Federal Reserve Bank of New York

Quarterly Review

Summer 1988 Volume 13 No. 2

Studies on Equities Markets

This Quarterly Review *is published by the Research and Statistics Group of the Federal Reserve Bank of New York. An introduction to this collection of studies on equities markets begins on page 1. Among the members of the staff who contributed to this issue are* GIKAS HARDOUVELIS *(on evidence on stock market speculative bubbles: Japan, the United States, and Great Britain, page 4; and on margin requirements and stock market volatility, page 80);* PAUL BENNETT *and* JEANETTE KELLEHER *(on the international transmission of stock price disruption in October 1987, page 17);* ROBERT ADERHOLD, CHRISTINE CUMMING, *and* ALISON HARWOOD *(on international linkages among equities markets and the October 1987 market break, page 34);* GEORGE SOFIANOS *(on margin requirements on equity instruments, page 47); and* ARTURO ESTRELLA *(on consistent margin requirements: are they feasible? page 61).*

A quarterly report on Treasury and Federal Reserve foreign exchange operations for the period May through July 1988 begins on page 90.

Introduction and Summary

Since October 1987, a number of careful investigations of the stock market crash have been prepared, and each has added to our understanding of what did—and what did not—occur. Studies have explored the reasons for the crash and have made recommendations for preventing another such episode. The collection of articles in this *Quarterly Review* represents an effort to achieve a still better understanding of certain significant technical issues related to equity market performance. Many of the questions examined here have been debated by economists and others for many years and will no doubt be debated for years to come. Looked at in that light, the results presented in these papers are offered not as definitive answers to these questions, but rather as contributions to the ongoing discussion of the workings of equity markets here and abroad.

The first three articles discuss the international character of the crash. One is an econometric test of the proposition that a particular form of speculative price development, called "rational speculative bubbles" by economists, preceded the crash in the United States, the United Kingdom, and Japan. The next two pieces analyze the worldwide transmission of the disruption from one national stock market to another. The last three articles examine the role of equity-related margin requirements in the United States. One summarizes the diverse margin rules in the various markets. Another discusses the analytical and conceptual issues surrounding the question of making margins "consistent" across markets. And the last piece introduces some new evidence into the debate about how margin requirements may affect stock market activity.

The stock market crash was a thoroughly international event, and its worldwide nature needs to be better understood. In the first article in this issue, Gikas Hardouvelis examines the notion that the October crash was preceded by the buildup of speculative price movement in major world stock markets. Noting that it is difficult to make an empirical distinction between bubble-type price movements and movements based on changes in fundamental values, Hardouvelis chooses to test a specific theoretical model of speculative behavior, rational price bubbles. With this approach, he finds that the data are consistent with the existence of such a speculative bubble in the United States in the period before the crash. He finds similar evidence in Japan, but concludes that the case for a pre-October bubble in the United Kingdom is weaker.

Hardouvelis' findings square with the widespread opinion that in the months leading up to the crash, stock prices in various centers had an upward bias that was not related in obvious ways to economic fundamentals. A somewhat loose but probably fair interpretation of the statistical work is that the October fall in stock prices was preceded by speculative trading activity that pushed prices above their fundamentals; and, once the correction was underway, it took on special dynamics of its own.

In the second article, Paul Bennett and Jeanette Kelleher focus on the dynamic interactions among stock price movements in different countries during the crash. Were the interactions characteristic of the behavior of major stock markets during prior, less dramatic periods of volatility? In what respects were the worldwide relationships in October unique? Did recent

trends in cross-border trading and investments in stocks influence these relationships?

Bennett and Kelleher estimate statistical equations describing how major markets had interacted during previous periods of stress. They find patterns that in certain key respects suggest that the international character of the downward break in stock prices in October should not be regarded as especially surprising. In the pre-October data, unusually high daily price volatility in one market tended to coincide with above-average volatility in other markets as well. Moreover, when prices became especially volatile in episodes prior to October 1987, the alignment of up and down movements among markets became unusually close—that is, foreign and domestic stock price movements tended to become more closely correlated.

The growing internationalization of stock trading and investment activities may have changed the patterns of interaction among national stock markets in recent years. Bennett and Kelleher find that price indexes in major markets have in fact moved more closely together in the 1980s than in earlier years, both on a day-to-day and a month-to-month basis. They also show that a given rise in daily volatility has, on average, been associated with a greater increase in correlation between markets in the 1980s than in the 1970s. However, the propensity of high volatility in one market to be associated with high volatility in others was about the same in the two decades.

To relate their findings to the crash, the authors examine how well their estimated relationships characterize the October interactions among major markets. In October 1987, correlations of day-to-day price movements among key markets increased approximately as they had in previous periods of high volatility. At the same time, however, the spillover of volatility from one market to another far exceeded even the substantial extent of transmission predicted by the precrash relationships. This aspect of the crash was unusual, particularly because—as noted above—little evidence existed in the precrash data to suggest that the propensity of volatility to spill over from market to market had risen in the 1980s.

Bennett and Kelleher's findings support the view that extreme price disruption in a major stock market is systematically associated with disruption in other markets. Thus, to the extent that the likelihood of excessive volatility can be reduced in any one major market, other markets stand to benefit as well.

In the next article, Aderhold, Cumming, and Harwood examine the possible roles of cross-border investment flows and of stock trading in centers outside the home market in promoting October's simultaneous downturns in major world stock markets. This analysis focuses on the patterns of international stock trading flows and price movements in the days surrounding the crash. Although the methodology of this article differs significantly from that of the preceding piece, the two sets of findings reinforce one another.

Aderhold, Cumming, and Harwood show that direct international linkages—cross-border investments and 24-hour trading—played at most a limited role in the simultaneous declines in major markets. Only in Japan did cross-border selling by nonresidents appear to exacerbate the crash significantly. Twenty-four-hour trading seems to have been an important factor only with regard to U.K. equities traded in the United States in the form of American depositary receipts (ADRs); price declines on these ADRs were transmitted into U.K. share prices. Overall, however, the direct international linkages among the largest markets were not developed enough to account for a dominant share of total activity in those markets during the crash period.

Nevertheless, information links among major markets are now extraordinarily good, and direct trading and clearing linkages are in the early stages of development and likely to evolve further. The authors suggest that the surge in foreign stock turnover in London during the crash hints at the broader potential for streamlined international trading links to transmit price reactions across markets in the future. Thus, while direct trading and investment linkages were not the principal cause of market interactions in the crash, the trend toward worldwide integration is continuing, and it may further increase the sensitivity of the major stock markets to one another.

The last three articles in this issue take up topics related to margin requirements on various equity instruments. In "Margin Requirements on Equity Instruments," George Sofianos outlines the structure of margin requirements for stocks, stock options, and stock index futures and options, not only for retail transactions but for professional trading as well. In the process of describing the margin rules, Sofianos' piece conveys the complex variety of approaches taken at the various exchanges. The differences in rules reflect not only differences in regulatory structures and in the roles assigned to margin requirements, but also the current diversity of clearing and settlement arrangements.

In the following article, Arturo Estrella provides some conceptual guidance for assessing the adequacy and consistency of equity-related margins among the numerous classes of instruments, participants, and trading arenas. He notes that whether margin levels are adequate or whether a sufficient degree of consistency exists across markets depends on the purposes assigned to margin requirements. Moreover, even when

the role of margins is reasonably well defined, consistency can be hard to define and evaluate.

Estrella illustrates this point by outlining an approach to evaluating the relative adequacies of stock and stock index futures margins, using protection of market integrity as the criterion. Briefly, his approach is to simulate a variety of price outcomes and to compare how well different systems of margins perform. The simulations take into account the risk diversification in index futures, the different amounts of time currently allowed for margin payments in the various markets, and the different levels and configurations of margin requirements. On the one hand, the results indicate that the cash market margins and the much lower initial futures margins provide a similar degree of protection against the possibility that price movements will exceed margin buffers. On the other hand, the likelihood of large margin calls is much greater in the futures market. Large margin calls arguably carry the potential to accelerate price movements or to raise concerns about the integrity of market participants and clearing mechanisms. Thus the assertion that margins are effectively similar in the two markets must be qualified to the extent that the higher-leveraged futures margining system depends on the ability to meet these sizable calls.

The need to assess the consistency of margins across markets in light of the objectives sought in imposing these requirements stands out especially clearly with respect to equity-related options. Options by nature can provide purchasers with greater leverage than other instruments. Nevertheless, option buyers stand to lose no more than their original premium payment, whereas option sellers face potentially unlimited risks due to price changes. If the goal of margin requirements is narrowly defined as protection against failed contract performance by writers of options, margins on stock-related options can be set so that the probability of losses exceeding margin buffers can be made as small as for stocks. On the other hand, margins set at levels consistent with an acceptably small probability of contract failure by option writers might also be consistent with a very high degree of implicit leverage, that is, very high gearing of risk by option purchasers. This high leverage in turn might conflict with other purposes of margin requirements.

Estrella explains that the diversity of clearing and settlement arrangements, which creates important differences among instruments in the timing of margin payment flows, is another obstacle to achieving consistent margin requirements for different equity-related instruments. More margin is needed to protect against losses when it takes several days to collect additional margin calls than when it takes only a few hours. Estrella concludes that determining proper degrees of consistency and adequacy for margin requirements must involve a large measure of good judgment in addition to technical analysis.

The link between the purpose of margins and their adequacy and consistency highlights another important issue: How much can margin requirements realistically be expected to accomplish? However important any one goal for margin requirements might appear, the question remains whether the tool can help with the job. In the final article in this issue, Gikas Hardouvelis examines the argument that margin requirements help protect the stock market by reducing excessive price volatility.

Hardouvelis investigates how the volatility of stock price movements since the 1930s has changed as Federal Reserve initial margin requirements have changed over the same period. His statistical results are consistent with the notion that higher margin requirements can help to reduce volatility. However, volatility of stock prices is not necessarily undesirable if it reflects changes in underlying determinants of values. Therefore, he extends his statistical formulation to control for volatility of fundamental influences on stock prices. He also adjusts for the historical propensity of the Federal Reserve to react to volatility in setting margin requirements. The simple relationship between stock price volatility and margin requirements could be a distorted indicator of the effect of margins on volatility, since margin requirement levels traditionally have been adjusted partly in response to erratic price changes. After statistically controlling for these factors, Hardouvelis finds that the original inverse relationship between margins and volatility holds up.

As noted earlier, the purpose of these articles is not to suggest that they—individually or collectively—are the final word on the various technical aspects of equity market behavior addressed in this issue. However, taken as a whole, they should provide insights and suggest new lines of inquiry as observers, analysts, and policymakers seek a better understanding of the complex forces at work in equity markets in the United States and elsewhere.

Evidence on Stock Market Speculative Bubbles: Japan, the United States, and Great Britain

The sudden worldwide collapse of stock prices in October 1987 has puzzled observers of financial market developments. President Reagan commented that the fall had nothing to do with the economy. Market analysts described the event as "absurd" or as "mindless herd movement." Indeed, it is hard to justify such a large drop in stock prices. Economists typically attribute large swings in stock prices to the impact of important economic news on financial markets. New information can cause investors to make drastic reassessments of the size of future cash flows or the future discount rates at which these cash flows are capitalized. But the adverse economic news that preceded the fall in stock prices on Monday, October 19, 1987 does not appear dramatic enough to have caused the unusual drop of 23 percent.[1]

The view that the stock price collapse cannot be explained by economic fundamentals leads to the question, Did the collapse represent an abrupt downward correction of an overvalued market or did the market become grossly undervalued after prices fell? This article focuses specifically on the possibility of overvaluation before the October crash in the three major national stock markets of the United States, Japan, and Great Britain. It proposes a new method of detecting market overvaluation and finds evidence consistent with this phenomenon.

[1]The adverse news included the disappointing U.S. trade deficit figures announced the previous Friday and reports of a possible tax law that would negatively affect mergers and acquisitions.

Overview

Persistent market overvaluation followed by market collapse is often referred to as a speculative bubble. Such bubbles may be triggered by an extraneous event that is unrelated to fundamental economic conditions; one group of investors buys with the expectation of a large capital gain, and others follow suit, without paying proper attention to economic factors such as future dividends or interest rates. If such behavior persists, it may feed on itself as consecutive waves of buying increase prices. Speculative bubbles may subsequently burst very suddenly; an overvalued market is fragile and a relatively unimportant piece of "bad" news may easily create pessimism and set off a selling wave.[2]

The traditional method of searching for market overvaluation or speculative bubbles counts the number of unusually high returns during the suspected bubble period and assesses the likelihood that the total number of these high returns could have arisen from chance.[3] An unusually high return (or a positive "abnormal" return) is a return higher than the risk-free rate plus the usual risk premium necessary to compensate

[2]Note that although the general description of a speculative bubble assumes some sort of collective market irrationality, irrationality is not a necessary characteristic of a speculative bubble. In a special case described later, agents know the market is overvalued but they remain in the market because they expect to be compensated for staying in an overvalued market.

[3]Olivier J. Blanchard and Mark W. Watson, "Bubbles, Rational Expectations, and Financial Markets," in Paul Wachtel, ed., *Crises in the Economic and Financial Structure* (Lexington, Massachusetts: Lexington Books, 1982), chap. 11, pp. 295-315.

risk-averse stockholders for the uncertainty associated with their security returns. In the absence of a speculative bubble, a very large number of unusually high returns would normally occur by chance only with a small probability. Hence a large number of unusually high returns constitutes evidence consistent with the presence of speculative bubbles. Unfortunately, although simple, the traditional test has low statistical power to detect speculative bubbles: Stock prices are very volatile and their swings generate both large positive and large negative returns. The latter tend to mask any existing bubble evidence.

In order to construct a more powerful test for bubbles, it is necessary to formulate a more precise economic account of the development of the bubble. One can imagine many different scenarios of market overvaluation, but this analysis restricts the possible scenarios to those in which investors *know* that the market is overvalued yet show no special desire to liquidate their positions and continue to buy or sell as they would in the absence of bubbles. This is a realistic working assumption for the period before October 1987. Robert Shiller provides survey evidence indicating that before October 1987, 71.7 percent of individual investors and 84.3 percent of institutional investors thought that the market was overvalued at the time.[4]

Explaining why investors did not get out of an overvalued market is more difficult. One could argue that the presence of highly liquid futures markets and associated trading strategies such as portfolio insurance led investors to the false belief that they could enjoy large positive returns in an upward market yet still avoid suffering a large loss if the market took a big plunge.[5] This article, however, pursues an explanation that does not depend on some sort of collective irrationality. Academic economists call it the "rational speculative bubble" hypothesis.

[4]The survey results are described in Robert J. Shiller, "Investor Behavior in the October 1987 Stock Market Crash;" National Bureau of Economic Research, Working Paper no. 2446, November 1987. The survey was conducted after the crash, so there is reason to suspect that the respondents' answers were influenced by the crash. Shiller also reports consistent answers to a similar question: only 36.1 percent of individual investors and 22.2 percent of institutional investors described themselves as bullish and optimistic relative to other investors before October 1987.

[5]The expression portfolio insurance is a misnomer for a dynamic portfolio allocation strategy designed to guarantee a specified minimum return. The strategy assumes a liquid market where one can sell stocks whenever the need arises. Portfolio insurance can work well when the number of insurers is small and they cannot influence the market. But when the same technique is employed by many insurers, liquidity in the market is destroyed. This is particularly true when noninsurers act in anticipation of what portfolio insurers will do. Thus portfolio insurers who assume the presence of a liquid market suffer from irrationality. The October 1987 stock market collapse provided an example of portfolio insurance failure exactly at the time the insurance was needed most.

In the case of a rational speculative bubble, investors know that the bubble may crash and that they will not be able to get out once the crash starts, but they remain in the market because they believe—for whatever reason—there is good probability that the bubble will continue to grow, bringing them large positive returns. These returns are expected to be higher than the risk-free rate plus the usual risk premium in the absence of bubbles, and large enough to compensate them *exactly* for the probability of a bubble crash and a large onetime negative return. Hence it is rational for investors to stay in the market. The expected extra return when no bubble crash occurs can be called the "bubble premium." The theory implies that the bubble premium is not only positive, but also increases during the lifetime of the bubble. The time trend in the bubble premium derives from the explosive nature of the bubble component of the stock price. As time goes on, the bubble component of the stock price grows larger and larger relative to the fundamental component. This growth implies that with the passage of time, the expected drop in the stock price in the case of a bubble crash grows larger too, necessitating a larger and larger bubble premium.

The evidence points to a positive and rising bubble premium for approximately a year and a half before October 1987 in the national stock markets of the United States and Japan. A positive and rising bubble premium is also present in the national stock market of Great Britain, but it appears much later, in mid-1987. Overall, the evidence is consistent with the hypothesis of rational speculative bubbles.

The nature of rational speculative bubbles

This section provides an intuitive description of a rational speculative bubble. A more detailed mathematical example is presented in the accompanying Box. Recall that a rational speculative bubble is a special case of a speculative bubble. The characteristic that makes a speculative bubble rational is the particular size of its expected rate of growth. The expected rate of growth of a rational speculative bubble is such that investors have no incentive to get out of the market, although they know the market is overvalued.

Rational bubbles and investor behavior

To understand how a rational speculative bubble works, let us consider a concrete example: Suppose that investors require a rate of return of 10 percent in order to invest in the stock market. This required rate of return of 10 percent equals the risk-free rate that they could get by investing, say, in Treasury bills or eurodollars, plus an extra return that represents a compensation for the risk they assume when investing in stocks,

Box: An Example of a Rational Speculative Bubble

For expositional simplicity, assume that the sum of the risk-free rate and the risk premium is constant over time and equals r. The presence of a time-varying risk-free rate or risk premium does not affect the main point of the example. Rationality of behavior and of expectations, together with market clearing, implies that the expected rate of return on a stock equals the required rate r:

(B1) $E_t R_{t+1} = r, \quad R_{t+1} \equiv (p_{t+1} - p_t + d_{t+1}) / p_t,$

where p denotes the stock price, d the dividend, and E_t the expectations operator at time t. Rearranging the expected arbitrage condition, B1, yields:

(B2) $p_t = (1/(1+r))\, E_t p_{t+1} + (1/(1+r))\, E_t d_{t+1}.$

Substituting for p_{t+1} in equation B2 and continuing recursively, one can derive the familiar present value model, which states that the price equals the infinite sum of expected future dividends discounted at the required rate of return r:†

(B3) $p^*_t = \sum_{i=1}^{\infty} [1/(1+r)]^i\, E_t d_{t+i}.$

Here p^*_t is the "market fundamental value" of the stock. Note, however, that p^*_t is not the only solution to B2. Any p_t of the following form is a solution as well:

(B4) $p_t = p^*_t + b_t, \quad \text{with } E_t b_{t+1} = (1+r)\, b_t.$

To see that equation B4 is a solution, observe that according to B4, $p_{t+1} = p^*_{t+1} + b_{t+1}$. Then, substitute p_t and p_{t+1} in B2 and check that B2 is satisfied. Equation B4 says that the market price can deviate from the market fundamental value by b_t, a bubble component, without violating the expected arbitrage condition B2 or B1. The intuitive reason why a bubble component can exist is straightforward: arbitrage conditions in financial markets are expressed in terms of rates of return, not in terms of price levels. Therefore, even if an asset is, say, overvalued by an amount b_t, it is still "rational" for an investor to buy it, if the degree of overvaluation is expected to grow every period at the rate r.

Observe that the characteristic that makes a bubble rational is its expected rate of growth and not necessarily its actual rate of growth. Therefore, theory cannot determine with precision the actual form of the bubble process. A multiplicity of bubble processes may exist. An obvious candidate is the following:

(B5) $b_{t+1} = (1+r)\, b_t + v_{t+1}, \quad E_t v_{t+1} = 0.$

The bubble process B5 satisfies the condition $E_t b_{t+1} = (1+r)\, b_t$ but explodes to infinity with the passage of time. Since the stock price cannot be infinite, the bubble process B5 is not realistic.

