Margin Requirements Across Equity-Related Instruments: How Level Is the Playing Field?

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When interest rates rose sharply in 1994, a number of derivatives-related failures occurred, prominent among them the bankruptcy of Orange County, California, which had invested heavily in structured notes called "inverse floaters."[1] These events led to vigorous public discussion about the links between derivative securities and financial stability, as well as about the potential role of new regulation. In an effort to clarify the issues, the Federal Reserve Bank of Boston sponsored an educational forum in which the risks and risk management of derivative securities were discussed by a range of interested parties: academics; lawmakers and regulators; experts from nonfinancial corporations, investment and commercial banks, and pension funds; and issuers of securities. The Bank published a summary of the presentations in Minehan and Simons (1995).

In the keynote address, Harvard Business School Professor Jay Light noted that there are at least 11 ways that investors can participate in the returns on the Standard and Poor's 500 composite index (see Box 1). Professor Light pointed out that these alternatives exist because they differ in a variety of important respects: Some carry higher transaction costs; others might have higher margin requirements; still others might differ in tax treatment or in regulatory restraints.

The purpose of the present study is to assess one dimension of those differences—margin requirements. The adoption of different margin requirements for otherwise identical risk and reward positions might create an uneven playing field that shifts traders and investors from high-margin to low-margin instruments as they seek greater leverage or lower carrying costs. This can result in inefficient trading, as when traders pay

Box 1
Eleven Ways to Buy the S&P 500 Index

- Purchase every one of the 500 stocks in the index;

- Buy one of a number of futures contracts trading on the S&P 500;

- Negotiate a forward contract on the index with a private intermediary, such as an investment bank;

- Buy a call option on the S&P 500, which would allow one to capture the capital gains on the S&P 500, should prices rise;

- Buy the 500 stocks in the index and a put option, yielding the same result as buying a call option, namely, ensuring against a drop in the price of the index while allowing one to benefit from a rise in its price;

- Buy a bond convertible into the S&P 500 at face value;

- Buy from a Wall Street dealer a structured note with an interest rate tied to the return on the S&P 500;

- Buy from a bank an equity-linked Certificate of Deposit that would pay a guaranteed minimum rate, but if the S&P 500 increased over a certain level, the interest rate would be tied to that increase;

- Buy a Guaranteed Investment Contract with the same linkage from a life insurance company;

- Enter into an equity swap where one would pay a floating interest rate (usually the London Interbank Offered Rate, known as LIBOR) and receive the rate of return on the S&P 500; or

- Buy a unit investment trust that holds the S&P 500; an example is a SPDR, traded on the American Stock Exchange.

Source: Professor Jay Light, as quoted in Minehan and Simons (1995), p. 6.

higher trading costs in order to gain the benefit of lower margin requirements, and it can reduce the ability of financial agents to distribute risks in a way that minimizes financial volatility.

This study focuses on equity-related instruments: stocks, stock index instruments, stock options, stock index options, futures on stocks and stock indexes, and options on those futures. Section I provides background on these financial instruments and on the markets in which they are traded. Section II demonstrates that, in the absence of margin requirements, strategies using options, futures, and options on futures can duplicate the returns on a leveraged purchase of stocks or a stock index. Though these strategies are shown to be identical in their risks and returns, differences in margin requirements might create incentives to prefer one strategy over others.

Section III provides a background for understanding margin requirements in stocks, options, futures, and futures options. This is essential to the modeling of margin requirements on each of the replicating portfolios discussed in Section II. Section IV develops a model to simulate the values arising from several identical positions obtained by combinations of stocks and stock derivatives. The results are then used to assess, for each of the strategies identified in Section II, the costs of margin requirements. This allows judgments about the relative effects of differential margin requirements.

Our primary conclusion is that the playing field is more level than a cursory focus on initial margin requirements might indicate. We find that the costs associated with margin requirements on equities or stock indexes—costs embedded in the Federal Reserve Board's Regulation T—are essentially fixed costs: Only in the event of extreme price declines do maintenance margin calls occur; Regulation T's initial margins are typically the sole source of margin-related trading cost. On the other hand, costs of margin requirements on derivatives, particularly on futures contracts, have a low fixed cost component but are more sensitive to the price of the underlying security: While maintenance margins on equities rarely come into play, the practice of requiring variation margin on derivatives induces highly variable costs.

[1] These notes paid an interest rate that fell when the general level of interest rates increased, exposing the county to revenue shortfalls that threatened its ability to meet its obligations, as well as to capital losses on the notes.

In short, players in the different markets might not select their instruments on the basis of initial margins, and the differences in average costs, though significant, might not be the primary reason to choose one instrument over others. Rather, investors and traders might be motivated by a choice between fixed and variable margin costs: Risk-tolerant investors choose instruments with high variable and low fixed costs, such as futures or options, while less risk-tolerant investors select instruments with low variable but high fixed costs. Rather than the playing field being uneven, each instrument might be traded on a different playing field.

Caveats are in order. This study does not address the effects of other factors affecting an investor's decision about which markets to use to achieve a path of financial returns; among these other factors are commissions and fees, taxes, and regulatory or legal restrictions. It is also based on a small subset of equity-related instruments traded on registered exchanges; over-the-counter (OTC) instruments, which have no standardized margin-related costs, are not considered. Finally, the analysis is based on simulations of prices following standard pricing models with random return-generating processes. While this incorporates known aspects of the probability distribution of returns on common stocks, the results cannot be generalized to specific portfolios in specific periods, nor can they be applied to conditions of extreme financial duress, during which probability distributions might be different from the norm.

I. Equity-Related Financial Instruments

According to Ritchken (1987), organized trading in stock options began in London in the eighteenth century. By the late eighteenth century, option trading had spread to the United States. Though tainted by abuses, such as investors granting call options to brokers who would recommend their stocks, the market remained unregulated until the broad securities regulation of the 1930s. Among the important legislative actions was the Securities Exchange Act of 1934 (Act of 1934), which formed the Securities and Exchange Commission (SEC) and authorized it to oversee exchanges and broker-dealers trading stock and stock options. The Act of 1934 also gave the Federal Reserve Board the authority to set margin requirements on a broad range of financial instruments.

Prior to 1973, the market for put and call options on common stocks was an OTC market conducted by dealers belonging to the Put and Call Dealers Association. Because options contracts were written directly between buyer and seller, counterparty risk (the risk that the other party would fail to perform) was high. And because the contracts were not standardized, they were illiquid and not easily resold. To remedy these problems, the Chicago Board Options Exchange (CBOE) was formed in 1973 to trade equity options (options on individual stocks). The CBOE provided standardized contracts and established a clearinghouse that guaranteed the performance of contracts, thereby shifting the counterparty risk from the buyer and seller to clearinghouse members. These innovations mitigated counterparty risk and enhanced liquidity by allowing exchange-traded options positions to be easily reversed by offsetting trades: A holder (writer) of a standardized call option could sell (buy) an identical call option, thereby neutralizing his position. The counterparty risk taken by the CBOE clearinghouse led it to establish initial and maintenance margin requirements to protect itself from failure of its clearing members.

In 1982, the CBOE initiated trading in put and call options on the S&P 100 stock index option, the first stock index option traded in the United States. In 1993, the CBOE began trading S&P 500 Depository Receipts ("Spiders"), the first Exchange Traded Fund (ETF), and options on Spiders. A popular way to mimic the S&P 500 index, Spiders differ from open-end mutual funds, such as Vanguard's S&P 500 Index Fund, in several important ways: They (and other ETFs) are traded continuously throughout the day, they can be sold short, and they can sell at a premium or discount to net asset value.[2]

Both equity options and options on ETFs, which trade like stocks, are American-style, meaning that they can be exercised at any time up to the expiration date. Stock index options are typically European-style, so they can be exercised only on their expiration day. For example, both European-style S&P 500 stock index options and American-style ETF options on Spiders are currently traded. Each S&P 500 stock index option contract (and each Spider option) is for 100 units of the S&P 500, and it expires on the third Friday of the delivery month. On June 13, 2003, the CBOE's S&P 500 stock index option contracts traded with delivery months of June, September, December, and March. Strike prices ranged from 500 to 1700. At

[2] The premium or discount is kept small by arbitrage. If, say, a discount emerges, a trader can buy the S&P 500 stocks and convert them into Spiders, thereby increasing the price of the underlying stocks and reducing the price of the Spiders.

the close of trading, the S&P 500 index was 988.61, and the premium on the 995 September call option was $35.00. Thus, one contract could be purchased for $3,500 (= 100 times $35.00). If, say, the S&P 500 index closed at 1015 on the third Friday of September, the holder of a Spider call option could pay $99,500 (= 100 times $995) to take delivery of 100 units of S&P 500 worth $101,500 (= 100 times $1,015). The sum of the gain on the option ($2,000) less the premium paid ($3,500) yields a net loss of $1,500. The loss, while regrettable, is smaller than the loss that would have been experienced if the options had expired unexercised.

