and silver, leads to an abnormal change in the slope of the futures curve of $-4.8 \times 0.2 \times .4 \approx 40\%$ of one standard deviation.

In summary, I find no effect on the futures price of front-month contracts after margin changes, but margin changes impact futures prices of long-term contracts such that the slope of the futures curve changes. Simply considering the average change in the slope after margin changes does not reveal any effect, and it is only when accounting for net speculator positions that the effect of margin changes becomes apparent. The economic magnitude is small, which is to be expected as margin changes are small relative to the futures price, and futures markets are a zero net supply market in which the short and long holders are similar.

6 Conclusion

I find that margins are set primarily as a multiple of the volatility of the futures price of the individual contracts, and that market–wide volatility measured by the VIX has some additional explanatory power in the time series. The relationship between margins and volatility has been very stable over time, showing that the exchange actively manages margins in response to changes in volatility. I find that margin levels matter for liquidity, and higher margins are associated with lower trading volume, higher price impact, and a decrease in open interest. Margin changes do not impact the futures price of front-month contracts, but do impact the futures price of long-term contracts. As a result, the slope of the futures curve changes after margin adjustments, and the direction of the change is consistent with a model in which speculators have a higher shadow cost of capital than hedgers. My findings imply that imposing too high margins can adversely affect liquidity, and that regulation of margins can make trading more costly for hedgers.

A Appendix: Commodity Futures and Margin Requirements

A commodity futures contract is a contract between two parties to exchange a specified commodity of standardized quantity and quality for a price agreed today (the 'futures price' or the 'strike price') with delivery occurring at a specified future date, the delivery date. The party agreeing to buy the underlying asset in the future is said to be long, and the party agreeing to sell the asset in the future is said to be short. When the two parties enter into the futures contract, no money exchanges hands, and hence the value of the futures contract is zero. Futures contracts are standardized contracts traded on an exchange. They are derivative contracts, and as such are in zero net supply: that is, when one counterparty enters into a long position in a futures contract there is a second counterparty who simultaneously enters into a short position in the same contract at the same strike price. Neither counterparty knows who the other counterparty is and both counterparties enter a legal agreement with the exchange rather than with each other.

When entering a futures contract on an exchange, the *clearing house* 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 clearing house. 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. 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. 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 which is less than or equal to the initial margin amount, he must bring the balance back up to the initial margin level again. This process is known as marking to market. At the expiry 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).

The design of futures contracts provides traders with exposure to price movements in the underlying commodity without taking on credit risk associated with the counterparty. Consider the issue of counterparty risk to the exchange. Denoting the futures price process by Φ_t, the buyer of a futures contract is obligated to pay the amount $\Phi_t - \Phi_T$ to the exchange over the interval $[t, T]$ as described above, and vice versa for the seller of the contract. Now suppose that the buyer defaults at some time $s < T$ (possibly due to trading activity other than futures trading). As soon as it becomes clear to the exchange that the counterparty is not able to honor his obligations and make his margin payments, the exchange cancels the contract with the buyer and sells the same contract to some other counterparty at the then prevailing futures price Φ_s. This ensures that the exchange will receive the amount $\Phi_s - \Phi_T$ over the interval $[s, T]$ from the new buyer. Also, the exchange has already received $\Phi_t - \Phi_{s-1}$ from the defaulting counterparty, plus the balance in his margin account. Thus, as long as this balance is not smaller than the price change $\Phi_{s-1} - \Phi_s$ (which only happens when a daily loss is larger than the previous day's margin requirement), the exchange suffers no loss. This discussion shows that the exchange has only a small credit exposure to its counterparties, which in turn also means that these counterparties have a small credit exposure to the exchange. As the exchange is taking on very little credit risk and has financial backing by its members, there is very little risk that it would ever default. In the unlikely event that the exchange did default, the exposure of a counterparty is limited to the size of the margin deposited.

Note that the exchange doesn't 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.

Futures exchanges have implemented several measures to guarantee performance on their contracts, as noted by e.g. Figlewski (1984) and Brennan (1986). First, the exchange sets initial and maintenance margin requirements to protect against the default of a counterparty. Second, futures contracts are marked to market on a daily basis, preventing the accumulation of losses (most exchanges reserve the right of marking to market several times a day if necessary). Third, the exchange sets daily price limits and circuit breakers, see Brennan (1986). Finally, every clearing member is obligated to guarantee the contracts entered into by its customers, and must participate in a contingency fund guaranteeing the performance of all contracts traded on the exchange.

Traders who wish to enter into a futures contract must do this through a clearing member, which must be registered as a Futures Commission Merchant with the CFTC if it will clear customer trading activity. Clearing members may obtain clearing privileges for all or a subset of cleared products. Requirements may vary with clearing privileges obtained but generally include risk based capital requirements. Clearing members assume full financial and performance responsibility for all transactions executed through them and all positions they carry. Conversely, as the counterparty to every position, the clearing house is held accountable to the clearing members for the net settlement from all transactions on which it has been substituted. The clearing house typically does not look to individual customers for performance or attempt to evaluate their creditworthiness or market qualifications, but looks solely to the clearing member firm carrying and guaranteeing the account to secure all payments and performance bond obligations. Clearing members may impose more stringent performance bond requirements on their customers than the minimums set by the clearing houses. This does not seem to happen in practice though: At the time of writing it's possible to trade futures contracts through E-Trade subject to the margin requirements set by CME Group.

Although typically positions are marked to market twice a day, the clearing house has the authority to perform additional mark-to-market calculations on open positions and call for immediate payment of settlement variation in times of extreme price volatility. According to CME Clearing, settlement variation payments through CME Clearing averaged $2.2 billion per day through June 30, 2010 and reached a historical record of $18.5 billion on October 13, 2008.[15]

Clearing members to CME Clearing may meet performance bond requirements using a wide variety of collateral (subject to haircuts), 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, bank sponsored cash management program, physical gold.

The term 'margin' means something different for futures than it does for stocks, as noted by e.g. Figlewski (1984). In stocks it means that you're borrowing money from your broker and paying interest to hold a position. In futures, it simply refers to the amount of money you need to have in your account. Margins for stocks are regulated by the Federal Reserve Board because it is a form of credit. In general, under Federal Reserve Board Regulation T (Credit by Brokers and Dealers), firms can lend a customer up to 50 percent of the total purchase price of a stock for new purchases. The rules of FINRA and the exchanges supplement the requirements of Regulation T by placing maintenance margin requirements on customer accounts. Under the rules of FINRA and the exchanges, the customer's equity in the account must not fall below 25 percent of the current market value of the securities in the account. Otherwise, the customer may be required to deposit more funds or securities in order to maintain the equity at the 25 percent level (and not the initial 50 percent level). The failure to do so may cause the firm to force the sale of the securities in the customer's account in order to bring the account's equity back up to the required level. Performance bonds, or margins, for futures have on the other hand not been regulated by authorities: The Commodity Exchange Act (§12a) has specifically prohibited the CFTC from setting the levels of margins. Hence, the clearing house for the exchange has had sovereign power to determine the margins. With the Dodd-Frank Bill this is changing, as the bill authorizes the CFTC to set margin requirements in order to protect investors trading in futures contracts.

B Appendix: Margin Setting

Several papers 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. Gay et al. (1986) empirically test the predictions of the model in Figlewski (1984). Although the exact level of margins depends on unobservable parameters such as the expected

[15] http://www.cmegroup.com/clearing/files/financialsafeguards.pdf

cost of higher margins and the aggregate utility function that the margin committee is attempting to maximize, the model has the empirical implication that margins should be set such that the probability of a margin deficit is equal across time and contracts. Although their results are mixed, they conclude that margin management has been consistent with this hypothesis. The simplest setting in Figlewski (1984) assumes daily returns are normally distributed with mean zero and volatility σ. For a given target probability of a margin violation p, the margin level M satisfies

$$p = P(r_t < M) = \frac{1}{\sqrt{2\pi}\sigma} \int_{-\infty}^{M} e^{-\frac{x^2}{2\sigma^2}}\, dx \tag{16}$$

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

Fenn and Kupiec (1993) use efficient contract design and present a model where both margins and settlement frequency are used to reduce settlement risk. They find that clearinghouses are less active in adjusting margins than the theory would suggest. With a fixed number of settlements per day, their model predicts that the ratio of margin to volatility is constant across time and contracts. However, if the exchange is allowed to perform intraday settlements this partially alleviates the need for higher margins, and the margin to volatility ratio reduces when volatility increases. Empirically, Fenn and Kupiec (1993) consider margins of three stock index futures contracts, and find that clearinghouses generally do not set margins in accordance with the conditions of either model. The models do not make predictions about the *level* of margins, but clearinghouses are less active in altering margin requirements in response to changes in margin conditions than either model predicts.

