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Managing Price Risk in Volatile Grain Markets, Issues and Potential Solutions

Andrew M. McKenzie and Eugene L. Kunda

During 2008 extreme price volatility in grain markets led to country elevators incurring unprecedentedly large margin calls on their futures hedges. As a result elevators' traditional liquidity sources and lines of credit were stretched to breaking point. This article explores the potential liquidity benefits of making available an Over-the-Counter Margin Credit Swap contract to grain hedgers. The swap would enable hedgers to draw upon sources of capital outside the farm credit system to provide liquidity needed to make margin calls. Simulation results clearly show that a Margin Credit Swap contract would provide significant liquidity benefits to hedgers during volatile periods.

Key Words: elevator, hedging, margin, swap

JEL Classifications: G32, G13, Q14

Country elevators have traditionally offset the price risk associated with producer spot and forward cash contracts by hedging grain in the futures market. (Indeed, the Illinois Grain Dealer Act requires hedging to within 5,000 bushels, the futures contract size.[1]) However, extreme price volatility in grain markets has led to elevators' incurring large margin calls on such hedged positions on a daily basis. Hedgers have historically relied on working capital or lines of credit to make margin calls but market conditions over the last year have stretched these liquidity sources to the breaking point, in some cases exceeding 10 times their traditional lines of credit.[2] When a hedger is unable to make a margin call the futures position is liquidated, the hedge no longer exists, and the hedger becomes a speculator in the cash market. Thus the transaction costs and risk levels associated with hedging grain have increased tremendously and as a result, during the summer of 2008, many elevators discontinued the practice of offering producers forward contracts for deferred delivery periods. In practical terms the traditional grain marketing system where producers have historically been able to lock in favorable prices and elevators have been able to profit from basis movements on stored grain has been seriously compromised during 2008.

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[1] Illinois Compiled Statutes, WAREHOUSES (240 ILCS 40/) Grain Code. (See http://www.ilga.gov/legislation/ilcs/ilcs4.asp?DocName=024000400HArt.+10&ActID=1412&ChapAct=240%26nbsp%3BILCS%26nbsp%3B40%2F&ChapterID=27&ChapterName=WAREHOUSES&SectionID=24796&SeqStart=1800000&SeqEnd=2400000&ActName=Grain+Code.)

[2] Lauren Etter and Scott Patterson, *Grain Elevators Caught Between Farm Boom, Credit Crunch* (Wall Street Journal, March 27, 2008), A12. (See http://online.wsj.com/article/SB120658304120967539.html#articleTabs%3Darticle (1).)

This paper provides an explanation of elevator risk management and marketing problems related to increased margin risk, and seeks to offer potential solutions. In particular, we explore the potential liquidity benefits of an Over-the-Counter (OTC) financial instrument—a Margin Credit Swap (MCS)—which is currently being developed by the Merchants' Exchange. The MCS is designed to provide a hedger with a source of capital to make margin calls. The MCS does not transfer ownership or interest in any enumerated commodity; nor is it a price discovery or risk management tool; rather, the MCS is a financing tool that enables hedgers to draw on sources of capital outside the farm credit system to provide liquidity needed to make margin calls. The MCS is a bilaterally negotiated OTC contract between commercial counterparties. Hedgers are swap buyers and liquidity providers are swap sellers. The price of the swap corresponds to (mirrors) the position the hedger takes in the relevant futures market ("the Reference Contract") in order to offset (hedge) a forward purchase of grain. Negotiations are conducted privately, and terms to be negotiated include the initial price for the transaction (Initial Settlement Price); the duration of the transaction; identification of the underlying Reference Contract; directionality of interest payments (uni– or bidirectional); and an interest rate. The directionality of the interest payments depend on whether the interest payments are "bi-directional," i.e., both sides of the MCS will pay for margin credit or "uni-directional," i.e., only one side of the MCS makes interest payments (the hedger). The interest rate represents the return for supplying margin credit. The hedger's position in the MCS is opposite to the position the hedger takes in the Reference Contract so that variation margin payments/collections in the Reference Contract are offset with the variation margin collections/payments in the MCS. On a daily basis, the holder of a positive account balance in the MCS (the hedger) pays the holder of a negative account balance in the MCS (the liquidity provider) an interest payment equal to the interest rate times the margin credit offered. At expiration the party with a positive account balance (the hedger) returns the margin to the party with a negative balance (the liquidity provider). MCS instruments inherently contain various counterparty risks. For example, elevators are exposed to credit provider default risk, and to farmer default risk resulting from production failure. From the credit providers' perspective, counterparty risk takes the form of elevators potentially defaulting on their MCS payments. The mechanics of executing, maintaining, and liquidating an MCS from the perspectives of all agents—farmer, elevator, consumer, broker, exchange, clearing member of exchange, and swap counterparty or credit provider—who are directly or indirectly involved in the transaction are explained in Figures 1–3. Figure 1 illustrates how an elevator initially forward contracting with a farmer for harvest delivery at $6.00/bushel, at a basis level of $0.30/bushel, enters into a hedge in the futures market of the Reference Contract at $6.30/bushel and simultaneously purchases a corresponding MCS contract at $6.30/bushel (Initial Settlement Price)[3] through a broker. Then, Figure 2 shows how the MCS contract would be maintained if price subsequently rises to $6.50, invoking a $0.20 margin call on the short hedge and a $0.20 margin collect on the long MCS. Finally, Figure 3 demonstrates how the MCS contract would be liquidated after a cash sale has been made. The futures hedge is offset or otherwise liquidated with an Exchange for Futures at the current futures price of the Reference Contract and the MCS is settled at the original Initial Settlement Price.