Like options, forward contracts have existed in the commodities markets for centuries. Forward contracts are customized OTC agreements between two parties. Like OTC options, they are not standardized, are difficult to resell, and can carry significant counterparty risk. The introduction of stock index futures contracts in 1982 was an innovation on a par with the development of exchange-traded equity and stock index options. Unlike forward contracts, stock index futures contracts are standardized instruments, traded on organized exchanges and cleared through clearinghouses that guarantee performance. Futures contracts have less counterparty risk because of the clearinghouse guarantee, and, unlike forward contracts, which typically involve no payments until they are exercised, futures contracts require regular collection of "variation" margin to protect the clearinghouse. Stock index futures contracts are now traded on the Chicago Mercantile Exchange (CME), the Chicago Board of Trade (CBOT), the Kansas City Board of Trade (KCBOT), and the New York Financial Exchange (NYFE).

Until recently, futures and futures options on individual stocks (so-called "single-stock" futures) were prohibited. In November 2002, after two years of discussion, single-stock futures began trading on two exchanges: OneChicago, a joint venture of the CME, CBOT, and CBOE; and Nasdaq-LIFFE, a joint venture of Nasdaq and the London International Financial Futures and Options Exchange (LIFFE). Nasdaq-LIFFE initiated trading of futures on ten individual stocks and on four ETFs.[3] OneChicago began by trading in futures on 21 individual stocks, four of which were also traded on Nasdaq-LIFFE.

A futures contract requires the seller to deliver the underlying instrument at the futures price set at the time of the contract. For example, one Russell 2000 contract traded on the CME has a notional value of $500 times the Russell 2000 index; at the June 13 closing index of 449.71, the notional value of one contract was, therefore, $224,855. The June 13 settlement price (closing price) for the September contract, expiring on the third Friday of September, was 450.75. Thus, the buyer of one September contract at the June 13 settlement price agreed to pay $225,375 (= 500 times $450.75) to take delivery of 500 units of the Russell 2000 on the third Friday of September. If the Russell 2000 was higher than 450.75 on that date, say, at 455, he would make a profit on the marked-up futures contract, paying 450.75 for a contract worth 455; the profit to the holder, and loss to the seller, would be $2,125 [= 500 x ($455 – $450.75)].

In 1982, the Commodities Futures Trading Commission (CFTC) allowed exchanges to trade options on any futures contract they traded. Exercisable at any time before expiration, hence American-style, an option on financial futures involves delivery of one specific futures contract at the exercise date. Options on futures expire at the same time the underlying futures contract expires, the third Friday of the futures delivery month. On June 13, 2003, a 1040 September call option on the September S&P 500 futures contract had a premium of $16.70, or $4,175 per contract (= 250 times $16.70). If, say, at the end of July, the call option had been exercised, the holder would have paid $260,000 (= 250 x $1,040) for a September S&P 500 futures contract. If the S&P 500 at that time had been 1050, the futures contract received would have been worth $262,500. The profit on the option ($2,500) partly defrays the $4,175 premium paid for the option, leaving a net cost of $1,675. If the futures contract is held after it is delivered, there are additional gains or losses as the contract is marked to market each half-day.

Contracts on stock and stock index options have been regulated by the SEC since its formation under the Act of 1934. After the Commodities Futures Trading Commission Act created the CFTC in 1974, a number of jurisdictional disputes arose between the SEC and the CFTC. These culminated in a 1981 agreement that the SEC would continue to regulate cash market products, like equity and stock index options, while futures and options on futures would be regulated by the CFTC. That agreement is still in effect.

[3] The ten individual stocks were Chevron Texaco, Exxon Mobil, Ford Motor, General Electric, General Motors, Honeywell, IBM, Intel, Microsoft, and Oracle. The four ETFs were the Nasdaq-100 tracking stock and contracts on the Russell 1000, Russell 2000, and Russell 3000 stock indexes.

II. Derivative Instruments and Replicating Portfolios

We now show that several strategies, called "replicating portfolios," can be designed using stocks and their derivative securities. Each of these portfolios uses different instruments to achieve identical risks and returns. Each is constructed to be costless, requiring no initial cash payments at the outset. Having shown that there are several strategies to construct portfolios with identical financial rewards and risks, using cash instruments, futures instruments, or derivatives, we next introduce margin requirements as a cash obligation. We then consider the effects of these requirements on the costs of each replicating portfolio. Variables and formulas are denoted by bold-faced type.

Consider an investor who structures a portfolio that will be liquidated at future time **T**. She can invest in common stock or a stock index, in a futures contract on the stock or stock index, in a call or put option on a futures contract on the stock or stock index, or in an option on the stock or stock index. A purchase at price **S** of common stock, of a stock index, or of an ETF can be financed by a margin loan in amount **D**; this is a "leveraged purchase of common stock." Interest on the margin loan, at rate **r**, accumulates until the debt is repaid at time **T**. After **T** periods ("days") have passed, the value of the stock is $\mathbf{S_T}$, the margin loan repayment is $\mathbf{D(1+r)^T}$, and $\mathbf{S_T - D(1+r)^T}$ is the profit or loss. Suppose now that no margin is required: The investor can borrow the full amount of the stock or stock index, that is, **D = S**, and the fully leveraged purchase is said to be "costless" because it requires no initial cash outlay. The terminal value of the fully leveraged purchase, *sans* margin requirements, is $\mathbf{S_T - S(1+r)^T}$.

This fully leveraged purchase can be replicated by the use of European-style options on the same underlying security. Purchase of a call option with strike price **X** at premium **C**, combined with simultaneous sale of a put option with the same strike price at premium **P**, will have a profit of $\mathbf{S_T - [X + (C\text{-}P)(1+r)^T]}$ at the end of **T** periods. The cost in brackets is the strike price plus the accumulated value at **T** of the income foregone from the initial net premium paid. The put-call parity theorem, a well-known theorem of option finance, states that the call and put premiums will be equal when the option strike price is selected to be $\mathbf{X = S(1+r)^T}$. For an option with this strike price, the option strategy is costless (**C = P**), and the value at time **T** is $\mathbf{S_T - S(1+r)^T}$. This strategy has the same initial cash outlay and terminal value as the leveraged purchase. It is, therefore, a replicating portfolio, identical to the leveraged purchase.

Yet another strategy that replicates the fully leveraged purchase (and the stock option strategy) is to buy a futures contract that expires after **T** periods. The futures price at the time the contract is made is **F** dollars. Because a futures contract is an agreement to make an exchange in the future, not a purchase or sale requiring a cash outlay, the futures contract, excluding margin requirements, is, like the fully leveraged stock purchase, costless at the outset. After **T** periods, it will be worth $\mathbf{S_T - F}$. But index arbitrage[4] by profit-seeking arbitrageurs will ensure that the futures price will be $\mathbf{F = S(1+r)^T}$, so the final value of the futures contract is $\mathbf{S_T - S(1+r)^T}$, identical to the value of the fully leveraged investment in common stock.

The final replicating portfolio we consider is purchase of a futures call option with strike price $\mathbf{X = S(1+r)^T}$, paying premium **C**, combined with simultaneous sale of a put option on the same futures contract at the same strike price and at premium **P**; the initial cash outlay is **C-P**, and the cost at **T** is $\mathbf{(C\text{-}P)(1+r)^T}$. Because one of the options will be exercised—either the put or the call will expire in the money—the value of this combination will be $\mathbf{F_T}$ at the expiration of the options. This must be equal to the cash stock price, $\mathbf{S_T}$, at that date, so the net profit will be $\mathbf{S_T - [X + (C\text{-}P)(1+r)^T]}$. Setting the strike price at $\mathbf{X = S(1+r)^T}$, and invoking the put-call parity theorem to ensure that **C = P**, the terminal value is $\mathbf{S_T - S(1+r)^T}$.[5] Once again, this is identical to the value at **T** of the fully leveraged purchase.

Thus, financial theory suggests that with four instruments (stock, futures, options on stocks, and options on futures), there are four equivalent strategies for achieving a final position equivalent to a leveraged purchase of common stocks. However, margin requirements will create differences in the attractiveness of these replicating portfolios. Before explicitly

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[4] Investors can buy the stock in the cash market for **S** dollars. The opportunity cost at time **T** will be $\mathbf{S(1+r)^T}$. Alternatively, they can buy a futures contract for **F** dollars. Both will be worth $\mathbf{S_T}$ at time **T**, and each has the same risk arising from the stock's price volatility. Thus, the equality $\mathbf{F = S(1+r)^T}$ is the equilibrium relationship between the futures and the cash price of the stock. If, for example, the stock price is too low and the futures price too high, the first investment (purchase stock) will be more profitable than the second investment (purchase a futures contract), and investors will buy stocks and sell futures contracts until the equality is restored.

[5] If option holders exercise options early, the pricing relationships on which our analysis rests will not be exact: An option that can be exercised early might have a value greater than a European option. However, this possibility is not likely to dramatically alter our results. Early exercise of options is typically associated with options that are deep in-the-money or for which the underlying asset pays a cash dividend at specific intervals.

modeling the effect of margin requirements, we review their nature and history.

