Prudential Margin Policy in a Futures-Style Settlement System

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INTRODUCTION

Futures market clearinghouses have compiled a noteworthy record of risk management. Over their history, a period that includes the Great Depression as well as the volatile markets of the 1980s, there have been remarkably few instances where a clearing member has failed on its payment obligation to a clearinghouse. As a result, there has never been a clearinghouse failure, and only rarely has a clearinghouse not satisfied its obligations in a prompt and timely fashion. Individual customers, of course, have failed, imposing losses on the futures commission merchant (FCM) through which they trade. But the tiered risk-bearing structure employed in the futures market has successfully insulated the clearinghouse, other FCMs, and other customers from the effect of those failures.

Although history suggests that futures clearinghouses have successfully managed risk exposure in an absolute sense, the historical default record alone does not provide any evidence on the efficiency with which clearinghouses have managed their risk exposure. Compared to other financial intermediaries, futures market clearinghouses are in a unique position to fine-tune their risk exposure through active management of initial margin requirements. In a futures-style settlement system, contract gains and losses are settled on a regular basis. The clearinghouse stands at the center of the settlement process, disbursing and receiving payments to and from clearing members. The clearinghouse can use the same highly developed bookkeeping and funds transfer system employed in the settlement process to receive and release margin. In this way, margin can reflect, on a timely basis, the risk outstanding in the clearing member's position. The ability to observe contract price, mark positions to market, and collect margin with little time delay affords the futures clearinghouses a unique opportunity to manage their risk exposure through the active use of margin requirements.

The primary objective of this study is to determine whether or not clearinghouses exploit their unique risk management opportunity. The margining behavior of futures clearinghouses are evaluated by comparing the historical behavior of clearinghouses to model-based measures of risk-management efficiency. Alternative models of active risk management are developed in which settlement frequency and optimal margin levels are

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determined by cost-minimizing considerations. In one model, the clearinghouse selects a margin level and a settlement frequency at the beginning of each day based on its updated information concerning price risk. In the second model, the clearinghouse monitors intraday price movements and initiates a settlement whenever the rise or fall in price threatens to exhaust the margin on one side of a contract. In both versions, the clearinghouse's margin policy is designed to minimize contracting costs which include margin costs, settlement costs, and the cost of allowing a deficit to arise in a clearing member's margin account. History suggests that clearinghouse margining systems have included aspects of both models.

In the context of the models' simplifying assumptions, cost minimization implies certain empirical predictions about the relationship between a contract's margin and the conditional price volatility underlying the contract. Clearinghouse margin policy is compared to the models' predictions using daily conditional volatility estimates. In this comparison, several different statistical measures of volatility are used: some are chosen to approximate the procedures used by clearinghouses, whereas others are more suitable as formal statistical models. The use of different volatility measures augments the robustness of the findings.

The predictions of the optimal margin model are compared to the empirical behavior of margins and volatility for stock-index futures contracts that have been traded on various exchanges since 1982. Stock-index futures are used for several reasons. First, regulatory proposals have specifically targeted margins on stock index futures. Second, the fact that similar contracts are cleared by different clearinghouses implies competition and potentially different risk management strategies. Third, these contracts have displayed considerable price volatility over their histories.

The empirical evidence suggests that clearinghouses are less active in setting stock-index futures margins than this theory of cost-minimizing risk management predicts. The results are invariant to the measure of volatility used. One possible interpretation of these results is that there is an explicit cost to changing the margin requirement that is ignored by the models used here. Another possible interpretation is that both default risk and futures trading costs are relatively insensitive to the level of initial margin. A third possible explanation is that political considerations induce clearinghouses to over-margin stock-index futures contracts.

THE ROLE OF THE CLEARINGHOUSE AND CLEARINGHOUSE MARGINS

A futures market clearinghouse stands at the center of the clearing and settlement process. All trades are ultimately cleared through a clearing member, and for every trade, the clearinghouse interposes itself between the clearing members, guaranteeing performance to each side.[1]

Bernanke (1990) provides a model of the economic role played by a futures market clearinghouse which explains the central importance of clearinghouse risk management. The clearinghouse guarantee encourages investor participation which adds liquidity to the futures market. The clearinghouse's performance guarantee means that traders need not be concerned with the creditworthiness of the other party to a trade and can therefore treat all futures contracts as interchangeable. Like any insurance arrangement, providing these guarantees exposes the clearinghouse to adverse selection and moral hazard. For

[1]Edwards (1984) provides a description of the role of the futures clearinghouse, and Rutz (1989) provides a detailed account of the clearance and settlement mechanisms used by different U.S. clearinghouses.

example, some individuals might find it profitable to trade in futures markets by collecting if there are gains and defaulting if there are losses.

Margins, Bernanke observes, are a principal means by which clearinghouses protect themselves against the insurance risk created by their role as guarantor. The primary alternative to margins is monitoring. The clearinghouse can monitor the financial condition of its members as well as their trading activity. Choosing the optimal quantity of margin is an optimization problem: the clearinghouse uses margin to the point where it is cost effective, and, beyond that, monitors, or accepts some adverse selection and moral hazard.

Figlewski (1984) details a similar view of margins.[2] He notes that, in contrast to stock margins, the sole purpose of futures margins is to protect the financial integrity of the contract and that the viability of every futures market depends on eliminating the risk of nonperformance as far as possible. He highlights three measures commonly used to reduce this risk: margins, daily settlement, and clearing or contingency funds. He emphasizes that while margins should be set at levels that guarantee performance, they should be set no higher than necessary to achieve that purpose because margins discourage participation by raising costs.

Figlewski 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. What that appropriate level is, he notes, will vary from situation to situation, depending on a number of factors. One factor is the probability that in the face of a margin violation, the account will ultimately turn in a loss. Given any desired degree of protection, he notes that margin requirements will have to change in response to market conditions.

Gay, Hunter, and Kolb (1986) test whether margins are set in a manner consistent with the specific model of Figlewski. They examine whether margins set on ten different commodity and financial futures contracts between 1979 and 1983 conform to the hypothesis of equal probability of a margin deficit across time and across contracts. Overall, they conclude that margin management has been consistent with this hypothesis (though their results are mixed) and they conclude that while the margin committee does not employ a formal methodology for determining margins, they behave as if they did.[3]

The literature tends to suggest, implicitly at least, an optimizing approach towards margin management. This article attempts to formally establish the implications of an optimal margin approach, and where possible, compare these implications with actual margin setting practice.