†It is assumed that the transversality condition holds, that is, $\lim_{i \to \infty} E_t[1/(1+r)^i] P_{t+i} = 0.$

The following example, advanced by Blanchard, is a realistic scenario of a bubble that grows for some time but eventually bursts:‡

(B6) $b_{t+1} = (1/q)\,(1+r)\, b_t + v_{t+1}$ with probability q; v_{t+1} with probability 1-q; with $E_t v_{t+1} = 0.$

In each period the bubble continues with probability q or crashes with probability 1-q. It is straightforward to check that the bubble process B6 satisfies the condition $E_t b_{t+1} = (1+r)\, b_t$, that is, the bubble is expected to grow at the rate r. However, on the condition that the bubble does not crash, the bubble is expected to grow at a rate higher than r: $E_t b_{t+1} | NC = (1/q)(1+r) b_t$. This implies that conditional on the event of no bubble crash, markets expect to receive a rate of return higher than r. This extra expected return is the bubble premium.§

The bubble premium is positive and increasing with time. To clarify these two properties of the bubble premium, let us continue the example by assuming that expected dividend payments are constant:

(B7) $d_{t+i} = d + u_{t+i}, \text{ with } E_{t+i-1} u_{t+i} = 0, \quad i = 1, 2, \ldots$

In this case the fundamental component p^*_t is constant over time and equals d/r, and the realized abnormal rate of return during the lifetime of the bubble is:

(B8) $R_{t+1} - r = [(1+r)((1-q)/q)\, b_t + u_{t+1} + v_{t+1}] / p_t.$

The expected abnormal rate of return conditional on no bubble crash taking place, that is, the bubble premium, is:

(B9) $E_t(R_{t+1} - r \mid NC) = [(1+r)(1-q)/q]\, b_t / p_t.$

Equation B9 shows that the bubble premium is positive and increasing with time. The term b_t/p_t is an increasing function of b_t. Since b_t is itself rising as the bubble unfolds, $E_t(R_{t+1}-r \mid NC)$ is increasing with time. Our test exploits these two properties of the bubble premium. In contrast, the Blanchard-Watson test exploits the fact that the realized abnormal return in equation B8 is on average positive. One of the reasons the Blanchard-Watson test has low statistical power is the presence of the noise terms u_{t+1} and v_{t+1}, which are absent from the bubble premium of equation B9.

‡Olivier J. Blanchard, "Speculative Bubbles, Crashes and Rational Expectations," *Economics Letters*, vol. 3 (1979), pp. 387-89.

§In "Rational Inflationary Bubbles," *Journal of Monetary Economics*, vol. 21 (January 1988), pp. 35-46, Behzad T. Diba and Herschel I. Grossman argue that once a rational bubble bursts, it cannot restart. However, they also show that a rational bubble can periodically shrink to a very small positive number. For the purposes of this article, the distinction between shrinking and bursting bubbles does not matter.

the risk premium. Suppose also that investors expect to receive a constant dividend equal to $5.0 each year. Then, according to the present value model of stock prices, the fundamental or bubble-free price of the stock is $5.0/0.10 = $50.0. The price will stay at $50.0 as long as the required rate of return (the discount rate) and the expected dividend remain constant. The investors' expected rate of return over their holding period equals the expected dividend of $5.0 plus the zero expected capital appreciation or depreciation, divided by $50.0. Thus the expected rate of return is 10 percent, the same as the required rate of return, and investors are satisfied.

Now suppose there is a bubble component on the stock price equal to $4.0, so that the market price is $54.0.[6] For simplicity, let the holding period horizon of investors be one year and assume that the probability that the bubble will crash to zero during the year is, say, 1/10, and the probability that it will continue after the end of the year is 9/10. Normally, if investors know the stock price is overvalued by $4.0, they will attempt to sell the stock, driving its price down to the fundamental level of $50.0. In the case of a general speculative bubble, investors stay in the market because they do not pay sufficient attention to fundamentals and do not know that the market is overvalued. However, in the case of a rational bubble, investors know the market is overvalued but have no incentive to sell because they expect that the bubble component will grow and compensate them appropriately.[7] Specifically, suppose that if the bubble continues, it will reach the level of $4.89 at the end of the year. Then the expected level of the bubble at the end of the holding period equals the probability of a bubble crash times the value of zero[8] plus the probability of no bubble crash times $4.89, that is, 1/10 $0.00 + 9/10 $4.89 = $4.40. The expected bubble level of $4.40 is exactly 10 percent higher than the original level of $4.0 and implies an expected capital gain of $0.40. It also implies that the expected rate of return from the stock is $(5.0 + 0.4)/$54.0 = 10 percent, which is the rate of return required to satisfy investors. Thus, when the expected value of the bubble at the end of the year is 10 percent above its level at the beginning of the year, investors have no incentive to get out of the market.

Positive bubble premium

Next, let us see how an unfolding rational bubble is consistent with the presence of a positive bubble premium. Recall that a bubble premium is the extra compensation that investors expect to receive while the bubble continues to grow. In the previous example, the rate of return investors expect to receive if the bubble does not crash is $(5.0 + 4.89)/$54.0 = 10.91 percent, and thus the bubble premium is 0.91 percent. The bubble premium is positive because it compensates investors for the negative excess return in case the bubble crashes. In the previous example, the expected return in case of a bubble crash is $(5.0 − 4.0)/$54.0 = 1.85 percent, which implies a negative expected excess return of −8.15 percent. Observe that 9/10 (0.91 percent) + 1/10 (−8.15 percent) = 0. This is the sense in which the bubble premium exactly compensates investors for the probability of a bubble crash and a negative onetime excess return.[9]

Increasing bubble premium

The bubble premium is not only positive but also grows progressively larger as long as the bubble continues. This growth occurs because the bubble component gets larger and larger relative to the fundamental component of the stock price. A higher bubble component implies a larger loss in case of a bubble crash, an outcome which necessitates a larger bubble premium. To clarify this point, let us continue the previous example. Assume that at the end of the year the bubble reaches the level of $4.89, which implies a new stock price of $54.89. If the bubble crashes at the end of the second year, investors expect to make a return of $(5.0 − 4.89)/$54.89 = 0.20 percent, which implies a negative excess return of −9.80 percent. This expected loss, larger in absolute terms than the corresponding excess return of −8.15 percent of the first year, necessitates a larger bubble premium. The new bubble premium

[6] For a discussion of how a bubble can start, see Diba and Grossman, "Rational Inflationary Bubbles."

[7] It is perhaps difficult to understand why investors expect the bubble to grow in the state of no crash. However, the point of the example is not to explain how such expectations are formed, but to show that once these expectations are formed, they can be consistent with an equilibrium in which the required rate of return is 10 percent.

[8] The bubble value of zero, that is, a return of the stock price to the fundamental value of $50.0, is assumed only for purposes of simplicity. It is possible that when a bubble crashes, the stock price overshoots or undershoots its fundamental value. The example in the Box allows for such possibilities by adding an error term to the bubble component.

[9] Clearly, the greater the probability of a bubble crash, the larger the bubble premium. To understand this point, let the probability of a bubble crash be 1/3 instead of 1/10. If investors are to stay in the market, they must expect that so long as no crash occurs, the bubble will grow from $4.0 to $6.6, or that the stock price will increase from $54.0 to $56.6. The overall expected bubble level is (2/3) $6.6 + (1/3) $0.0 = $4.4, which is 10 percent larger than the current bubble of $4.0, as is the case in the example of the text. As in the text, the expected rate of return from the stock (which equals the sum of the dividend of $5.0 plus the expected capital gain of $0.4, divided by the current price of $54.0) is 10 percent; thus, investors have no incentive to get out of the market. However, the bubble premium is larger. The bubble premium can be found from the expected rate of return in the state of no crash, which is equal to $(5.0 + 2.6)/$54.0 = 14.07 percent. Thus the bubble premium is 4.07 percent and is larger than the bubble premium of 0.91 percent in the text.

should be such that 9/10 times the bubble premium, bp, equals 1/10 times 9.80 percent, that is, (9/10) bp = (1/10) 9.80 percent. This equality implies a bubble premium of (10/9)(1/10) 9.80 percent = 1.09 percent, which is larger than the previous bubble premium of 0.91 percent.

To see the rising bubble premium in an alternative way, recall that investors will have no incentive to liquidate their positions if during the second period they expect to receive their required rate of return of 10 percent. Since the stock price at the beginning of the second year is $54.89, investors are satisfied if in addition to the $5.0 in dividends, they also expect the price on the average to rise by $0.49 to $55.38, so that the expected rate of return is ($5.0 + $0.49)/$54.89 = 10 percent. Now recall that the example assumes two possible states, one with a bubble crash and one without. In the state of a bubble crash, the bubble component, currently at $4.89, will drop to zero, causing the price to drop to $50.0. If investors are satisfied with an overall expected price level of $55.38, they must expect that in the state of no bubble crash, the price will rise by $1.09 to the level of $55.98, so that the expected price is (9/10) $55.98 + (1/10) $50.0 = $55.38. Put differently, investors expect that in the absence of a bubble crash they will make a return of ($5.0 + $1.09)/$54.89 = 11.09 percent. Thus the bubble premium is 1.09 percent and is higher than the bubble premium of the first year.

Realized abnormal return versus bubble premium

If at the end of the second year the bubble does not crash, the example suggests that the price will rise to $55.98 and investors will receive exactly their bubble premium of 1.09 percent. In the example, the realized abnormal return at the end of a year does not differ from the bubble premium, a subjective expected abnormal return at the beginning of the year; thus, realized abnormal returns are also positive and growing over time. In practice, however, realized abnormal returns are positive and growing over time only in an average sense. For example, if the bubble does not crash, there is no guarantee that at the end of the second year the stock price will be $55.98. Many unforeseen events occur that may affect the stock price, driving it either above or below the level of $55.98. Thus, during the lifetime of the bubble, realized abnormal returns will fluctuate considerably, and this volatility may mask their upward trend. Empirically, this volatility is particularly problematic when the lifetime of the bubble is short. In contrast, the bubble premium is not affected directly by the volatility of the stock market. For this reason, the empirical methodology focuses on the bubble premium.

The example discussed in this section has made a number of simplifying assumptions. These include a constant risk-free rate, a constant risk premium, and a constant probability that the bubble will collapse even as the bubble grows. These assumptions were made for expository purposes only. They are not required for the empirical analysis that follows.

Measurement of the bubble premium

The previous section showed that in the presence of rational speculative bubbles, investors expect to receive a positive bubble premium that increases over time as the bubble unfolds. This section describes the empirical measurement of the bubble premium. Recall that the bubble premium is an extra return investors expect to receive over their required rate of return, as long as the bubble does not burst.

Methodology

Let R denote the realized rate of return of a stock, which consists of the dividend payment during the period plus the realized capital gain or loss at the end of the period. During the lifetime of the bubble, R can be decomposed into the following four components:

$$(1) \quad R = rf + rp + bp + e,$$

where rf denotes the risk-free rate, say, the eurodollar deposit rate, an observable variable at the beginning of the period; rp and bp denote the risk premium and the bubble premium respectively, variables known subjectively to market participants at the beginning of the period but not directly observable; and e denotes an unanticipated random disturbance arising from unforeseen events. The sum of the risk-free rate and the risk premium represents the required rate of return, or the discount rate. The sum bp + e is the realized abnormal return during the bubble period. The bubble premium, bp, is zero during periods with no bubbles.

The sum of the bubble premium and risk premium, bp + rp, represents the excess return over the risk-free rate that market participants *expect* to receive provided that the bubble does not crash. The realized excess return at the end of the period, R − rf, is what market participants *actually* receive. The difference between the actual and the expected excess return is the disturbance e. If investors' expectations are rational, then the disturbance e cannot be predicted at the beginning of the period and has an expected value of zero. Put differently, the assumption of rational expectations implies that the investors' expected compensation for assuming risk and investing in a bubble period, rp + bp, is *on the average* equal to the actual compensation, R − rf. Thus the observable R − rf can be

used in conjunction with the assumption of rational expectations in order to estimate the unobservable sum of the risk premium and bubble premium.

The sum of the risk premium and bubble premium can be estimated by regressing R − rf on variables known to market participants at the beginning of the period. The regression equation decomposes R − rf into a predictable component—an estimate of bp + rp—and an unpredictable random component representing news that develops after the beginning of the holding period. The regression equation is as follows:

$$(2)\quad R - rf = [a + b_1 x_1 + \ldots + b_j x_j] + e,$$

where $x_1, \ldots, x_j$ are variables known to market participants at the beginning of the period. When this regression is run over the sample period before the crash, the regression fit—the estimated item in the brackets—represents the excess return expected if no bubble crash takes place and is a proxy for the sum of the risk premium and bubble premium.

The information variables $x_1, \ldots, x_j$ of the above regression equation were chosen to maximize explanatory power over the entire sample period (September 1977 through December 1987). They are financial variables such as volatility measures and interest rate spreads within or across countries. Volatility measures are obvious empirical proxies for the risk premium, but interest rate spreads are also good proxies for risk and bubble premia. To understand this point, recall that financial variables are the aggregate outcomes of investors' actions in financial markets. These actions are motivated not only by investors' expectations of future profits but also by their willingness to assume risk and their knowledge of a possible underlying bubble. Thus, in equilibrium, financial variables provide information about the risk premium and the bubble premium. For example, the spread between the Japanese 10-year government and industrial bond yields represents a proxy for corporate risk; the spread between the 12-month and 3-month eurodollar deposit rates represents a proxy for the risk of a change in interest rates 3 months hence.[10]

The holding period over which returns are calculated is assumed to be either 3 or 12 months. Shorter holding periods are perhaps more representative of the horizons of active investors but are less useful for

[10]For more information on the regression variables and the statistical techniques that were employed, see the technical version of this paper, entitled: "Evidence on Stock Market Speculative Bubbles: Japan, United States, and Great Britain," Federal Reserve Bank of New York, Research Paper no. 8810, February 1988.

Table 1

Realized Excess Stock Returns

(Percent Return in Domestic Currency)

	Three-Month Holding Period					
	December 1977 to March 1985			April 1985 to December 1987		
	Japan	United States	United Kingdom	Japan	United States	United Kingdom
Mean	10.1	3.1	8.4	22.6	9.7	7.6
Standard deviation	25.0	29.7	31.4	44.9	44.0	49.7
Correlation with						
Japan	1.00			1.00		
United States	0.24	1.00		0.58	1.00	
United Kingdom	0.39	0.52	1.00	0.64	0.88	1.00
	Twelve-Month Holding Period					
	September 1978 to March 1985			April 1985 to December 1987		
	Japan	United States	United Kingdom	Japan	United States	United Kingdom
Mean	9.8	2.9	9.8	33.1	17.1	19.3
Standard deviation	11.6	15.7	12.2	20.6	10.3	12.6
Correlation with						
Japan	1.00			1.00		
United States	0.30	1.00		0.37	1.00	
United Kingdom	0.32	0.61	1.00	0.29	0.75	1.00

Note: Excess stock returns are realized total returns, including dividends, minus the 3-month (12-month) eurodeposit rate of 3 (12) months earlier. They correspond to R-rf of equation 2 in the text. All returns are annualized. Note that in the period March-April 1985, the dollar began a downward slide.

uncovering speculative bubbles because returns over short periods have a large variance and are not easily predictable.[11] The large swings in stock prices over short horizons would mask any evidence of a positive and rising bubble premium.[12] Note, however, that the holding period assumption is only a practical tool and does not affect the conclusions regarding the presence of speculative bubbles.

Preliminary data analysis

Before turning to the estimation of the bubble premium and the risk premium, it is instructive to perform a preliminary data analysis. Table 1 presents summary statistics of the realized excess rate of return R − rf. Consistent with the previous discussion, excess rates of return are less volatile in the 12-month horizon than in the 3-month horizon. Also note that after March 1985, excess rates of return increased, a necessary development if bubbles are to be found.[13]

Table 2 presents summary information from prelimi-

[11]This technique of searching for bubbles depends critically on the predictability of stock returns because it utilizes the bubble premium, which is an expected as opposed to a realized abnormal return. Financial economists have recently shown that contrary to the traditional random walk hypothesis of stock prices, stock returns are indeed predictable, but over longer horizons. See Eugene F. Fama and Kenneth R. French, "Permanent and Temporary Components of Stock Prices," *Journal of Political Economy,* vol. 96 (April 1988), pp. 246-73; and Gikas A. Hardouvelis, "Margin Requirements, Volatility, and the Transitory Component of Stock Prices," Federal Reserve Bank of New York, Research Paper no. 8818, July 1988.

[12]Stock price volatility is more pronounced at the daily level. Thus it is not surprising that Santoni was unable to find evidence consistent with the presence of speculative bubbles when he examined daily stock returns in the U.S. stock market before October 1987. See Gary S. Santoni, "The Great Bull Markets 1924-29 and 1982-87: Speculative Bubbles or Economic Fundamentals?" Federal Reserve Bank of St. Louis *Review,* November 1987, pp. 16-30.

[13]Data on eurodeposit rates represent London midmorning rates (after October 1986 they are closing rates) during the last trading day of the month and were provided by DRI. Stock returns are based on national stock market indexes on the last trading day of the month. For Japan and Great Britain, the data come from the Morgan Stanley Capital International Indices data bank. For the United States, the data reflect the S&P 500 and come from the Citibase data bank and the *Wall Street Journal.*

Table 2

The Predictability of Excess Stock Returns

$$R - rf = a + b_1 x_1 + \ldots + b_j x_j + e$$

Sample: December 1977 to December 1987, 121 observations

			Significance Level			
				Chow Tests		
Three-Month Holding Period	$\bar{R}^2$	**SEE**	Test of $b_1 = \ldots = b_j = 0$	Periods 1 vs. (2+3)	Periods 1 vs. 2	Periods 2 vs. 3
Japan	.07	30.9 percent	.060	.002	.190	.001
United States	.13	31.9	.000	.880	.020	.044
United Kingdom	.10	35.1	.001	.260	.000	.007
Twelve-Month Holding Period						
Japan	.47	13.3 percent	.000	.000	.041	.000
United States	.16	14.3	.427	.000	.001	.000
United Kingdom	.32	10.5	.000	.000	.000	.003

Notes: $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom; SEE is the regression standard error. Significance levels lower than .050 constitute evidence for rejecting the null hypothesis. R is the annualized total gross return, and rf is the risk-free rate, that is, the 3- or 12-month eurodeposit rate for each country and holding period. The estimation uses all overlapping observations with the necessary adjustments; see Lars P. Hansen, "Large Sample Properties of Generalized Methods of Moments Estimators," *Econometrica,* vol. 50 (July 1982), pp. 1029-54. Period 1 runs from December 1977 through July 1982, period 2 from August 1982 through March 1985, and period 3 from April 1985 through December 1987. In the 12-month horizon of Japan, the sample begins in September 1978. The information variables x_i are as follows: (1) for Japan, in the 3-month horizon: spread between 10-year Japanese government bond yield and 3-month euroyen rate, spread between 3-month and 1-month euroyen rates, spread between 3-month and 1-month eurodollar rates, spread between 10-year Japanese government and industrial bond yields, and spread between 3-month eurodollar and euroyen rates; in the 12-month horizon: spread between Japanese government 10-year bond yield and 12-month euroyen rate, spread between 12-month and 3-month eurodollar rates, spread between 12-month eurodollar and euroyen rates, and yen/dollar exchange rate volatility; (2) for the United States, in the 3-month horizon: spread between 3-month and 1-month eurodollar rates, and spread between 3-month eurodollar and euroyen rates; in the 12-month horizon: lagged dependent variable, spread between 12-month eurodollar and europound rates, spread between 12-month and 3-month eurodollar rates, and spread between 30-year and 5-year U.S. government yields; (3) for the United Kingdom, in the 3-month horizon: lagged dependent variable, spread between 12-month eurodollar and europound rates, and volatility of U.K. stock prices; in the 12-month horizon: lagged dependent variable, europound rate, and spread between the 20-year and 5-year British government bond yields.

nary regressions utilizing the whole sample, including postcrash data. Observe that the explanatory power of the information variables, measured by the R^2 statistic, is much higher in the 12-month holding period. This result is consistent with the finding of Fama and French and others that stock returns are more predictable over longer horizons. The table shows the results of testing the hypothesis that all slope coefficents $b_1, \ldots, b_j$ are jointly zero: $b_1 = \ldots = b_j = 0$. Zero slope coefficients would imply that the sum of the risk premium and bubble premium is constant over time. In five of the six cases the hypothesis is, however, rejected, an outcome that shows that excess stock returns are partially predictable and that, in the absence of bubbles, risk premia are time-varying.