III. Margin Requirements for Equity-Related Securities

The function of a "margin requirement" varies according to the security bought or held. In equity markets, where broker-dealers or other financial institutions lend money to customers for purchasing or holding common stocks, margin requirements rest on four philosophical legs. The first, *lender protection*, is to ensure that the broker-dealer's loan is repaid, mitigating systemic problems arising from broker-dealer failures. The second, *investor protection*, is to limit the ability of investors or traders to expose themselves to excessive risk through the leverage allowed by borrowed funds. The third, *market protection*, is to enhance market stability by providing an equity cushion that reduces the probability of margin calls, mitigating forced sales in times of falling prices, and raises the cash cost of purchasing stocks, inhibiting overly optimistic buyers in times of rising prices. The fourth, *credit allocation*, arises from a concern about the potential diversion of credit from legitimate business uses to speculative activity.

But for derivative securities there is no explicit loan to be protected. Furthermore, protecting investors from themselves and enhancing stability of the market for the underlying security are distinctly secondary considerations. Rather, as noted above, the primary purpose of margin requirements on derivatives is to provide a performance bond, protecting each party from the costs of the counterparty's failure to complete the contractual obligation. For example, the writer (seller) of a call option on common stock has the obligation to deliver the specified number of shares (typically 100 shares per option contract) if the buyer exercises the option. Should the writer fail to deliver on time, the buyer will have overpaid for the option and will not receive the benefit of the hedging or other strategy that motivated the purchase.

Margin requirements have several key characteristics: (1) the *initial margin,* the minimum equity required at the time a position is taken; (2) the *maintenance margin*, the minimum equity to be maintained during the time a position is open; (3) the *variation margin*, the additional margin required, or release of margin allowed, as prices of underlying securities change; (4) the *settlement period*, the interval between times when the value of the account is updated and calls for additional margin are issued; (5) the *payment period*, the time allowed for initial or additional margin to be posted to the account; and (6) the *acceptable collateral*, the collateral that can be used to meet initial or maintenance margin calls. We consider each of these characteristics in the equity, options, and futures markets. Our focus is on the rules that apply in the New York Stock Exchange (NYSE), the Chicago Board Options Exchange (CBOE), and the Chicago Mercantile Exchange (CME). Standards set at other exchanges typically mirror standards at these major exchanges. Minimum margin requirements set by the exchanges are subject to approval by the appropriate regulatory agency—the Securities and Exchange Commission for stocks and stock options, and the Commodities Futures Trading Commission for futures and futures options.

A distinction is often made between "strategy-based" and "portfolio-based" margin systems. Strategy-based margin systems consist of fixed rules, often independent of the precise characteristics of an account, such as its volatility or asset structure. To the extent that strategy-based systems recognize combinations of securities, they do so by applying fixed rules for "offsets" in defined combinations. Thus, Regulation T's requirement that the margin be no less than 50 percent of the value of common stock is strategy-based, as is the CBOE's rule that the margin required of a covered call option be equal to 50 percent of the value of the underlying stock. Strategy-based margin systems are typically set at the federal or exchange levels.

Portfolio-based margin systems set margin requirements by simulating the value of the account over a pre-set interval of time, using the asset allocation, volatility, and price characteristics specific to the customer's account. Margin requirements are then set to avoid all but worst-case outcomes. Portfolio-based margin systems are typically used by broker-dealers and clearinghouses. Regulatory agencies are in the process of reducing reliance on strategy-based systems and focusing their efforts on evaluation and monitoring of portfolio-based systems implemented by exchanges and clearinghouses. We will discuss portfolio-based margining below, when we address margin requirements at clearinghouses.

Margin Requirements for Common Stocks

Margin requirements for common stocks are set at three levels. First, "federal margin requirements" are embodied in the Federal Reserve System's Regulation

Table 1
Margin Requirements for Single-Equity Securities

Security Type	Exchange	Margin (Speculator)		Margin (Hedger, et al.)	
		Initial	Maintenance	Initial	Maintenance
Single Stocks	New York Stock Exchange	50% [a]	25% [b]	50% [a]	25% [b]
	American Stock Exchange	50% [a]	25% [b]	50% [a]	25% [b]
	Nasdaq	50% [a]	25% [b]	50% [a]	25% [b]
Single Stock Options	American Stock Exchange (AMEX, CBOE)	See Table 2	See Table 2	See Table 2	See Table 2
Single Stock Futures	OneChicago (CME)	20% [c]	20% [c]	20% [c]	20% [c]
	Nasdaq-LIFFE (NQLX)				

Source: Federal Reserve System, New York Stock Exchange, Chicago Board Options Exchange, OneChicago, Nasdaq-LIFFE, Chicago Mercantile Exchange, *Wall Street Journal.*
[a] Percent of value, Board of Governors of the Federal Reserve System, Regulation T.
[b] Percent of value, New York Stock Exchange, American Stock Exchange, and Nasdaq.
[c] Percent of value, OneChicago (joint venture of Chicago Mercantile Exchange, Chicago Board of Trade, and Chicago Board Options Exchange).

T, for broker-dealer loans, and Regulation U, for loans by bank and nonbank institutions. These regulations have been discussed recently in this *Review* (Fortune 2000 and 2002). Regulation T specifies those stocks and equity-related instruments that are marginable, that is, that have loan value, and it sets their margin requirements. The current margin requirements are shown in Table 1.

An investor purchasing, say, $100,000 of common stock, can borrow no more than 50 percent of the purchase price, or $50,000; the equity (or "margin") required is, therefore, $50,000. The investor who sells $100,000 of common stock short must place the proceeds with the lender of the stock as collateral and must also have equity of $50,000 in his account. Thus, the effective margin for a short seller is 150 percent of the initial value of the position.[6] The purpose of the margin for a loan to buy stock is to protect the broker as a lender of cash; the purpose in a short sale is to protect the broker as a lender of securities.

Regulation T requires that initial margin be posted within one "payment period" of the trade, defined as the number of business days in the "standard settlement cycle" plus two days. Because the standard settlement for common stocks is three days, the payment period for common stocks is five days. Initial margin can be in the form of cash, exempt securities (such as U.S. Treasury or municipal bonds), margin securities, or a transfer from the Special Memorandum Account, or SMA (see Fortune 2000).[7] Only the loan value of a margin security can be used to meet margin calls, so if an investor wants to deposit, say, $10,000 in shares of margin stock to meet a federal margin call, only 50 percent, or $5,000, can be used to meet the call.

Under Regulation T, the Federal Reserve Board has the authority to set maintenance margin requirements for equities. However, the Board has delegated this authority to the exchanges on which the stocks are traded, subject to the SEC's approval of the exchange as a Self Regulatory Organization (SRO). Positions in margin accounts are marked to the market at the end of each day, at which time calculations for federal margin excess or deficiency are made: A federal margin deficiency arises when the account's margin is less than the margin required by Regulation T. No federal margin calls are issued if a federal margin deficiency exists, but margin-deficient accounts are "restricted" until the margin is restored to the initial level required by Regulation T.[8]

[6] Brokers typically require collateral of 102 percent of the value of securities they lend, thus raising the effective margin required for a common stock short sale to 152 percent.

[7] The SMA is a margin account's record of cash deposits and of transfers of excess margin from the margin account. With some restrictions, SMA balances can be used to satisfy margin calls.

[8] Owners of restricted accounts cannot withdraw funds or substitute securities if this would further increase the margin deficiency.

The exchanges on which the stock is traded set "exchange" margin requirements.[9] Currently, the exchange margin requirements for common stock traded on the New York Stock Exchange, the American Stock Exchange, and Nasdaq are uniform: NYSE Rule 431 and NASD Rule 2520 require maintenance margin of at least 25 percent of the value of stock held long and 30 percent of the value of stock sold short. Specific hedged positions are subject to different requirements. For example, stocks sold short against the box (a long position offset by a short position) must maintain margin equal to 5 percent of the long position. The settlement period for exchange margins is daily, that is, the value of, and margin in, an account are computed at the close of trading, and any margin calls are immediately issued. Rule 431 requires satisfaction of exchange margin calls within 15 days. The collateral allowed by NYSE is that allowed by Regulation T: Margin calls can be satisfied by deposit of cash, exempted securities, or margin securities, or by a transfer from the SMA. Again, only the loan value of securities can be used to meet a margin call. For example, with an exchange margin of 25 percent, only 75 percent of the deposit of margin stock can be used to meet an exchange margin call.

Brokers also set "house" margin requirements using portfolio-based margin systems. House margins can be no lower, and are often higher, than exchange margin requirements. Recent indications suggest that house margin requirements have typically been 35 percent of the value of margin securities, although during the stock market bubble of the late 1990s some brokers set house margin requirements on specific classes of stock as high as 100 percent (no loan value). While stock exchange rules require that margin calls must be met within 15 days, brokers rarely allow that much time: House margin calls are rarely outstanding for more than five business days,[10] and brokers can require immediate payment or unilaterally liquidate under-margined positions at their discretion. Variation margin is not mandated by federal, exchange, or house margin requirements. Thus, daily price fluctuations do not give rise to margin calls unless the margin falls below the level required by the house or by the exchange.