Our paper presents a simulation analysis to (1) highlight the greater liquidity demands placed on country elevators during the 2006–2008 bull

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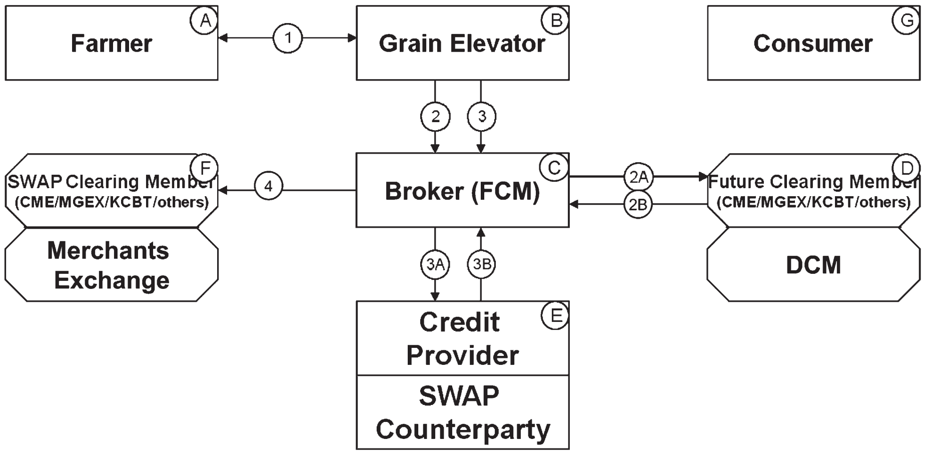
[3] The Initial Settlement Price is an individually negotiated term of the MCS and may be at any price, not necessarily at the same price as the hedge in the Reference Contract. For a short hedger, a lower Initial Settlement Price would provide additional credit for meeting the initial margin requirement. An Initial Settlement Price above the hedged price would not provide margin credit to the hedger until the Daily Settlement Price of the Reference Contract is above the MCS Initial Settlement Price. The MCS would serve as a contingent line of credit in effect only when prices reach a predetermined level.



① **Forward contract** between A+B @ $ 6.00/bu

② **Hedge:** B sells Dec08 Contract @ $ 6.30/bu
- ***2A**: C order to sell Dec08 Contract @ $ 6.30/bu*
- ***2B**: D fills Dec08 Contract @ $ 6.30/bu*

③ **SWAP:** B buys MCS @ $ 6.30/bu
-**3A**: *C order to buy MCS @ $ 6.30/bu*
-**3B**: *E fill MCS @ $ 6.30/bu*

④ **Open position** MCS @ $ 6.30/bu

Figure 1. Executing the Swap

commodity market, and (2) evaluate the differences in elevator (hedger) liquidity demands from using an MCS versus simply holding a futures margin account—in the traditional sense—without an MCS. Specifically, we examine the issue of liquidity from the perspective of a representative country elevator that forward contracts corn from farmers at planting time (April 1), with the expectation of receiving the crop at harvest time each year (December 1). We assume the elevator will hedge his forward contracted new crop cash bushel obligations by selling an equal number of December corn futures bushels on April 1. By opening this futures position the elevator manages its price risk and establishes a harvest–time buy basis for its new crop purchases. However, to effectively implement the hedge the short-futures position must be held open until December 1 (a period of approximately 170 days), thus exposing the elevator to potentially large daily margin calls when prices increase.