Letting M_t denote the optimal margin (as a percentage of price), Fenn and Kupiec (1993) show that the optimal margin-volatility ratio is given by

$$\frac{M_t}{\sigma_t} = \sqrt{\tau}\Phi^{-1}\left(1 - \frac{\rho\tau}{\theta}\right) \tag{17}$$

where σ_t is the conditional volatility of the contract, τ is the settlement frequency ($\tau = 1$ for daily settlements, $\tau = 0.5$ for two daily settlements), ρ is a measure of the margin cost per unit of time, and θ is the ex-ante expected cost per unit deficit in the margin account. Φ^{-1} is the inverse of the cumulative normal distribution function. Although ρ and θ are unknown to the econometrician, the prediction of the model is that the margin-volatility ratio is constant across contracts and across time.

Common for the above papers is that there's a one-to-one relationship between margins and volatility, which comes from the normality assumption. Later papers such as 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. Longin (1999) argues that the clearing house only loses money when there is a large futures price change such that the investor's margin account is wiped out, the investor receives a margin call, but does not meet this margin call, and thus only the extreme price movements should matter for margin setting. The beauty of extreme value theory is that different processes of daily price changes lead to the same form of the distribution of extremes: the distributions of extremes for different processes are differentiated by the value of the parameters of the distributions of extremes only. Longin (1999) considers the silver futures contract on COMEX (using data from 1975 to 1994) and shows that, for a given conservative value of the probability of a margin violation, the appropriate margin level obtained under the normality assumption is well below those obtained with the extreme value distribution. Extreme value theory relies on the estimation of a 'tail parameter,' describing the distribution of extreme events, and as the estimation of this parameter requires a long sample period Longin (1999) considers constant (not time-varying) margins. Dewachter and Gielens (1999), also employing extreme value theory, re-estimates the tail parameter using a rolling window and finds that the implied margin for the NYSE composite index is higher and more volatile than the actual historical margin (using data from 1980 to 1990). Cotter (2001) calculates constant margins under both Gaussian assumptions and using extreme value theory, as well as time-varying margins based on a GARCH(1,1) model. Using 12 major European stock index futures contracts, he shows that assuming normality leads to setting margins too low. Broussard (2001) discusses how to estimate the extreme value parameters when considering contract specific price limits. Because price-limits basically sensor extreme price movements, tail observations will occur at a higher probability than those calculated from the empirical distribution.

C Appendix: Advisory Notices

When the CME Group changes margins, they do so by issuing an advisory notice. Kim Taylor, president of CME Clearing, explains on OpenMarkets (a blog presented by the CME Group) on May 4, 2011, how the exchange announces margin changes:

> We typically change margins after a market closes because we have a full view of the market liquidity of that trading day. And, we also provide at least 24 hours notice of margin changes to give market participants time to assess the impact on their position and make arrangements for funding.[16]

The CME publishes announcements on changes in performance bond requirements in their advisory notices which may be found online.[17] As an example of an announcement regarding changes in performance bond requirements, Table C.1 shows part of an advisory notice by the CME on May 4th, 2011, announcing a change in performance bond requirements for silver taking effect after the close on May 5th. For hedgers, the initial and maintenance margins are identical and denoted by 'Hedge/Member.' For speculators, the initial margin is the 'Speculator' margin, and the maintenance margin is the same as the 'Hedge/Member' margin. The advisory notice shown in Table C.1 increases the initial margin on silver from

[16]http://openmarkets.cmegroup.com/clearing/understanding-margin-changes/#utm_source=rss&utm_medium=rss&utm_
margin-changes

[17]www.cmegroup.com/tools-information/advisorySearch.html.

16,200 to 18,900, a 16.67% increase, and increases the maintenance margin from 12,000 to 14,000, also a 16.67% increase.

Futures contracts on the same commodity are available with different times to expiry: For gold, it's always possible to trade in contracts for delivery during the current calendar month and the next two calendar months, and contracts exist for select months up to 6 years in the future. The contracts are divided into different 'tiers' depending on the time to expiry. Most often, but not always, the margins for different tiers are changed in lock-step, but I do not have data on margins for all tiers for all contracts, or for the specification of different tiers (which vary over time). Table C.2 shows an advisory notice changing the contracts in tier 3 and introducing tier 4 for silver and gold futures. As seen in Table C.1 the margin requirements are set to identical amounts for all tiers, but this is not always the case. As mentioned above, I do not have information on margins for all tiers for all contracts, and I also do not have information on which contracts belong to which tiers. Hence, my analysis will be based on margin changes for front-month contracts. There is no selection bias in my data, as I have data on margins for front-month contracts for all commodities, and I treat all futures contracts in the same way in my analysis.

D Appendix: Commitments of Traders

The Commitments of Traders report published weekly by the CFTC shows the aggregate positions of speculators and hedgers, divided into five categories: Producers and Merchants, Swap Dealers, Money managers, Others, and Non-Reportable. Producers and Merchants as well as Swap Dealers are hedgers whereas Money Managers and Others are speculators. Table D.1 shows as an example the COT report for crude oil on September 27, 2011. For Producers/Merchants, the COT report shows long and short open interest, and for the remaining three reportable categories the report shows long positions, short positions and spread positions. Spread positions are positions where the trader goes long a futures contract with one expiration date and short another futures contract in the same commodity with another expiration date, that is, the trader is speculating that the slope of the futures curve will change. Thus, the total long positions are the 'long positions' plus the 'spread positions,' and similarly for the total short positions. The column 'Total' lists the total reportable long and short positions. The total open interest is shown next, and the 'non-reportable' positions are simply calculated as the difference between the total open interest and the reportable long/short positions.

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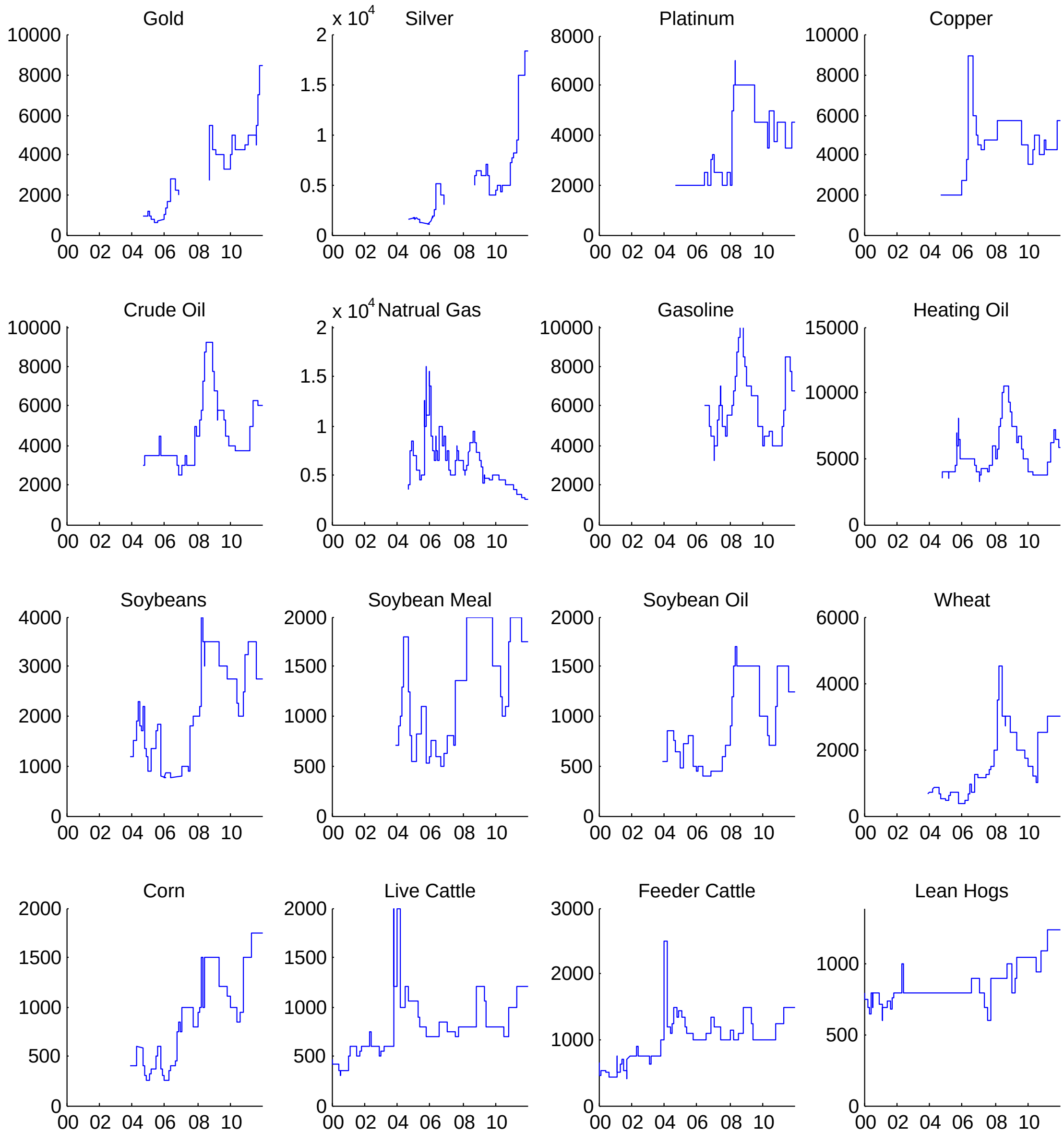