THE ANALYTICS OF OPTIMAL PRUDENTIAL MARGIN LEVELS AND SETTLEMENT INTERVALS

This section develops a model in which both margin and settlement frequency are used to reduce settlement risk. The model is intended as a benchmark by which to judge clearinghouse margin policy.[4] It is consistent with the paradigm of efficient contract design [Brennan (1986)] which maintains that in

[2]One difference is that Figlewski's discussion focuses on customer as opposed to clearing member margins.

[3]Gintner (1991) investigates the hypothesis of equal probability of a margin deficit between stock index-futures and cash market transactions.

[4]The model is more general, however, and that it could serve as a model of collateral management in other contexts, such as the management of bank capital by a regulator. See Craine and Nelson (1990) for a treatment of the bank capital adequacy issue as an application of the optimal margin problem.

competitive financial markets, financial contracts are designed to minimize contracting costs.

Model 1: Fixed Number of Daily Settlements

Assumptions. Assume that the clearing member enters into a futures contract at time t and deposits margin equal to K_t. The futures price, P_t, then fluctuates over time. It is convenient for the purpose of this study to assume that P_t follows a continuous-time, zero-drift wiener process with instantaneous variance σ_t^2 between t and $t + 1$.[5]

At time $t + 1$, the position must be settled. That is, at $t + 1$, if not before, there must be a cash settlement of the gains or losses realized on the contract. If the unit of time is one day, then this assumption says that futures contracts are settled at least once daily, and possibly more often. If there are multiple settlements, they are assumed to occur at the end of each of several sub-intervals of equal length τ. Thus, $1/\tau$ settlements take place, where $1/\tau$ is an integer greater than 1. The change in the value of the contract over a sub-interval of length τ is normally distributed with mean 0 and variance $\sigma_t^2\tau$.

Contracting costs include margin, settlement and settlement-failure costs. Margin costs are given by ρK_t where ρ is the unit cost of margin per unit of time.[6] Margin costs represent a form of liquidity costs; the rate of return on alternative assets may exceed that which is available on riskless assets that are suitable for posting as margin. Alternatively, in cases where margin requirements can be satisfied with letters of credit, the commitment fee charged by the issuing bank is a measure of the liquidity cost. Settlement costs are administrative in nature. They include: the cost of marking positions to market, notifying members of their payment obligations, and processing payments. Over the interval t to $t + 1$, these costs are assumed to be γ/τ where γ is the cost per settlement and $1/\tau$ is the number of settlements.[7]

More problematic to interpret and model are settlement failure costs. First, default does not necessarily occur—and historically, has generally not occurred—whenever contractual losses exceed margin. There are many reasons member firms voluntarily absorb losses in excess of margin. A member's liability is not limited to the collateral posted in the member's margin account. Furthermore, if it defaulted, a clearing member would be precluded from trading in the future, depriving it of income. Clearly, however, a *necessary* condition for failure to occur is that losses exceed margin.

Defining $\tilde{L}_t(\tau)$ as the random loss on a futures position over the interval τ, settlement failure costs are assumed to be of the form,

$$\theta\left[\sum_{i=1}^{1/\tau} \max(\tilde{L}_t(\tau) - K_t, 0)\right] \tag{1}$$

The parameter θ can be thought of as the ex ante expected cost per unit deficit in the margin account. For risk management purposes, the clearinghouse is concerned with

[5]It is implicitly assumed that the risk management system design does not affect the stochastic process generating futures contract prices. The main issue here concerns the level of futures market margins and the volatility of the contract's price. Although this is a controversial issue, the preponderance of evidence to date suggests that volatility is not affected by the level of required margins [see Kupiec (1993), or France (1991)].

[6]Brennan (1986) and Telser (1981) model margin costs in a similar fashion. Aside from such costs imposed on individuals, the market bears a cost in terms of decreased participation and liquidity as margin requirements are increased.

[7]Only variable costs are relevant; the fixed cost of automated trade-matching systems and so forth are taken as given.

expected failure costs which are given by,

$$\frac{\theta E_t[\max(\tilde{L}_t(\tau) - K_t, 0)]}{\tau} \tag{2}$$

where $E_t(.)$ denotes the expectations operator conditional on information available at date t.

Efficient Contract Design. The paradigm of efficient contract design assumes that the clearinghouse chooses margin and settlement intervals that minimize total expected contracting costs per unit of time, which are given by,

$$C_t(K_t, \tau, \sigma_t) = \frac{\theta E_t[\max(\tilde{L}_t(\tau) - K_t, 0)]}{\tau} + \rho K_t + \gamma/\tau \tag{3}$$

Optimality requires the clearinghouse to form daily estimates of conditional volatility, $\hat{\sigma}_t$, set margin levels based on these estimates, and partition the day into an appropriate integer number of settlement periods. If $dF_t[.]$ represents the loss density function at time t, the first-order condition for margin is given by,

$$\rho - \frac{\theta}{\tau}\int_{K_t}^{\infty} \{dF_t(L_t(\tau))\} = 0 \tag{4a}$$

which can be written as,

$$Pr_t(\tilde{L}_t(\tau) > K_t) = \rho\tau/\theta \tag{4b}$$

where $Pr_t(X)$ represents the probability of event X occurring at time t. Under the assumption of normally distributed losses, the probability can also be expressed as,

$$1 - \Phi(K_t/\sigma_t\tau^{1/2}) = \rho\tau/\theta \tag{4c}$$

where $\Phi(.)$ represents the cumulative normal distribution function.[8]

These optimality conditions have several implications. From (4b), the shorter the settlement interval, τ, the smaller should be the probability of a margin deficit at the next settlement. Suppose a clearinghouse settles once a day and it sets margins so that the probability of a margin deficit at the end of a day is 5%. If the exchange then moves to twice a day settlement (because, for example, variable settlement costs have declined) this model indicates that the probability of a margin deficit at the end of each half day should be 2.5%. Under such a rule, the expected number of occurrences of a margin deficit over a day is fixed (in this example, it is 5%) regardless of the number of daily settlements.