Simulation Approach

Daily sequences of new crop December corn futures prices are simulated for hypothetical crop years beginning April 1 and ending December 1. Two simulations analyses are conducted based upon historical corn futures prices observed during the 1996–2005 and 2006–2008 periods. The first period is considered to represent a period of "normal" price volatility, while 2006–2008 bull market is chosen to capture the period of unprecedented high volatility.

Daily futures price changes are assumed to follow Geometric Brownian Motion and to be log-normally distributed, as in the Black-Scholes and Merton model. So we can write the discrete sequence of daily futures prices as:

$$(1) \qquad \ln FP_{t+\Delta t} = \ln FP_t + \left(\mu - \frac{\sigma^2}{2}\right)\Delta t + \sigma\sqrt{\Delta t}\varepsilon,$$

where ln $FP_{t+\Delta t}$ is the natural logarithm of the December new crop corn futures settlement prices observed in a sequence of daily increments (Δt). The term $(\mu - \sigma^2/2)\Delta t$ is the mean change in daily futures prices, the term $\sigma\sqrt{\Delta t}$ is the standard deviation of daily futures price changes, and ε is a random drawing from the standard normal distribution with a mean of zero and a standard deviation equal to one.

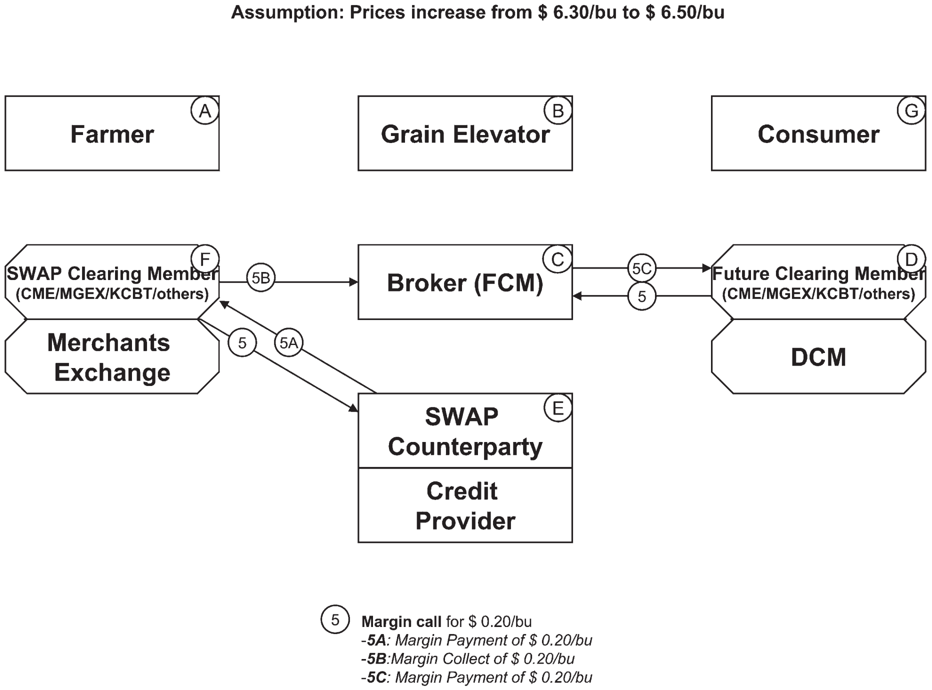

Assumption: Prices increase from $ 6.30/bu to $ 6.50/bu
Farmer
A
Grain Elevator
B
Consumer
G
SWAP Clearing Member (CME/MGEX/KCBT/others)
F
Merchants Exchange
5B
Broker (FCM)
C
5C
5
Future Clearing Member (CME/MGEX/KCBT/others)
D
DCM
5
5A
SWAP Counterparty
E
Credit Provider
5 Margin call for $ 0.20/bu
-5A: Margin Payment of $ 0.20/bu
-5B: Margin Collect of $ 0.20/bu
-5C: Margin Payment of $ 0.20/bu