Table 2 also presents tests of structural change of the parameters a, $b_1, \ldots, b_j$, with the break points occurring in July 1982, the time when a bull market began around the globe, and in March 1985, the time when the dollar began a downward slide. Although coefficient instability can be caused by the inability of the information variables $x_1, \ldots, x_j$ to capture the variability in the risk premium adequately, it can also be caused by the presence of speculative bubbles. The tests reveal considerable instability, particularly at the March 1985 break point, indicating that speculative bubbles could be present after March 1985.[14]

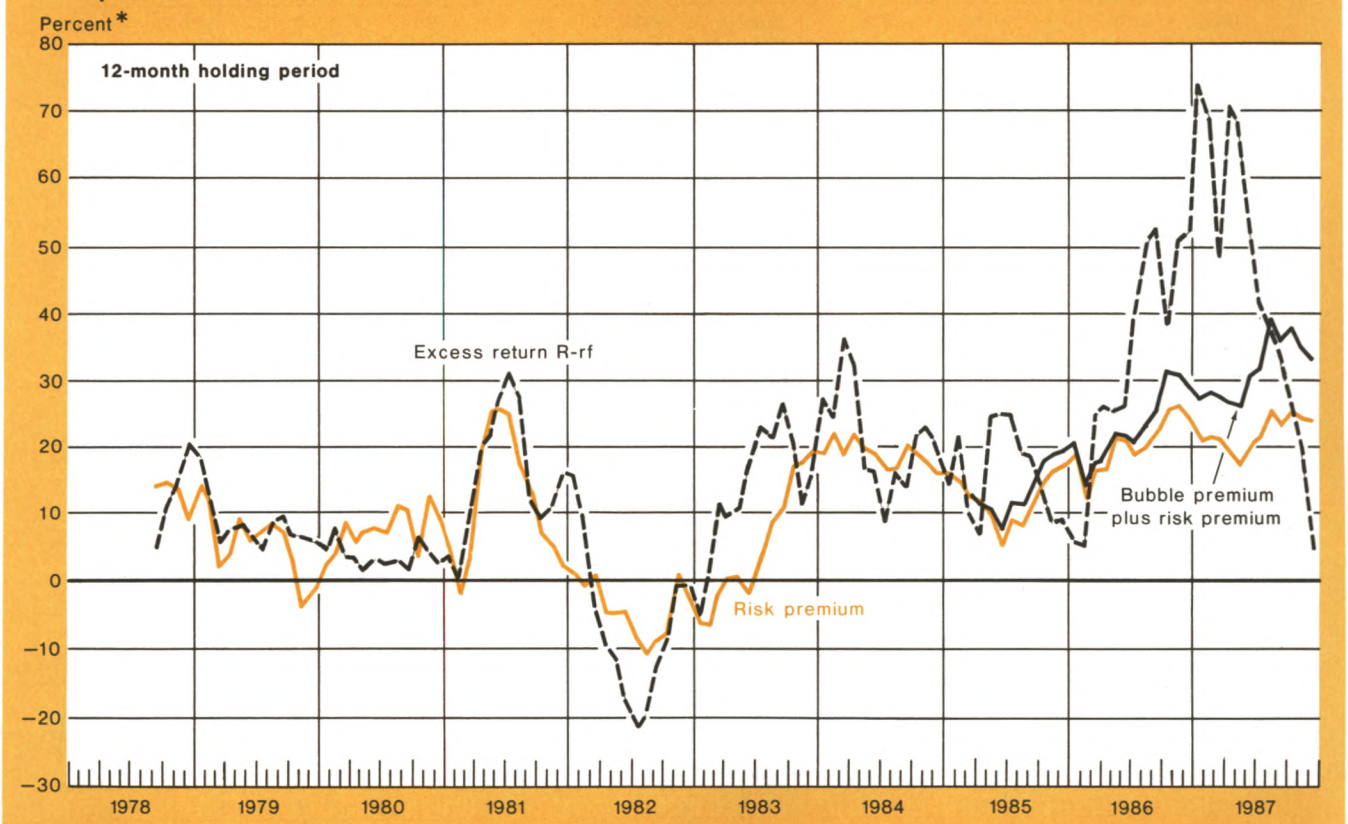
Estimation

Let us turn now to the actual estimation of the risk premium and the bubble premium. Regression equation 2 can be used to estimate the sum of the risk premium

[14]The presence of bubbles can cause instability, but the reverse is not true: the presence of instability does not necessarily imply the presence of speculative bubbles. Coefficient instability can be caused by many other factors.

Chart 1

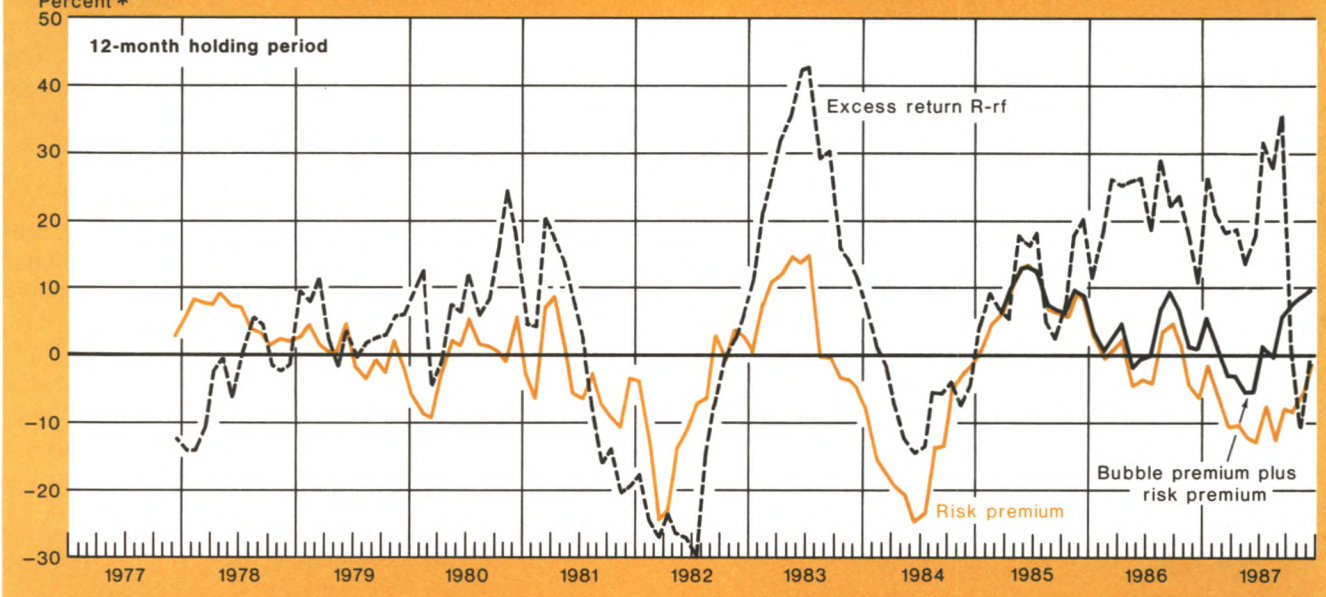
Japanese Stock Returns



*Annualized rates of return.

Chart 2

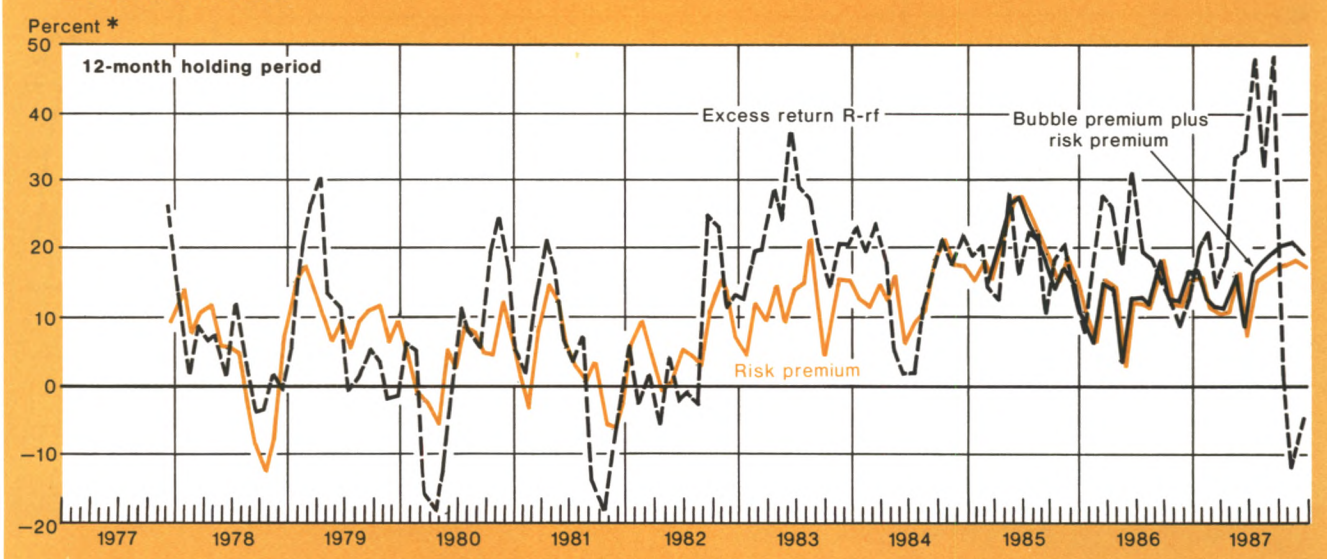
U.S. Stock Returns



*Annualized rates of return.

Chart 3

U.K. Stock Returns



*Annualized rates of return.

and bubble premium. In order to partition the estimated sum into its two separate components, it is necessary to make two reasonable assumptions: first, it is assumed that during the earlier part of the sample there were no speculative bubbles. This assumption makes it possible to use the data of the earlier period, specifically from September 1977 through March 1985, in order to estimate the parameters a, b_1, ..., b_j of equation 2 that characterize the evolution of the risk premium.[15] Second, it is assumed that the parameters a, b_1, ..., b_j that characterize the risk premium over the subperiod from September 1977 through March 1985 remain the same during the subperiod from April 1985 through September 1987 and that any observed changes are caused by the presence of a bubble.

These assumptions make it straightforward to estimate the risk premium over the period from April 1985 through September 1987. One simply utilizes the estimated parameters a, b_1, ..., b_j from the September 1977-March 1985 sample together with the information variables of the April 1985-September 1987 sample.

Constructing the bubble premium involves estimating a new set of parameters, a', b_1', b_2', ..., b_j', over the period from April 1985 through September 1987. The bubble premium is calculated using the difference between the new estimates a', b_1', ..., b_j' and the old estimates a, b_1, ..., b_j, together with the information variables of the later period. Specifically, the estimation method allows for possible instability in the regression coefficients throughout the April 1985 to September 1987 sample period through the use of a rolling regression: beginning in April 1985, the coefficients of equation 2 are reestimated every month, with a new month added to the sample each time.[16] Thus every month in the post-March 1985 sample has an associated set of regression coefficients. These coefficients, together with the information variables of each month, provide an empirical proxy for the sum of the risk premium plus the bubble premium. Since the risk premium is already estimated, one can promptly deduce the size of the bubble premium by simple subtraction.[17]

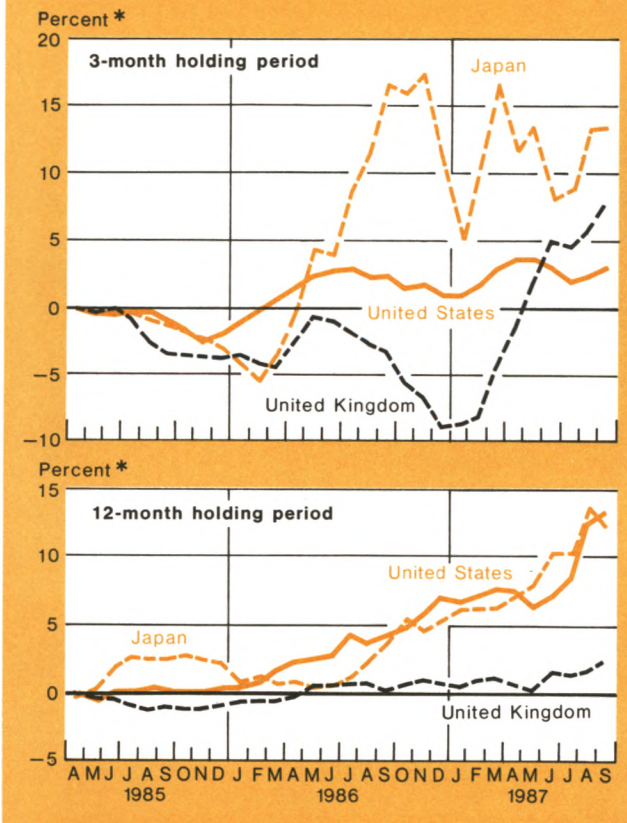
Empirical evidence on rational speculative bubbles

Charts 1, 2, and 3 present plots of the realized excess return $R - rf$ (dashed black line), the risk premium (solid colored line), and the post-March 1985 sum of the risk premium and the bubble premium (solid black line) for the national stock markets of Japan, the United States, and Great Britain. A 12-month holding period horizon is assumed in each case. Observe that

[15]The assumption that no bubbles were present before April 1985 simplifies the exposition but does not invalidate the conclusion on the presence of a bubble after April 1985. If a bubble were present during the earlier part of the sample, then the results of the article would simply be interpreted as evidence that the bubble became stronger after April 1985.

Chart 4

Bubble Premium



*Annualized rates of return.

[16]A single regression over the April 1985 to September 1987 period allows for a more abrupt change in the estimated coefficients from the earlier period but does not allow the coefficients to vary during the April 1985 to September 1987 period itself. It turns out that the resulting bubble premium from a single regression is very similar to the one from the rolling regression.

[17]As noted earlier, one of the assumptions underlying the methodology is that the parameters of the reduced form equation 2 that describe the time variability of the risk premium do not change during the post-March 1985 suspected bubble period. However, the mere presence of bubbles should increase the riskiness of holding stocks. In a rational bubble, investors expect the volatility of stocks to increase as the bubble unfolds because the size of the potential loss (and gain) increases with time. Thus the constructed bubble premium is the sum of two components: the expected abnormal return conditional on no crash taking place plus the extra risk premium due to the presence of bubbles. The presence of this extra risk premium does not affect the interpretation of the results, however, because it cannot exist without the presence of rational bubbles; if it exists, it indicates the presence of a bubble.

after 1985, realized excess returns are positive in all three countries. Indeed, during the last three years investors received higher rates of return in the stock markets than in the eurocurrency markets, a finding that suggests but does not constitute firm evidence that speculative bubbles are present. Evidence for the presence of speculative bubbles would be a positive and rising bubble premium. Recall that the bubble premium is an expected excess return over and above the risk-free rate plus the risk premium and is present only during the lifetime of the bubble. In Charts 1, 2, and 3 the bubble premium is the gap between the two solid lines after March 1985; for clarity, it is plotted separately in Chart 4.

Chart 4 shows that, indeed, the bubble premia are positive and increasing with time. Japan and the United States show the strongest bubble evidence, and in both countries the evidence is stronger when a 12-month holding period is utilized. In Great Britain the evidence is mixed because in the 3-month holding period the bubble premium becomes positive only after mid-1987.

To confirm the upward trend of the bubble premium, one can regress the bubble premium, bp, on a linear time trend:

$$(3)\quad bp = c + d\ TIME + u,$$

and test the hypothesis that the slope coefficent, d, is positive. Table 3 presents the regression results. In all six cases the slope coefficients are positive and significantly different from zero and thus confirm the positive evidence of the charts on the existence of rational speculative bubbles.

Table 3 also presents results from regressions in which the dependent variable is the realized abnormal return, bp + e, instead of the expected abnormal return, bp. These results offer similar evidence of an upward trend, but the evidence is relatively weak. As noted earlier, the noise term e creates excessive volatility and tends to mask the upward trend.[18]

This method of detecting speculative bubbles differs significantly from the traditional method of counting the number of abnormal positive returns, bp + e. The traditional test requires independent observations and thus, if an adequate number of observations is to

[18]The sample in Table 3 begins in January 1986 because earlier estimates of the bubble premia tend to be negative and thus result in an overestimate of the upward trend in the bubble premia.

Table 3

Is There a Time Trend in the Bubble Premium?

Sample: January 1986 to September 1987, 21 observations

$$bp = c + d\ TIME + u$$
$$bp + e = c' + d'\ TIME + v$$

	c	d	$\bar{R}^2$	SEE	c′	d′	$\bar{R}^2$	SEE
Three-month holding period								
Japan	−6.88	.77*	.43	5.4	56.14†	−1.32	−.01	38.8
	(5.57)	(.24)			(31.21)	(1.58)		
United States	−0.43	.13*	.36	1.0	10.30	.21	−.05	26.3
	(1.14)	(.05)			(19.28)	(.83)		
United Kingdom	−14.34*	.39*	.21	4.2	−92.71*	3.17*	.23	33.2
	(5.45)	(.19)			(46.23)	(1.35)		
Twelve-month holding period								
Japan	−7.39*	.63*	.91	1.2	12.74	1.72*	.29	15.8
	(1.09)	(.05)			(14.26)	(.74)		
United States	−4.81*	.52*	.89	1.1	7.21	.92*	.47	5.9
	(.56)	(.03)			(4.48)	(.22)		
United Kingdom	−2.64*	.10*	.70	0.4	−15.10	.81†	.18	9.7
	(0.39)	(.01)			(13.75)	(.43)		

*Significant at the 5 percent level.
†Significant at the 10 percent level.
Note: bp is the bubble premium, the expected abnormal return conditional on no bubble crash taking place, and bp + e is the realized abnormal return (see equation 1 of the text). $\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom. SEE is the regression standard error. Numbers in parentheses are corrected OLS standard errors; the correction is due to the overlapping intervals.

be obtained, can only be performed using the 3-month holding period. There is only a maximum of two nonoverlapping observations in the case of a 12-month holding period. Table 4 tabulates the realized abnormal returns, bp + e, for the 3-month holding period. Take, for instance, the subperiod January 1986 to September 1987, which contains seven nonoverlapping observations. In Japan, the holding period sequence January-April-July-October shows four positive and three negative abnormal returns, while the other two holding period sequences, February-May-August-November and March-June-September-December, show five positive and two negative abnormal returns. Clearly, one cannot reject the null hypothesis that these abnormal returns were generated by chance. For example, the case of five positive abnormal returns out of seven returns can arise from chance with probability 0.227.[19] In the United States, the number of positive abnormal returns is five for the first holding period sequence, four for the second, and six for the third. In Great Britain, the evidence against the likelihood that the results could be due to chance is the weakest: four positive abnormal returns in the first sequence, three in the second, and four in the third. Overall, these findings show that the traditional runs test is unable to reject the null hypothesis of no bubbles. The procedure of relying on bubble premia clearly has more power.

Finally, it should be noted that the hypothesis of rational bubbles cannot predict how much a market would collapse once a bubble bursts. Although the example presented in the Box assumes that the market returns to its fundamental value after the bubble bursts, the market could, in reality, overshoot or undershoot its fundamental value. For example, in October 1987 the U.K. market that had earlier shown weak bubble evidence fell by about as much as the U.S. market, although the latter had shown strong bubble evidence.[20]

Table 4

Realized Abnormal Returns*

April 1985 to September 1987
Three-Month Holding Period
(In Percent)

Date	Japan	United States	United Kingdom
1985			
April	−4.80	−16.39	−6.76
May	−2.30	−4.55	2.88
June	−7.60	6.87	−35.27
July	11.78	4.86	−35.12
August	−17.96	−19.40	−16.64
September	−26.27	−38.86	−22.94
October	−4.99	−21.13	−2.28
November	−26.28	11.87	−7.84
December	−10.22	44.54	7.43
1986			
January	−15.98	18.91	−13.11
February	13.51	28.45	−3.27
March	74.07	37.17	42.27
April	71.29	34.27	18.24
May	67.69	22.02	−24.02
June	−2.25	8.00	−14.00
July	39.98	−11.80	−38.04
August	68.83	−4.42	−17.17
September	62.10	−41.02	−65.83
October	−4.83	−1.47	−28.52
November	−22.00	−19.03	−35.07
December	−8.20	2.34	−11.70
1987			
January	77.58	33.46	19.01
February	58.64	46.00	46.66
March	60.56	73.17	54.20
April	57.92	5.74	37.19
May	62.49	−5.15	53.31
June	9.90	2.32	68.84
July	−36.45	25.23	63.63
August	−15.99	41.02	10.61
September	5.36	8.59	19.20

*Realized abnormal returns refer to bp+e of equation 1 in the text. They are annualized.