A second implication of the model concerns the relationship of margin to daily price volatility. If (4c) is solved for the margin-volatility ratio, it yields

$$K_t/\sigma_t = \tau^{1/2}\Phi^{-1}(1 - \rho\tau/\theta) \tag{5}$$

where $\Phi^{-1}(.)$ is the inverse of the cumulative normal distribution function. Equation (5) indicates that for fixed τ, ρ, and θ, the ratio of margin to daily volatility is constant. A closely related implication of the model concerns the behavior of the *daily* non-coverage probability, NCP_t. The non-coverage probability is the probability that a one day movement in prices exceeds margin. Under the assumption of normally distributed

[8]If the ex ante loss from a margin account deficit is a nonlinear function of the margin account deficit, the first-order conditions do not have the form of (4a) and (4b). Consequently, although margin rules would behave similarly to the ones described, in general, they would not take the form of simple statements about the probability of a margin account deficit.

prices, NCP_t is given by,

$$NCP_t = 1 - \Phi(K_t/\sigma_t) \quad (6)$$

Like the margin-volatility ratio, under this model NCP_t is predicted to remain fixed across days with an equal number of settlements.[9]

Finally, cost-minimizing risk-management requires that, in addition to altering margin, the number of daily settlements should be adjusted in response to changes in conditional volatility. While once-a-day settlement might be optimal during periods of low volatility, more frequent daily settlement might be cost-minimizing for high volatility periods. Formally, the values of K_t and τ that minimize (3) are both functions of σ_t.[10] When the optimal number of daily settlements increases, it can be shown that the optimal margin-volatility ratio declines and the one-day non-coverage probability measure increases.[11] Consequently, to the extent that estimated fluctuations in these measures correspond to periods of increased or decreased settlement activity, such fluctuations are not necessarily inconsistent with cost-minimizing behavior.

Model 2: Endogenous Intra-day Settlements

Model 1 posits that margins and settlement intervals are determined at the beginning of each day in response to conditional volatility and the levels of the other settlement parameters. In the futures market, information concerning the futures price is continuously available. Thus, rather than making the decision about how often to mark-to-market at the beginning of each day, clearinghouses may instead make their decision based on price movements they observe during the day. Indeed, it is clear that, at least since 1987, this is to some extent what the clearinghouses do. On October 19, 1987, for example, all three futures clearinghouses studied here determined that at least one unscheduled settlement was necessary. Yet, under the approach of Model 1, the conditional volatility at the *beginning* of the day would not have warranted the additional settlements.

In reality, because margin collection requires time, endogenous intra-day settlements reduce but do not eliminate settlement risk. However, for modeling purposes, it is assumed that the ideal conditions under which settlement risk is eliminated are satisfied. With settlement failure costs assumed to be zero, margins are chosen to minimize the sum of margin and *expected* settlement costs. Expected, rather than actual, settlement costs are relevant because the actual number of settlements is unknown ex ante.

Letting ρ and γ denote margin and settlement costs as before, the cost function under this approach is given by,

$$C_t(K_t, \sigma_t) = \rho K_t + \gamma E_t(\tilde{n}) \quad (7)$$

where $\tilde{n}$ denotes the random number of settlements. The first-order condition for margin is,

$$\frac{-dE_t(\tilde{n})}{dK_t} = \frac{\rho}{\gamma} \quad (8)$$

[9]Assuming fixed values for ρ and Φ. The derivation of (4c)−(6) obviously relies on the assumption of normality. As long as price changes over adjacent settlement intervals are i.i.d. and symmetrically distributed about zero, conditions similar to (4c)−(6) will be implied by (4b).

[10]Given the necessity of an integer number of settlements, τ does not vary continuously; for small fluctuations in σ_t, τ remains fixed, while for larger fluctuations, the optimal settlement interval decreases with volatility.

[11]These properties of the optimal margining system can be demonstrated by simulation.

The expected number of daily settlements at the beginning of day t, $E_t(\tilde{n})$, is the product of first-passage probabilities. For the purposes of this study, it is not necessary to compute an exact expression for $E_t(\tilde{n})$. If loss increments are normally distributed, $E_t(\tilde{n})$ depends only on the ratio K_t/σ_t, where as before, σ_t denotes daily volatility. Letting the function $f(K_t/\sigma_t)$ denote the expected number of settlements, the first-order condition becomes,

$$-f'(K_t/\sigma_t) = \rho\sigma_t/\gamma \tag{9}$$

and total differentiation of (9) implies that,

$$\frac{d(K_t/\sigma_t)}{d\sigma_t} = \frac{-\rho}{\gamma f''(K_t/\sigma_t)} \tag{10}$$

Assuming that an interior value of K_t minimizes (7), $f''(.)$ is positive, and so (10) implies,

$$\frac{d(K_t/\sigma_t)}{d\sigma_t} < 0 \tag{11}$$

According to expression (11), a rise in price volatility will result in a reduction in the margin-volatility ratio. This contrasts with Model 1, eq. (5), where, over fixed settlement intervals, margin varies in proportion to price volatility. The intuition is the following. An optimal response to increased price volatility is to increase both margin levels and the expected number of settlements. Because the latter is a decreasing function of K_t/σ_t, this ratio must fall.

EMPIRICAL ANALYSIS OF CLEARINGHOUSE MARGIN POLICY

If a clearinghouse follows a cost minimizing margin setting policy, according to this model, its behavior will produce certain empirical regularities. If it follows a policy allowing positive settlement risk with (perhaps) multiple regular intra-day settlements, the optimality conditions of Model 1 imply that among days with the same number of regular settlements, the ratio of margin to price volatility should remain fixed. If, on the other hand, a clearinghouse follows a cost minimizing margin policy that includes endogenous intra-day settlements, its margin history will be characterized by a negative relationship between the margin-volatility ratio and volatility.

The predictions of the theoretical models are compared to the margin histories of three stock index futures contracts: the Standard and Poor's 500 composite traded on the Chicago Mercantile Exchange (CME) and cleared by that exchange's clearing division; the New York Stock Exchange Composite (NYSE Composite) traded on the New York Futures Exchange (NYFE) and cleared by the Intermarket Clearing Corporation (ICC);[12] and the Major Market Index (MMI) traded on the Chicago Board of Trade (CBOT) and cleared by the Board of Trade Clearing Corporation (BOTCC). The S&P 500 and NYSE Composite contracts began trading soon after the CFTC approved stock index futures in early 1982, while the MMI began trading in August, 1985. The sample period spans the time between the introduction of the contracts and February, 1990.

Margin and Settlement Histories

In futures markets, margin requirements are stated as a dollar amount rather than as a percentage of the contract value. Margin histories for the three contracts are reported in Table I. Over the sample period, margins were changed 10 times on the S&P 500

[12]Prior to January, 1986, the NYSE composite contract was cleared by NYFE's own clearinghouse, NYFECH.