Transactions in common stocks and many other securities are cleared through the Depository Trust and Clearing Corporation (DTCC), created by a recent merger of the National Security Clearing Corporation (NSCC), which provided clearing and settlement services, and the Depository Trust Corporation (DTC), which maintains the electronic registry of stock ownership. While DTCC has membership criteria and uses capital standards and other methods of ensuring that its members make the payments that transactions require, it does not set margin requirements for common stocks.

Margin Requirements for Equity or Equity Index Options

Once the terms of, and parties to, a trade are verified, the obligation to deliver and make payment for option contracts is assumed by the clearinghouse. In the case of exchange-traded equity options, all clearing is done by the Options Clearing Corporation (OCC). The OCC establishes margin requirements to ensure that the risk it acquires from performance guarantees is minimal.

The options exchanges establish both initial and maintenance margin requirements, specify the payment period within which margin must be paid, and dictate the instruments that are acceptable for satisfaction of margin requirements. The CBOE's Rule 12.2 follows the federal and exchange standards for common stock payment periods by specifying that initial margin must be obtained as promptly as possible but no later than five days after the trade, and that maintenance margin must be obtained as promptly as possible but within 15 days of the margin deficiency. The CBOE requires that option contracts be marked to market daily: At the end of each trading day, margin surplus or deficiency is calculated, and margin calls are issued by 7:00 a.m. the following day. Margin calls must be satisfied by 9:00 a.m. unless a waiver is granted. Margin can be paid in cash or in "cash equivalents" as defined in Regulation T's section 220.2: U.S. Treasury securities, negotiable bank CDs, bankers acceptances issued by U.S. banks and payable in the United States, and money market mutual funds.

Table 2 shows the CBOE's minimum margin requirements for naked options—options that are not used as hedges or in combination with other options—as well as for several option spreads and combinations. For example, under CBOE Rule 12.3, the buyer of a CBOE-listed option less than nine months to expi-

[9] Exchanges also have the authority to set initial margin requirements if they do not violate the requirements of Regulation T. This authority is rarely used, although there are some prominent examples of exchanges setting 100 percent initial margins for some highly volatile stocks.

[10] The SEC's Rule 15c3-1 requires a charge against a broker-dealer's net capital for margin calls outstanding for more than five days. This discourages brokers from extending calls beyond that time.

Table 2
Margin Requirements for Listed Equity-Related Options
Chicago Board Options Exchange

Position	Underlying Security	Margin Requirement
Naked Option: **Long Put or Long Call**	Equity Broad Index Narrow Index	Initial: 100% of premium (75% if expiration > 9 months) Maintenance: None
Naked Option: **Short Put or Short Call** (any expiration)	Broad Index Narrow Index Equity	Initial: 100% of premium + 15% of underlying value (if broad index) or 20% of underlying value (if equity or narrow index) – amount out of the money[a] Maintenance: Equal to initial
Covered Call: **Short Call + Long Stock**	Broad Index Narrow Index Equity	Initial: No requirement on short call; 50% on long stock (Reg T) Maintenance: No requirement on short call; 25% on long stock (NYSE)
Long Straddle: **Long Put and Long Call[b]** (equal strike prices)	Broad Index Narrow Index Equity	Initial: 100% (75% if > 9 months) of premiums on both options Maintenance: None
Short Straddle: **Short Put and Short Call[b]** (equal strike prices)	Broad Index Narrow Index Equity	Initial: Greater of short put or short call requirement + 100% of premium on other side Maintenance: Equal to initial
Call Spread: **Long Call + Short Call** **Put Spread:** **Long Put + Short Put**	Broad Index Narrow Index Equity	*If short option expires at or before long option:* Initial: long paid in full (short proceeds can apply) + (1) difference between long call and short call strikes, if positive; or (2) difference between short put and long put strikes, if positive *If short option expires after long option:* Initial: long paid in full (short proceeds can apply) + margin required for naked short option Maintenance: Equal to initial
Collar: **Long Put + Short Call** **+ Long Stock** (put strike < stock < call strike)	Equity Broad Index Narrow Index	Initial: Put premium + 50% of underlying value (Reg T) Maintenance: Lower of (1) 25% of call strike, or (2) 10% of put strike + amount put is out of the money

Source: Chicago Board Options Exchange Margin Manual, April 2000; Chicago Board Options Exchange Constitution and Rules, March 2001.
[a] Minimum margin is option proceeds + (a) 10% of underlying security value if a call, or (b) 10% of strike price if a put.
[b] If index, underlying index and index multiplier are same; if equity, same stock underlies both.
[c] Applies if underlying security is the same for both options.

ration must pay in full, and the seller (writer) of a naked equity option must satisfy an initial margin requirement equal to the option sale's proceeds plus the greater of (a) 10 percent of the value of the underlying securities, or (b) 20 percent of the value of the underlying security less the amount by which the contract is out-of-the-money.[11] The initial margin requirement formula must be maintained throughout the life of the contract; hence all gains and losses give rise to variation margin so that, for example, the naked call option writer must maintain margin equal to the option's premium plus the greater of (a) 10 percent of the underlying security value, or (b) 20 percent of the underlying security value less the amount out-of-the-money.

Options written in combination with other options or underlying securities have lower margin

[11] If the option written is a put, the requirement is sales proceeds plus the greater of (a) 10 percent of the *strike price*, or (b) 20 percent of the underlying value less the out-of-money amount.

requirements. For example, writers of covered call options, in which a call option is written while the underlying stock is held, face only the Regulation T and exchange requirements for the long stock position: an initial margin of 50 percent of the value of the stock, as set in Regulation T, and 25 percent of the value, as set by the NYSE and other exchanges.

Margin in the Futures Markets

The CME and the CBOT have developed a common margin system for index futures and futures options. As discussed above, until recently CFTC regulations limited equity-related futures and futures options to stock index contracts, such as the S&P 500. In November 2002, trading in "single stock futures" began. This includes trading in ETFs. Single stock futures and futures options are traded on OneChicago, a joint venture of CME, the CBOE, and the CBOT, or on Nasdaq-LIFFE. The CME minimum margin requirements are reported in Table 3. OneChicago's margin requirements for single stock contracts are reported in Table 1.

Orders for futures and futures options are processed through firms called Futures Commission Merchants (FCMs), which act as the equivalent of stock brokerage firms. Many FCMs are members of the clearinghouse for the exchange on which they trade. FCMs that are not clearing members must clear their trades through a clearing member.

As in the options market, there is no explicit credit risk, but each party faces the risk that the other party will fail to deliver or accept delivery of the underlying security. At the CME and CBOT, an initial margin requirement, called "original margin," is set to assure performance. Original margin is higher for "speculators" than for "other" customers (hedgers, specialists, and market makers).[12] The New York Board of Trade (NYBOT), on the other hand, does not currently have different requirements for "speculators" than for "others."

At the CME and CBOT, maintenance margin requirements for both "speculators" and others are set at the original margin required of others. Thus, speculators' excess original margins can be lost before maintenance margins come into play, while "others" must meet margin calls for any losses. Maintenance margin is obtained through collection of variation margin at least twice a day. At the end of each day, an FCM's accounts are marked to market, and any gains or losses since the previous mark-to-market are recorded. By 6:40 a.m. the following day these gains and losses are reflected in calculations of "settlement variation," after which the CME instructs settlement banks to credit gains to the FCM or to collect variation margin. At 11:15 a.m., positions are marked to market again, and a mid-day variation margin is paid or collected at 2:00 p.m. Thus, margin positions are restored to the "other" original margin level at least twice a day. Margin at the "other" level is maintained at the exchange clearinghouses, while the excess required of speculators is typically kept by the FCM. For example, for a futures contract on the Russell 1000, the CME requires an original margin of $4,250 for speculators and $3,400 for others. The maintenance margin for both is set at the initial "other" level ($3,400), and variation margin is collected at least twice a day to ensure that this is done. The $3,400 maintenance margin is kept at the CME clearinghouse. If the trader is a speculator, the excess initial margin, $850, is kept at the FCM.

In contrast to requirements for stocks, stock options, and single-security futures, margin requirements for stock index futures are stated in absolute dollars. Thus, the percent of margin required will vary inversely with the stock index. For example, as noted above, a contract on the Russell 1000 at the CME must have original margin of $4,250 for speculators. If the Russell 1000 index is 525, the notional value of a futures contract is $262,500 ($500 times the index), and the speculator's original margin requirement is 1.6 percent of the value of a contract. But if the index rises to 600, the margin required is 1.4 percent of the contract value.

Clearinghouses collect margins from member FCMs on either a gross margin or a net margin basis: Gross margining is used at the CME, CBOT, and NYBOT; net margining at other exchanges. Gross margin means that margin is collected on both short and long positions; net margin means collection only on net (long minus short) positions. For example, if a non-speculator at an FCM is long 1000 S&P 500 futures contracts, and another non-speculator at that FCM is short 900 S&P 500 contracts, the FCM's net position is 100 long contracts, and its gross position is 1900 contracts. At the minimum CME gross margin requirement of $14,250 per S&P 500 contract, the FCM would collect margin of $27,075,000 (= $14,250 x 1900). If net margin is used, the margin deposited by the FCM would be only $1,425,000.