Conclusion

Despite the difficulty of uncovering speculative bubbles from the data, this article isolated evidence consistent with the hypothesis of rational bubbles in the national stock markets of Japan and the United States before the October crash. In Great Britain the evidence is somewhat weaker. Evidence for the presence of rational bubbles is a positive and increasing bubble premium, which market participants require in order to invest during a bubble period. During the lifetime of a rational speculative bubble, market participants expect to receive positive abnormal returns (bubble premia) as compensation for the probability of a bubble crash and

[19] This is the probability of obtaining two or less negative tickets (five or more positive tickets) when drawing seven times with replacement from a box that contains two tickets, one positive and one negative. There are 128 possible sequences of positives and negatives, out of which 1 sequence contains exactly zero negatives (seven positives), 7 sequences contain exactly one negative (six positives), and 21 sequences contain exactly two negatives (five positives). Thus (1 + 7 + 21) / 128 = 0.227.

[20] Those who question the rational bubbles hypothesis as a general characteristic of stock market fluctuations typically argue that any evidence interpreted as a rational bubble can also be interpreted as arising from the econometrician's ignorance about unobservable market fundamentals. For a review of such arguments, see James D. Hamilton, "On Testing for Self-Fulfilling Speculative Bubbles," *International Economic Review*, vol. 27 (October 1986), pp. 545-52. Although this criticism of speculative bubbles is plausible in general, it cannot be easily applied to the specific evidence in the text. It is very hard to construct a story based on fundamentals that can explain both the sudden collapse of stock prices in October 1987 and the previous upward trend. This difficulty becomes immediately evident once one tries to use Hamilton's examples.

a large onetime loss. The size of the bubble premium grows over time as the bubble unfolds because the degree of market overvaluation rises. As the magnitude of the potential loss during a crash increases, investors require progressively larger compensation. Indeed, the data show a positive and rising bubble premium for one and a half years before October 1987 in the national stock markets of Japan and the United States, and for half a year before October 1987 in the national stock market of Great Britain.

Gikas A. Hardouvelis

The International Transmission of Stock Price Disruption in October 1987

One of the most striking features of the October 1987 collapse of equities prices was its worldwide scope. During the month of October, prices in many countries dropped even more than in the United States (Table 1), and day-to-day volatility reached extraordinary levels in many markets. Thus an adequate understanding of the event must include some grasp of why the disruptions so quickly circled the globe.

Were the spillovers of huge, correlated price movements typical of how world stock markets tend to interact under stress? Or, alternatively, were the market interactions of October 1987 unprecedented? Is it likely that future price disruptions would spread worldwide?

This article presents evidence that the interactions among international stock price movements during the October crash were in certain respects similar to the reactions of major markets to volatility in the past. Our principal findings are as follows:

- The statistical evidence from before October 1987 clearly shows that when one major market experiences particularly large price changes, other countries' stock prices will typically be subject to higher volatility also.
- Nevertheless, in last year's crash, the spread of high volatility from one major market to another was considerably greater than the earlier statistical relationships would have predicted.
- The pre-October 1987 evidence also indicates clearly that, when volatility is high, the price swings in major markets tend to become more highly correlated. That is, even well before the crash, when price swings in major markets became enlarged, they also became increasingly likely to go in the same direction.
- During the crash period, these correlations between up and down price movements generally increased, in accordance with the earlier, precrash pattern.
- Viewed from a longer time perspective, stock price movements in major markets have become increasingly similar in the 1980s, compared to the 1970s and before. This development appears generally consistent with the ongoing strengthening of cross-border trading, listings, and investment activities. The increased similarity of price moves has been comparatively small, however, and does not appear to have decisively influenced how markets interacted in October 1987.

In short, while the crash was *qualitatively* similar to prior episodes in that the volatility spread from market to market and correlations among some markets strengthened, the particular *degree* to which volatility spread was unusual. Indeed, in this respect, the October pattern of market interactions was unique, yet not easily attributable in a direct sense to the trend toward integrated world equities markets.

Market volatilities and correlations

The interaction among stock markets can be characterized by assessing the volatilities of prices in different markets and the degree to which day-to-day price movements are correlated with one another. *Volatility* is a statistical characteristic of price behavior in a single market. In this article, volatility is measured as the

standard deviation of daily percent price movements.[1] *Correlation* is a statistical attribute of a pair of markets. Here, correlation is measured as the correlation coefficient between percent changes in price indexes for pairs of markets.[2]

Note that a high correlation between price movements in two markets does not necessarily imply that they experience similar volatilities. It may be, for example, that even though two markets tend to move up and down at the same time, the size of the movements in one market (its volatility) is much greater than in the other.

To begin, let us review how volatilities and correlations behaved during the October 1987 crash. Chart 1 shows the volatility of daily price changes during 30-day periods in four equities markets. It is evident that the volatilities of daily price movements rose sharply and virtually simultaneously in major markets around the time of the crash. Chart 2 shows the correlation coefficients of daily price movements, also during 30-day periods, in three pairs of stock markets. The chart reveals that the October 1987 correlation between U.S. and Japanese stock price changes was higher than average. Between the United States and the United Kingdom, correlation was moderately above average, but the correlation of daily price movements in the U.S. and German markets was slightly below average.

How should this October pattern of volatilities and correlations be interpreted? Unfortunately, pure economic theory does not provide simple rules on how stock prices in different countries should interact, either routinely or under stress. Economic forces that benefit companies listed in one country could either help or hinder companies listed elsewhere. Changes in exchange rates, for example, could conceivably make one stock market go up and another go down. On the other hand, it is possible that a jolt in oil prices might affect a number of major markets similarly.

It is also the case that some stock traders may react not only to relevant news and announcements but also to foreign stock price movements themselves. As Chart 2 shows, economic events and trading patterns have most often caused stock prices in different major markets to be positively correlated. To some extent this positive correlation might become self-reinforcing if it prompts domestic traders to adopt a conditioned response to foreign price change even when they do not fully understand its source. Indeed, in the face of particularly large price swings abroad, such responses by domestic traders could dominate domestic price movements as well. Thus it seems plausible that, within short time horizons, high price volatility in one market could lead to increased volatility in a second market, with unusually high correlation between the price movements.

The October 1987 collapse may have been a particularly important example of traders' quick responses to foreign price changes not easily explained by adverse news or economic fundamentals. Large price swings in one market may thus have led directly to similar large swings in another.

This article explores the extent to which the October 1987 pattern of responses was typical. In the sections that follow, we seek to determine whether earlier episodes of high volatility were associated with increased volatility in other major markets. We also investigate whether correlations among price movements rose during previous periods of high volatility. Clearly, the relative importance and qualitative nature of identifiable world events affecting markets will vary from one his-

[1] A "standard deviation" is a statistical measure of the amount of dispersion in a particular series of numbers. For example, if daily price changes have a standard deviation of, say, 1 percent, then it is typical for prices on a given day to rise or fall 1 percent above or below the average underlying trend.

[2] The "correlation coefficient" is a statistic that varies between minus one and plus one. A value near zero means that daily percent movements in two markets bear essentially no relationship to each other during the period. A positive value means that when one market rises at more than its trend rate, the other on average rises above its trend rate as well. A positive value close to one means that when one market's rise equals one standard deviation above its trend, then the other market can on average be expected to rise at close to one standard deviation above its trend as well.

Table 1

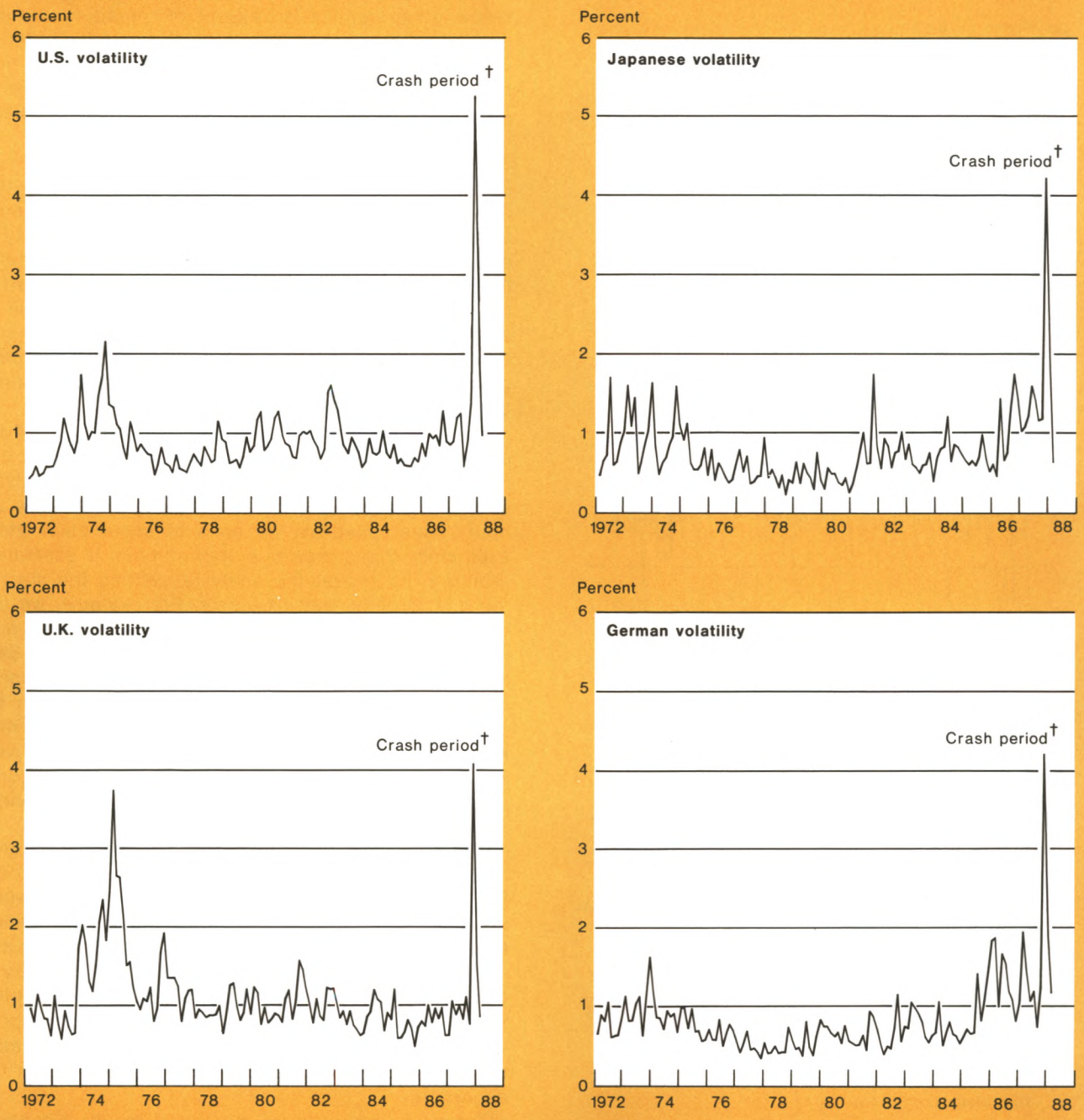
October 1987 Changes in World Stock Prices*

Country	Percent Stock Price Change
Australia	−58.3
Hong Kong	−56.3
Singapore/Malaysia	−40.1
Mexico	−38.7
Norway	−29.8
United Kingdom	−26.1
Spain	−25.5
Switzerland	−23.4
Belgium	−23.2
West Germany	−22.9
Netherlands	−22.6
France	−22.0
Canada	−21.8
United States	**−21.5**
Sweden	−20.7
Italy	−15.5
Austria	−14.9
Japan	−12.6
Denmark	−12.6

*Percent changes between September 30 and October 31, 1987, local currency indexes; data from Morgan Stanley Capital International.

Chart 1

Daily Stock Price Volatility *



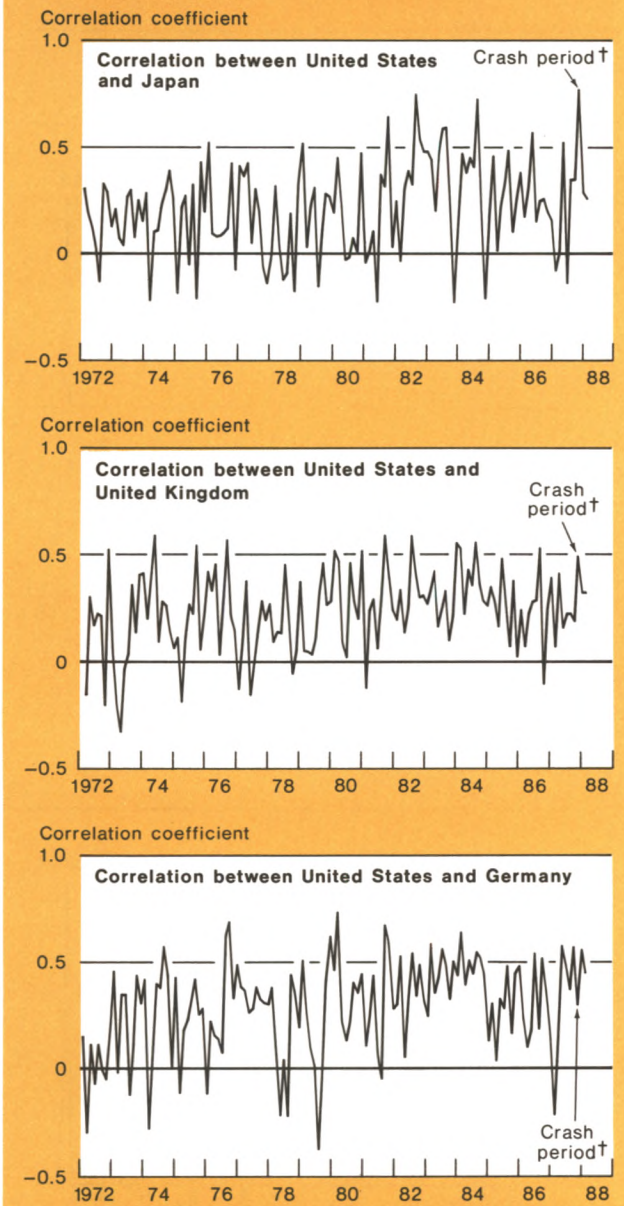
* Standard deviations of daily percent changes, computed for nonoverlapping 30-trading-day periods.

† The crash period is the 30-trading-day period beginning on October 16, 1987 and ending in the United States and Japan on December 1, 1987 and in the United Kingdom and Germany on November 27, 1987.

Sources: Morgan Stanley Capital International and Federal Reserve Bank of New York.

Chart 2

Daily Stock Price Correlations*



*Correlation coefficients between daily percent changes in stock price indexes, computed for nonoverlapping 30-trading-day periods.

†The crash period is the 30-trading-day period beginning on October 16, 1987 and ending in the United States and Japan on December 1, 1987 and in the United Kingdom and Germany on November 27, 1987.

Sources: Morgan Stanley Capital International and the Federal Reserve Bank of New York.

torical period of volatility to the next. Sorting out the driving factors behind each episode is beyond the scope of this article. Rather, our approach will be to see whether identifiable patterns of spreading volatility and steady or rising correlations characterized market interactions in previous periods of uncertainty. If they did, one might have to be prepared for similar patterns should the markets once again enter a stressful period.

Spreading volatility

Regression analysis was used to test the assertion that higher day-to-day volatility in one major market tends to be accompanied by higher expected volatility in other markets. The regression model posits that a higher standard deviation of daily percent price changes in one market during a 30-day period will be associated with a higher standard deviation in a second market during that same period, when daily price changes in the second market occur after daily price changes in the first.

Since stock trading takes place virtually around the clock in the various stock markets of the world, it is necessary in implementing the analysis to establish some particular market as the starting point of the 24-hour "days" used as the units of observation. However, since this choice of a starting point is essentially arbitrary, we repeat the analysis, shifting the start of the day to other major markets. For example, we can define the 24-hour day as starting in the New York market and measure the standard deviation of 30 daily stock price movements in that market. Then, a corresponding standard deviation can be computed for the subsequent price changes occurring in Japanese markets within the same set of 24-hour days. Alternatively, we can start the day in Japan, in which case the corresponding volatility calculations for the New York market are shifted forward by one calendar day.

The next step is to estimate a regression equation that uses volatility in the starting market to predict the level of volatility in another market trading within the same day. For example, in the equation assuming that the day starts in the United States, a positive regression coefficient indicates that the volatility of daily Japanese price movements tends to be high in those 30-day periods in which U.S. daily stock price volatility is high. Conversely, a zero or negative regression coefficient would be inconsistent with this assertion.

Table 2 summarizes the regression results. Equations were estimated over 30-trading-day periods from 1980 to September 1987, and also from 1972 through 1979. As hypothesized, increased volatility in the starting market is associated with higher volatility in the other markets. The results are qualitatively similar whether

the equations are estimated for 24-hour days beginning in the United States, Japan, or the United Kingdom. (See also Appendix A.)

Association between volatility and correlation

The second hypothesis to be tested is that higher volatility in one market will lead to increased correlation between daily price movements in that market and daily price movements in other markets. We computed 30-day correlation coefficients between the daily price changes in pairs of markets within the same 24-hour days. Again, different sets of 30-day correlations were calculated using varying assumptions about where the 24-hour days start.

The regression equation hypothesis was that the higher the volatility in the first market trading in the day, the closer the correlation between daily price movements in that market and price movements in a second market. These estimated effects of volatility on correlation coefficients for the period from 1980 through September 1987 and the period from 1972 to 1979 are summarized in Table 3. All are positive; that is, the higher the 30-day level of volatility in the first market trading in the day, the higher the 30-day correlation between daily price movements in that first market and price movements in another. Not only are all the regression coefficients positive in each estimation period, but in many cases they are also statistically significant (Appendix A, Table A1). These findings support the hypothesis that even prior to October 1987, high volatility tended to be associated with higher correlations in the price movements of different markets.[3]

Evidence on the strengthening of linkages over time

Casual empirical support abounds for the notion that world stock markets have become more closely linked in recent years. According to one survey, the number of stocks traded globally (that is, on a daily basis in at least one center outside the home market) rose from 236 in 1984 to 493 in 1987.[4] In addition, the amount of

[3]These results were not affected by one notable complication in the data. No Saturday trading data were used for Japan even though Saturday trading may have occurred. This omission could interfere with the estimated relationships when the 24-hour day starts in the United States or the United Kingdom on Fridays and is implicitly assumed to continue on Monday in Japan. Nevertheless, when we ran the regressions again, throwing out such Friday-Monday combinations, the results were little changed.

[4]*Euromoney*, May 1987, pp. 187-222.

Table 2

Effects of High Stock Price Volatility on Stock Price Volatility in Other Markets

Standard Deviations of Day-to-Day Percent Changes in Stock Price Indexes

	1980 to September 1987 Estimates		1972 to 1979 Estimates	
	Normal Stock Price Volatility‡	Change in Volatility Associated with High Volatility in Market Where Day Begins§	Normal Stock Price Volatility‡	Change in Volatility Associated with High Volatility in Market Where Day Begins§
Day begins in the United States				
Japan volatility	.74	+.17*	.64	+.32†
United Kindom volatility	.88	+.22†	1.19	+.41†
West Germany volatility	.81	+.05	.68	+.20†
Day begins in Japan				
United Kingdom volatility	.88	+.14*	1.16	+.29†
West Germany volatility	.82	+.00	.69	+.26†
United States volatility	.85	+.10	.80	+.22†
Day begins in the United Kingdom				
West Germany volatility	.86	+.27†	.63	+.17†
United States volatility	.90	+.28†	.76	+.17†
Japan volatility	.79	+.28†	.60	+.16*

‡Predicted volatility from estimated equation relating volatility in the indicated market to volatility where the day starts, based on the average 1972 to September 1987 level of volatility in the day-starting market.

§Change in predicted volatility when day-starting volatility rises from 1972 to September 1987 mean value to two standard deviations above that mean.

*Effect of day-starting volatility on volatility in indicated market is statistically positive at the 95 percent level.

†Effect of day-starting volatility on volatility in indicated market is statistically positive at the 99 percent level.