Figure 1
Dollar Maintenance Margin for Each Contract

This figure shows historical maintenance margins in dollars over time for each of the 16 futures contracts in the study data set. The maintenance margin is per contract traded.

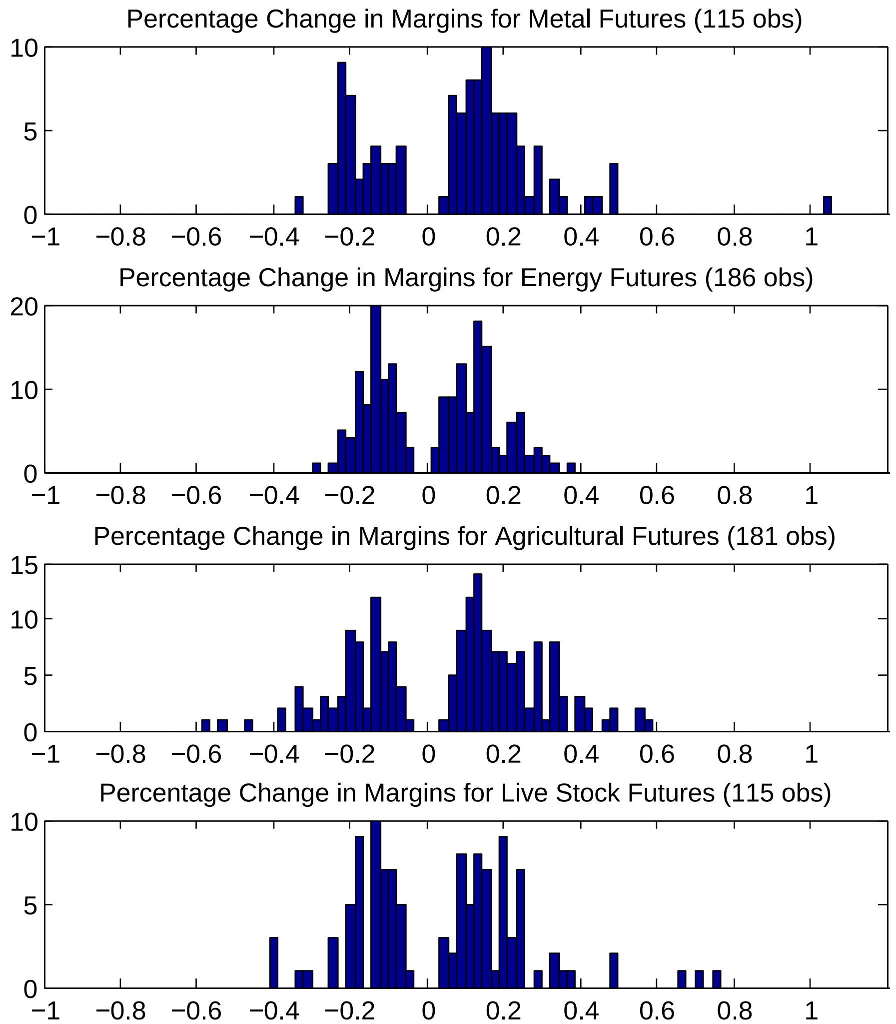

Figure 2
Histogram of Magnitude of Margin Changes
This figure shows histograms of the magnitude of the margin changes in my data set, separately for each sector.

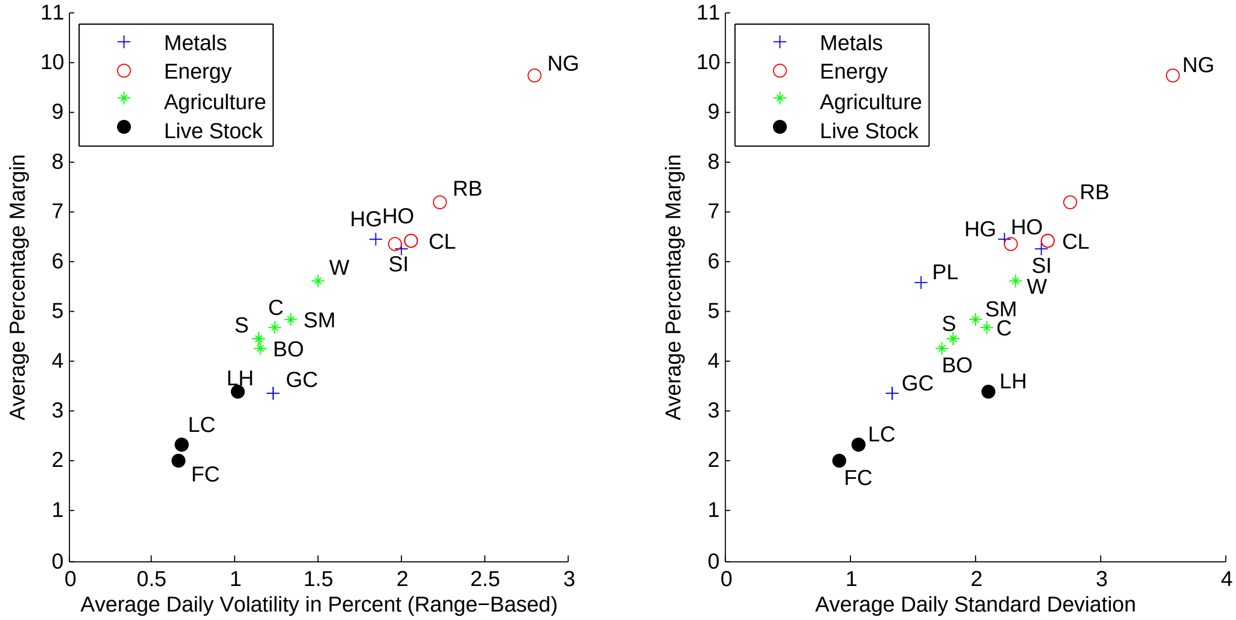

Figure 3
Average Margins and Volatility
The left plot shows the average percentage margin as a function of the range-based measure of the futures price volatility, and the right plot shows the average percentage margin as a function of the average daily futures price volatility. The plots illustrate the high explanatory power of both volatility measures, with the range-based measure the strongest.