There has been some debate over the possibility that traders at exchanges using net margin systems are

[12] The distinction among customers is similar to the practice in the stock market, where Regulation T exempts market makers and other specialists from the requirements that public customers face, requiring only that lenders maintain "good faith" margins.

Table 3

Margin Requirements for Equity Index Securities

Security Type	Exchange	Security Traded [Symbol or Multiple[a]]		Margin (Speculator)		Margin ("Other")	
				Initial	Maintenance	Initial	Maintenance
Exchange Traded Funds	American Stock Exchange (AMEX)	Dow Jones Indl	[DIA]	50%	25%	50%	25%
		Nasdaq 100	[QQQ]	50%	25%	50%	25%
		Russell 1000 (iShares)	[IWB]	50%	25%	50%	25%
		Russell 2000 (iShares)	[IWM]	50%	25%	50%	25%
		Russell 3000 (iShares)	[IWV]	50%	25%	50%	25%
		S&P 500	[SPY]	50%	25%	50%	25%
		S&P 500 (iShares)	[IVV]	50%	25%	50%	25%
	Chicago Board Options Exchange (CBOE)	Nasdaq 100	[QQQ]	50%	25%	50%	25%
		S&P 100 (iShares)	[OEF]	50%	25%	50%	25%
		S&P 500	[SPY]	50%	25%	50%	25%
Index Options	Chicago Board Options Exchange (CBOE)	Dow Jones Indl	[DJX]	Table 2 (broad)	Table 2 (broad)	Table 2 (broad)	Table 2 (broad)
		Nasdaq 100	[NDX]	"	"	"	"
		Russell 2000	[RUT]	"	"	"	"
		S&P 100	[OEX, XEO]	"	"	"	"
		S&P 500	[SPX]	"	"	"	"
Index Futures[b]	Chicago Board of Trade (CBOT)	Dow Jones Indl	[$10 x Indx]	$10,000	$10,000	$10,000	$10,000
	Chicago Mercantile Exchange (CME)	Nasdaq 100	[$100 x Indx]	$11,250	$ 9,000	$ 9,000	$ 9,000
		Nikkei 225	[$ 5 x Indx]	$ 6,250	$ 5,000	$ 5,000	$ 5,000
		Russell 1000	[$500 x Indx]	$ 4,250	$ 3,400	$ 3,400	$ 3,400
		Russell 2000	[$500 x Indx]	$15,000	$12,000	$12,000	$12,000
		S&P 500	[$250 x Indx]	$17,813	$14,250	$14,250	$14,250
	New York Financial Exchange (NYFE)	NYSE Comp	[$500 x Indx]	$10,000	$10,000	$10,000	$10,000
		Russell 1000	[$500 x Indx]	$10,000	$10,000	$10,000	$10,000
Index Futures Options	Chicago Board of Trade (CBOT)	Dow Jones Indl	[$100 x Prem]	Table 2 (broad)	Table 2 (broad)	Table 2 (broad)	Table 2 (broad)
	Chicago Mercantile Exchange (CME)	Nasdaq 100	[$100 x Prem]	"	"	"	"
		Russell 1000	[$500 x Prem]	"	"	"	"
		Russell 2000	[$500 x Prem]	"	"	"	"
		S&P 500	[$250 x Prem]	"	"	"	"
	New York Financial Exchange (NYFE)	NYSE Comp	[$500 x Prem]	"	"	"	"

Source: Data obtained from each exchange.

[a] For futures and futures options the contract value is determined by a multiple of the underlying stock index or the future option premium.

[b] In September 2003, initial margins for index futures, as a percent of cash index level, were as follows: S&P 500: speculator = 6.9%, other = 5.5%; Nasdaq: speculator = 8.1%, other = 6.5%; Russell 2000: speculator = 5.8%, other = 4.7%.

advantaged relative to those at gross margin exchanges. The argument is that traders will shift to exchanges using net margin systems because smaller clearinghouse margins are required. However, Rutz (1989) discounts this, noting that commodities regulations require FCMs to collect margins on gross positions.[13] A clearinghouse using net margin does not

[13] Section 1.58 of the Commodity Futures Trading Commission Act of 1974, Title 17, Chapter 1, of the Code of Federal Regulations, requires FCMs to collect exchange-required margin on "each position."

give its FCM customers an advantage because the customer must have margin consistent with his gross positions. The only effect is that the clearinghouse holds the net margin, while the FCM holds the excess of gross margin over net margin. In short, the distinction between net and gross margins at the clearinghouse affects only the division of the total margin between the FCM and the clearinghouse.

Original margin requirements at the CME and CBOT can be met in a variety of ways: cash (in several currencies), U.S. Treasury securities, letters of credit issued by approved banks, selected common stocks in the S&P 500, sovereign Canadian bonds, discount notes or noncallable bills of several federally supported mortgage credit agencies, and certain money market mutual funds. Variation margin must be paid in cash through settlement banks accepted by the clearinghouse.

Clearing House Margin

The Depository Trust and Clearing Corporation (DTCC), the clearinghouse for common stocks, does not set margin requirements because it does not loan money to customers, nor does it have any obligation after trades are cleared and settled. Once the trade is cleared, the DTCC is no longer a party to any contract. In contrast, clearinghouses at options, futures, and futures-options markets incur counterparty risk from the date a contract is initiated until the contract's expiration. The equivalent of a "house margin" is, therefore, set by the clearinghouse associated with each exchange.

Clearinghouse margins are established using a dynamic portfolio-margining model, rather than the static, rules-based approaches used at the exchanges. The clearinghouse for options, the Options Clearing Corporation, uses a portfolio-based system called Theoretical Intermarket Margin System (TIMS). The clearinghouses for futures and futures options at the CME, CBOT, NYBOT, OneChicago, and Nasdaq-LIFFE use a similar portfolio-margin system, called Standard Portfolio Analysis of Risk (SPAN).

The purpose of a portfolio-based margining system is to provide estimates of the losses that might be experienced on an account over the interval of time that the clearinghouse allows for margin calls to be satisfied. That interval is generally looser in the stock market, where brokers can require immediate (intraday) payment but often give several days (rarely more than five, but up to 15) for good customers. Clearinghouses in the options, futures, and futures-options markets have a weaker relationship with traders because the clearing FCM puts them at one degree of separation. Thus, clearinghouses are less focused than brokerage firms on the business losses that might ensue from aggressive margin collection. As noted above, the OCC requires a daily margin settlement in stock options, hence a one-day interval, while the clearinghouse at the CME, where margin settlement is twice daily, uses an interval of a half day.

An ideal portfolio margining system would generate a complete probability distribution of losses over the selected interval. This would require information on the joint probability distribution of the prices of all underlying securities: All the relevant moments of the distribution (mean returns, variances or "volatility," covariances, and higher moments) would be accurately measured and used. The characteristics of each derivative security—its expiration date, convexity, volatility, and so on—would be ascertained. Then the returns for each account would be simulated, and margin would be set according to a loss criterion, such as requiring margin to cover any losses up to those with a probability of one percent or less.

The portfolio-margining systems currently in use fall short of this ideal. Kupiec (1994) described and simulated the SPAN system. The first step in SPAN is to construct classes of stock index futures and index futures option instruments based on the underlying index. Prices of securities within each class are assumed to be perfectly correlated, while across-class correlations are treated as zero except in certain circumstances. For each class, the values of several risk parameters are chosen, and a matrix of these parameters for each security class is constructed. This "risk array" is sent to each clearing member. The FCM then uses the SPAN model and the common risk array to calculate the potential value of each account's gain or loss over a one-day period.

The primary risk parameters used in SPAN are the "futures-price scan range" and the "implied-volatility scan range." The futures-price scan range is derived by using historical data to compute the range of absolute changes in futures prices, assuming 95 and 99 percent confidence intervals and selected past window lengths (60 days, 120 days, and one year). The precise futures-price scan range is then chosen from these computations by the CME's margin committee. Because futures contracts have no convexity, the futures-price scan range directly measures the gains or losses on those contracts; therefore, it directly determines the margin requirement on a futures contract. The convexity of futures options means that gains or losses will depend on the initial prices as well as the

Table 4

Jump Diffusion Parameters for Daily Returns[a,b]
Joint Estimation with Weekend Dummy Variables
January 3, 1990 to June 30, 2003

	S&P 500		NASD Comp		Russell 2000	
Parameters	Intraweek	Weekend	Intraweek	Weekend	Intraweek	Weekend
Simple Drift						
(α)	.0388	.1650	.1817	.1776	.1555	.1774
	(2.26)*	(6.22)*	(11.7)*	(–.22)	(11.6)*	(1.02)
Simple Volatility						
(σ)	.5049	.5122	.6022	. 6097	.4389	.4062
	(29.8)*	(.39)	(36.3)*	(0.44)	(+31.8)*	(–1.81)*
Jump Frequency						
(λ)	.8461	.6485	.7837	.7636	.7031	.8808
	(51.1)*	(–6.81)*	(+66.5)*	(–.68)	(49.1)*	(4.96)*
Mean Jump						
(θ)	–.0173	–.1264	–.1802	–.1764	–.1380	–.2838
	(–.92)	(–5.14)*	(–10.9)*	(.20)	(–7.34)*	(–6.56)*
Jump Standard Deviation						
(δ)	.9663	1.2010	1.5862	1.7378	1.0841	1.0989
	(+58.9)*	(11.7)*	(142.4)*	(8.29)*	(75.0)*	(0.79)

Note: See Box 2 for definitions. Asterisks indicate statistical significance at the 5 percent level.