Table 3

Effects of High Stock Price Volatility on Correlations between Stock Price Movements

Correlations between Daily Percent Changes in Stock Price Indexes

	1980 to September 1987 Estimates		1972 to 1979 Estimates	
	Average Correlation Coefficient‡	Change in Correlation Associated with High Volatility in Market Where Day Begins§	Average Correlation Coefficient‡	Change in Correlation Associated with High Volatility in Market Where Day Begins§
Day begins in the United States				
Japan-U.S. correlation	.26	+.21†	.16	+.03
U.K.-U.S. correlation	.29	+.16	.19	+.02
West Germany-U.S. correlation	.36	+.13†	.22	+.10*
Day begins in Japan				
U.K.-Japan correlation	.14	+.08*	.04	+.00
West Germany-Japan correlation	.22	+.06	.12	+.10†
U.S.-Japan correlation	.08	+.03	.05	+.05
Day begins in the United Kingdom				
West Germany-U.K. correlation	.27	+.29†	.06	+.02
U.S.-U.K. correlation	.24	+.20*	.10	+.03
Japan-U.K. correlation	.18	+.20*	.02	+.04

‡Correlation coefficient predicted from estimated equation relating correlation between the indicated markets to volatility where the day starts, where starting-market volatility is set to its 1972 to September 1987 average level.
§Rise in predicted correlation coefficient when day-starting volatility is raised from its 1972 to September 1987 mean to two standard deviations above that mean.
*Effect of day-starting volatility on correlation in indicated market is statistically positive at the 95 percent level.
†Effect of day-starting volatility on correlation in indicated market is statistically positive at the 99 percent level.

cross-border buying and selling of stocks in many markets has risen dramatically since 1980 (Table 4). Exchanges have been establishing a variety of international trading links for equities and derivative products.[5]

These improving connections and increasing cross-border activities imply that participants' awareness of, and responsiveness to, daily foreign stock market developments have been growing as well. Greater cross-border investments have increased the need for participants to stay informed about securities price performances. Changes in communications and trading technology have made it easier to track and respond to overseas developments, including price developments. In addition, unifying trends in the world economy such as increased trade and wider international operations by business corporations may have made stock prices in different centers sensitive to an increasingly similar set of underlying influences.

It is at least possible that these stronger linkages between stock markets may have influenced the market interactions of October 1987. The following sections address this possibility in more detail.

[5]For a list of some recently established equity trading links between U.S. and foreign exchanges, see *Securities Week*, July 6, 1987, p. 1.

Table 4

Cross-Border Stock Transactions

Gross Purchases and Sales of Domestic Stocks by Nonresidents (In Billions of U.S. Dollars)

	United States*	Japan†	Germany‡	Canada§
1980	75.2	26.2	6.8	12.4
1981	75.5	43.7	6.9	9.2
1982	79.9	34.6	6.3	5.2
1983	134.1	71.5	13.4	8.4
1984	122.6	78.3	12.4	8.8
1985	159.0	81.9	36.9	11.9
1986	277.5	201.6	77.9	20.2
1987	481.9	374.7	76.8	45.7

*U.S. Treasury International Capital data.
†Japanese Ministry of Finance.
‡Deutsche Bundesbank, *Balance of Payments Statistics, Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank,* Series 3.
§Statistics Canada, *Security Transactions with Non-Residents* and *Quarterly Estimates of the Canadian Balance of International Payments.*

Stronger connections among volatilities and correlations?

A possible consequence of the increased awareness of foreign developments could be a stronger propensity

for high price volatility in one market to be associated with a rise in price volatility abroad and with higher price correlations between markets. In effect, a given rise in foreign volatility may spark a bigger domestic response now that participants are watching other markets more closely.

With respect to the link between volatility and correlation, there is strong statistical evidence that the relationship has strengthened over time. We performed formal statistical tests on each of the equations linking price correlations to price volatility. These tests showed that between the 1970s and the 1980s most of the regression coefficients relating volatility to correlation increased by statistically significant amounts. The size and significance of the measured increases were very similar whether the relationship was allowed to change in 1980 or 1983 (Appendix A, Table A3).

However, with respect to the linkage between volatility in one market and volatility in others, no persuasive evidence was found that the relationship had strengthened. Formal tests yielded little or no support for the assertion that the regression coefficients linking volatilities in different markets had increased between the 1970s and the 1980s (Appendix A, Table A3).

Closer percentage changes?

A related, but slightly different way of characterizing how stock markets interact is to ask how large a percent change in one country's stock price index should be expected when another country's index changes by a given percentage. For example, if the U.S. market rises by one percent, how much would the Japanese market be likely to rise subsequently? For want of a better name, this statistic can be referred to as a "beta" coefficient between the two markets. A beta as high as one would mean that, on average, percentage changes in the two markets tend to be of the same size and sign.[6]

[6]Betas can be computed by directly regressing percent price changes on one another, or, alternatively, combining the correlation and volatility figures for 30-day periods using the formula, beta = r times (s2 / s1), where r is the correlation coefficient, s1 is volatility in the first market, and s2 is volatility in the second market. Table 5 applies the latter approach with one further adjustment: Since r and s2 have been shown in the first part of the article to vary systematically through time with changes in s1, the betas in Table 5 have been adjusted to eliminate differences between 1970s and 1980s values attributable to variations in s1 between the decades. Alternative methods of calculating betas, however, give similar results (Appendix A, Table A4).

Table 5

"Betas" between Stock Markets

Expected Percent Change in Stock Prices Associated with a One Percent Price Change in Market Where Day Begins*

	1980 to September 1987 Estimates		1972 to 1979 Estimates	
	Effect with Normal Volatility Where Day Begins	Effect with High Volatility Where Day Begins	Effect with Normal Volatility Where Day Begins	Effect with High Volatility Where Day Begins
Day begins in the United States				
Price change in:				
Japan	.22	.30	.12	.13
United Kingdom	.30	.34	.26	.23
West Germany	.34	.29	.17	.20
Day begins in Japan				
Price change in:				
United Kingdom	.17	.16	.06	.05
West Germany	.25	.16	.11	.20
United States	.09	.07	.05	.10
Day begins in the United Kingdom				
Price change in:				
West Germany	.22	.31	.04	.03
United States	.20	.26	.06	.06
Japan	.13	.20	.01	.02

Effects computed using the formula for a simple regression "beta," rs/s, where r is the correlation coefficient between percent price changes in the starting market and in another market, s* is the standard deviation of percent price changes in the starting market, and s is the standard deviation of percent price changes in the other market. Values of r and s for normal and high values of s* are computed using the mean 1972 to September 1987 value of s* and a value of two standard deviations above that mean, in conjunction with estimated regression equations relating r and s to s*.

As Table 5 shows, betas for the 1980s period are uniformly higher than for the 1970s, a finding which is again consistent with growing intermarket awareness and trading. Estimates of betas using other methods confirm that these associations between pairs of percent changes have become closer in recent years (Appendix A, Table A4).

Monthly interactions

As a further check on how the pattern of market interactions had been evolving prior to October, monthly average price movements were examined. Monthly movements of course abstract from day-to-day swings. Thus, the monthly averages focus on the broader downward shift in stock price levels from before to after the crash, instead of daily movements. Was it normal for monthly market movements in different markets to behave as similarly as they did around October 1987? Had monthly average movements of prices in different markets become significantly more similar in the 1980s?

To answer these questions, we estimated regression equations explaining monthly average stock price indexes in four countries on the basis of domestic economic variables and foreign stock prices. Including economic variables (inflation, industrial production, unemployment, and short- and long-term interest rates) sharpens the focus on stock market dynamics by holding constant other more fundamental determinants of stock prices. Thus, the estimated regression equations can be used to see how movements in foreign stock prices normally affect domestic stock prices. (See Appendix B for a fuller explanation.)

Table 6 summarizes the regression estimates showing how strongly monthly average domestic stock prices in four countries are influenced by foreign stock price changes when economic influences are held constant. For example, if the average level of stock prices in each of six major foreign countries fell by 1 percent in a given month, then the equation predicts that U.S. stock prices would be 0.83 percent lower as a result, even if no U.S. economic variables changed.

By letting the size of the regression coefficients linking foreign and domestic stock prices change after 1981, the equation allows for a possible strengthening of the relationship. Before 1981, a 1 percent drop in foreign stock prices would have lowered U.S. prices by only 0.72 percent. Of the four countries, three show an increased sensitivity to foreign stock price movements after 1981. Although none of these increases in sensitivity achieves statistical significance, the increases are generally consistent with the modest increases in day-to-day betas found above (Table 5 and Appendix A, Table A4). The monthly equations were also re-estimated, allowing the coefficients to shift at other dates, and the results are qualitatively similar to those obtained when the 1981 change is allowed (Appendix B, Table B2).

The monthly equations were estimated starting in 1950 or the early 1960s, depending on data availability for each country, with the estimation periods ending in September 1987. Thus the monthly results provide additional evidence that even well before the crash, world stock prices were significantly linked. As the day-to-day movements also demonstrated, the closeness of monthly percent price movements in different markets appears to have increased moderately in recent years.

The October crash

We have yet to determine how well the pre-October day-to-day and monthly-average estimated relationships fit the pattern of events during the crash. Was the degree of volatility spillover in line with what earlier estimates would have indicated? Were the pre-October

Table 6

Tests of Changing Sensitivity of National Stock Price Indexes to Monthly Movements in Foreign Stock Markets*

Estimated Percent Change in Monthly Average Domestic Stock Price Index Corresponding to One Percent Change in Each of Six Monthly Average Foreign Stock Price Indexes, Controlling for Domestic Real Output, Price Level, Unemployment, and Short- and Long-Term Interest Rates.

	United States	Japan	United Kingdom	West Germany
Sensitivity before December 1981	.72	.37	.82	.45
Sensitivity after January 1982	.83	.57	.54	.58
Change†	+.11	+.20	−.28	+.13

*See Appendix B for details.
†None of these estimated increases in sensitivity to foreign stock prices is statistically greater than zero, using a one-tailed test at a 95 percent level of significance.

Table 7

Explaining the October 1987 Spillovers

Actual and Predicted Measures of Spillovers of Market Disruptions during the October 1987 Stock Market Crash

	Correlation Coefficient			Volatility			Beta		
	Normal Value§	October Prediction‖	October Actual	Normal Value§	October Prediction‖	October Actual	Normal Value§	October Prediction‖	October Actual
Day begins in the United States									
Japan	.26	.97	.77	0.7	1.6	4.2*	.22	.30	.62
United Kingdom	.29	.70	.49	0.9	1.6	4.1†	.30	.23	.38
West Germany	.36	.91	.29*	0.8	1.2	4.2†	.34	.21	.29
Day begins in Japan									
United Kingdom	.14	.50	.68	0.9	1.1	4.2†	.17	.13	.67
West Germany	.22	.52	.59	0.8	1.0	4.2†	.25	.05	.60
United States	.08	.22	.18	0.9	1.3	5.3†	.09	.16	.22
Day begins in the United Kingdom									
West Germany	.27	.88	.72	0.9	2.0	4.2*	.22	.44	.75
United States	.24	.74	.59	0.9	1.8	5.2†	.20	.33	.78
Japan	.18	.70	.29	0.8	2.0	4.2	.13	.35	.30

§Predictions using equations estimated from January 1980 through September 1987, setting the independent variable, the standard deviation of starting-market percent price changes, to its mean value for 1972 through September 1987.
‖Predictions using equations estimated from January 1980 through September 1987, setting the independent variable, the standard deviation of starting-market percent price changes, to its actual October 1987 period value.
*Hypothesis that October observation was generated by the statistical model estimated through September 1987 is rejected at the 95 percent level.
†Hypothesis that October observation was generated by the statistical model estimated through September 1987 is rejected at the 99 percent level.

relationships between volatility and correlation on target in the crash? Were percent movements—day-to-day and month-to-month—in line with what the earlier equations would have predicted?

To answer these questions, actual October 1987 daily volatility in each major market was used to predict volatility in other markets, correlations among markets, and betas between markets, based on the estimated pre-October statistical relationships. In addition, analogous simulations of the crash were run using the pre-October monthly equations.

The results based on the daily movements (Table 7) indicate some notable qualitative similarities between the crash and earlier episodes. The pre-October relationship predicted that the correlations in daily price movements between pairs of major markets would increase substantially. Indeed, most correlations showed a clear rise (see also Chart 2). The one exception was the U.S.-German correlation, which actually fell in October, contrary to the earlier pattern that would have predicted a correlation increase.

A more striking difference between the October and earlier patterns was observable in the extent to which volatility spread. For example, given the U.S. volatility spike, volatilities in Japan and the U.K. would "typically" have doubled, and German volatility would have risen noticeably as well. In fact, as Table 7 shows, these volatilities increased by factors of four to six times above normal levels. A similar pattern of sur-

Table 8

Actual and Predicted Monthly Stock Price Changes

September to November 1987

	Actual Price Change* (In Percent)	Predicted Price Change† (In Percent)
S&P 500	−26.3	−26.5
Tokyo index	−11.9	−18.0
West German index	−34.3‡	−13.9
U.K. index	−26.3‡	− 9.8

*Percent change, September 1987 average to November 1987 average.
†Each country's index is predicted using a regression equation, based on domestic economic variables and foreign stock price indexes, estimated through September 1987. See Appendix B for details.
‡Hypothesis that November observation was generated by the statistical model estimated through September 1987 is rejected at the 99 percent level.

prisingly large volatility spillover shows up when the day is started outside the United States.

With the unusual spread in volatilities, the betas relating percent changes in major markets to one another jumped as well. While betas would have been expected to rise only slightly or even decline, most rose substantially. The one exception was again the U.S.-Germany beta, whose value during the crash period was slightly lower than during more normal times.

These results are consistent with the common view that a wave of panicky selling circled the globe, with traders paying an unusually large amount of attention to price developments in foreign markets in the absence of fundamental news sufficient to account for the disruption. The panic among participants probably explains the unanticipated extent of volatility spillover.

Monthly interactions around October 1987

The actual monthly average price changes in the crash were neither consistently larger nor consistently smaller than the predicted changes from the regression equations (Table 8).

The U.S. price index fell about as much as expected, given the drops everywhere else. The Japanese index fell less than the equation predicted. (It is tempting to attribute this result to the circuit-breaker system installed in Japan following the stock market debacle in the 1960s.) Both the U.K. and German indexes fell substantially more than the equations indicated. While the equations did not predict accurately in three of the four cases, the prediction errors were dispersed around the actual outcomes. This suggests that the basic degree of linkage among monthly average prices in different stock markets during the crash was neither clearly stronger nor weaker than it had been prior to October.[7]

It does not appear that the prediction errors can be systematically linked to the strengthening relationships between stock markets identified in the monthly regression equations: The U.K. and German equations showed the least persuasive evidence that domestic stock prices were becoming more responsive to foreign stock prices, while the actual October drops in those two countries substantially exceeded the predicted drops. The Japan regression equation showed a fairly distinct strengthening of the linkage, but the actual Japanese price drop was far less than the forecast. (See Appendix B, Table B2.)

[7]Since the predicted price changes for each of the four markets take actual foreign price changes in the period as given, if there were in fact consistent under- or over-prediction in Table 8, then the true error would be greater for the system of equations as a whole. This does not appear to be a problem, however, since the errors are dispersed.

Conclusion

Although a panic is a unique event, the crash experience conformed to the pre-October pattern in important respects. The coincidence of volatility surges in major stock markets was qualitatively similar to earlier patterns found in the data, as were the increases in correlations between price movements in most markets. At a monthly-average level, the large downward shift in prices worldwide—while unprecedented in magnitude—was qualitatively similar to earlier relationships among stock markets as well.

Although the crash interactions were a clear demonstration of the preexisting interdependencies among major stock markets, the October events differed from earlier patterns in the extent of the volatility spillover from one market to another. Since there is no evidence that the propensity of volatility shocks to spread had strengthened before the crash, it seems unlikely that the unexpected degree of October spillover can be accounted for by a tightening of relationships among markets during the 1980s.

It seems fair to conclude that if huge price movements were again to occur in one of the world's major stock markets, the disruptions would be likely to spread worldwide. This assessment suggests that measures to prevent excessive volatility in one market, such as "circuit breakers" or deeper margin buffers, if successful, could have international benefits. One caveat to our conclusion derives from the modest signs in the 1980s data that world stock prices in different countries have been tending to move more similarly than before. If this trend continues, some increased degree of international regulatory coordination would become necessary to augment the effectiveness of domestic measures in lessening the chances of another market collapse.

Paul Bennett
Jeanette Kelleher

Appendix A: Estimating Relationships among Stock Market Volatilities and Correlations

This appendix describes four sets of statistical computations used in the text. The first section outlines the tests used to determine whether the level of stock price volatility in a market influences the correlations between stock price movements in that market and in other markets. The second section describes analogous procedures for testing how stock price volatility in a market is related to volatility in other stock markets. The third section presents formal tests for identifying changes over time in the statistical relationships among volatilities and correlations. The fourth section outlines calculations of coefficients linking percent changes in one stock market to percent changes in another; these coefficients are referred to as "betas" in the text, although this terminology is somewhat different from the standard usage in financial economics. The accompanying tables (A1 through A4) provide the statistical results.

1. *Tests of the link between volatility and correlation.* The first hypothesis to be tested states that periods of high price volatility in stock markets also tend to be periods of high price correlations among stock markets. Implicit in our approach is the notion that high volatility is leading to high correlations, perhaps because participants in a second market only react to changes in a first market when those changes are large. Volatility in stock index a, s_t^a, within a 30-trading day period, t, is measured as the standard deviation of daily percent changes. Analogously, r_t^{ab} is the correlation coefficient between stock markets a and b within period t. The regression equation estimated across periods t is:

$$\ln ((1+r_t^{ab}) / (1-r_t^{ab})) = A + Bs_t^a + e_t,$$

where A is a constant and e_t is the regression error. The transformation of r_t^{ab} on the left-hand side of the equation creates an asymptotically normal dependent variable; this transformation is needed since r_t^{ab} ranges only between plus and minus one.*

*T.W. Anderson, *An Introduction to Multivariate Statistical Analysis* (New York: John Wiley & Sons, 1958), p. 78.

Table A1

Impact of Volatility on Correlation of Stock Prices‡

	Regression Coefficients				Autocorrelation Rho		R-squared	
	Jan. 1, 1972 to Dec. 31, 1979		Jan. 1, 1980 to Oct. 15, 1987					
	A	B	A	B	Jan. 1, 1972 to Dec. 31, 1979	Jan. 1, 1980 to Oct. 15, 1987	1972-79	1980-87
Day starts in the United States:								
Japan	0.24*	10.49	−0.18	84.03†	—	—	0.01	0.15
West Germany	0.14	36.05*	0.30	53.52*	—	—	0.05	0.08
United Kingdom	0.30*	9.26	0.36*	26.21	—	—	0.00	0.03
Japan	0.21*	13.04	−0.29	95.70†	−0.10	0.24*	0.02	0.19
Germany	0.14	35.97	0.05	79.85†	0.24*	0.26*	0.11	0.14
United Kingdom	0.35*	4.06	0.38*	24.91	0.15	−0.05	0.02	0.03
Day starts in Japan:								
West Germany	0.03	30.55†	0.29*	20.28	—	—	0.08	0.03
United Kingdom	0.07	0.81	0.11	23.82*	—	—	0.00	0.04
United States	−0.04	17.45	0.09	8.56	—	—	0.02	0.01
West Germany	0.05	27.39†	0.29*	20.71	−0.22*	0.21	0.12	0.06
United Kingdom	0.03	5.98	0.12	22.09	0.19	−0.57	0.03	0.04
United States	0.02	9.40	0.08	9.57	−0.20	0.01	0.05	0.01
Day starts in United Kingdom:								
West Germany	0.07	4.89	−.24	74.14†	—	—	0.00	0.13
United States	0.12	7.13	−.02	47.38*	—	—	0.01	0.05
Japan	−0.08	9.93	−.11	45.06*	—	—	0.02	0.06
West Germany	−0.08	4.20	−.26	77.79*	0.01	0.02	0.00	0.14
United States	0.15	5.63	−.04	40.64	0.13	0.12	0.03	0.06
Japan	−0.09	10.37	.01	32.20	0.05	0.22*	0.02	0.10

‡Estimated equation is $\ln ((1+r)/(1-r)) = A + Bs + e$.
*Coefficient estimate is statistically significant at the 95 percent level, one-tailed test.
†Coefficient estimate is statistically significant at the 99 percent level, one-tailed test.