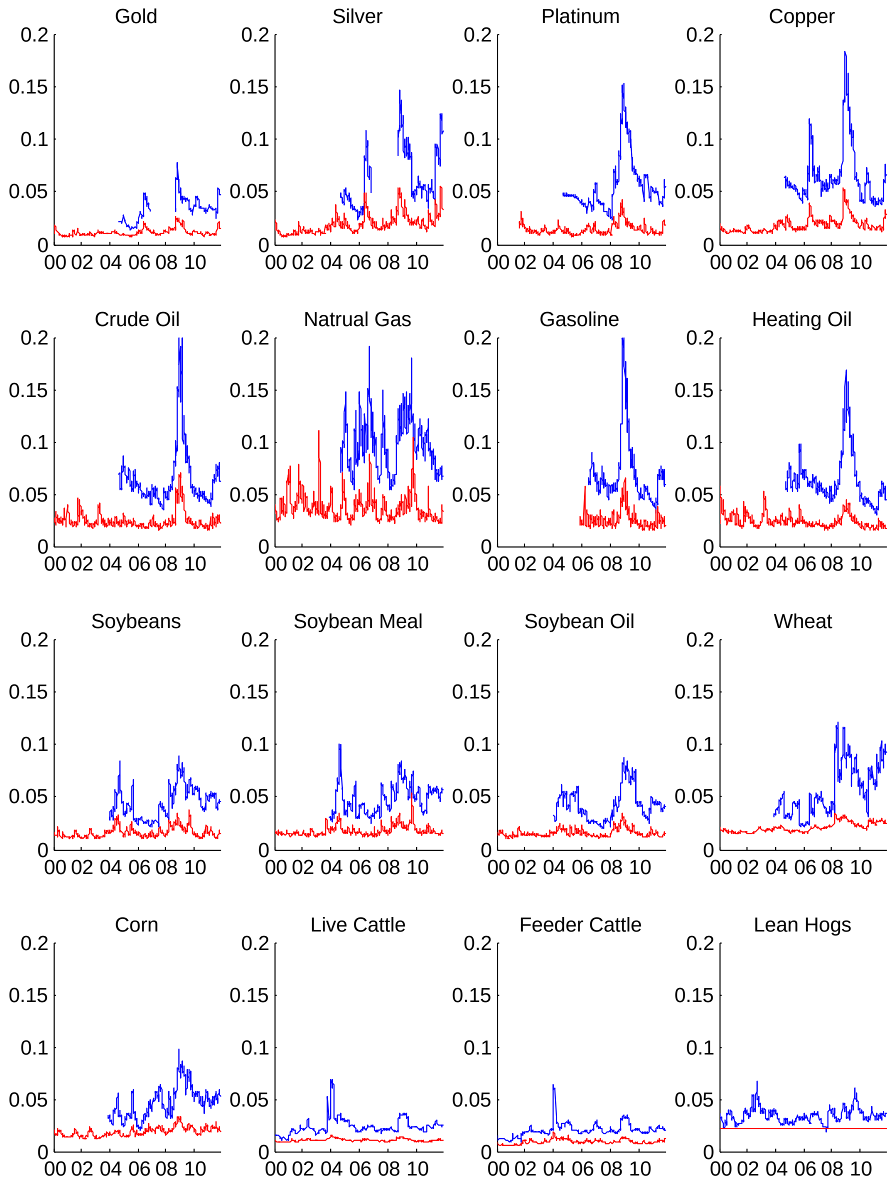

Figure 4

Percentage Maintenance Margins and Volatility for Each Contract

Historical maintenance margins as a percentage of the futures price (top blue line) and conditional volatility estimated by a GARCH(1,1) model (bottom red line) for each of the 16 futures contracts in the data set.

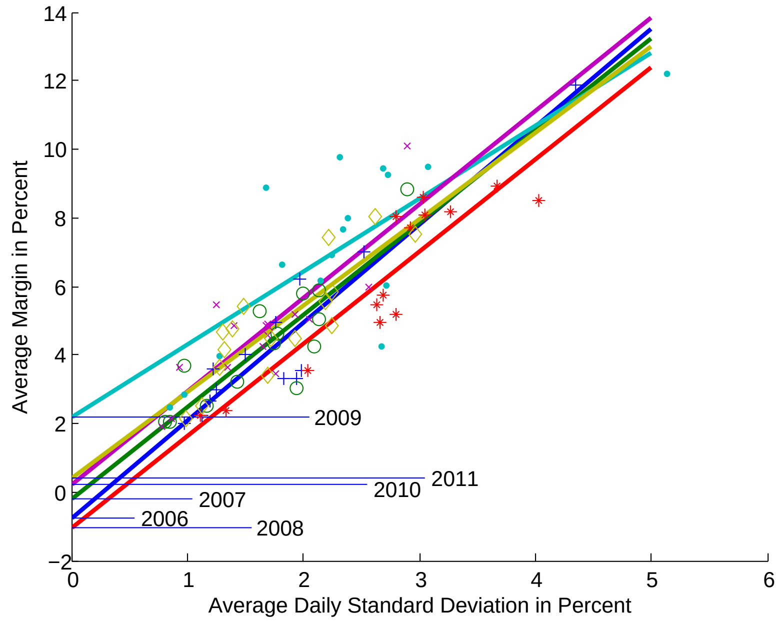

Figure 5
Average Margins and Volatility by Year
This figure shows regression lines relating the average percentage margin to the futures price volatility for each year in my sample.

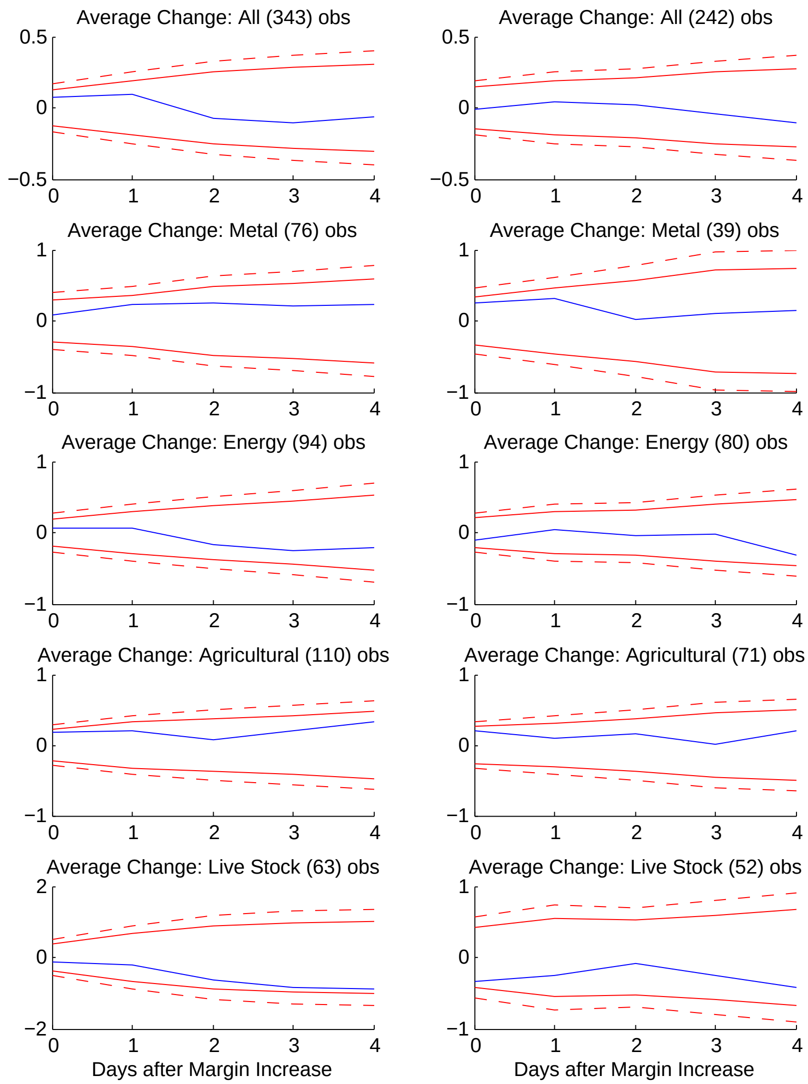

Figure 6
Standardized Changes in Futures Price after Margin Changes
***t*-Test of Zero Average Change**

This figure uses standardized returns of the futures price after margin increases (standardized GARCH(1,1) residuals). The left column of plots shows the average cumulative standardized change after margin increases in blue. The solid and dashed red lines show 95% and 99% confidence intervals based on a *t*-test. The right column of plots shows the average cumulative standardized changes after margin decreases in blue. There is no evidence of abnormal returns on front-month futures contracts following margin changes.