Figure 2. Maintaining the Swap

In this paper we further assume futures prices adhere to Efficient Markets Hypothesis (EMH). The EMH implies that current futures price FP_t will equal expected futures price at contract maturity (McKenzie and Holt, 2002; McKenzie et al., 2002). In this case the expected return from holding a futures contract until maturity, μ, will be zero, and Equation (1) reduces to:

$$\ln FP_{t+\Delta t} = \ln FP_t - \frac{\sigma^2}{2}\Delta t + \sigma\sqrt{\Delta t}\varepsilon. \tag{2}$$

To implement the simulations σ, the expected volatility per annum is estimated from the sample standard deviation of daily percentage futures price changes observed between April 1–December 1 for each year in our two historical periods, and where daily percentage futures price changes are defined as: $\ln((FP_t)/FP_{t-1})$.[4] When price limit moves occurred, the percentage price change was calculated using either the opening or closing futures price on the first nonlimit day. We estimate σ to be 23% for the 1996–2005 period, based upon 1,704 daily observations. In contrast, and as expected, σ is estimated to be much higher (30%) for the 2006–2008 period, based upon 376 daily observations.[5] For each of the two simulations, 100 price sequence iterations, yielding 170 consecutive days of prices for each iteration, are generated by drawing a random number, ε, from the unit normal distribution. Simulated futures prices were not restricted by daily price limits, and the largest simulated daily price change in absolute terms was 36 cents per bushel. This price, which was generated assuming 30% volatility, exceeds the current daily price limit of 30 cents per bushel imposed on corn futures market by the Chicago Board of Trade. Only 0.04% of all simulated prices exceeded the 30 cents limit. The first price ($\ln FP_t$), used in each iterative sequence,

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[4] An anonymous reviewer noted that an alternative to estimating volatilities based upon historical daily prices would be to use implied volatilities inferred from options markets.

[5] December corn futures prices used in the study span the period April 1 through May 19 for 2008.

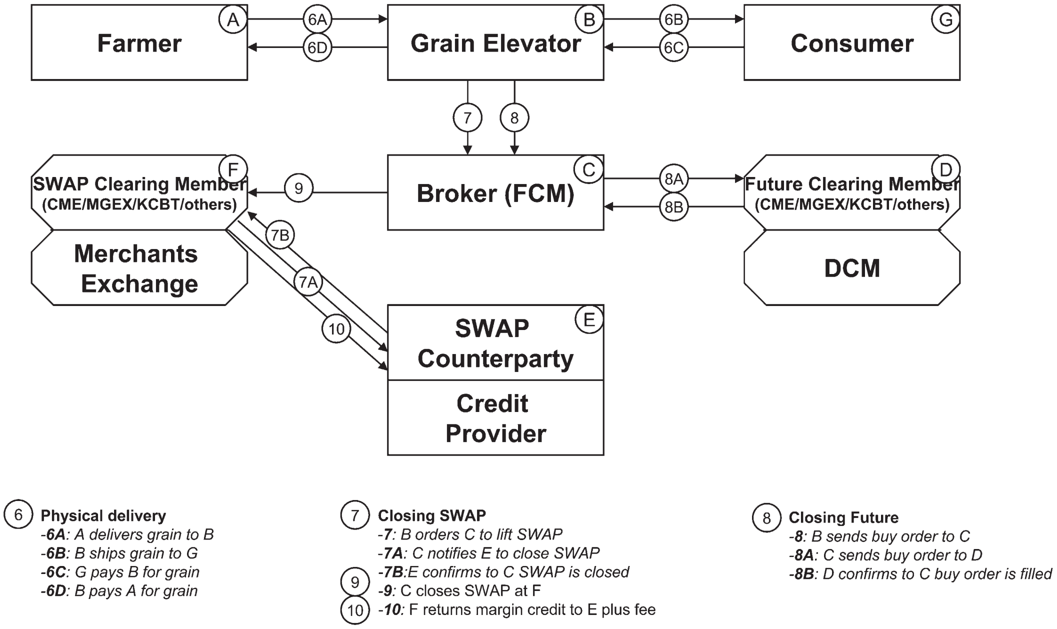
Farmer
A
6A
6D
Grain Elevator
B
6B
6C
Consumer
G
7
8
SWAP Clearing Member (CME/MGEX/KCBT/others)
F
Merchants Exchange
9
Broker (FCM)
C
8A
8B
Future Clearing Member (CME/MGEX/KCBT/others)
D
DCM
7B
7A
10
SWAP Counterparty
E
Credit Provider
6 Physical delivery
-6A: A delivers grain to B
-6B: B ships grain to G
-6C: G pays B for grain
-6D: B pays A for grain
7 Closing SWAP
-7: B orders C to lift SWAP
-7A: C notifies E to close SWAP
-7B: E confirms to C SWAP is closed
9 -9: C closes SWAP at F
10 -10: F returns margin credit to E plus fee
8 Closing Future
-8: B sends buy order to C
-8A: C sends buy order to D
-8B: D confirms to C buy order is filled

Figure 3. Liquidating the Swap

is 5.86, or in levels (350.49 cents per bushel), which is the average closing futures price over the 2006–2008 period.