[a] Returns are measured as 100 times the daily log price relative, that is, in percent. Intraweek returns have one day between closings. Weekend returns are three-day returns, measured from close on Friday to close on Monday. There were 3,420 trading days and 4,944 calendar days in the sample.

[b] t-statistics are in parentheses. The t-statistic for the intraweek parameters is for the null hypothesis that the parameter is equal to zero. The t-statistic for the weekend parameter value is for the null hypothesis that the weekend parameter differs from the intraweek value. An asterisk indicates rejection of the null at 5% significance.

price variability. The futures-price scan range is, therefore, an input to the risk array used with a futures-option pricing model to compute margin requirements for futures options.

The second parameter, the implied-volatility scan range, is relevant to setting margin requirements for futures options because, again as a result of convexity, volatility is an essential input to option pricing. For each index futures class, the implied volatility of the underlying security is computed for nearest-quarter expiration at several strike prices. An average of those implied volatilities is computed, and then the frequency distributions of volatility changes for several time windows are formed. The 95th and 99th percentile values of volatility changes are computed, and the implied-volatility scan range is then chosen from these by the margin committee.

Other risk parameters are the "calendar spread charge," which is an additional margin required to reflect price volatility on futures options with different expiration dates; the "short option charge," which is the minimum margin requirement for a short option; and the "inter-commodity spread charge," which reflects *ad hoc* judgments about correlations across instruments.

SPAN calculations are done for a pre-set list of 16 scenarios, each differing in the combination of risk parameters. For example, "futures price unchanged, volatility up the full scan range" is one scenario, while another is "futures price down 1/3 of scan range, volatility up the full scan range." The greatest loss calculated for the 16 scenarios becomes the preliminary margin requirement for futures options in the account. This is then modified by incorporating exchange minimums and other criteria to obtain a final margin requirement.

Kupiec found that the SPAN model worked quite well as a margin-setting system. His simulations of SPAN showed that the margin required exceeded the one-day loss on hypothetical accounts on almost 100 percent of the days. The few exceptions were during the 1987 stock market break, when futures prices fell by more than the scan range and implied volatilities rose sharply. This demonstrates one of the limitations of portfolio-margin systems: During periods of financial stress, the historical correlations upon which models must rely no longer apply. As one observer remarked after the near-failure of Long Term Capital Management, "In bad times all the correlations go to unity."

IV. Across-Instrument Margin Requirements: Simulations

In this section we use simulation methods to measure the margin-related costs associated with each of the four replicating portfolios outlined in the second section. Our simulations of margin requirements were done in several steps. First, for three common stock indexes (the Standard & Poor's 500, the NASDAQ Composite, and the Russell 2000) data were collected on the daily close-to-close returns, exclusive of dividends, for each of the 3,420 trading days from January 3, 1990, through June 30, 2003. The parameters of a

Box 2
The Jump-Diffusion Model

The jump-diffusion model builds on the simple diffusion model of stock returns. Rather than having all variability reflected in a normally distributed "surprise," the jump-diffusion model has a second source of variability in asset returns: the effect of a random number of "jumps," either upward or downward, in stock returns, each jump having a randomly selected effect on the *return*. The advantage of the jump diffusion model over the simple diffusion model is that it incorporates known characteristics of the distribution of stock returns: negative skewness and leptokurtosis. A simple diffusion model, in contrast, generates returns that follow the "bell-shaped" Normal probability distribution.

Using bold-faced type to indicate a random variable, the jump-diffusion model of the rate of return, net of cash dividend, is

$$(1) \qquad \mathbf{R} = \alpha + \sigma\mathbf{e} + \mathbf{v}, \qquad \mathbf{e} \sim N(0,1)$$

The first two terms capture the simple diffusion model, α representing the mean return, σ the standard deviation, or volatility, of the return, and **e** being a Standard Normal random variable (Normally distributed with mean 0 and standard deviation 1) that describes the shocks affecting the return.

The jump component of the return-generation model, **v**, is the sum of **x** normally distributed shocks, where **x** is a Poisson random variable. The only parameter describing the Poisson distribution is λ, which is the mean number of jumps in a period. The actual number of shocks can range between zero and infinity (**x** = 0, 1, 2, …, ∞). If a jump occurs, the size of the effect on **R** attributable to it, denoted as $\mathbf{s_i}$ for the ith shock (i = 0, 1, 2, …, x), is also a random variable. The size of each shock, $\mathbf{s_i}$, is Normally distributed with mean θ and standard deviation δ. The mathematical description of the jump part of equation (1) is, then,

$$(2) \qquad \mathbf{v} = \sum_{i=0}^{x} s_i \qquad \mathbf{s_i} \sim N(\theta,\delta) \qquad \mathbf{x} \sim PO(\lambda) \qquad \mathbf{x} = 0, 1, 2, \ldots, \infty$$

If the number of jumps, **x**, were fixed, **v** would be the sum of **x** Normally distributed random variables; hence **v** would be Normally distributed and the jump-diffusion model would reduce to a simple diffusion model. Thus, it is the variability in the number of jumps, **x**, that gives the jump-diffusion model its power.

It can be shown that the moments for the distribution of the return, **R**, over T periods, under a jump-diffusion model are:

Mean $(\alpha - \tfrac{1}{2}\sigma^2)T$
Standard Deviation $[\sigma^2 + \lambda(\theta^2 + \delta^2)]^{1/2}\sqrt{T}$
Skewness $\lambda[\theta(\theta^2 + 3\delta^2)/[\sigma^2 + \lambda(\theta^2 + \delta^2)]^{3/2}/\sqrt{T}$
Kurtosis $\lambda[(3\delta^4 + 6\delta^2\theta^2 + \theta^4)/[\sigma^2 + \lambda(\theta^2 + \delta^2)]^2/T.$

Note that if $\lambda = 0$, both skewness and kurtosis are zero. When $\lambda > 0$, that is, when there are shocks, both skewness and kurtosis can exist. The direction of skewness in stock returns depends solely on the mean effect of a shock. In particular, when the mean shock is negative ($\theta < 0$), the distribution of stock returns will be skewed to the left; when the mean shock is positive ($\theta > 0$), the distribution of stock returns will be skewed to the right.

Whenever shocks have either a mean effect ($\theta \neq 0$) or a variable effect ($\delta > 0$), the distribution of total returns will be leptokurtic, that is, the distribution will exhibit an above-normal frequency of returns around the mode.

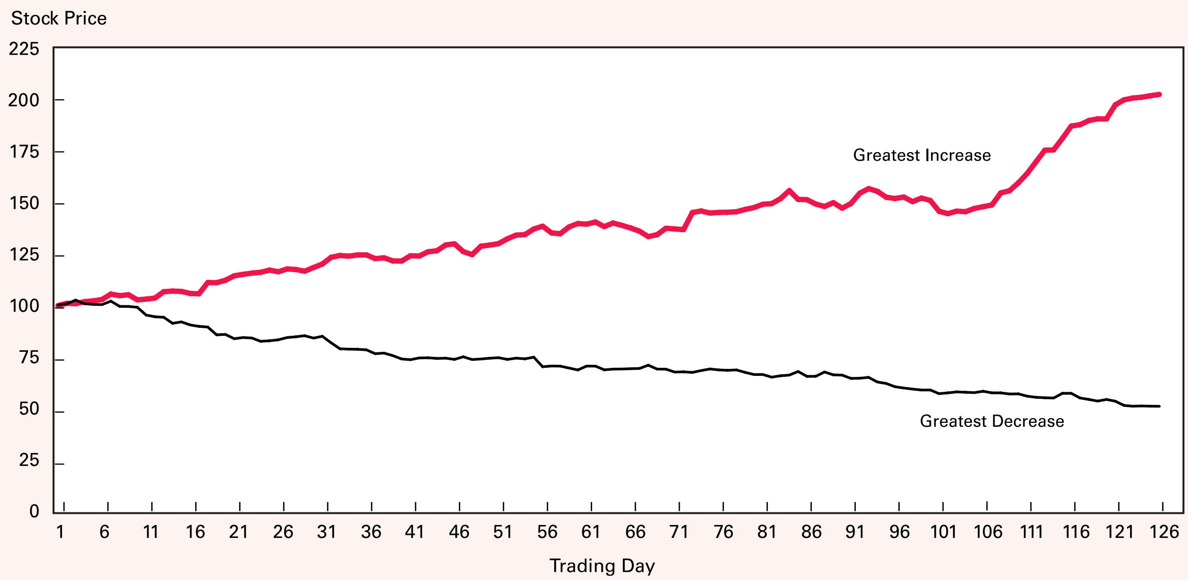
jump diffusion model of these returns were estimated using Maximum Likelihood methods as described in Fortune (1999). The basic features of the jump-diffusion model are summarized in Box 2. The parameter estimates are reported in Table 4. Based on evidence that the stock-return generating process is different over weekends, the estimation allows the parameters to differ for weekend observations (Friday close to Monday close) and for intraweek observations. Table 4 shows that the jump process plays an important role: There is about one shock per trading day ($\lambda = 1$); a shock's mean effect is to reduce stock returns ($\theta < 0$), and the variability of the effect of a shock (δ) is sizable relative to the variability of the "normal" volatility (σ).