(8 increases, 2 decreases); 7 times on the NYSE Composite (5 increases, 2 decreases); and 11 times on the MMI (8 increases, 3 decreases).

Table I also reports the histories of these contracts' settlement frequencies, both routine and non-routine settlements. Over the sample period, the NYSE Composite was routinely settled once a day, and the MMI twice a day. The S&P 500 was routinely settled once a day before March 1, 1988, and twice a day thereafter.

Before February, 1987, no clearinghouse had instituted a non-routine intra-day settlement. The NYSE Composite contract had its first non-routine settlement on February 10, 1987, and the other two contracts followed on October 19, 1987. It is doubtful that, in the periods preceding the initiation of non-routine settlements, any of these clearinghouses were following a Model 2 style margin policy where non-routine settlements are used to eliminate settlement risk. Table II reports the history of trading days on which the absolute size of close-to-close returns exceed margin.[13] These histories show that on all of the contracts, in the period before the initiation of non-routine settlements, there are numerous instances when daily price changes exceed required margin.[14] However, once the clearinghouses began the practice of using non-routine settlement, they settled intra-day on most, though not all, days when the close-to-close return exceeded margin.

Price Volatility

The analysis of clearinghouse margin setting behavior requires estimates of conditional price volatility. More precisely, it requires knowledge of how the clearinghouses estimate price volatility. Discussions with the clearinghouses indicate that they use several basic estimators. These include a so-called "root-t roll" (RTR) volatility estimate, in which return standard deviations are estimated from a moving sample of fixed size from the immediate past, and a nonparametric estimator based on the magnitude of the most recent price movements. Both are estimated over alternative windows, often ranging between 30 and 120 trading days. The sample window periods may be altered by the clearinghouses if, in their judgment, these past sample periods are not characteristic of potential market movements. These basic estimators are often augmented with implied volatility estimates derived from the market prices of options on index futures, and judgmental forecasts.

This analysis uses three measures of return volatility: a 30-trading-day RTR, a 100-day rolling nonparametric measure, and a maximum likelihood standard deviation estimate from a GARCH-T(1, 1) model.[15] Previous research indicates that a GARCH(1, 1) model adequately characterizes the time dependence in conditional stock return volatility, and GARCH estimates indicate that returns are better characterized by a conditional student t's distribution than by a conditional normal.[16]

[13]For the MMI contract, and the S&P contract after March 1, 1988, the filter is modified to twice the initial margin rate in order to compensate for their two routine daily settlements.

[14]Because these tables are based upon close-to-close price changes, they understate the frequency with which margin was violated. If this filter is applied to daily high-to-low price differentials, margin would be violated more frequently.

[15]Price volatility is computed as return volatility times the previous day's closing price. The nonparametric measures of volatility are not reported directly; rather, they are used to calculate non-parametric non-coverage probabilities. To calculate these probabilities, the absolute value of price changes from the last 100 trading days are ranked. Margin on day t is then compared to this ranking, and if the largest J price movements exceed margin, the non-coverage probability is $J/2$ percent. J is divided by two because it is implicitly assumed that the nonparametric distribution is symmetrical; therefore, half the extreme price movements violate the margin of a long position, and half of them violate the margin of a short position.

[16]A more complete discussion of the GARCH-T estimates is available from the authors upon request.

Table I
MARGIN HISTORY

Date	S&P 500	NYSE Composite	MMI
Apr 5, 1982	$1500		
May 10, 1982		$1500	
Oct 26, 1982	$2500		
Aug 8, 1985			$1250
May 23, 1986			$1500
Jan 27, 1987			$2000
Jan 28, 1987			$3000
Feb 2, 1987	$5000		
Jun 17, 1987		$1750	
Oct 20, 1987	$7500	$4000	
Oct 21, 1987			$5000
Oct 23, 1987	$10,000	$5000	
Oct 26, 1987			$7000
Oct 28, 1987			$10,000
Oct 29, 1987	$12,500		
Oct 30, 1987	$15,000		
Dec 21, 1988	$10,000		
Jan 7, 1988		$4000	
Apr 18, 1988			$15,000
Apr 21, 1988			$10,000
Sep 22, 1988	$4000		
Oct 21, 1988			$2500
Nov 16, 1988		$2250	
Jan 19, 1989		$1750	
Jul 5, 1989			$2000
Oct 16, 1989	$5000	$3000	
Oct 17, 1989	$6000		$5000

Notes: Prior to Mar 1, 1988, the S&P 500 regularly settled once daily; after this date, the contract has two regular daily settlements. The NYSE Composite contract has one regular daily settlement. The MMI contract has two regular daily settlements.

Contract	Extra Intra-Day Settlement History Pre-Crash	Post-Crash
S&P 500	0	11
NYSE Composite	22	9
MMI	0	3

Notes: The data are the number of dates on which at least one extra intra-day settlement occurred.

Assessing the Margin Policy Performance of Clearinghouses

Because non-routine settlements were not in use before the crash, the pre-crash and post-crash margin histories are examined separately.

Table II
DAYS ON WHICH CLOSE-TO-CLOSE MARKET PERCENT CHANGES EXCEED REQUIRED MARGIN RATES

	Year	Date	Contract % Change	Margin Rate	Number of Extra Settlements
S&P 500	1982	August 17	4.64	2.88	0
		August 20	3.48	2.75	0
		August 23	2.70	2.65	0
		October 6	3.22	2.46	0
		October 11	2.58	2.29	0
		October 18	2.34	2.24	0
		October 25	−4.05	2.16	0
		November 3	3.84	3.63	0
	1986	January 8	−2.76	2.34	0
		March 11	2.23	2.21	0
		April 30	−2.10	2.08	0
		June 9	−2.35	2.03	0
		July 7	−3.12	1.98	0
		September 11	−4.93	2.03	0
		November 18	−2.68	2.06	0
	1987	January 5	2.30	2.03	0
		January 22	2.24	1.87	0
		October 16	−5.30	3.35	0
		October 19	−22.90	3.54	3
		October 21	8.71	6.33	1
		October 26	−8.64	8.06	2
	1989	October 13	−6.31	2.25	1
NYSE	1982	August 30	−4.86	4.23	0
		October 25	−3.88	3.77	0
	1986	July 7	−2.98	2.07	0
		September 11	−4.60	2.12	0
		November 18	−2.48	2.14	0
	1987	January 5	2.37	2.13	0
		January 22	1.99	1.96	0
		March 30	−2.29	1.78	1
		April 3	2.04	1.80	1
		April 13	−2.18	1.81	0
		April 14	−2.39	1.85	0
		April 21	2.02	1.85	0
		May 5	1.89	1.84	0
		May 15	−2.14	1.81	0
		May 19	−2.20	1.86	0
		May 26	2.28	1.89	0
		September 22	2.40	2.01	0
		October 6	−2.46	1.91	0
		October 14	−2.74	1.99	1
		October 15	−2.25	2.04	0