Once the sequences of futures prices have been generated, we rank the final days' prices from largest to smallest and select the six sequences with the highest prices on day 170. From the perspective of our representative elevator these potential sequences would result in the largest losses from holding a short–futures position, and hence would be most likely to incur the largest level of margin calls, and hence require the most working capital to finance. This ranking procedure is akin to using a Value at Risk measure to categorize the worst expected loss over a given time interval, under normal market conditions, at a given confidence level (Jorion, 1997). In our case the time interval is 170 days, market conditions are defined in terms of the volatility associated with two historic time periods, and the confidence level is set at the 5% level.

Results

The six "worst" sequences of daily prices, generated under the assumption of 23% expected volatility (corresponding to historical volatility level for 1996–2005 period) are presented in Figure 4. Recall, these sequences are "worst case scenarios" as they would result in the largest futures losses for our representative elevator. Similarly, the six "worst" sequences based on volatility levels for the 2006–2008 period are presented in Figure 5. As expected, the price paths in Figure 5 tend to increase at a faster rate and exhibit greater volatility than those presented in Figure 4. Given an assumed volatility of 30%, it can be seen from Figure 5 that there is a 5% chance that futures prices will be at a level of 525 cents per bushel or higher by day 170, when the hedge is closed out. In contrast, given an assumed 23% volatility level, it can be seen from Figure 4 that there is only a 1% chance that futures prices will be at a level of 515 cents per bushel or higher.

By simulating the entire price paths for the six "worst" case scenarios, over the 170 day hedging periods, we are able to analyze in more detail the extent to which large daily price spikes would impact our representative elevator in the form of margin calls. To clarify how the mechanics of variation margin and the MCS would work in practice, we present in Table

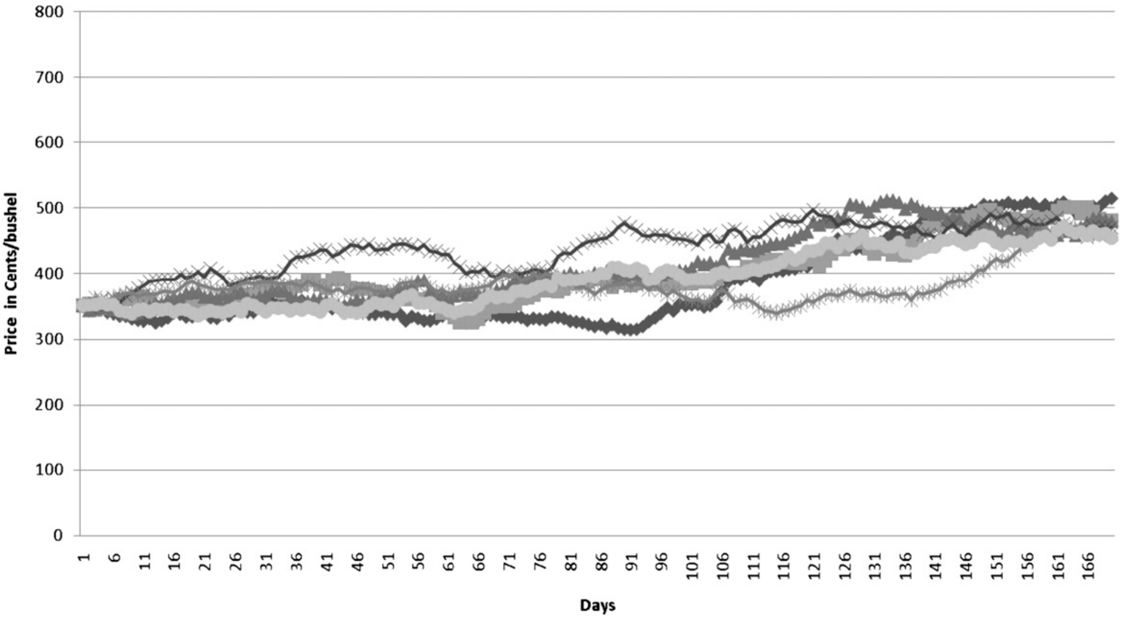

Figure 4. Simulated December Corn Futures Price Time Paths—Six Worst Case Scenarios—Based on an Assumed Volatility of 23%