Appendix A: Estimating Relationships among Stock Market Volatilities and Correlations *(continued)*

Since the standard deviation and correlation coefficient variables are constructed using daily data on market prices in various parts of the world, the starting point for the 24-hour day must be selected. Which market, a or b, will be used to measure the standard deviation for period t must also be decided. It is assumed that market a is the first market open in the 24-hour day. The regression is estimated over nonoverlapping 30-day periods in the 1970s and 1980s; each period makes up one observation with its own correlation and volatility.

The results are shown in Table A1, with and without autocorrelation corrections. The U.S. data are daily closing figures for the S&P 500 index. Data for the other three countries are daily stock indexes from Morgan Stanley Capital International.

Weekends presented a problem in defining a 24-hour day. It was assumed that days that begin during a calendar Friday are interrupted over the weekend and completed during the first part of calendar Monday. But difficulties arose with those periods in which the days were assumed to begin in the United States (or the United Kingdom) and to end in Japan. Stocks trade in Japan on some but not all Saturdays; consequently, it is possible that the relevant correlation should be between price movements on calendar Fridays and Saturdays when trading occurs. To assess the importance of this problem, preliminary regressions were run using an alternative data set in which days beginning during calendar Fridays and ending during calendar Mondays were dropped. The regression estimates were very similar to those obtained when these days were included. Thus, the problem appeared to be minor, and the fuller data were used in the final estimates. (Note that since initial price volatility in Japan is computed as the percent change between Friday and Monday closes in Japan, the analogous problem does not exist for 24-hour days starting in Japan.) Those 24-hour days in which at least one of a given pair of markets was closed were deleted before construction of the 30-day-time-period series for the regressions relevant to that particular pair of markets.

2. *Tests for spreading volatility.* Analogous regressions were estimated using volatility as the dependent variable, measured as the standard deviation of daily percent price changes within 30-day periods (Table A2).

3. *Tests for structural breaks.* Combining the samples from the 1970s and 1980s, we allowed a dummy variable to interact with the slope coefficient for each of the correlation-volatility and the volatility-volatility equations (Table A3). The shift coefficients (B_2) were

Table A2

Impact of Volatility on Other Market Volatility‡

	Regression Coefficients				Autocorrelation Rho		R-squared	
	Jan. 1, 1972 to Dec. 31, 1979		Jan. 1, 1980 to Oct. 15, 1987					
	A	B	A	B	Jan. 1, 1972 to Dec. 31, 1979	Jan. 1, 1980 to Oct. 15, 1987	1972-79	1980-87
Day starts in the United States:								
Japan	−1.95*	0.64†	−3.31†	0.33*	0.46†	0.58†	0.35	0.37
West Germany	−3.00†	0.41†	−4.32†	0.10	0.56†	0.64†	0.47	0.41
United Kingdom	−2.12†	0.48†	−2.96†	0.37†	0.72†	0.31†	0.66	0.29
Day starts in Japan:								
West Germany	−3.09†	0.38†	−4.81†	0.00	0.46†	0.63†	0.55	0.39
United Kingdom	−3.14†	0.26†	−3.89†	0.17*	0.76*	0.32†	0.60	0.12
United States	−3.39†	0.29†	−4.10†	0.13	0.71†	0.46†	0.60	0.23
Day starts in United Kingdom:								
West Germany	−3.55†	0.33†	−3.00†	0.38†	0.57†	0.74†	0.41	0.51
United States	−3.53†	0.29†	−2.95†	0.38†	0.71†	0.38†	0.66	0.33
Japan	−3.61†	0.33*	−2.85†	0.43*	0.50†	0.63†	0.31	0.42

‡Estimated equation is $\ln (S_{OTHER}) = A + B (\ln S_{STARTING}) + e$, where S is a standard deviation of percent daily price changes.
*Coefficient estimate is statistically significant at the 95 percent level, one-tailed test.
†Coefficient estimate is statistically significant at the 99 percent level, one-tailed test.

Appendix A: Estimating Relationships among Stock Market Volatilities and Correlations *(continued)*

Table A3

Dummy Variable Tests for Strengthening Relationships

Shift in 1980

	Regression Coefficients				Autocorrelation	
	A	B_1	B_2	B_1+B_2	Rho	R-squared
Relationship between Correlation and Volatility‡						
Day starts in the United States:						
Japan	0.10	25.08*	29.40†	54.48†	—	0.14
West Germany	0.19	30.62*	34.96†	65.58†	—	0.17
United Kingdom	0.32†	6.86	24.19†	31.15†	—	0.09
Day starts in Japan:						
West Germany	0.15*	15.38	19.47*	34.85†	—	0.09
United Kingdom	0.09	−1.35	27.47†	26.12†	—	0.09
United States	0.02	10.51	5.40	15.92	—	0.02
Day starts in United Kingdom:						
West Germany	0.00	9.39	40.38†	49.77†	—	0.16
United States	0.09	9.23	26.89†	36.12†	—	0.08
Japan	−0.08	10.45	31.79†	42.24†	—	0.12
Relationship between Other Market Volatility and Starting Market Volatility§						
Day starts in the United States:						
Japan	−2.57†	0.51†	−0.01	0.50†	0.53†	0.37
West Germany	−3.66†	0.28†	−0.04*	0.24*	0.61†	0.47
United Kingdom	−2.57†	0.40†	0.05*	0.45†	0.62†	0.59
Day starts in Japan:						
West Germany	−4.09†	0.18†	−0.04*	0.14*	0.58†	0.47
United Kingdom	−3.39†	0.22†	0.05*	0.27†	0.65†	0.51
United States	−3.74†	0.22†	−0.02	0.20†	0.63†	0.47
Day starts in United Kingdom:						
West Germany	−3.35†	0.37†	−0.06*	0.31†	0.67†	0.50
United States	−3.36†	0.33†	−0.03*	0.30†	0.60†	0.54
Japan	−3.33†	0.38†	−0.04	0.34†	0.56†	0.37
Shift in 1983						
Relationship between Correlation and Volatility‡						
Day starts in the United States:						
Japan	0.04	38.37†	29.51†	67.88†	—	0.12
West Germany	0.13	46.60†	29.09†	75.69†	—	0.13
United Kingdom	0.29	18.27	15.46*	33.73*	—	0.04
Day starts in Japan:						
West Germany	0.13	29.07†	−0.56	28.51†	—	0.06
United Kingdom	0.08	11.17	9.98	21.15*	—	0.03
United States	0.05	4.68	15.47	20.15*	—	0.03
Day starts in United Kingdom:						
West Germany	0.12	7.93	32.15†	40.08†	—	0.07
United States	0.18	7.97	19.99*	27.96*	—	0.03
Japan	0.04	7.70	21.60*	29.30*	—	0.04

‡Estimated equation is $\ln((1+r)/(1-r)) = A + (B_1+B_2D)\ s + e$.
§Estimated equation is $\ln(S_{OTHER}) = A + (B_1 + B_2D)(\ln(S_{STARTING})) + e$.
*Significant at 95 percent level, one-tailed test.
†Significant at 99 percent level, one-tailed test.

Appendix A: Estimating Relationships among Stock Market Volatilities and Correlations *(continued)*

Table A3

Dummy Variable Tests for Strengthening Relationships *(continued)*

Shift in 1983

	Regression Coefficients				Autocorrelation	
	A	B_1	B_2	B_1+B_2	Rho	R-squared
Relationship between Other Market Volatility and Starting Market Volatility§						
Day starts in the United States:						
Japan	−2.53†	0.53†	−0.06*	0.47†	0.50†	0.39
West Germany	−3.49†	0.32†	−0.07†	0.25†	0.52†	0.49
United Kingdom	−2.68†	0.38†	0.05*	0.43†	0.64†	0.59
Day starts in Japan:						
West Germany	−4.14†	0.17†	−0.06†	0.11	0.52†	0.49
United Kingdom	−3.33*	0.24†	0.06†	0.30†	0.62†	0.51
United States	−3.70†	0.21†	0.01	0.22†	0.63†	0.47
Day starts in United Kingdom:						
West Germany	−3.30†	0.38†	−0.09†	0.29†	0.58†	0.52
United States	−3.42†	0.30†	−0.01	0.29†	0.64†	0.53
Japan	−3.20†	0.42†	−0.08†	0.34†	0.52†	0.39

‡Estimated equation is $\ln((1+r)/(1-r)) = A + (B_1+B_2D)\, s + e$.
§Estimated equation is $\ln(S_{OTHER}) = A + (B_1 + B_2D)(\ln(S_{STARTING})) + e$.
*Significant at 95 percent level, one-tailed test.
†Significant at 99 percent level, one-tailed test.

generally significantly positive for the correlation equations and not significant for the volatility equations. When the shift was allowed in 1983 instead of 1980, quite similar results concerning the size, sign, and significance of shifts were found.

4. *Calculation of betas.* Beta coefficients, b, are defined by the regression equation on logarithm changes,

$$D(\ln p2) = a + b\, D(\ln p1) + e,$$

where

$$b = r\,(S2/S1).$$

Here r is the correlation coefficient between percent changes in p1 and p2, S1 and S2 are the corresponding standard deviations, and D indicates first differences.

Table A4 shows three different measures of b, for two time intervals each. The first measure is the average of betas for 30-day periods, calculated with 30-day values of r, S1, and S2. The second measure is the same, except the values of r and S2 are predicted values from regression equations that estimate r and S2 as dependent on S1 (see above); average values of S1 over 1972 through September 1987 are used. Thus this second measure is net of the effects of changes through time in market volatility. The third measure is directly estimated with daily data. A significant statistic for the third measure reflects a t-test on the difference in coefficient values, where t is calculated assuming two independent samples with different variances.

Appendix A: Estimating Relationships among Stock Market Volatilities and Correlations *(continued)*

Table A4

Beta Coefficient Estimates

Relating Percent Changes in Daily Stock Price Indexes

	Average Betas from 30-Day Periods†		Average Betas Adjusted for Volatility Changes‡		Average Betas, Directly Estimated§	
	1980 to Sept. 1987	1972-79	1980 to Sept. 1987	1972-79	1980 to Sept. 1987	1972-79
Day starts in the United States:						
Japan	.23	.14	.22	.12	.24*	.15
United Kingdom	.31	.27	.30	.26	.31	.29
West Germany	.36	.20	.34	.17	.33*	.20
Day starts in Japan:						
United Kingdom	.19	.08	.17	.06	.18	.11
West Germany	.25	.13	.25	.11	.20*	.14
United States	.09	.03	.09	.05	.08	.04
Day starts in United Kingdom:						
West Germany	.19	.04	.22	.04	.19*	.05
United States	.20	.07	.20	.06	.20*	.06
Japan	.12	.00	.13	.01	.12*	.02

†Betas were computed for each 30-day period as rS1/S2, where r is the correlation coefficient and S1 and S2 are the standard deviations for each period. Averages for 30-day periods during 1972-79 and the 1980s are shown.
‡Predicted values were calculated for r and S1 from equations relating them to S2, setting S2 to its 1972 to September 1987 average and using separately estimated equations for the 1970s and 1980s.
§Estimated using simple daily regressions of percent changes in pairs of markets.
*Directly estimated beta for the 1980s is significantly greater than for the 1970s at the 95 percent level.

Appendix B: Monthly Regression Model Relating Foreign and Domestic Stock Price Indexes and Controlling for Economic Variables

An econometric model was estimated to measure the effects of foreign stock prices on domestic stock prices while controlling for key economic variables. An equation was estimated for each of four countries. In each equation the dependent variable was a monthly-average domestic stock price index, and the explanatory variables included short- and long-term interest rates, industrial production, the CPI, and the unemployment rate. Each of these economic variables was included as an explanatory regression variable contemporaneously and with five months of lagged values. Contemporaneous monthly-average values of stock indexes for six major countries were also included as explanatory variables. In addition, error autocorrelation coefficients (rho (-1) and rho (-2)) were estimated and found to be statistically significant.

The regression results for the United States, Japan, the United Kingdom, and West Germany are shown in Table B1. Explicit allowance was made for the coefficients on foreign stock price indexes to change starting in January 1985. (The variable transformations made to allow such coefficient changes are explained in a footnote to Table B1.)

As the R^2 for each equation shows, the explanatory variables account for between 40 and 80 percent of the monthly variation of the dependent variable. The autocorrelation terms account for virtually all remaining variation (since the R^2 that includes the explanatory power of the rho coefficients is nearly unity in each case).

The foreign stock index coefficients are almost all positive (or are quite small), with sizable and statistically significant positive coefficients on several foreign stock indexes in each equation. This finding is consistent with the hypothesis that foreign and domestic stock prices are positively correlated, even after economic trends have been taken into account. It should be noted, however, that since stock price indexes tend to be quite correlated through time, the size of one foreign

Appendix B: Monthly Regression Model Relating Foreign and Domestic Stock Price Indexes and Controlling for Economic Variables *(continued)*

Table B1

Regression Coefficients for the United States, Japan, the United Kingdom, and West Germany

Sensitivity of National Stock Markets to Movements in Domestic Economic Variables and Foreign Stock Prices

(Monthly Data;† All Variables in Log Form)

	Dependent Stock Price Index							
	S&P 500		Tokyo Index		UK Index§		West German Index	
Independent Variables:†	Through Dec. 1984	Jan. 1985 Shift‡	Through Dec. 1984	Jan. 1985 Shift‡	Through Dec. 1984	Jan. 1985 Shift‡	Through Dec. 1984	Jan. 1985 Shift‡
Constant term	−.38		−.64		−3.26		3.14*	
Foreign stock price indexes:								
United States			.11	+.71*	.41*	−.01	.09	+.32
Japan	.03	+.24*			.10	−.22	.14	−.18
United Kingdom	.14*	+.02	.09	−.13			.09*	−.19
West Germany	.10*	+.00	.14*	−.01	.12	−.04		
France	.03	+.02	.00	+.03	−.04	+.07	.11*	−.07
Canada	.37*	+.01	.02	−.49*	.04	+.33	−.01	−.15
Italy	.04	−.10	.02	+.06	.13*	−.17	.10*	+.15
Domestic variables:								
Short-term rate	.04*		.01		−.08*		−.03	
(-1)	−.04*		.04		−.03		.00	
(-2)	.01		−.09*		.01		−.01	
(-3)	.02		−.03		−.03		−.03	
(-4)	−.02		−.01		−.05		−.04	
(-5)	.00		−.07		−.06		−.01	
Long-term rate	−.25*		.21*		−.24*		−.25*	
(-1)	.02		−.01		−.25*		.17	
(-2)	−.06		.01		−.08		−.05	
(-3)	.02		.03		−.07		−.06	
(-4)	.01		−.06		.01		.11	
(-5)	.00		−.01		.08		−.09	
Industrial production	.15		.02		.41*		.15	
(-1)	.30*		.02		.26		.45*	
(-2)	−.04		.06		.09		.52*	
(-3)	.08		.03		.07		.09	
(-4)	.18		.02		.10		−.17	
(-5)	.04		.04		−.01		−.10	
Consumer price index	.35		−.01		.58		−1.42	
(-1)	−.61		.05		.92*		.26	
(-2)	−.49		−.21		−1.00*		−.17	
(-3)	.03		.05		.11		−.09	
(-4)	.20		.93*		.04		.95	
(-5)	.16		.26		.04		−.10	
Unemployment	−.00		.01				.01	
(-1)	.02*		−.01				.01	
(-2)	.00		.02				.01	
(-3)	.01		.01				.02	
(-4)	.01		.03*				−.01	
(-5)	.01		.01				.01	
rho (-1)	.91*		1.34*		1.22*		.96*	
rho (-2)	.03		−0.35*		−.28*		−.15*	
R^2	.809		.437		.714		.804	
R^2 (error based at original level)	.999		.999		.997		.991	

*t-statistic significant at the 95 percent level for a one-tailed test (critical value = 1.645).

†For S&P 500 equation, data are for August 1950 through September 1987. For Tokyo index equation, data are for August 1963 through September 1987. For U.K. index equation, data are for August 1961 through September 1987. For West German index equation, data are for August 1967 to September 1987.

‡Coefficient on the shift variable corresponding to the independent variable X_t and constructed according to the formula: shift variable = D8485 * (X_t − $X_{12/84}$), where D8485 equals zero through December 1984 and one thereafter, and where $X_{12/84}$ equals the December 1984 value of the independent variable X_t.

§Unemployment rates for the United Kingdom were not available on a consistent basis for the sample period.

Appendix B: Monthly Regression Model Relating Foreign and Domestic Stock Price Indexes and Controlling for Economic Variables *(continued)*

stock index's influence relative to the size of another's is estimated with a high degree of uncertainty. By contrast, a more consistent story emerges from the sums of these coefficients in each equation. Similarly, the individual shift coefficients are hard to interpret, with sizable shifts in positive or negative directions.

Table B2 imposes some order by comparing the totals of the coefficients on foreign stock indexes with the totals of these coefficients plus the sum of the shift coefficients. These latter totals are the new, postshift coefficient sums. Suppose, for example, that all foreign stock prices were to rise by 10 percent. Then, according to the Table B2 sums (lower left-hand corner), prior to 1985 this increase would have been associated on average with a 7.1 percent change in the S&P 500, assuming there were no associated change in underlying U.S. economic variables. Had the foreign stock price rise occurred after January 1985, however, the associated rise in the S&P 500 index would have been 9.7 percent when other variables were held constant.

Table B2 also summarizes the results of reestimating the statistical equations when the foreign stock price coefficient shifts were allowed to occur at earlier dates.

Table B2

Changing Sensitivity of National Stock Markets to Movements in Foreign Stock Markets*

	United States		Japan		United Kingdom		West Germany	
Date of Hypothesized Structural Shift	Sensitivity before Shift	Sensitivity after Shift	Sensitivity before Shift	Sensitivity after Shift	Sensitivity before Shift	Sensitivity after Shift	Sensitivity before Shift	Sensitivity after Shift
Jan. 1971	.80	.74	.35	.44	.54	.78	.74	.51
Jan. 1979	.74	.82	.33	.56	.86	.55	.45	.44
Jan. 1982	.72	.83	.37	.57	.82	.54	.45	.58
Jan. 1985	.71	.97†	.38	.55	.76	.71	.52	.40

*See Table B1 for 1985-shift regressions. The statistics shown here equal the sums of estimated foreign stock price coefficients, with and without the shift coefficients, for each of the four equations. The stock price indexes used were the S&P 500 for the United States and broad indexes available from Citibase for Japan, the United Kingdom, West Germany, Canada, France, and Italy.
†Sensitivity after shift is larger, at a 95 percent level of statistical significance (one-tailed test).

International Linkages among Equities Markets and the October 1987 Market Break

Equities markets around the world lost, in total, about $1.2 trillion in market capitalization during the October 1987 crash. Half of the losses took place on stock markets outside the United States. The speed, size, and simultaneity of the price declines in such a wide variety of markets stunned participants and observers alike and prompted a search for explanations.

In the United States, structural features such as the market-making mechanism and the interaction of the stock market with equity-related futures and options markets have received considerable attention. But these features differ across national boundaries and hence do not easily explain the similar downturns around the globe.

This article considers the role of direct international linkages across markets in promoting October's simultaneous downturns. These linkages take two principal forms: cross-border equity investment and stock trading in centers outside the home market. A review of the October experience suggests the following:

- Direct international linkages cannot explain the worldwide decline in equities markets in mid-October. In the three largest equities markets—New York, Tokyo, and London—cross-border selling of equities played a significant role only in Tokyo, and trading of stocks outside the home market mainly affected U.K. equities traded in the form of American depositary receipts.
- The limited role of direct international linkages in the crash in these markets reflected the small scale of international equity investment and 24-hour trading relative to activity in the large markets and the absence of heavy selling by cross-border investors based in some large countries.
- Thus, the primary international linkage was indirect. In the charged atmosphere of October 19 and 20, market participants read steep price declines overseas as signals of the price direction in their own market.
- In the weeks after the crash, international investors liquidated large amounts of equities and slowed other financial investment overseas. But the slowdown fell short of the widespread withdrawal and repatriation of funds feared in the immediate wake of the crash. It appears that many sellers resided outside the G-10 countries and had few investment opportunities at home.

The surge in international activity in equities

Cross-border investment

Equities achieved unusual prominence in international investment after 1984. Investors participated in overseas equities markets by building a portfolio of foreign stocks, investing in mutual funds specializing in global equities, and purchasing derivative equity instruments such as convertible bonds and equity warrants. An impression of the growth of cross-border investment can be gained by looking at five major domestic markets for which timely, though imperfect, data are available:[1] Canada, Germany, Japan, the United Kingdom, and the United States.