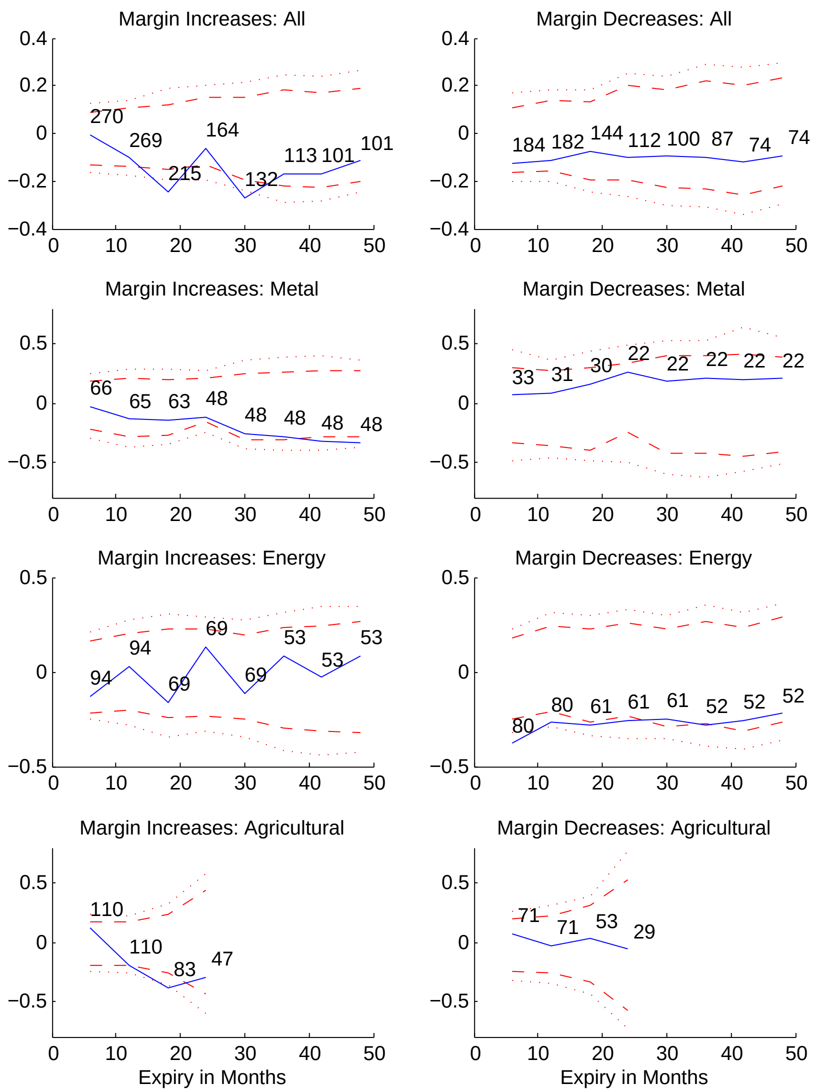

Figure 7
Average Change in Slope of the Futures Curve on Days of Margin Changes
Bootstrapping Tests of Zero Average Change in Slope

This figure uses standardized changes in the slope of the futures curve on the days of margin changes. The horizontal axes show the expiry of the futures contracts in months, and the vertical axes show the average standardized changes in the slope of the futures curve. The left column of plots considers the effect of margin increases, whereas the right column considers the effect of margin decreases. The numbers above the blue line are the number of observations for each point on the futures curve. The dashed and dotted red lines show the 95% and 99% confidence intervals, respectively, based on bootstrapping.

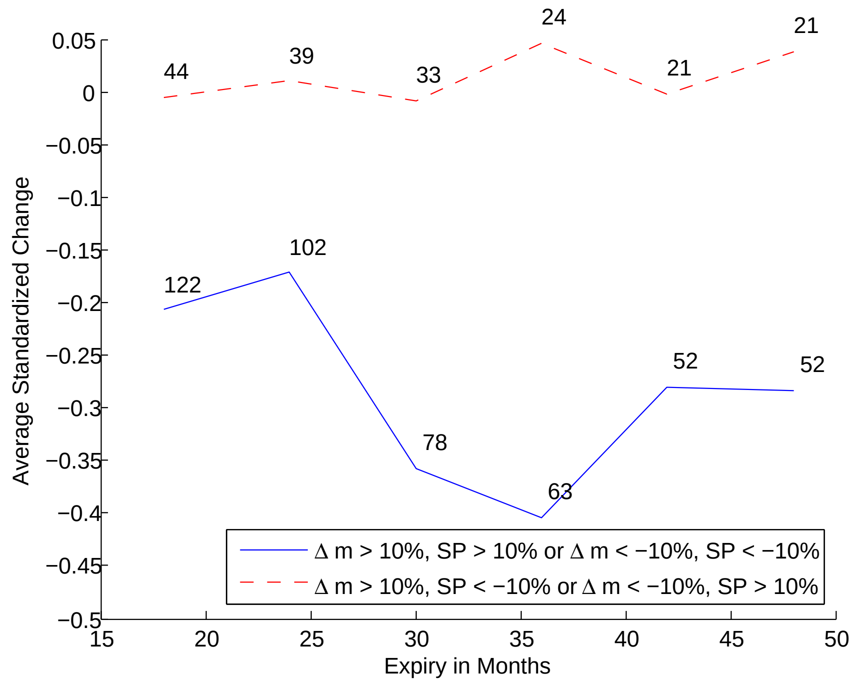

Figure 8
Average Change in Slope of the Futures Curve on Day of Margin Changes, Where The Data are Grouped by Sign of Margin Changes and Sign of Speculator Positions

This figure uses standardized changes in the slope of the futures curve on the day of margin changes. The horizontal axis shows the expiry of the futures contracts in months, and the vertical axis shows the average standardized change in the slope of the futures curve. I consider two groups of observations. In the first, the sign of the margin change is the same as the sign of net speculator positions: This group contains margin increases when speculators are net long, and margin decreases when speculators are net short. The solid blue line shows the average standardized change in the slope for this group. Consistent with my prediction, the slope of the futures curve decreases. The second group contains observations where the sign of the margin change is the opposite of the sign of net speculator positions: This group contains margin increases when speculators are net short, and margin decreases when speculators are net long. For this group, my prediction is that the slope of the futures curve should increase. The dashed red line shows the average standardized change in the slope for this group. The numbers above the lines are the number of observations for each point on the futures curve.

Table 1
Futures Contracts

Contract	Symbol	Size	Settlement	First obs
Gold	GC	100 troy ounces	Physical	01-Sep-2004
Silver	SI	5,000 troy ounces	Physical	01-Sep-2004
Platinum	PL	50 troy ounces	Physical	01-Sep-2004
Copper	HG	25,000 pounds	Physical	01-Sep-2004
Crude Oil	CL	1,000 barrels	Physical	01-Sep-2004
Natural Gas	NG	10,000 mmBtu	Physical	01-Sep-2004
RBOB Gasoline	RB	42,000 gallons	Physical	12-Jun-2006
Heating Oil	HO	42,000 gallons	Physical	24-Sep-2004
Soybeans	S	5,000 bushels	Physical	24-Nov-2003
Soybean Meal	SM	100 short tons	Physical	24-Nov-2003
Soybean Oil	SO	60,000 pounds	Physical	24-Nov-2003
Wheat	W	5,000 bushels	Physical	24-Nov-2003
Corn	C	5,000 bushels	Physical	24-Nov-2003
Live Cattle	LC	40,000 pounds	Physical	01-Jan-2000
Feeder Cattle	FC	50,000 pounds	Cash	01-Jan-2000
Lean Hogs	LH	40,000 pounds	Cash	01-Jan-2000

This table lists the futures contracts in my data set. For each contract, the columns show the contract name, contract symbol, contract size, settlement type, and the date of the first margin change in my data set. Here mmBtu stands for millions of British thermal units (a measure of energy) and, by convention, 1 mmBtu = 28.26 m^3 of natural gas at a defined temperature and pressure. 1 U.S. bushel = 8 corn/dry gallons = 2150.42 cu in. $\approx$ 35.2391 liters, 5,000 bushels of corn is approximately 127 metric tons, and 1 short ton equals 2,000 pounds, so 100 short tons is approximately 91 metric tons.