1 the price impacts associated with the "worst" case simulated price sequence under the 30% volatility level assumption. To conserve space we only present simulated prices and attendant effects for the first and last five days in the sequence. On day one the elevator sells one December corn futures contract at a closing price of 350.49 cents per bushel to hedge 5,000 bushels of corn bought from a farmer on a forward contract. At this point the elevator buys one MCS swap contract (based on 5,000 bushels of corn) at a price of 320.49 cents per bushel from a credit provider (such as a bank). The MCS provides the elevator with $1,500 worth of credit, which is simultaneously deposited in a margin account with a broker to cover the initial margin on the corn futures position. We assumed the negotiated interest rate between the MCS buyer and seller was set at a 5% level. Our analysis ignores agent risk preferences. For example, if the MCS buyer is risk averse he (she) may be willing to pay positive premiums in excess of interest costs to transfer their margin credit risk to an MCS seller.

On day 2 December corn futures price closes higher at 352.87 cents per bushel. This triggers a margin call in the futures account of $119.24, which is simultaneously offset by a transfer of $119.24 variation margin from the MCS seller's account to the MCS buyer's account. In effect this transfer of credit maintains the elevator's futures margin account at the initial $1,500 level and negates the need for the elevator to raise the $119.24 itself. The MCS swap seller has provided the elevator with cumulative margin credit of $1,619.24, and charges an annualized interest payment of 5% or $0.22 for this service. This cumulative interest payment translates into a charge of 0.01 cents per bushel (second row and last column of Table 1). As price continues to rise on days three through five the same process occurs and it becomes clear that the MCS removes the liquidity burden of financing a short–futures position during a bull market.

The second half of Table 1 shows the last five days of the life of the hedge and MCS contract. Note that as price falls between days 167–168 the elevator's futures margin account is credited $210.04 and this money is transferred to the MCS seller along with the interest payment on the cumulative margin

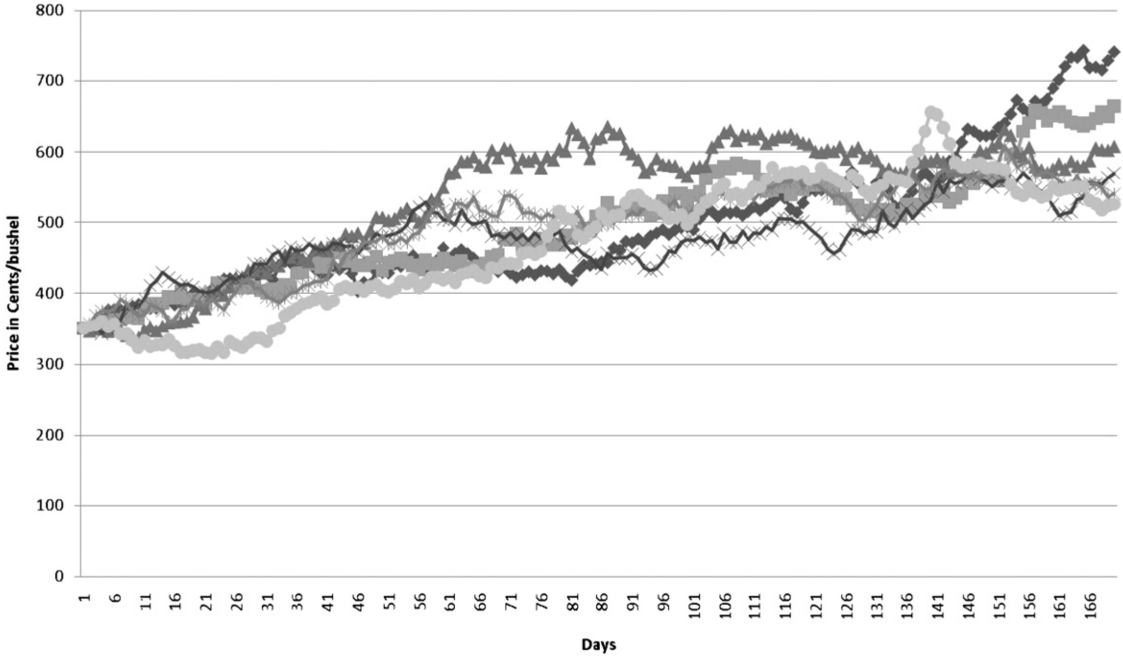

Figure 5. Simulated December Corn Futures Price Time Paths—Six Worst Case Scenarios—Based on an Assumed Volatility of 30%

credit. We assume that all contract positions are closed out at the opening price of $740.51 on day 171. The elevator buys back the corn futures contract resulting in a hedging loss of $19,501. Also at this time the elevator sells the MCS and the credit provider buys the MCS at the initial price of $320.49 offsetting the contract. The margin credit of $21,001.02 is