The second step was to use the parameters of the return process to simulate the path of returns on, and the price path of, the underlying stock index. Each simulated value was referred to as a "day." The under-

Figure 1

Simulated Nasdaq Composite Index

Range over 126 Trading Days



Source: Author's calculations.

lying index level was then used to generate a path of prices for the related futures index, stock index options, and futures options. Stock and futures option prices were generated by a jump-diffusion modification to the standard Black-Scholes option pricing model. A 180-calendar-day horizon, containing 126 trading days, was assumed. Every fourth trading day (Monday to Tuesday, Tuesday to Wednesday, and so on) was designated a weekend, and the weekend parameter values were used to simulate the prices on those days.

Each day's index level differs according to random draws from the Normal distribution that defines a simple diffusion process and from the mixed Poisson and Normal distributions that define the jump diffusion process. The price paths over the 180-calendar-day horizon were simulated for 10,000 replications, allowing the probability distribution of stock index and related-security prices to be obtained for each day. Figure 1 shows the simulated price paths with the greatest increase and the greatest decrease for the most volatile index, the Nasdaq Composite. The path with the greatest increase had a doubling of price, while the path with the greatest decrease showed smaller volatility and a halving of price. A more detailed description of this process is available in Box 3.

The third step was to form the four replicating portfolios discussed above: a fully levered purchase of the index, a futures contract, simultaneous purchase of an index call option and sale of an index put option, and simultaneous purchase of an index futures call option and sale of an index futures put option. The initial and maintenance margin requirements as reported in Tables 2 and 3 were then applied to the simulated values of each of the four portfolios, and the margin deficiency for each day was calculated as the actual equity less the required margin. This was done for each of the 126 trading days in a repetition and then repeated for 10,000 repetitions. The result is 10,000 randomly selected trials of 126-trading day margin requirements.

For the margin deficiency simulations, the initial and maintenance margin requirements for the stock index are 50 percent (Regulation T) and 35 percent, respectively. The latter is the modal maintenance margin requirement adopted by NASD members in the late 1990s. The initial margin requirement for stock index futures is 6.9 percent for the S&P 500, 8.1 percent for the NASD Composite, and 5.8 percent for the Russell 2000. These are the CME's initial margins for "speculators," translated from the absolute dollar values shown in Table 3 to percentages of the initial index

Box 3
Simulating Asset Prices

Our simulations of **R**, the daily return on a stock or stock index, begin with econometric estimation of the five parameters (α, σ, λ, θ, and δ) that describe the jump-diffusion processes in equations (1) and (2) of Box 2. Once estimates of α and σ are available, a random number generator is used to create the standard normal random variable, **e**, for each "day," and the first part of equation (1) in Box 2, that is, the simple diffusion component, α + σ**e**, is calculated.

The jump effect, **v**, is then calculated by using the estimate of λ in a Poisson distribution to calculate the random number of jumps, **x**, on each day. The parameters describing the mean size and variability of the size of each jump (θ and δ, respectively) are used with a Normal random number generator to create the size of each of the jumps during a day. The value of **v** is calculated using equation (2) in Box 2, and this is added to the simple diffusion component of **R** described above. The result is, for a single day, a simulated value for **R**.

This is done for each of the 126 trading days in a 180 calendar-day period. The same five parameter values are used for each day, but on each day there are different values of **e** and **v**, and hence a different value of **R**, because different draws from the random number generator **s** are made. Once this is done for all 126 trading days, a single price path ("trial") has been computed. This exercise is repeated until 10,000 trials have been completed. The result is 10,000 paths, each for 126 days, of the rate of return on the underlying index. This is transformed to the level of the index simply by multiplying the previous index level by the current day's rate of return, using the formula $S_t = S_{t-1}(1+R_t)$ where R_t is the simulated index return for the t^{th} day in a trial.

The simulated path of the futures contract on the underlying stock index is then calculated. Using the notion of index arbitrage to link spot and futures prices, the futures price in a contract expiring at the end of 180 calendar days is the spot price "grown" at the fixed daily rate of interest, denoted by r; thus, $F_t = S_t\,(1+r)^{180}$.

Call and put option prices for the stock index are computed using a jump-diffusion variant of the Black-Scholes option pricing model. For each possible number of jumps in a day (**x** = 0, 1, 2,…) the values of the call and put options are computed using Black-Scholes; call them $C_t\,(S_t, x)$ and $P_t\,(S_t, x)$, where S_t is the day's index value and x is a specific number of jumps. Then the call and put option premiums are computed as a weighted average of these number-of-jump-specific call and put option prices, or:

$$C_t = \sum_{x=0}^{\infty} [e^{-\lambda}\lambda^x \,/\, x!]C_t(S_t,x), \text{ and}$$

$$P_t = \sum_{x=0}^{\infty} [e^{-\lambda}\lambda^x \,/\, x!]P_t(S_t,x).$$

The weights are the Poisson distribution probabilities associated with each number of jumps; these probabilities depend on the parameter λ, which measures the average number of jumps on any day. This gives, for each day in a trial, the simulated stock index option values. Repeating this for each of the 126 trading days gives a single price path, and doing the same thing for all 10,000 trials completes the computation of 126 days of option prices for each of 10,000 trials.

The values of call and put options on futures contracts are computed in the same way. That is, for each possible number of jumps in a day, the values $C_t\,(F_t, x)$ and $P_t\,(F_t, x)$ are computed. These are the call and put option premiums given the day's futures price and the number of jumps. The value of the futures call or put option is also computed as the weighted average of the number-of-jump-specific option values, with the weights determined by the Poisson distribution.

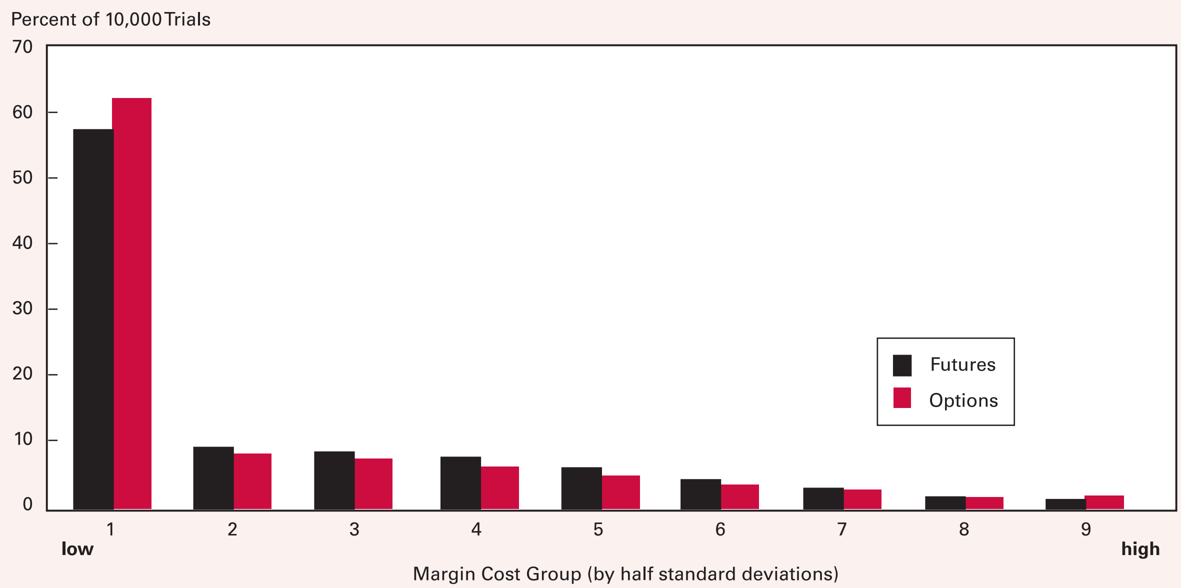
At the end, we have six 126 X 10,000 matrices of values, one matrix for each of the prices involved: the index price, its futures price, prices of call and put options on the index, and prices of call and put options on the index futures contract. These prices are then used to calculate the required margin and actual margin on each "replicating portfolio" on each day.

A 126 X 10,000 matrix of cash margin calls is constructed. From this matrix the "final" margin cost is calculated as the accumulated value at the end of the 180 calendar days of each margin call, assuming payment is made at the end of the day on which the call is issued.

Figure 2

Margin Cost Distribution

Nasdaq Index Futures and Options



Source: Author's calculations.

value in mid-June 2003. Because variation margin is collected, maintenance margins on index futures contracts are equal to initial margins. The initial margin requirements for options on the stock index and on its index futures contracts are those reported in Table 2 for a long call and a short put, both naked: The margin required on the long call is the initial long call premium; the margin on the short put is the day's short put premium plus 15 percent of the index value less the out-of-money value of the short put option.