Table 2
Margin Changes by Contract

Contract	Avg. Maint. Margin (%)	Changes	Increases/ Decreases	Avg. Days btw. Change	Avg. (%) Increase	Avg. (%) Decrease
			Metals			
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
All	5.4	115	76/39	91	20.76	-17.33
			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
All	7.5	186	101/85	56	14.36	-13.60
			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
All	4.7	181	110/71	77	21.71	-19.05
			Live-stock			
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	2.6	115	63/52	112	20.11	-15.33
			All Sectors			
All	5.2	597	350/247	82	19.33	-16.56

This table shows the average maintenance margin for each contract as a percentage of the futures price, 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 3
Net Speculator Positions

Contract	Mean	Std	Min	Max
Gold	0.26	0.20	−0.45	0.51
Silver	0.27	0.13	−0.04	0.57
Platinum	0.42	0.19	−0.21	0.73
Copper	0.04	0.18	−0.32	0.44
Crude Oil	0.03	0.06	−0.17	0.18
Natural Gas	−0.08	0.09	−0.27	0.13
RBOB Gasoline	0.20	0.06	0.03	0.30
Heating Oil	0.05	0.06	−0.13	0.21
Soybeans	0.12	0.14	−0.30	0.35
Soybean Meal	0.13	0.11	−0.24	0.34
Soybean Oil	0.09	0.13	−0.21	0.39
Wheat	−0.01	0.11	−0.29	0.29
Corn	0.11	0.12	−0.18	0.32
Live Cattle	0.13	0.10	−0.13	0.35
Feeder Cattle	0.15	0.14	−0.24	0.42
Lean Hogs	0.06	0.13	−0.28	0.37

This table shows the average net speculator positions for each contract, as well as its standard deviation, minimum, and maximum, based on weekly observations from the COT report. Net speculator positions are defined as

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

Table 4
Average Margins and Potential Explanatory Variables

Contract	Avg. Margin (%)	Annualized Volatility		Tail Risk Margin	Skewness	q_{99} (%)
		Return	Range			
Gold	3.37	21.14	19.44	4.11	0.00	3.74
Silver	6.26	40.13	31.67	7.28	−0.71	7.17
Platinum	5.58	24.91		6.39	−0.57	5.26
Copper	6.44	35.37	29.14	8.81	−0.09	6.52
Crude Oil	6.43	40.85	32.50	8.05	0.33	8.55
Natural Gas	9.72	56.66	44.30	12.99	1.28	11.79
RBOB Gasoline	7.20	43.66	35.30	17.90	−0.05	9.30
Heating Oil	6.37	36.15	30.99	9.27	0.10	7.84
Soybeans	4.46	28.81	18.10	7.72	−0.45	5.36
Soybean Meal	4.85	31.69	21.08	7.40	−0.89	5.82
Soybean Oil	4.26	27.47	18.25	7.29	0.20	5.18
Wheat	5.62	36.88	23.66	9.76	0.28	7.29
Corn	4.68	33.19	19.62	10.19	0.21	6.20
Live Cattle	2.33	16.91	10.82	3.52	0.24	3.59
Feeder Cattle	2.02	14.48	10.49	3.02	−0.28	2.82
Lean Hogs	3.41	33.44	16.16	4.11	0.94	8.72

This table shows summary statistics for the average maintenance margin and potential explanatory variables for each contract. I measure volatility using the standard deviation of daily returns as well as the daily range: $\sqrt{1/(4\log(2))}[\log(\text{Daily High}) - \log(\text{Daily Low})]$. Both volatility measures are annualized, assuming 250 trading days per year. The fifth column shows the percentage margin level based on extreme value theory, targeting a margin violation rate of 1%. The sixth column shows the skewness of returns, and the last column the 99%-quantile of absolute returns as a percentage. The data on daily highs and lows for platinum seem stale and thus unreliable, and I thus omit the range-based volatility measure for platinum.

Table 5
Explanatory Variables for the Average Margin Level

Dependent Variable: Average Percentage Margin

	1	2	3	4	5	6	7
Standard Deviation	2.53^{***}		0.80^{**}			2.65^{***}	2.47^{***}
Range-Based Volatility		3.37^{***}	2.31^{***}			1.91^{***}	1.99^{***}
Tail-Risk Margin				0.61^{***}		0.01	0.03
99%-quantile					0.75^{***}	-0.49^{***}	-0.47^{**}
Skewness							0.17
$\bar{R}^2$	0.84	0.95	0.96	0.41	0.71	0.98	0.98

This table shows the results of regressions of the average percentage margin on explanatory variables. 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, volatility measured by the daily range, the margin level predicted by extreme value analysis, the 99%-quantile of the distribution, and the absolute value of skewness.

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

Table 6
Percentage of Days with Margin Violations

Initial Margins												
Contract	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Gold				0.0	0.4	0.5		1.2	0.4	0.0	0.0	0.3
Silver				0.0	0.0	1.5		0.0	0.0	0.8	0.0	0.4
Platinum				0.0	0.0	0.8	0.0	1.2	0.0	0.0	0.0	0.3
Copper				0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.1
Crude Oil				0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.7	0.2
Natural Gas				3.6	0.4	0.4	0.0	0.0	1.2	0.4	0.0	0.5
RBOB Gasoline								0.0	0.0	0.0	1.4	0.2
Heating Oil				0.0	0.4	0.0	0.0	0.4	0.0	0.0	0.0	0.1
Soybeans			0.0	0.0	1.6	1.2	1.2	0.0	0.0	0.4	0.0	0.6
Soybean Meal			7.7	0.4	0.8	0.4	1.2	0.0	0.0	0.4	0.0	0.5
Soybean Oil			0.0	0.8	0.8	0.4	0.8	0.4	0.0	0.4	0.0	0.5
Wheat			0.0	1.6	2.0	2.4	0.4	0.8	0.0	2.4	0.0	1.3
Corn			0.0	1.6	2.4	2.8	0.4	0.4	0.0	0.8	0.0	1.1
Live Cattle	1.2	1.2	0.0	0.0	0.4	1.2	0.8	1.2	1.2	0.8	1.7	0.9
Feeder Cattle	0.4	0.0	0.4	0.0	0.0	0.8	0.0	0.4	0.4	0.4	0.0	0.3
Lean Hogs	1.2	1.6	1.6	0.0	0.8	0.8	2.4	1.2	1.6	0.8	2.9	1.2
Average	0.9	0.9	1.2	0.5	0.7	0.9	0.6	0.5	0.3	0.5	0.4	0.5
Maintenance Margins												
Contract	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Gold				0.0	2.8	2.3		2.5	0.4	0.4	0.0	1.2
Silver				2.4	1.6	4.5		1.2	1.2	1.2	0.0	1.7
Platinum				0.0	0.0	0.8	0.0	1.6	0.0	0.0	0.0	0.3
Copper				1.2	0.0	0.8	0.0	0.4	0.0	0.4	0.0	0.3
Crude Oil				0.0	0.0	0.4	0.8	1.2	0.0	0.0	2.1	0.5
Natural Gas				3.6	1.6	1.2	0.8	0.0	1.2	0.4	0.0	0.9
RBOB Gasoline								1.2	0.0	0.0	2.1	0.7
Heating Oil				0.0	2.0	0.0	0.0	0.8	0.0	0.4	2.8	0.7
Soybeans			3.8	2.4	3.2	2.0	2.0	1.6	0.4	0.8	0.0	1.7
Soybean Meal			7.7	2.8	4.0	1.2	1.2	0.0	0.0	1.2	0.0	1.5
Soybean Oil			0.0	1.6	2.0	2.8	2.4	2.4	0.4	0.8	0.0	1.6
Wheat			3.8	2.8	2.8	6.4	2.4	2.0	0.0	4.4	0.0	2.9
Corn			0.0	2.0	2.8	4.8	1.6	2.8	0.4	2.4	3.2	2.4
Live Cattle	3.6	2.4	0.8	0.8	0.8	1.6	2.0	1.6	1.2	1.2	3.4	1.9
Feeder Cattle	2.4	0.4	0.4	2.4	0.4	1.2	2.0	1.6	0.4	1.2	0.0	1.3
Lean Hogs	2.4	2.0	2.0	0.4	0.8	2.4	3.6	3.2	2.8	2.4	2.9	2.1
Average	2.8	1.6	2.3	1.5	1.6	2.2	1.4	1.5	0.5	1.1	1.0	1.4

This table shows the percentage of days with a margin violation based on daily close-to-close price changes, for each contract and each year.