Table II (continued)

	Year	Date	Contract % Change	Margin Rate	Number of Extra Settlements
		October 16	−5.10	2.09	1
		October 19	−21.29	5.03	0
		October 21	8.62	6.01	0
		October 26	−8.50	7.18	0
	1988	January 8	−6.27	5.48	0
	1989	October 13	−5.98	3.05	1
MMI	1986	July 7	−3.52	1.66	0
		September 11	−4.71	1.66	0
	1987	October 19	−25.09	2.72	1
	1989	October 13	−6.95	1.47	0

Note: Dates on which absolute value of return exceeds twice the daily margin rate on MMI, and on the S&P 500 after March 1, 1988.

Pre-Crash

The margin history given in Table I strongly suggests that margin policy was less active than implied by this study's models. During the pre-crash period there were but two margin changes in $5\frac{1}{2}$ years on the S&P 500 contract, one change in $5\frac{1}{2}$ years on the NYSE Composite contract, and three changes in 2 years on the MMI contract. At issue is whether price volatility varied sufficiently to warrant more frequent margin changes. For all three contracts there seems little doubt that it did.

Conditional price volatility estimates and the margin-volatility ratios for the three contracts are plotted in Chart 1, and sample statistics for the margin-volatility ratio are presented in Table III.[17] For the S&P 500 contract there is over a fourfold difference between the sample minimum and maximum margin-volatility ratio. At its minimum, margin was set equal to 1.43 standard deviations of the contract price, while at its maximum margin was 5.85 standard deviations. For the NYSE Composite contract, the disparity was even larger; the ratio reached a minimum of 1.41 compared to a maximum of 7.27. For the MMI, which traded over a shorter period, there was a three-and-a-half-fold difference between the minimum (1.07) and maximum (3.86) values of the margin-volatility ratio. Table III shows large differences in annual averages for the margin-volatility ratio as well. On the S&P 500 and NYSE Composite contracts, for example, the ratio's average value in 1985 was nearly twice its average value in 1986. Although fluctuations in the margin-volatility ratio of this magnitude could in principle, be accounted for by changes in liquidity, settlement, or settlement failure costs, given the inactivity of the margin level over the period, this explanation appears unlikely.[18]

Absent cost data, the model offers no guidance on the *level* of the margin-volatility ratio that minimizes the clearinghouse's costs. However, if price changes are assumed to be normally distributed, a margin-volatility ratio of 1.65 is adequate to protect against

[17]Conditional volatility is the maximum likelihood GARCH-T estimate. Plots of the 30-day RTR volatility measure are similar; the correlation of these two volatility measures is approximately 0.95.

[18]Variations across contracts are in line with the predictions of Model 1. Means for the S&P 500 and NYSE contracts, which settled once a day, are close in all years except 1987, and generally exceed the mean on the MMI, which settled twice a day.

Table III
MARGIN-VOLATILITY RATIO HISTORY

Pre-Crash History

					Annual Averages					
Contract	Min	Max	Mean	Std. Dev.	1982	1983	1984	1985	1986	1987
S&P 500	1.43	5.85	3.51	0.98	2.72	3.78	4.09	4.32	2.39	3.46
NYSE Comp	1.41	7.27	3.81	1.28	3.86	4.23	4.62	4.86	2.71	2.30
MMI	1.07	3.86	2.10	0.62					1.65	2.44

Note: Average of daily values. Daily volatility is calculated using a 30-day RTR. 1987 average are calculated through Oct 16, 1987.

Post-Crash History

					Period Averages			
Contract	Min	Max	Mean	Std. Dev.	87:4	88:1 88:3	88:4 89:3	89:4 90:1
S&P 500	1.27	10.06	4.62	1.82	3.37	6.67	3.67	3.75
NYSE Comp	1.42	9.33	4.28	1.64	2.63	5.82	3.42	3.74
MMI	0.96	14.37	4.70	2.99	2.63	8.21	2.55	3.77

Note: Average of daily values. Daily volatility is calculated using a 30-day RTR. The actual periods corresponding to the reported period averages are determined by the dates on which margin changed.

95% of all expected price changes, and a ratio of 2.33 is adequate to provide a 99% level of protection. The margin-volatility ratio on the S&P 500 and NYSE contracts generally exceed these levels.

Chart 2 shows the behavior of the daily non-coverage probabilities for each contract using different probability measures: the 30-day RTR, the GARCH-T, and the non-parametric measure. They show that under the RTR and non-parametric distributions, the estimated non-coverage probability is close to 0 for large portions of the sample period. Under the fatter-tailed *t* distribution, non-coverage probabilities are generally higher. The variations in the non-coverage probability across time are roughly the same under all three distributions. Therefore, the contention that margin policy was insufficiently active does not appear to be distribution specific.

Post-Crash

In the days following the market crash the clearinghouses took a more active role in managing settlement risk. They initiated non-routine intra-day settlements and increased the frequency of margin changes. There is also evidence that during this period, at least two of the clearinghouses, the CME clearing division and the BOTCC, relied on a Model 2 type risk management policy.

Table IV provides daily information on margin, volatility, and settlement between Friday, October 16 and Friday, October 30, 1987. Following the market's drop on Monday, October 19th, margins on all three contracts were raised. However, only the ICC increased margins in proportion to the estimated increase in conditional price volatility. The CME and BOTCC opted to raise margins less than proportionally, and to rely instead on multiple intra-day settlements. The CME had at least one non-routine intra-day settlement each day the week of the 19th to the 23rd, and on 4 of the 5 days in the following week; while the BOTCC added at least one settlement to its two regular settlements on the 19th, 20th, and 21st.