Table 1. Margin and MCS Accounts for the "Worst" Case (Scenario 1) Simulated Price Sequence Assuming 30% Volatility

Day	Futures Price (cents/ bushel)	Margin Call ($ per contract)	Margin Withdrawal ($ per contract)	Cumulative Margin Credit ($ per contract)	Daily MCS Interest Payment ($ per contract—5% interest)	Cumulative Interest per Contract (cents/bushel)
1	350.49 (320.49 MCS)			1,500.00	0.21	0.00
2	352.87	119.24		1,619.24	0.22	0.01
3	360.67	389.90		2,009.14	0.83	0.03
4	364.06	169.16		2,178.30	0.30	0.03
5	376.63	628.54		2,806.84	0.38	0.04
164	718.20		1,217.06	19,885.50	2.72	5.35
165	719.11	45.67		19,931.16	2.73	5.40
168	714.91		210.04	19,721.12	8.10[a]	5.56
169	728.51	680.02		20,401.15	2.79	5.62
170	740.51	599.87		21,001.02	2.88	5.68

[a] It should be noted that the MCS interest payment is much larger on day 168 because it covers days 166 and 167 which include a weekend.

returned to the credit provider plus any final interest payment. Thus the net result for the elevator is the $19,501 hedging loss plus a $283.87 (equivalent to 5.68 cents/bushel) interest payment paid to the credit provider. It should be emphasized that if the elevator financed his margin calls by borrowing from a bank at a 5% interest rate, instead of using the MCS, the net result at the end of the hedging period would be identical. The main difference between financing margin calls in the traditional sense versus using an MCS is that the MCS daily liquidity requirements during the life of the hedging period are much less onerous. Clearly, comparing the dollar amounts needed to finance margin calls (column 3) with the cost of maintaining the futures position with an MCS (columns 6 and 7), the MCS contract is a potentially attractive instrument for elevators with liquidity needs.

Next we consider the extent to which greater liquidity demands are placed on country elevators during periods of extreme price volatility. The goal is to illustrate the additional dollar requirements needed to finance a representative elevator's preharvest short–futures position when volatility increases from 23 to 30%, as in the recent 2006–2008 bull market. Tables 2 and 3 present various liquidity demand measures for our simulated scenarios assuming a 23% and a 30% volatility level respectively. The first column ranks scenarios from worst (1), resulting in largest futures loss, to best (6), resulting in smallest futures loss. Comparing columns 2 and 3, between Tables 2 and 3, we see that the flow of dollars in and out of the futures margin account almost doubles in size for the higher volatility scenarios. Similarly, the total amount of credit needed to finance the futures position for the 170 day period (column 4) is twice as much for the 30% volatility scenarios. Our results suggest, assuming a 23% volatility level, there is a 5% chance that an elevator hedging 200,000 bushels of corn in April would need $267,225 or more in total credit to finance the position. In contrast, assuming 30% volatility, there is a 5% chance that $419,712 or more would be needed to finance the same position. Similarly, there is a 1% chance that $401,089 or more would be