Table 7
Determinants of Margins over Time

Dependent Variable: Daily Percentage Margin, Number of Observations = 27243

Panel A: Without m_{t-1}					
σ_{t-1}^{GARCH}	2.55***			2.34***	2.27***
Quantiles_{t-1}		1.12***		0.12***	0.09***
VIX_{t-1}			0.58***		0.21***
$\bar{R}^2$	0.57	0.45	0.11	0.57	0.58
Contract FE	Y	Y	Y	Y	Y
Panel B: With m_{t-1}					
m_{t-1}	0.98***	0.98***	0.99***	0.98***	0.98***
σ_{t-1}^{GARCH}	0.08***			0.07***	0.07***
Quantiles_{t-1}		0.03***		0.00	0.00
VIX_{t-1}			0.01***		0.01**
$\bar{R}^2$	0.99	0.99	0.99	0.99	0.99
Contract FE	Y	Y	Y	Y	Y

This table shows the OLS panel regression of margin levels on potential explanatory variables. The model is

$$m_{n,t} = \beta' x_{n,s} + \varepsilon_{n,t}, \quad n = 1, \ldots, 16,\ t = 1, \ldots, T,$$

where $m_{n,t}$ is the percentage margin for contract n on day t. Standard errors are clustered by contract and time.

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

Table 8
Effect of Margin Levels
Weekly Changes in Raw Series, Number of Observations = 7695

Panel A: Dependent Variable—Percentage Change in Volume						
	1	2	3	4	5	6
σ_t^{GARCH}		−5.47	1.13		−5.01**	−0.15
VIX_t		−1.61	−0.45			
$Margin_t$	−0.03**		−0.03**	−0.02***		−0.02**
$\bar{R}^2$	0.13	0.13	0.13	0.13	0.13	0.13
Time FE	N	N	N	Y	Y	Y
Contract FE	Y	Y	Y	Y	Y	Y

Panel B: Dependent Variable—Percentage Change in Price Impact						
	1	2	3	4	5	6
σ_t^{GARCH}		−7.46***	−12.29***		−8.98***	−12.09***
VIX_t		3.17	2.31			
$Margin_t$	−0.00		0.02	−0.01		0.02
$\bar{R}^2$	0.04	0.04	0.04	0.04	0.04	0.04
Time FE	N	N	N	Y	Y	Y
Contract FE	Y	Y	Y	Y	Y	Y

Panel C: Dependent Variable—Percentage Change in Open Interest						
	1	2	3	4	5	6
σ_t^{GARCH}		0.47	−2.16		2.61	−0.81
VIX_t		−0.95	−1.31			
$Margin_t$	0.00		0.01	0.01**		0.02*
$\bar{R}^2$	−0.00	−0.00	−0.00	−0.00	0.00	−0.00
Time FE	N	N	N	Y	Y	Y
Contract FE	Y	Y	Y	Y	Y	Y

I regress weekly changes in volume, market impact, and open interest on contract-specific volatility, the VIX, and the percentage margin requirements. The regressions shown in columns one to three have contract fixed effects, and the regressions shown in columns four to six have both contract and time fixed effects. Standard errors are clustered by time and contract.

Table 9
Effect of Margin Levels
Weekly Abnormal Levels, Number of Observations = 7711

Panel A: Dependent Variable—Abnormal Level of Volume						
	1	2	3	4	5	6
σ_t^{GARCH}		-6.66^{**}	3.82		-4.59^{**}	6.55^{**}
VIX_t		−2.74	−0.96			
Margin_t	-0.04^{***}		-0.04^{***}	-0.04^{***}		-0.06^{***}
$\bar{R}^2$	0.22	0.22	0.22	0.22	0.22	0.22
Time FE	N	N	N	*Y*	*Y*	*Y*
Contract FE	*Y*	*Y*	*Y*	*Y*	*Y*	*Y*

Panel B: Dependent Variable—Abnormal Level of Price Impact						
	1	2	3	4	5	6
σ_t^{GARCH}		−2.99	-7.69^{**}		−2.09	-9.57^{***}
VIX_t		7.97^{**}	7.13^{*}			
Margin_t	0.01		0.02	0.02		0.04^{***}
$\bar{R}^2$	0.02	0.02	0.02	0.02	0.02	0.02
Time FE	N	N	N	Y	Y	Y
Contract FE	Y	Y	Y	Y	Y	Y

Panel C: Dependent Variable—Abnormal Change in Open Interest						
	1	2	3	4	5	6
σ_t^{GARCH}		1.57	5.74		-6.05^{**}	3.39
VIX_t		-14.38^{***}	-13.63^{***}			
Margin_t	-0.03^{**}		−0.02	-0.04^{***}		-0.05^{***}
$\bar{R}^2$	0.00	0.01	0.01	0.00	0.00	0.00
Time FE	N	N	N	Y	Y	Y
Contract FE	Y	Y	Y	Y	Y	Y

This table uses standardized levels of volume, liquidity, and changes in open interest. Specifically, the daily observations for each series are adjusted for any systematic variation over the trading cycle, as described in the text. I regress weekly abnormal levels of volume, price impact, and weekly abnormal growth in open interest on contract-specific volatility, the VIX, and the percentage margin requirements. The regressions shown in columns 1 to 3 have contract fixed effects, and the regressions shown in column 4 to 6 have both contract and time fixed effects. Standard errors are clustered by time and contract.

Table 10
Effect of Margin Changes on Front-Month Prices

Dependent Variable: Standardized Returns

	All Observations			$\lvert\Delta m_t^i\rvert, \lvert\text{SP}_t^i\rvert > 10\%$			$\Delta m_t^i, \lvert\text{SP}_t^i\rvert > 10\%$		
	1	2	3	4	5	6	7	8	9
Δm_t^i	0.25		0.12	0.38		0.17	0.58		0.28
	[0.68]		[0.25]	[0.99]		[0.32]	[1.27]		[0.35]
SP_t^i			0.20			0.23			−0.33
			[0.63]			[0.68]			[−0.44]
$\Delta m_t^i \times \text{SP}_t^i$		1.27	0.65		1.31	0.50		2.09	2.38
		[0.92]	[0.35]		[0.93]	[0.26]		[1.33]	[0.65]
$\bar{R}^2$	−0.00	−0.00	−0.00	−0.00	−0.00	−0.00	0.00	0.00	−0.01

This table shows the results of regressing the standardized returns on front-months contracts on days with margin changes on the size of the margin change, net speculator positions, and an interaction term of the margin change and net speculator positions:

$$\tilde{r}_t^i = \alpha\Delta m_t^i + \beta\text{SP}_t^i + \gamma\Delta m_t^i \times \text{SP}_t^i + \varepsilon_t, \quad t \in \{\text{Days with margin changes}\},$$

where $\tilde{r}_t^i$ is the standardized return on day t for commodity i, Δm_t^i is the margin change on day t for commodity i, and SP_t^i is the net speculator position for commodity i on day t, defined as (Long Speculator Positions − Short Speculator Positions)/Total Open Interest. If margin changes matter in combination with net speculator positions, the coefficient of the interaction term should be negative and significant, whereas the coefficients of the margin change and net speculator positions should be insignificant. Columns one to three include all margin changes in the regression (583 observations). To avoid the results being clouded by observations with small net speculator positions, in which case margin changes should not impact the futures price, columns four to six only include margin changes larger than 10%, and only changes for which net speculator positions are larger than 10% (272 observations). Margin increases may have a different effect on prices than margin decreases, as investors may hit their margin constraints after margin increases, and columns seven to nine therefore only include margin increases (174 observations). None of the coefficients are statistically significant, and I fail to find evidence that margin changes move the prices of front-month futures contracts.