Subsequent to the initial increase in margins, all clearinghouses raised margins *at least* once more before the end of the following week, Friday, October 30th. The heavy reliance on intra-day settlement in the days following the crash may have reflected a high demand for liquidity among market participants, and consequently, a temporary increase in the relative cost of margin.

Chart 1 and Table III show that, subsequent to the October 1987 crash, margin-volatility ratios were subject to even larger fluctuations than before the crash. There was an 8-fold difference between the minimum and maximum value for the S&P 500 margin-volatility ratio, a 7-fold difference for the NYSE Composite, and a 14-fold difference for the MMI. At its maximum, margin on the MMI was set equal to an estimated 14.37 times the standard deviation of price changes. Averages of daily values taken over four different sub-periods suggest that in the first three quarters of 1988, margin policy was particularly conservative, averaging from 6 to 8 times price volatility.[19] It was during this time that the CME switched from once-a-day to twice-a-day settlement, indicating an even more conservative approach.

Excluding the period immediately following the crash, infrequent use was made of special intra-day settlements; two were called for at the CME, eight at the ICC, and none at the BOTCC. Given the lack of intra-day settlement activity, it appears unlikely that the variation in the margin-volatility ratio (Chart 1 and Table III), and in the corresponding

[19]These sub-periods are determined by dates on which there were changes in the margin requirements.

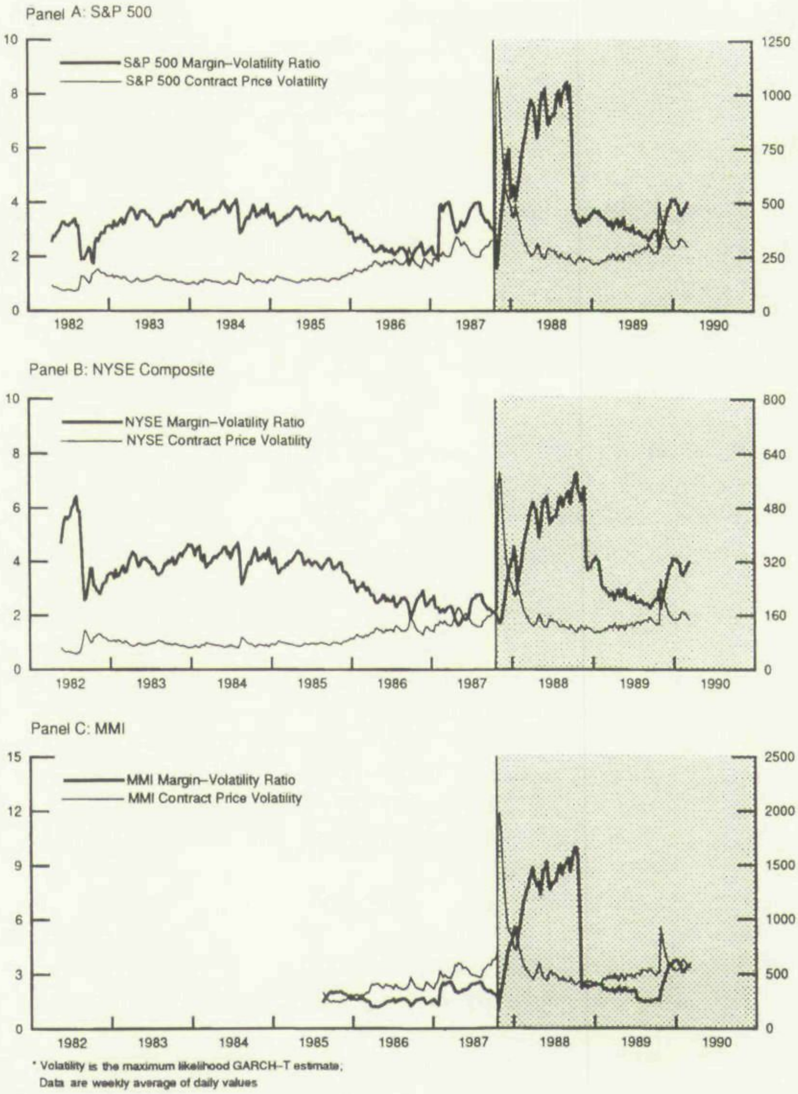

Chart 1.
Stock index futures price volatility and margin-volatility ratios.

non-coverage probability measures (Chart 2), can be explained in terms of shifts in the expected number of intra-day settlements.

Chart 3 shows scatter plots of the margin-volatility ratio and the conditional price volatility pairs for the three stock index-futures contracts over the post-crash sample period. The scatter plots show three distinct margin regimes: the right-most grouping in each panel is associated with the October, 1987 crash period. This corresponds to the most active period of intra-day settlements. The middle group of points corresponds to the high-margin environment of 1988, and the group of points nearest the origin corresponds to the post-1988 margin setting history. The different regimes that are apparent in the plots could correspond to changes in either the cost of settlement, γ, or the cost of margin ρ. Although the scatter plots are consistent with the predictions of a Model 2 style margining system, again, the infrequent use of intra-day settlements outside of the

Table IV
MARGIN, VOLATILITY, AND SETTLEMENT AROUND THE CRASH

Contract	Date	Margin	Price Volatility	Margin-Volatility Ratio	Extra Settlements
S&P 500	10/16	5000	1895	2.64	0
	10/19	5000	2259	2.21	3
	10/20	7500	5273	1.42	2
	10/21	7500	5545	1.35	1
	10/22	7500	6209	1.21	1
	10/23	10,000	5868	1.71	1
	10/26	10,000	5669	1.77	2
	10/27	10,000	5375	1.86	1
	10/28	10,000	5349	1.87	0
	10/29	12,500	5177	2.42	1
	10/30	15,000	5358	2.80	1
NYSE	10/16	1750	988	1.77	0
	10/19	1750	1216	1.43	1
	10/20	4000	2919	1.37	0
	10/21	4000	2981	1.34	0
	10/22	4000	3362	1.19	0
	10/23	5000	3186	1.57	0
	10/26	5000	3064	1.63	0
	10/27	5000	2928	1.71	0
	10/28	5000	2964	1.72	0
	10/29	5000	2790	1.79	0
	10/30	5000	2574	1.74	0
MMI	10/16	3000	1895	1.58	0
	10/19	3000	2128	1.41	1
	10/20	5000	4802	1.04	2
	10/21	5000	5073	.98	1
	10/22	5000	5826	.86	0
	10/23	7000	5452	1.28	0
	10/26	7000	5213	1.34	0
	10/27	10,000	4868	2.05	0
	10/28	10,000	4919	2.03	0
	10/29	10,000	4726	2.12	0
	10/30	10,000	4900	2.04	0

Note: Daily volatility is the maximum likelihood GARCH-T estimate.