[1]Data measuring international flows in equities are, like most capital flow data, subject to a number of shortcomings. The problems include confusion between *residence* and *nationality*, gaps in coverage, difficulties in recording conversions of convertible bonds

Cross-border investment in equities picked up sharply from 1985 until the beginning of the fourth quarter of 1987. In 1986 in particular, net equity purchases by nonresidents more than tripled in the United States and Germany and rose by more than one half in the United Kingdom (Table 1). Generally, stock markets throughout Europe and the Far East appeared to benefit from strong international purchases.

Japan, however, was a notable exception, as international investors sold Japanese shares out of concern that the market was overvalued. These international investors, mainly U.S. and U.K. institutional accounts such as trust and pension funds, had been net purchasers of Japanese shares until 1984.[2] Ironically, the selling developed just before the yen began to rise and sizable dollar returns on yen investments emerged.

The buying in the North American and U.K. markets and the selling in Japan increased in the first nine months of 1987. Net nonresident purchases in the first three quarters in Canada, the United Kingdom, and the United States exceeded the amounts purchased in these markets in the full year 1986, while net sales in Japan picked up as rapidly increasing prices drove Japanese price-to-earnings ratios to 60 or more, compared with 15 to 30 in other major markets.

Who were the major buyers in the surge in cross-border investment? The nationality of the end-investors is often difficult to determine because many investors make their overseas investments through international financial centers. A large portion of investment activities in the United Kingdom are conducted on behalf of investors located outside the country, such as U.S. pension funds and other international institutional accounts. Substantial amounts of equities are purchased through Switzerland and some offshore centers, which serve international clients from both industrial and developing countries.

Nevertheless, it appears that in 1986 participation in cross-border equity investment was geographically broad-based, with investors in all five major countries in Table 1 increasing their net cross-border purchases. U.K. and Japanese residents expanded their buying most sharply. Large flows through international centers such as the United Kingdom and Switzerland suggest that at least a portion of cross-border equity investment came from outside the G-10 countries.

In the first nine months of 1987, however, Japanese residents alone appeared to fuel the continued expansion of cross-border equity investment; their buying

Footnote 1 continued
and equity warrants into shares, and reporting errors. The definition of equities varies from country to country: some include preferred stock while others do not. An investment position may be classified as a direct investment or a portfolio investment depending on the share of outstanding equity held by a single investor. Finally, in this article, cross-border equity flows for the United Kingdom are measured by proxies.

[2]The net sales position of nonresidents in Japan may sometimes be overstated. Nonresidents can acquire Japanese shares by exercising equity options on eurobonds, usually in the form of equity warrants. These acquisitions are not included as nonresident purchases in some statistics, such as those produced by the Tokyo Stock Exchange (TSE), while sales of such shares are included as nonresident sales. The Bank of Japan's capital flow statistics in Table 1 include a measure of equity acquired through exercising options and still report very large net sales.

Table 1

The Expansion of Cross-Border Equity Flows before the Break

In Billions of Dollars

Nonresident Net Purchases*				**Net Purchases of Foreign Equities***			
	1985	1986	1987		1985	1986	1987
Of domestic equities in			Jan.-Sept.	By residents of			Jan.-Sept.
Canada	0.8	0.5	4.2	Canada	0.4	1.6	0.3
Germany	2.1	6.8	2.9	Germany	1.6	2.4	−0.6
Japan	−0.7	−15.8	−21.9	Japan	1.0	7.0	13.5
United Kingdom†	6.0	9.6	11.2	United Kingdom‡	5.6	10.5	5.3
United States	4.9	18.7	23.3	United States	1.9	2.4	1.6

*(−) = net sales.

†Transactions by overseas residents in U.K. company securities; believed to be largely equities.

‡Net purchases of ordinary shares of overseas companies by nonbank financial institutions.

Sources: Statistics Canada, *Security Transactions with Nonresidents,* Table 3; Statistics Canada, *Quarterly Estimates of the Canadian Balance of International Payments,* Table 1; Deutsche Bundesbank, *Balance of Payments Statistics, Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank,* Series 3, Table 5d; Bank of Japan, Foreign Department, *Balance of Payments Monthly,* "Long-Term Capital"; Central Statistical Office (United Kingdom), *Financial Statistics,* Tables 7.1 and 8.7; U.S. Department of Commerce, *Survey of Current Business,* Tables 2, 6, and 9; Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin,* Table 3.24.

accounted for two-thirds of the net equity purchases by residents of the five countries cited in Table 1. From January to September, Japanese residents purchased $13.5 billion net—an amount that, when annualized, was more than double the previous year's purchases. Much of those funds flowed to the United States. According to U.S. Treasury data, Japanese purchases of U.S. equities came to $9.5 billion in the first nine months of 1987.

Despite the growth in cross-border equity investment, the share of foreign ownership remained low in the largest markets. The foreign-held share of equities outstanding was lowest in Japan and the United States at around 5 percent, and somewhat higher in the United Kingdom at 10 percent. In contrast, foreign ownership ranged from 25 percent to 35 percent in some other European markets.

Cross-border trading

Cross-border investors not only increased their net purchases in 1986 and 1987, but also traded their portfolios more actively. The value of their gross transactions soared over 1986 and 1987 (Table 2). Viewed across market centers, the rise was geographically broad-based in 1986, but became somewhat more concentrated in 1987, because of the continued rapid growth of cross-border transactions in the Japanese and U.S. equities markets.[3]

Viewed by country of investor residence, transactions by residents of Japan and the United States accounted for most of the growth of cross-border transactions in 1986 and 1987. The high value of transactions reflected the importance of institutional investors, including mutual funds, in the two countries and the emphasis placed on active management of institutional investment portfolios. Japan's equity transactions more than doubled in the first nine months of 1987 compared with the previous year. Cross-border equity trading by residents of the four countries cited in Table 2 accounted for roughly half of the total transactions volume by nonresidents recorded in those same four countries. Available bilateral flow data suggest that U.K. residents accounted for a large part of the remainder.

Growth in transactions by nonresidents, however, coincided with strong growth in home market transactions by domestic residents, so that in many larger markets, the foreign share of transactions remained low. In Japan, for example, nonresidents churned their stock portfolios to realize gains from rising prices in the overall market. In value terms, their gross transactions during the first nine months of 1987 more than tripled on an annual basis compared to 1984 (Table 3). This increase was less, however, than the rise for any other investor group in the Japanese market. Foreign transactions represented just over 10 percent of the turnover on the major stock exchanges in the United States and Japan, around 20 percent in the United Kingdom (where a large proportion of all nonresident transactions in London involved foreign stocks listed on the International Stock Exchange), and nearly 25 percent in Canada and Germany.

In summary, by September 1987, the activities of cross-border investors had grown considerably in most major equity markets, but the foreign share of total stocks outstanding and of transactions volume remained fairly low in the largest markets. Thus, quite concentrated selling by nonresidents would have been

[3]Transactions data are not available for the United Kingdom.

Table 2

The Expansion of Cross-Border Equity Transactions Value before the Break

Sum of Gross Purchases and Sales in Billions of Dollars

Nonresident Transactions				**Transactions in Foreign Equities**			
	1985	1986	1987		1985	1986	1987
In domestic equities in			Jan.-Sept.	By residents of			Jan.-Sept.
Canada	11.3	18.9	33.7	Canada	18.8	32.8	37.5
Germany	38.3	77.1	59.3	Germany	20.6	43.1	48.1
Japan	81.3	189.6	278.0	Japan	10.0	34.8	88.6
United States	159.0	277.5	359.7	United States	45.7	100.2	142.0

Sources: Statistics Canada, *Security Transactions with Nonresidents*, Table 3; Statistics Canada, *Quarterly Estimates of the Canadian Balance of International Payments*, Table 11; Deutsche Bundesbank, *Balance of Payments Statistics, Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank*, Series 3, Table 5d; Bank of Japan, Foreign Department, *Balance of Payments Monthly*, "Long-Term Capital"; U.S. Department of Commerce, *Survey of Current Business*, Tables 2, 6, and 9; Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin*, Table 3.24.

necessary to make a profound impact on stock prices in New York, London, and Tokyo.

Twenty-four-hour trading

Trading of stocks on exchanges outside the home country was the other principal channel for increased international equities trading and investment. Markets for foreign stocks had developed chiefly in New York and London. Those markets remained confined to particular segments of the global equities market, notably U.K. stocks in New York and Continental European stocks in London. Only a small market for foreign stocks existed in Tokyo.

In New York, the principal instrument for trading in overseas shares is the American depositary receipt (ADR). ADRs are certificates that represent a given number of shares of a foreign firm and are traded like the public shares of U.S. companies. U.S. commercial banks hold the underlying foreign shares in custodial accounts in their London branch offices. The most actively traded ADR issues, with few exceptions, are the "sponsored" programs of U.K. companies.[4]

Agent banks estimate that the ADR investor base is largely institutional; about 10 percent to 20 percent is retail. Institutional ADR investors are often newcomers to the international share markets. Some have bylaws that prevent them from purchasing securities not registered in the United States while others may be able to hold shares directly but prefer to keep some holdings in ADR form for liquidity reasons (essentially because New York's five-day settlement period is often short compared to other markets).

The International Stock Exchange (ISE) in London has the most extensive market in foreign equities. Before the market break in October, about 800 foreign equities were quoted on the ISE's automated quotation system (SEAQ International); roughly 200 were actively traded. The London foreign share market primarily consisted of European equities, with French and German shares accounting for about a third of the value of securities traded daily in September 1987. Trading in U.S. shares, in contrast, amounted to only 5 percent of daily transactions value or about $50 million per day. Trading in Japanese stocks was somewhat greater, amounting to around 10 percent of daily transactions value or roughly $100 million a day.[5]

From Big Bang—the liberalization of the U.K. domestic securities markets in October 1986—to September 1987, foreign share trading on the ISE grew 70 percent, reaching £525 million ($850 million) a day. Before the October 1987 market break, it constituted almost one-third of total equity turnover value on the exchange. Foreign equities were also widely traded in London off the ISE; the ISE estimated the off-exchange volume to be roughly equal to that on the exchange. Institutional investors dominated trading in foreign equities, as reflected in an average transaction size of £140,000, roughly five times that of the domestic sector; and over half of the trading was done by nonresidents.

The foreign stock section of the Tokyo Stock Exchange (TSE) grew rapidly from a very low base but remained relatively unimportant. Trading value in the first nine months of 1987 tripled from the previous year but still amounted to only 1.5 percent of TSE trading value. Listings rose from 11 companies at the end of 1984 to 67 in September 1987. Most of the listings were intended primarily to improve name recognition with Japanese investors as a means of attracting funds in other markets rather than to promote significant trading of the company's shares on the TSE. The number of foreign companies whose shares were actively traded in Tokyo was small.

Thus, compared to cross-border investment, 24-hour trading represented a more limited and specialized channel for the transmission of disturbances from one equities market to another. As a general phenomenon, it had not developed to the point where it could easily spread a stock market decline around the globe.

[4]Under a sponsored ADR program, a foreign company designates a U.S. commercial bank as custodian for the ADR program.

Table 3

Gross Transactions of Nonresidents on the Tokyo Stock Exchange

	Percent of Total Transactions*	Value of Transactions*†	Turnover Ratio‡
1984	15.1	15.2	116
1985	13.3	16.0	100
1986	11.5	30.2	165
1987: Jan.-Sept.	10.3	39.5	284

*By calendar year.

†In trillions of yen.

‡The turnover ratio was calculated by dividing the value of nonresidents' gross transactions for an entire calendar year by the value of their shareholdings as of March of the following year. For example, the turnover ratio for 1985 is based on gross transactions for calendar year 1985 divided by equity holdings as of March 1986. For 1987, however, the ratio was calculated by dividing gross transactions through September by equity holdings at the end of that month.

Source: Tokyo Stock Exchange.

[5]The ISE points out that trading volumes in foreign shares are volatile. For the first six months of 1987, German and French shares accounted for 26 percent of trading value; U.S. shares, 8 percent; and Japanese shares, 21 percent.

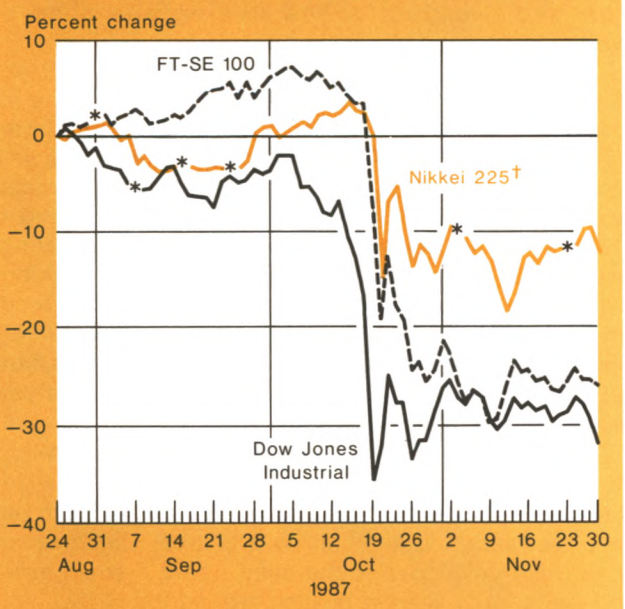
The role of linkages in the crash

Stock markets turned down sharply in mid-October in New York, Tokyo, and London, but the precise timing of the events differed among the cities in two important respects (Chart 1). First, while New York's fall began on October 14, London and Tokyo did not experience large declines until the following week. The ISE began falling slowly with New York on October 14, but a storm on Friday the 16th prevented people from getting to work, virtually closing the market. London's first large decline occurred on October 19. Tokyo did not fall sharply until October 20. Second, although a severe decline occurred in all markets on October 19 or 20, New York and Tokyo recovered somewhat while London continued to fall over the next three weeks, reaching its low on November 9. The London pattern was far more common both on the European continent and in most of the Far East outside Japan.

For the three largest equities markets, a discernible role for cross-border investment and overseas trading in equities during the market break was confined to two instances: heavy sales by nonresidents in Tokyo on October 20 and price declines in U.K. ADRs traded in New York around October 19. Thus, direct linkages were not alone responsible for the rapid spread of the break to virtually all of the world's equities markets.

Chart 1

Dow, FT-SE 100, and Nikkei 225 Indexes



* Holiday.

† Nikkei 225 data for Saturday trading twice a month are not included.

U.S. equities

Most accounts of the New York market break focus on the actions of U.S. residents and do not attribute a major role to nonresident investors. The Brady Commission report made no mention of nonresident selling in New York on October 19 or 20. The SEC staff report recorded rumors that international investors were "dumping" U.S. stocks but concluded that the volume of selling was not heavy. U.S. Treasury data also suggest that nonresident selling could not have been heavy since, on balance, nonresidents purchased U.S. stocks in October.[6]

Sales of U.S. stocks in London on October 19 by U.S. institutional investors may have played a small role by providing early indications of the strength of selling pressures to come that day. According to the SEC staff report, much of the London trading in U.S. stocks on October 19 and 20 apparently was arranged in New York and executed in London. The report attributed much of the transactions volume to U.S. prenegotiated trades crossed in London and to U.S. futures-related and other special purpose trades.

The volume of trading of U.S. equities in London, however, remained relatively small. For U.S. stocks included in the Dow Jones Industrial Average, the number of shares traded probably never exceeded 3 percent of New York share volume on any day between October 14 and October 21. In the week of October 19, the value of turnover in U.S. stocks was about normal; however, the number of deals rose sharply. From the resulting lower average transactions value, the ISE inferred that retail business assumed more importance. One explanation consistent with both the U.S. and London reports is that U.S. institutions traded in London on October 19 and 20 and withdrew for the balance of the week.[7]

The liquidity available in U.S. stocks in London apparently declined after October 19, making transactions difficult. The International Stock Exchange reported that U.S.-affiliated market makers, on orders from their head offices, did not always quote prices in the week beginning October 19. The loss of liquidity in U.S. shares was common to other foreign equities traded in London. The spread between best bid and

[6] See *The Report of the Presidential Task Force on Market Mechanisms*, January 1988, and U.S. Securities and Exchange Commission, Division of Market Regulation, *The October 1987 Market Break*, February 1988, chap. 11.

[7] The ISE report on the crash appeared in the Exchange's publication, *The Quality of Markets Quarterly*, Winter 1987-88.

best offer (the "touch") widened. For the 200 most active foreign shares (accounting for 60 percent of foreign share volume), the touch rose from about 0.8 percent precrash, a spread about equal to that for the most liquid U.K. shares, to 1.2 percent postcrash.

Some linkage of price movements in London and New York can be observed around October 19 in two major stocks that trade 24 hours a day, IBM and Exxon. (The shares of relatively few U.S. companies traded actively around the clock at the time.) However, the overlap in trading days and the difficulties in placing or executing orders that emerged in both markets make the extent of a New York-London price cycle virtually impossible to identify. Both stocks opened roughly 1 percent to 2 percent lower in London than they had closed in Tokyo on October 14, October 15, and October 19, all days of large price declines in U.S. stocks (Charts 2 and 3). Using London opening prices understates London's effect, since trading continues for five hours before the New York market opens.

The size of London's price decline on October 19 is probably particularly understated by using opening prices. London prices for IBM and Exxon opened down, but the London market dropped throughout the day. New York opened roughly 10 percent below the previous day's close in both stocks; a good part of the drop may already have occurred in London. The fall in London could conceivably have accounted for as much as one-third of the total decline in the prices of these two stocks on October 19. Similarly, both stocks opened much higher in London on October 20, as they did a few hours later in New York.

In contrast, price movements in Tokyo bore little relationship to price movements later in London and New York. Trading volume in foreign shares in Tokyo, never large, declined sharply after October 19 to less than half the September average. Trading of U.S. shares in Tokyo was clearly too small to have had a significant effect on prices of U.S. stocks in London or New York. Indeed, prices of both IBM and Exxon rose most days between October 13 and October 23 in the Tokyo market, including October 19. A similar lack of correlation between Tokyo and domestic price movements can be found for other U.S. and U.K. stocks.

Chart 2

Global Trading in Exxon Shares

Market-to-Market Price Changes

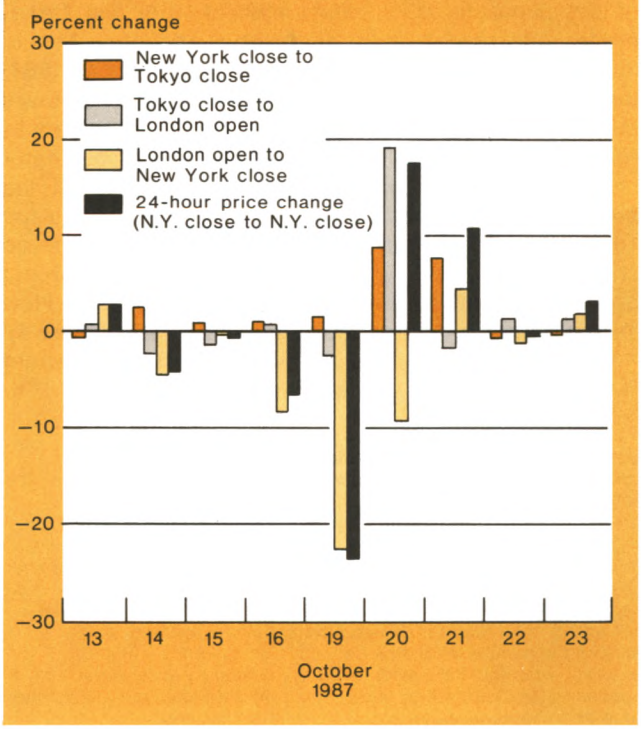
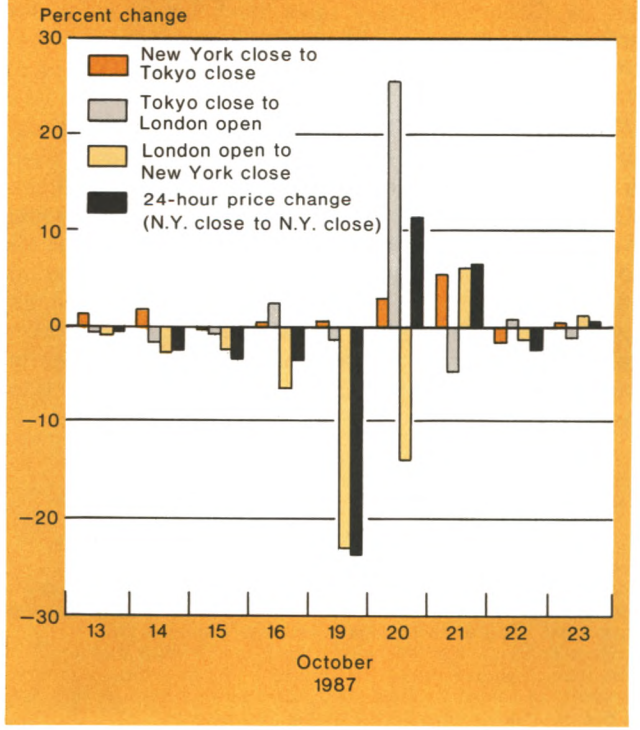


Chart 3

Global Trading in IBM Shares

Market-to-Market Price Changes



Japanese equities

Although nonresidents owned only about 5 percent of the Japanese market and accounted for about 10 percent of trading value, they were able to influence the October 20 downturn strongly. The October 19 declines on the New York and London exchanges heightened the fear of an impending major correction in Tokyo. That fear may have been exacerbated by the anticipated supply overhang stemming from the huge Nippon Telegraph and Telephone offering scheduled for November. These worries may have led to some price-insensitive selling by investors outside Japan.