Table 11
Effect of Margin Changes on the Slope of the Futures Curve (651 Observations)

Dependent Variable: Standardized Change in Slope

	Day Before Change			Day Of Change			Day After Change		
	1	2	3	1	2	3	1	2	3
Const	−0.06	−0.08	−0.04	−0.19	−0.16	−0.26	0.03	0.01	0.09
	[−0.49]	[−0.60]	[−0.22]	[−2.00]	[−1.80]	[−3.35]	[0.43]	[0.13]	[1.20]
Δm_t^i	0.20		−0.18	0.06		0.92	0.31		−0.04
	[0.78]		[−0.24]	[0.21]		[1.91]	[0.49]		[−0.04]
SP_t^i			−0.28			0.67			−0.45
			[−0.96]			[2.18]			[−1.94]
$\Delta m_t^i \times \text{SP}_t^i$		1.27	2.08		−1.20	−4.77		1.66	2.14
		[0.81]	[0.58]		[−2.09]	[−3.45]		[1.10]	[1.18]
$\bar{R}^2$	−0.00	0.00	−0.00	−0.00	0.00	0.03	0.00	0.01	0.01

This table shows the results of the panel data regression

$$\Delta \tilde{s}_{t,k}^i = \alpha \Delta m_t^i + \beta \text{SP}_t^i + \gamma \Delta m_t^i \times \text{SP}_t^i + \varepsilon_t, \quad t \in \{\text{Days with margin changes}\},$$

where $\Delta \tilde{s}_{t,k}^i$ is the standardized change in slope on day t for commodity i, Δm_t^i is the margin change, SP_t^i is the net speculator position, defined as (Long Speculator Positions − Short Speculator Positions)/Total Open Interest, $k = 12, 18, 24, 30, 36, 42, 48$ denotes the expiry of the contract in months, and the t-statistics are shown in brackets, based on standard errors clustered by event date. Economic theory predicts that the effect of margin changes on the slope of the futures curve should depend on net speculator positions, denoted SP in the regression. Consistent with this, the table shows that when margin changes are interacted with net speculator positions, the point estimate is negative and the t-statistic is highly significant. There is no effect on the slope of the futures curve on the days before and after the change is implemented, supporting the hypothesis that the change in the slope of the futures curve is due to the change in margin requirements. The estimations only include observations for which $|\Delta m_t^i| > 10\%$ and $|\text{SP}_t^i| > 10\%$.

Table 12
Effect of Margin Changes on Slope of the Futures Curve (By Expiry)

Dependent Variable: Standardized Change in Slope By Expiy

Expiry	12M	18M	24M	30M	36M	42M	48M
Const	−0.24	−0.19	−0.27	−0.31	−0.35	−0.28	−0.26
	[−2.12]	[−1.66]	[−2.00]	[−1.85]	[−1.85]	[−1.69]	[−1.57]
Δm_t^i	−0.05	0.68	1.60	0.67	0.73	0.82	1.11
	[−0.08]	[1.11]	[1.93]	[0.63]	[0.62]	[0.81]	[1.07]
SP_t^i	0.55	0.45	0.90	0.71	0.82	0.61	0.62
	[1.19]	[0.96]	[1.74]	[1.16]	[1.24]	[1.11]	[1.10]
$\Delta m_t^i \times \text{SP}_t^i$	0.69	−3.82	−6.65	−5.32	−5.10	−3.49	−4.39
	[0.30]	[−1.52]	[−2.05]	[−1.34]	[−1.18]	[−0.96]	[−1.18]
$\bar{R}^2$	−0.01	−0.00	0.03	−0.00	−0.01	−0.02	−0.01
Observations	200	166	141	111	87	73	73

The table shows the results of the panel data regression

$$\Delta \tilde{s}_{t,k}^i = \alpha \Delta m_t^i + \beta \text{SP}_t^i + \gamma \Delta m_t^i \times \text{SP}_t^i + \varepsilon_t, \quad t \in \{\text{Days with margin changes}\},$$

where $\Delta \tilde{s}_{t,k}^i$ is the standardized change in slope on day t for commodity i, Δm_t^i is the margin change, and SP_t^i is the net speculator position, defined as (Long Speculator Positions − Short Speculator Positions)/Total Open Interest, $k = 18, 24, 30, 36, 42, 48$ denotes the expiry of the contract in months, and t-statistics are shown in brackets. Economic theory predicts that the effect of margin changes on the slope of the futures curve should depend on net speculator positions, denoted SP in the regression. Consistent with this, the table shows that when interacting margin changes with net speculator positions, the point estimate is always negative, although only statistically significant for 24M contracts. The estimations only include observations for which $|\Delta m_t^i| > 10\%$ and $|\text{SP}_t^i| > 10\%$.

Table C.1
Advisory Notice from the CME-Group on May 4, 2011

Current Rates as of Wednesday May 04, 2011: New Rates as of Thursday May 05, 2011 COMEX 5000 SILVER FUTURES (SI)								
CC	Rate Type	Description	Change	ISO	Current Initial	Current Maint.	New Initial	New Maint.
SI	Spec	Tier 1	Increase	USD	16,200	12,000	18,900	14,000
SI	Hedge/Member	Tier 1	Increase	USD	12,000	12,000	14,000	14,000
SI	Spec	Tier 2	Increase	USD	16,200	12,000	18,900	14,000
SI	Hedge/Member	Tier 2	Increase	USD	12,000	12,000	14,000	14,000
SI	Spec	Tier 3	Increase	USD	16,200	12,000	18,900	14,000
SI	Hedge/Member	Tier 3	Increase	USD	12,000	12,000	14,000	14,000
SI	Spec	Tier 4	Increase	USD	16,200	12,000	18,900	14,000
SI	Hedge/Member	Tier 4	Increase	USD	12,000	12,000	14,000	14,000

Advisory notice from the CME Group announcing a change in the margin requirements for silver futures contracts. Margins for both speculators and hedgers are changed, and the announcement shows the previous margins as well as the new margins taking effect at the close of the next business day. Source: CME Group

Table C.2
Advisory Notice from the CME-Group on February 3, 2011

The rates will be effective after the close of business on Friday, February 04, 2011.

TIER CHANGES FOR Gold Futures (CX-GC) and Silver Futures (CX-SI)

Tiers	New	Old
3	7th — 12th Nearby	Greater than 6th Nearby
4	Greater than 12th Nearby	

Advisory notice from the CME Group announcing a change in the tiers for gold and silver futures contracts. The definition of tier 3 is changed and a new tier 4 is introduced. The changes take effect at the close of the next business day. Source: CME Group

Table D.1
Commitments of Traders Report for Crude Oil on September 27, 2011

Position	Hedgers		Speculators		Total
	Producers/ Merchants	Swap Dealers	Money Managers	Others	
Long	191,916	223,854	215,424	104,779	735,973
Short	338,417	216,404	73,890	108,627	737,338
Spread		247,471	163,934	168,297	579,702
Total Rept. Long = Long + Spread	191,916	471,325	379,358	273,076	1,315,675
Total Rept. Short = Short + Spread	338,417	463,875	237,824	276,924	1,317,040
Open Interest					1,380,562
Non-Reportable Positions					
Long					64,887
Short					63,522

The table shows the commitment of traders for Crude Oil on September 27, 2011. Reportable traders are classified into Producers and Merchants, Swap Dealers, Money Managers, and Others. For each category, the report lists the long, short and spread positions (there are no spread positions for producers and merchants). Spread positions consist of partly offsetting long and short positions in different expiration dates, and the total long positions are thus the 'long positions' plus the 'spread positions,' and similarly for the total short positions. The column 'Total' lists the total reportable long and short positions. The total open interest is shown next, and the 'non-reportable' positions are simply calculated as the difference between the total open interest and the reportable long/short positions.
Source: CFTC Commitment of Traders Report, Disaggregated Futures Only Report.