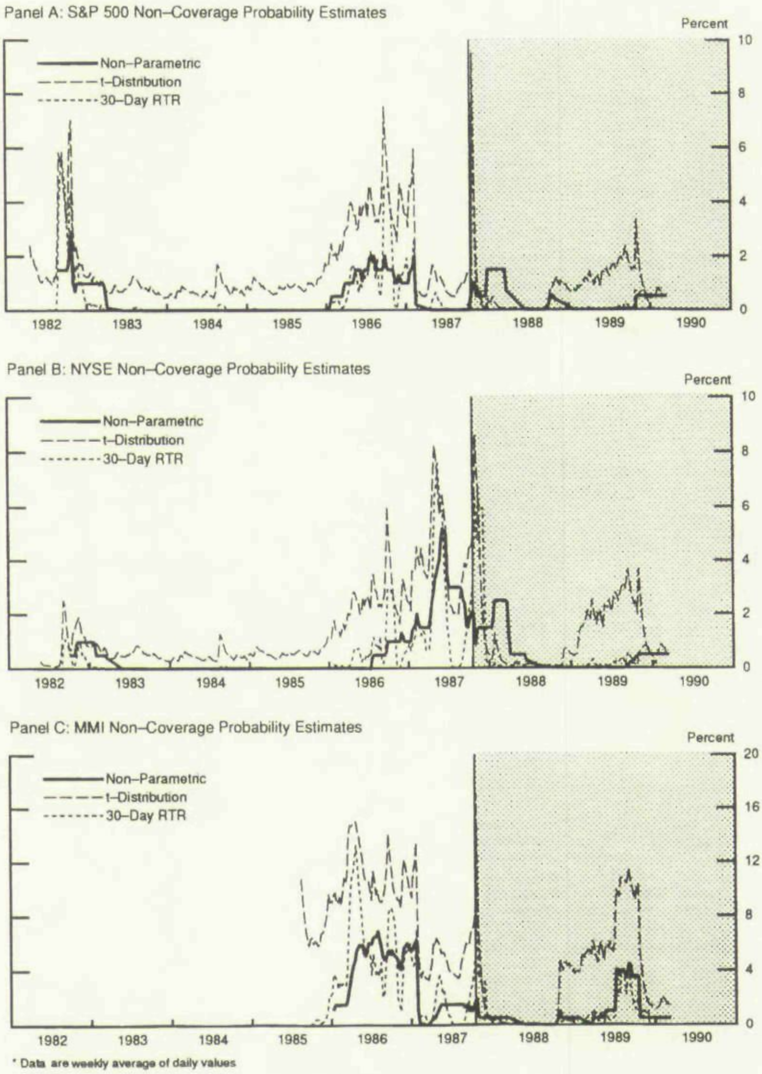

Chart 2.
Stock index futures non-coverage probability estimates.

immediate crash period suggests that it is unlikely that the clearinghouses were following a Model 2 style margining system over this entire period.

DISCUSSION

The models of this study assume that a clearinghouse attempts to minimize a particular contract cost structure. They are meant to be suggestive only. However, Model 1 can be viewed as a simple formalization of operational rules that clearinghouses say they use and which has gained wide acceptance in the literature. Model 2 is less familiar; however, the days immediately following the crash provide some evidence of the use of a Model 2-type risk management system, at least over this period of time.

It is assumed that clearinghouses update margin in response to the most recent information on price volatility. It may be that volatility is updated on a less frequent