Table 2. Liquidity Measures for Six "Worst" Scenarios Assuming 23% Volatility

Scenario	Total Margin Calls ($/contract)	Total Margin Withdrawals ($/contract)	Cumulative Margin Credit ($/contract)	Cumulative MCS Interest ($ payment)	Cumulative MCS Interest (cents/bu)	Maximum Margin Credit (level in $)	Largest Daily Margin Credit $ Increase	Largest Weekly Margin Credit $ Increase	Largest Cumulative Margin Credit $ Increase[a]
1	22,456.30	14,238.79	10,027.23	108.39	2.17	10,027.23	859.02	2,163.83	2,163.83
2	23,840.19	17,303.76	8,036.43	129.97	2.60	9,058.18	772.34	1,655.84	2,780.10
3	22,014.82	15,524.65	7,990.17	150.38	3.01	9,592.77	1,081.28	1,296.12	1,664.94
4	24,924.47	18,933.50	7,490.97	193.19	3.86	8,826.55	854.06	1,770.07	2,342.51
5	20,445.71	14,960.21	6,985.50	102.57	2.05	7,530.41	963.52	2,216.12	2,511.89
6	20,438.03	15,257.40	6,680.63	117.45	2.35	7,552.38	708.61	1,289.78	1,172.49
Average	22,353.25	16,036.39	7,868.49	133.66	2.67	8,764.59	873.14	1,731.96	2,105.96
Std Dev	1,803.00	1,746.87	1,186.29	33.78	0.68	1,035.65	133.63	403.40	590.66

[a] This refers to the largest cumulative margin credit increase in dollars brought about by consecutive daily futures price increases.

needed to finance the position assuming 23% volatility, while $840,040 or more would be needed to finance the position assuming 30% volatility. As can be seen from columns 5 and 6 the corresponding liquidity requirements associated with using MCS contracts would be much less. For example, assuming 30% volatility there is a 5% chance that $10,200 or more in MCS interest payments would be needed to finance the 200,000 bushel position. Finally, the last three columns of Tables 2 and 3 reflect the additional amount of money that must be deposited in the futures margin account during the largest price spikes. Column 8 indicates the largest dollar amount that must be placed in the margin account following the largest price increase recorded for a given day—or in other words the largest margin call. Column 9 shows the largest dollar increase in margin money over the course of a week—this of course corresponds to the week with the largest rise in prices. Column 10 presents the largest dollar increase in margin money over a course of consecutive daily price increases. In practical terms, when prices trend higher for a number of days in a row, this can place severe liquidity demands on elevators' working capital. Once again comparing these three columns across Tables 2 and 3, it is immediately apparent that liquidity demands are much greater during periods of extreme volatility.

Table 3. Liquidity Measures for Six "Worst" Scenarios Assuming 30% Volatility

Scenario	Total Margin Calls ($/contract)	Total Margin Withdrawals ($/contract)	Cumulative Margin Credit ($/contract)	Cumulative MCS Interest ($ payment)	Cumulative MCS Interest (cents/bu)	Maximum Margin Credit (level in $)	Largest Daily Margin Credit $ Increase	Largest Weekly Margin Credit $ Increase	Largest Cumulative Margin Credit $ Increase[a]
1	42,143.73	22,642.71	21,001.02	283.87	5.68	21,102.56	1,165.28	3,313.46	3,798.69
2	39,417.36	23,693.74	17,223.62	284.48	5.69	17,223.62	1,789.76	2,917.90	5,026.89
3	41,258.29	28,418.64	14,339.66	351.61	7.03	15,738.35	1,624.55	2,729.19	4,334.11
4	38,449.92	27,489.91	12,460.02	254.72	5.09	12,513.24	1,511.95	2,161.42	2,671.85
5	37,551.43	28,056.87	10,994.56	284.59	5.69	14,393.47	1,440.39	1,998.66	3,005.71
6	36,358.16	27,630.28	10,492.93	254.89	5.10	17,036.73	1,407.97	1,913.91	4,938.46
Average	39,196.48	26,322.02	14,418.63	285.69	5.71	16,334.66	1,489.98	2,505.76	3,962.62
Std Dev	2,204.80	2,487.01	4,053.98	35.38	0.71	2,923.80	211.22	565.36	983.01

[a] This refers to the largest cumulative margin credit increase in dollars brought about by consecutive daily futures price increases.

Conclusions

In summary, while our results—liquidity demands for elevators are higher during periods of extreme volatility—are not surprising, it is of great practical interest to quantify and highlight the additional dollar amounts needed during these periods. The recent 2006–2008 bull market has brought this issue to the forefront of industry concerns, and has received considerable attention from government bodies like Commodities Futures Trading Commission, from industry organizations such as National Grain and Feed Association, and from farmers groups. The fallout has negatively impacted farmers during the 2008 crop year with elevators refusing to offer forward contracts on 2009 production. In light of these problems the Merchants Exchange is currently running a pilot program to gauge the potential liquidity benefits of an MCS contract. Our paper explains the mechanics of how the MCS contract would work, and the extent to which it would help relieve the recent liquidity demands experienced by country elevators. Clearly, our results would suggest that an MCS contract would provide significant liquidity benefits to hedgers during periods of extreme volatility.

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