In calculating the margin call for each day, we assumed that if the margin deficiency is negative (there is excess margin), the trader lets the credit balance stay in the account rather than withdrawing it in cash. If the margin deficiency is positive, the trader must make cash payments to satisfy the deficiency. Any prior excess margin can be used to satisfy the deficiency, but cash must make up any remaining shortfall. Using these rules, cash margin calls were constructed for each day and for each repetition. Each day's cash payment was then accumulated to the end of the 180th calendar day at the riskless rate of interest. The final result is a total cash cost of margin calls for each of the 10,000 trials. This allows an assessment of the burden of margin costs across equity-related instruments and of the potential effect that these costs have on choices by traders and investors.

The simulations do not consider some important aspects of investor choice. Most importantly, we assume that the initial position is held for the full 180 days. Clearly, investors have the option to exit their portfolios at any point, and a sequence of dismal days with margin calls will induce many investors to sell their positions. But we have not incorporated a model of exit choice into the simulations, so we assume that investors hold their positions for the entire period. Our estimates of margin costs are, therefore, overstated if the investor exits early. We also do not incorporate price limits—a prominent feature of futures contracts—into our simulations.

Results

Figure 2 and Table 5 summarize the information on the distribution of margin costs for each of the four portfolios. Figure 2 shows the distribution of margin cost for the Nasdaq Composite as a histogram. The relative frequency of margin costs in each cost group is shown for index futures and for index options. Margin cost groups are defined in terms of standard deviations from the average margin cost for the instrument.

Table 5
Distribution of Cost of Margin Calls[a]
Selected Common Stock Price Indexes
Percent of Initial Stock Index

	Security Class			
	Stock Index	Index Futures	Stock Options	Futures Options
S&P 500				
Maximum	59.5%	43.6%	88.0%	88.5%
99th Percentile	51.3	30.9	64.3	64.8
95th Percentile	51.3	24.4	52.2	52.8
75th Percentile	51.3	13.8	33.3	33.7
50th Percentile	51.3	7.1	25.7	26.0
25th Percentile	51.3	7.1	25.6	26.0
Minimum	51.3	7.1	25.1	26.0
Nasdaq Composite				
Maximum	69.1%	59.7%	119.9%	120.4%
99th Percentile	57.8	42.2	85.0	85.5
95th Percentile	52.1	33.2	68.5	69.0
75th Percentile	51.3	18.3	41.6	42.1
50th Percentile	51.3	8.4	30.1	30.5
25th Percentile	51.3	8.3	30.1	30.5
Minimum	51.3	8.3	30.1	30.5
Russell 2000				
Maximum	61.5%	45.5%	93.8%	94.3%
99th Percentile	51.5	30.1	64.5	65.1
95th Percentile	51.3	23.2	51.9	52.4
75th Percentile	51.3	12.6	32.8	33.3
50th Percentile	51.3	6.0	25.2	25.5
25th Percentile	51.3	6.0	25.2	25.5
Minimum	51.3	6.0	25.2	25.5

[a] The cost of margin calls is computed as follows: The margin call on each day is calculated and "grown" to the 180th calendar day at the riskless rate of interest. These daily cumulative costs are then summed to obtain the aggregate cost of margin calls. Results are expressed as a percent of the initial value of the stock index (assumed to be $100).

Group 1, the lowest group, consists of final costs between 0.5 and 1.0 standard deviations below the mean, group 2 represents observations between the mean and 0.5 standard deviations below the mean, group 3 is observations between the mean and 0.5 standard deviations above the mean, and so on. Group 9 is observations more than three standard deviations above the mean. Note that the margin cost data are standardized for purposes of exposition, and that the means (and standard deviations) are different for futures and options. Expressed as a percent of the initial underlying index, the mean and standard deviation for Nasdaq futures margin cost are 14.1 percent and 8.7 percent, respectively; for Nasdaq options, they are 37.8 percent and 13.5 percent, respectively. Thus, margin costs are higher and more variable for index options than for index futures.

Figure 2 shows that the frequency distributions of margin costs are similar for futures and options. About 58 percent of futures observations and 62 percent of options observations are in the lowest-cost group. About 2 percent of observations are in the highest group—over three standard deviations above the mean margin cost. The lower boundary of this highest group is about 40 percent for futures and 78 percent for options.

Table 5 shows the distribution of the absolute dollars of margin cost, expressed as a percentage of the initial stock index (assumed to be $100). Thus, for the Nasdaq Composite, the 99th percentile of margin costs for the stock purchase strategy is 57.8 percent of the initial index level, or $57.80 per $100 of initial value.

The median margin cost is highest for the stock purchase strategy, lowest for the futures contract, and intermediate for the index option and index futures option strategies. Thus, for the S&P 500, the median cost is 51.3 percent for the stock index, 7.1 percent for the futures index, and about 26 percent for the option contracts. Stock index derivatives are a lower-cost way of getting the returns on the index, with the margin cost advantage being particularly great for futures index contracts. This is true for all three indexes, and it is true for all indexes up to approximately the 90th percentile. In short, there is at least a 90 percent probability that derivatives will carry lower margin costs than outright purchase.

If the advantages are so great, why don't all traders use derivatives? One reason is that there are non-margin cost differences among the three strategies. For example, price limits in futures contracts make them less liquid and, therefore, less desirable. But another reason is that in particularly bad times, the margin costs jump more sharply for derivatives than for outright purchase of the stock index. Consider the Nasdaq Composite. There is a one percent chance that the futures index margin costs will rise to 42.2 percent or more—still below the 57.8 percent margin cost associated with outright purchase, but well above the 8.4 percent median margin cost. And the option contracts fare even worse in bad times: The 99th percentile for option margin costs is about 85 percent—well above the stock index's 57.8 percent and the futures index's 42.2 percent.

Thus, an investor's choice of which strategy to adopt is not a simple matter of considering the average level of margin costs. It also depends on the sensitivity of margin costs to changes in the underlying stock index and on the investor's taste for risk. Risk-tolerant investors might prefer the use of derivatives because the low average cost compensates them for the rare experience of high margin costs. Investors who do not tolerate risk well might prefer the strategy of outright purchase.

V. Summary and Conclusions

Innovations in financial instruments have broadened the ways that investors can achieve their desired risk and return characteristics. This study shows that, absent any cash costs from trading (bid-ask spreads, commissions and fees, cash payment for margin requirements), the following are identical ways to invest in the S&P 500 index: a fully leveraged purchase of a "Spider"; taking a long position on a futures contract on the S&P 500 index; buying a call option on the S&P 500 and simultaneously selling a put option, both at a specific price; and buying a futures call option while simultaneously selling a futures put option, again at a specific strike price. While stock index instruments are the focus of the study, the same principles apply to investing in individual stocks or their derivatives.

Why would an investor prefer one strategy over another? The reason must lie in differences in costs, or in legal and regulatory features that make one market different from another or that inhibit entry into one or more markets. This study focuses on one aspect of the decision—costs related to margin requirements. Regulations at the federal, exchange, house, and clearinghouse levels require investors to put up cash or acceptable securities to meet margin (equity) requirements.

The study describes the current margin requirements on stocks, stock options, futures contracts, and futures contract options. It notes that one of the important differences between margin requirements on stocks and on stock derivatives is that maintenance margin requirements on derivatives are set at the initial margin requirement level, with variation margin required to maintain the equality. In contrast, requirements on stocks are set at the time of purchase but do not change after purchase unless prices decline sufficiently to induce maintenance margin calls. Thus, margin requirements on derivatives should be more variable over the holding period than requirements on stock.

This hypothesis is supported by a stochastic simulation of the prices of three stock indexes: the Nasdaq Composite, the S&P 500, and the Russell 2000. Margin requirements for these indexes and for index-related derivatives are calculated, and the costs of the cash margin calls are computed. The primary conclusion is that the average (median) cost of margin requirements for index futures contracts is far less than the average cost of stock index margin requirements, while the average cost of margin requirements on stock index options is between that for stock indexes and index futures but closer to the former. Thus, an investor focusing on average experience would have a strong incentive to hold futures contracts and a moderate preference for options contracts over outright purchase of a stock index. The same ranking would, of course, apply to holding individual stocks.

However, the margin requirement costs of futures and options are highly variable. While the futures contract margin cost is always less than the almost fixed margin cost of holding the index itself, the futures investor can experience dramatic fluctuations in margin costs. The same is true for options contracts, where investors have a small chance of incurring greater margin costs than in an outright purchase. Investors who forego the fixed costs of stock ownership accept the highly variable costs of derivatives, exposing themselves to a small chance of facing liquidity problems that force an untimely exit from positions. Thus, the ranking of strategy preferences will depend on investors' preferences: Risk-tolerant investors, who focus on average costs rather than cost variability, will choose futures contracts; less risk-tolerant investors have reason to choose options contracts or outright purchase.

The study shows that the structure of margin costs is rather complex, and that it is difficult to determine whether the playing field is level because not all investors are identical. The conventional view that margin costs provide a clear incentive to use derivatives—particularly futures contracts—ignores the differences in the fixed vs. variable cost structure of margin costs: Investors are sorted into different markets, allowing all instruments to be financially viable.

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