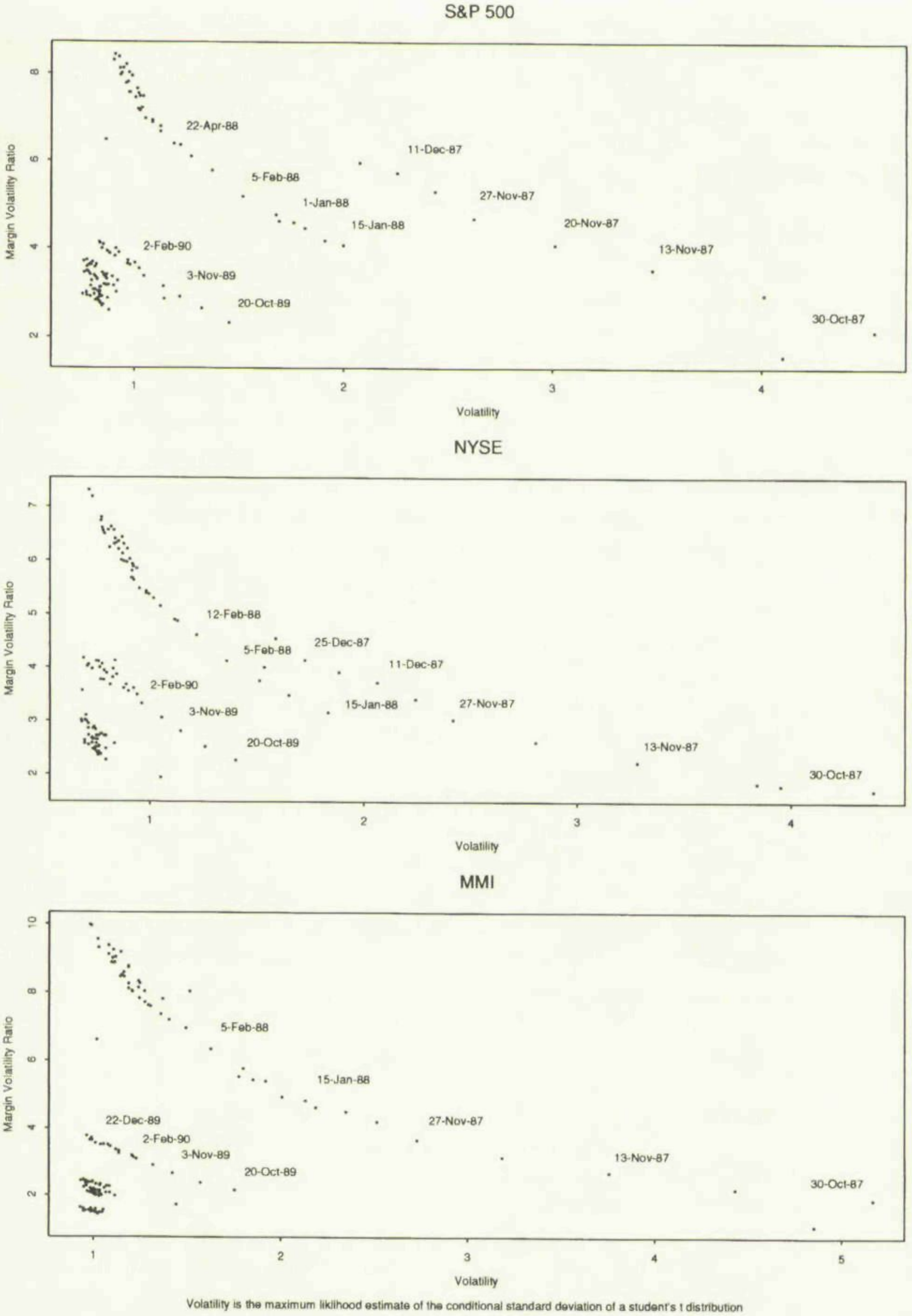

Chart 3.
Scatter plots of the margin-volatility ratio vs. conditional price volatility.

basis—monthly, rather than daily, for example. But it is clear that at times clearinghouses monitor volatility and fine-tune margins on a daily basis, as they did in the weeks following the crash. Even if margins were adjusted only monthly, the large swings observed in the relationship of margin to price volatility would not have arisen.

There remains a statistical issue of how to properly model conditional returns, particularly in the tails of the distribution. Although the statistical methods used in this study simulates those used by the clearinghouse, it is possible that the clearinghouses' judgmental forecasts play a major role in setting margin, and that these forecasts provide superior estimates of the relevant tail probabilities. It is doubtful, however, that any statistical model will remove the time variability in the observed prudential non-coverage risk.

One way to reconcile clearinghouses' behavior with a rational cost-minimizing approach to risk management is to assume that it is costly to alter initial margin requirements. In the presence of significant margin adjustment costs, the margin committee might set initial margin higher on average and not reset margins until it has a high degree of confidence that volatility has substantially changed. Such costs could produce an optimal margin rule that results in a margin history with infrequent margin changes and large swings in the margin-volatility ratio. Although there is some evidence that clearinghouses behave in this fashion, it leaves open the question of why it is costly to change initial margins.

It is possible that clearinghouses choose to manage risk by using their authority to require additional margin during the day. Clearinghouses have the authority to require additional margin at any time and these additional margin calls do not require an intra-day settlement. Because they do not require settlement, calls for additional margin are not reflected in the data of this study. If posting initial margin is costly, meeting additional margin requirements must be even more costly because, unlike initial margin, additional margin must be posted within 1 hour of notification and it must be posted in cash or cash equivalents. Because of the higher costs associated with a call for additional margin, it is unlikely that it would be cost minimizing for an exchange to maintain (fixed) low initial margin levels and rely on frequent additional margin calls for risk management.

An alternative explanation of the findings is: (1) because of strict monitoring and clearinghouse clearing membership requirements, margins are not an important risk control tool; and (2), the cost of posting margin is insignificant relative to other trading costs. There is evidence that, from the clearing house point of view, the costs associated with low margins (relative to volatility) are minor. The clearinghouse's knowledge of the clearing member, including its financial condition and trading activity in other markets may be the primary means by which the clearinghouses safeguard their interests. During periods of low margin requirements, contract price changes have frequently exceeded margin, but rarely has this lead to a clearing member default. Moreover, the protection afforded the clearinghouse by margin is always less than it appears because there is generally no margin collected on positions open and closed within a day.[20] Given the membership requirements and the monitoring undertaken by clearinghouses, the apparent clearinghouse reluctance to fine-tuning margins may reflect the fact that, on the margin, there is little residual clearing member risk to control. Although this may explain why margins are not changed frequently, it does not explain why they are not set at a low level to minimize trading costs. If high levels of margin are to be consistent with a rational cost-minimizing risk management system, it must also be the case that the cost of margin is an insignificant component of trading costs.

A third explanation for clearinghouses' behavior is that political considerations enter into the margin decision rule. It is possible that political pressures encourage

[20]At the BOTCC's regularly scheduled intra-day settlement, margin is posted on trades matched as of 10:30 AM.

clearinghouses to require higher margin than they would require otherwise.[21] If true, the observed clearinghouse margin policies would not have been consistent with the cost-minimizing models developed herein. The higher politically motivated margins would not have required the clearinghouse to fine-tune margins for risk management reasons since contracts would be on average over-margined when compared to the cost-minimizing margin level.

CONCLUSION

This article develops alternative models of an efficient prudential margin management policy for a futures style settlement system. The models are based on the theory of efficient contracts as applied to the clearinghouse problem of managing settlement risk. These models take alternative approaches: one approach allows for a positive but efficient amount of settlement risk; the second approach (theoretically) eliminates settlement risk. These models of efficient margin management imply relatively simple optimality conditions that could be easily implemented in a "real world" clearing and settlement setting. The models provide a rigorous basis for understanding the functions of margin and settlement frequency, and understanding their interrelationship in an efficient futures-style settlement system.

Empirically, the margin history of three stock index futures contracts, the S&P 500 index future, the NYSE Composite index future, and the MMI index future are reviewed. Each contract is cleared by a different clearinghouse and subject to different margin policies. The margin setting histories of these contracts are compared to estimates of the optimality criteria from the alternative efficient margin management models. The results indicate that the clearinghouses generally do not set margins in accordance with the conditions of either model of efficient margin policy. Clearinghouses are less active in altering margin requirements in response to changes in market conditions than either model predicts. These models *do not* suggest that clearinghouses set margins at levels too low or too high to minimize their costs. Indeed, without the relevant cost information, the models cannot determine what the cost-minimizing margin level is.

The historical record does suggest that clearinghouses could have improved the efficiency with which they set margins. However, a different conclusion might be reached if it could be shown that: (1) there are significant costs to changing margin; (2) given other safeguards such as, capital requirements, and membership standards, the costs of under- or over-margining, are of limited economic significance to the clearinghouse and its members; (3) there are political reasons for over-margining stock-index futures contracts.

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[21]Clearinghouses may have over-margined stock index-futures contracts owing to the political threat of regulation.

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