Nonresidents placed orders to sell Japanese stock in Tokyo early on the morning of October 20. Most of these orders were "market" orders. That is, the saitori member who matches buy and sell orders on the exchange was instructed to sell the stock at the current price.[8] According to TSE rules, if a buyer cannot be found at the current price, the saitori member drops the price a notch at about 10 minute intervals until a buyer is found. However, prices are only allowed to fall on average about 15 percent from the previous day's close. On October 20, buyers proved difficult to find and the price floors on many stocks were reached.[9]

Over the rest of the week, however, Japanese residents absorbed large amounts of shares from nonresidents who were liquidating their holdings. According to Tokyo Stock Exchange data, nonresidents sold over ¥1 trillion ($7 billion) of stock from October 19 to October 24. Continued heavy sales the following week are reflected in Japanese balance of payments data that show nonresident sales of over $12 billion for all of October.

The TSE bore most of the nonresident selling pressure on October 20. Few Japanese companies traded in the United States in ADR form. Trading of Japanese stocks in London was also small, although international investors made heavier use of the London market for Japanese stocks in the week of the crash. Measured in value terms, transactions in Japanese shares expanded five times. The surge occurred even though Japanese dealers were not obliged to quote prices in Japanese stocks on SEAQ on October 20, according to the ISE.

[8]Unlike a specialist on the New York Stock Exchange, the saitori member does not take positions in stocks.

[9]Price limits did not halt trading in foreign stocks, since the limits operate differently for domestic and foreign stocks. For domestic stocks, price limits for the current trading day are calculated from the previous day's close. For foreign stocks, the TSE uses the closing price in the home or another major overseas market as its benchmark. In practice, this means that a foreign stock can drop more than 15 percent in the home market and then still drop an additional 15 percent in Tokyo. SmithKline Beckman, for example, fell 30 percent from October 19 to October 20 in Japan.

U.K. equities

While some market analysts have argued that direct sales of U.K. shares in London by nonresidents, particularly European investors, may have influenced the London crash, the behavior of domestic residents was the driving force in the decline. Some U.K. institutional investors sold heavily, while other U.K. institutions were reluctant to buy, a reflection of the unusually large equity positions they had taken on. Added to this was the overhang from the British Petroleum (BP) underwriting and from commitments to take up shares from previously scheduled U.K. company "rights" offerings. These factors prevented institutional investors from supporting the market with buying—a degree of which might have been expected otherwise—and led them to reduce heavy equity positions to make room for the new issuance coming onto their books.[10]

The more important international influence on U.K. stock prices was trading of top U.K. company shares in the form of ADRs. Large net sales of U.K. ADRs in the United States would have been reflected in a sharp contraction in ADRs outstanding and a net flowback of underlying registered shares into the London market. The analysis below of the 10 largest sponsored U.K. ADR programs during October and November shows that a significant withdrawal from U.K. shares in ADR form in fact occurred.

The development of a deep market for leading U.K. shares in New York, backed by the increased liquidity of the domestic U.K. equity market after Big Bang, made U.K. shares more accessible and attractive to international investors. From May to September 1987, the share turnover (adjusted for the number of ordinary shares per ADR) of the top 18 U.K. ADR programs was roughly 4 percent to 5 percent of total U.K. customer share turnover in London. The top 18 represent the bulk of U.K. ADR trading volume in New York. The top 10 U.K. ADR programs analyzed here had adjusted share trading volumes that ranged between 12 percent and 70 percent of their combined London and New York turnover in August and September 1987 (Table 4).

Differences in U.S. and U.K. investor attitudes toward U.K. shares should, at the margin, be reflected in U.K.

[10]Most major U.K. institutional investors were members of the subunderwriting group in the record £3.7 billion BP privatization. The subscription period ended on October 24. As in previous privatizations, the BP indenture included a "clawback" provision designed to assure maximum retail investor participation. Whenever retail subscriptions exceeded the shares set aside for those investors, shares allocated to institutions could be "clawed back" to meet retail demand. The institutions, therefore, would typically oversubscribe—sometimes by a factor of 10—to have a better chance of being allotted the number of shares desired. Consequently, in the BP offering, when retail investors failed to materialize once the sell-off in London began, institutions revised their expectations and anticipated receiving shares far in excess of the amount desired.

ADR creation or liquidation because of arbitrage between markets. Differences in attitude can reflect differing expectations about exchange rates and other variables influencing investment returns. When such differences lead to selling pressure from international investors, we would expect to find that U.K. ADRs had been broken down into their constituent shares and sold into the U.K. stock market. ADRs outstanding for individual issues, in fact, tend to ebb and flow significantly from month to month, within a range of 7 percent in either direction, according to ADR banks.

In October, the 10 ADRs studied showed large flowback on balance, followed by further flowback in November. Outstandings of 4 of the 10 U.K. ADRs fell by more than 7 percent, and those of 2 more fell between 5 percent and 7 percent in October. The variation ranged from an increase of 0.2 percent to a 14 percent contraction. Outstandings of the 10 ADRs declined by 6 percent on average when weighted by the value of ADRs outstanding at the end of July (Table 4). In November, which may have been as important as October because of the five-day settlement period for New York exchanges and the extended decline of the U.K. market, all 10 ADRs experienced flowback. Although only 1 program contracted more than 7 percent, another 4 had flowback between 4.5 percent and 7 percent. The weighted average level of flowback declined to about 4 percent, with the range spanning 0.8 percent to 9 percent. Other U.K. ADR programs showed mixed trading results over the two months, with heavy flowback reported for some and ADR creation for others.

Table 4

Ten Leading U.K. ADR Programs: Volume and Flowback Data*

	1987			
	Aug.	Sept.	Oct.	Nov.
Percent of total trading volume†				
Low	12.3	21.0	10.5	8.1
High	70.4	66.0	64.1	61.5
Median	42.4	43.3	29.3	29.9
Weighted-average‡	47.5	45.5	35.2	31.5
Creation/flowback (+/−):§				
Low	−8.4	−5.2	−14.3	−8.9
High	37.0	20.7	0.2	−0.8
Median	−2.0	1.5	−6.5	−4.5
Weighted-average‡	4.2	1.8	−5.9	−3.8

*Top ten sponsored U.K. ADR programs: Hanson, Glaxo, Jaguar, BP, Beecham, Saatchi, ICI, Reuters, Shell Transport, and British Gas.

†ADR ordinary share equivalent volume as a percentage of the sum of U.K. share volume and ADR ordinary share equivalent volume.

‡Weighted by the value of ADR certificates outstanding at the end of July.

§Percentage change in ADRs outstanding over the period. Flowback is defined as a decline in outstandings over the period.

Sources: S&P's *Security Owner's Stock Guide*, ADR agent banks.

The size of the flowback does not alter the earlier conclusion that domestic, not foreign, selling was the major trigger in the U.K. decline. In comparison with London trading volume in the days following October 19, the number of U.K. shares represented by this level of flowback was not overwhelming. Net sales of ADRs in New York, however, did bid down prices in New York, a development that may have had an important negative psychological effect in London.

To see how trading in New York may have influenced price behavior in London, changes in closing ADR prices in New York from the London close earlier that day were compared with closing price changes in London the following day. The period considered was the week before and after October 19. The results of this analysis were averaged across 10 leading U.K. companies with ADR programs and are summarized in Chart 4.

Around October 19, changes in the London prices of the 10 shares tended to reflect changes in their ADR prices in New York after London's close on the previous business day. On October 20, for example, those shares declined 14 percent in London after the ADR prices had fallen 11 percent on October 19. The price declines in New York on October 16 may have been related in part to a storm in London that brought trading there to a virtual halt, although the market was still technically open. Together, the size of flowback in October and the pattern of price changes around October 19 suggest that some significant selling pressure on U.K. stocks emanated from the ADR market in New York.[11]

Implications for other market centers

Elsewhere in Europe and the Far East, where the foreign share of ownership and transactions was greater than in the largest markets, the effect of nonresident selling was probably more pronounced. Relatively heavy selling in some smaller markets can be seen in the bilateral flow data from some large countries. For example, U.S. residents sold substantial amounts in

[11]Nevertheless, ADR flowback and price declines for individual shares were not closely tied in October, underscoring the point that overseas investors were not the driving force in the U.K. stock market decline. Reuters, for instance, registered a 44 percent price decline in October but showed below average flowback of 2½ percent. Shell Transport, by contrast, showed a below average price decline of 20 percent over the same period but showed heavy flowback of close to 14 percent.

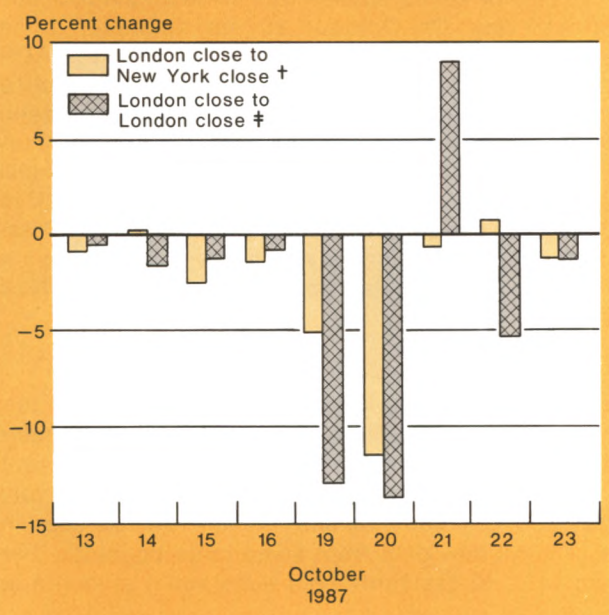
some European countries and in some Asian countries (including Japan) in October.

It seems likely that the ability to trade European stocks in London somewhat accelerated the spread of the worldwide decline to other European markets, an effect that did not seem to hold for U.S. and Japanese shares. Trading of foreign equities on the ISE rose sharply during the week of the crash. In some cases—the ISE report on the October market break mentions French equities—selling pressures in London were transmitted directly to the domestic market as market makers sold in the home market the shares they had absorbed from investors in London.

Even though the direct linkages were stronger in markets other than the three largest equities markets, cross-border investment and 24-hour trading of equities probably did not create connections strong enough to explain the synchrony in the world's equities markets. Thus, the principal linkage was most likely an indirect one. In the panicky environment surrounding the crash, market participants interpreted steep price declines in overseas markets as signals of impending declines in their own markets.

Chart 4

Influence of New York Trading in U.K. Shares on Day-to-Day Price Changes in London *



* Averages for 10 leading U.K. equities traded in ADR form in New York.

† Change in prices from the London close to the New York close.

‡ Change in London closing prices from the previous day.

International linkages after the October break

Although cross-border selling of equities cannot explain the global spread of the crash, substantial cross-border net sales did occur in the weeks after the market break (Table 5). These sales no doubt contributed to the weak tone in worldwide stockmarkets in the last quarter of 1987. Indeed, heavy cross-border selling created fears that international investors, shaken by the October crash, were liquidating investments of all types in the major markets and repatriating funds to their home markets, a view that became known as the "homing" hypothesis.

The available data suggests, however, that the pattern of cross-border transactions in the weeks after the break more closely resembled the development of flows in the U.S. securities markets than the flows envisioned by the homing hypothesis. Some investor segments clearly decided to reduce their equity investments, but others maintained their holdings. Cross-border demand for government securities picked up shortly after the crash, but a sharp temporary slowing of corporate debt issuance in the euromarkets lasted into early 1988. As a result, the banking system—and the central banks—played an increased role in international financial intermediation.

Cross-border trading after the crash

Sales by cross-border investors in the major equities markets in the weeks after the crash were substantial. After liquidating $12 billion in Japan in October (primarily in the second half of the month), nonresidents sold another $9 billion in November. In the United States, nonresidents, who were on balance net buyers in October, sold nearly $7 billion in November. In Germany and, to a lesser extent, in Canada, nonresident selling continued to be heavy relative to market size in November. In total, cross-border sales amounted to $30 billion in four markets—Canada, Germany, Japan, and the United States—in October and November.[12]

Another sign of cross-border investor withdrawal was a drop in total transactions value after October, suggesting that nonresidents not only sold stocks but traded their portfolios less actively. The value of nonresidents' gross transactions was unusually high in October in four major countries (Table 6), well above the average in the first nine months of 1987. However, the value as a share of total turnover on the major

[12] Available statistics do not indicate the scale of net sales of foreign equities in London.

stock markets did not rise above levels seen earlier in 1987. Transactions value dropped sharply in November to levels well below the monthly average for the first nine months in all markets. This broad-based slowdown in activity was accompanied by reduced trading of foreign stocks in domestic markets. Trading of foreign stocks declined sharply on the Tokyo Stock Exchange, and after a surge in October, fell close to its lows for the year in London.

The identity of the heavy sellers in the fourth quarter of 1987 is a mystery. U.K. residents accounted for as much as a third, or around $10 billion, of the outflows in the major markets. The United Kingdom's importance as a seller is borne out in bilateral flow data for the major markets. But the United Kingdom channels funds from many U.S. and other foreign institutional and large investors who run their international portfolios out of London.

Residents of the other four major countries for which data are available do not account for much of the sales. Of this group, U.S. residents were the only substantial net sellers, but the sales were less than $3 billion for October and November combined. A large part of that sum appears attributable to sales by U.S.-based

Table 5

Cross-Border Equity Flows before and after the Market Break

In Billions of Dollars

Nonresident Net Purchases*	1987-III	1987-IV	1988-I	1987 Oct.	1987 Nov.	**Net Purchases of Foreign Equities***	1987-III	1987-IV	1988-I	1987 Oct.	1987 Nov.
Of domestic equity in						By residents of					
Canada	1.3	−1.0	−0.6	−0.3	−0.5	Canada	−0.1	0.4	0.1	−0.3	0.1
Germany	0.8	−4.2	−0.9	−2.0	−1.4	Germany	0.4	0.6	1.9	0.6	−0.3
Japan	−8.0	−21.5	6.6	−12.4	−8.5	Japan	3.5	3.3	−0.6	2.4	0.8
United Kingdom†	5.4	3.9	−0.2	N.A.	N.A.	United Kingdom‡	1.2	−9.6	−1.0	N.A.	N.A.
United States	5.0	−7.8	−0.2	2.5	−6.7	United States	0.4	−3.9	0.7	−2.1	−0.7

*(−) = net sales.

†Transactions by overseas residents in U.K. company securities; believed to be largely equities.

‡Net purchases of ordinary shares of overseas companies by nonbank financial institutions.

Sources: Statistics Canada, *Security Transactions with Nonresidents,* Table 3; Statistics Canada, *Quarterly Estimates of the Canadian Balance of International Payments,* Table 1; Deutsche Bundesbank, *Balance of Payments Statistics, Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank,* Series 3, Table 5d; Bank of Japan, Foreign Department, *Balance of Payments Monthly,* "Long-Term Capital"; Central Statistical Office (United Kingdom), *Financial Statistics,* Tables 7.1 and 8.7; U.S. Department of Commerce, *Survey of Current Business,* Tables 2, 6, and 9; Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin,* Table 3.24.

Table 6

Cross-Border Equity Transactions Value before and after the Market Break

Sum of Gross Purchases and Sales in Billions of Dollars

Nonresident Transactions	1987-III	1987-IV	1988-I	1987 Oct.	1987 Nov.	**Transactions in Foreign Equities**	1987-III	1987-IV	1988-I	1987 Oct.	1987 Nov.
In domestic equities in						By residents of					
Canada	11.2	9.4	6.8	4.3	2.6	Canada	13.4	13.4	8.9	5.7	4.4
Germany	22.5	17.0	13.7	8.4	5.2	Germany	17.9	11.6	11.6	5.7	3.1
Japan	85.9	76.5	74.3	41.2	20.8	Japan	40.3	36.4	38.4	14.4	10.8
United States	136.8	122.2	95.4	58.0	34.0	United States	52.1	47.3	35.7	23.9	14.5

Sources: Statistics Canada, *Security Transactions with Nonresidents,* Table 3; Statistics Canada, *Quarterly Estimates of the Canadian Balance of International Payments,* Table 11; Deutsche Bundesbank, *Balance of Payments Statistics, Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank,* Series 3, Table 5d; Bank of Japan, Foreign Department, *Balance of Payments Monthly,* "Long-Term Capital"; U.S. Department of Commerce, *Survey of Current Business,* Tables 2, 6, and 9; Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin,* Table 3.24.

mutual funds investing in foreign stocks. They sold $2.4 billion of stocks in October and November to meet redemptions and switches out of international funds—roughly 15 percent of the assets of *all* international mutual funds at the end of 1986.

Indeed, residents of Japan, Germany, and Canada were net buyers of overseas equities in the fourth quarter of 1987. Japanese net purchases, a major force in the expansion of cross-border investment, slowed in November and December after substantial net purchases in October.

A large part of the $20 billion balance of net sales appears to be from countries that, like the United Kingdom, traditionally channel investment from industrial and nonindustrial countries. Estimated sales from Switzerland accounted for roughly $3 billion; from Asian centers, about $7 billion; and from other European countries, around $3 billion. It seems likely, then, that a significant portion of the disinvestment came from outside the G-10 countries. In Germany, for example, selling by residents of Switzerland, offshore centers, and LDCs came to roughly 40 percent of fourth quarter 1987 net sales by all nonresidents.

Investment behavior of international investors

The apparent concentration of selling from international centers calls into question the homing hypothesis that circulated in the weeks following the crash. As noted earlier, the homing hypothesis posited that international investors, alarmed by the October crash, liquidated investments of all types in the major markets and repatriated the funds to their home markets.

Two observations seem inconsistent with the homing hypothesis. First, investors in the wealthiest countries—Japan, Germany, and the United States—did not flee the international equities markets, although Japanese and German residents slowed their external investments after October and U.S. residents sold a relatively small portion of holdings. Residents of these countries had played an important role in the surge in cross-border equity investment, accounting for a $26 billion increase in net cross-border equity investments from the end of 1985 to September 1987.

These investors could have most easily repatriated any proceeds from sales of their overseas assets. In contrast, residents outside the G-10 countries who sold equities would have had more limited domestic investment opportunities and are more likely to have reinvested their funds with international banks or in the international markets.

Second, the pattern of cross-border investments in the fourth quarter of 1987 resembles the flows in U.S. domestic markets more than the withdrawal and repatriation of funds posited by the homing hypothesis. In the international as in the U.S. securities markets, investors responded to the October break with caution. Some investors sharply reduced their equity portfolios. Many investors sought out the relative safety of the government bond markets. Cross-border investment in the major domestic bond markets—chiefly in government bonds—recovered sharply in November after net sales in October, when rapidly rising interest rates promoted a shift to shorter-term investments. On balance, nonresident bond purchases outweighed sales in the fourth quarter in the five major countries examined (Table 7). Issuance of eurobonds by Japanese and U.S. borrowers—mainly corporations—slowed abruptly after the crash, however, as did corporate bond issuance in the United States, which in November and December fell by more than a third from its monthly average in 1987.

The international banking system therefore intermediated a larger share of cross-border financial flows than it had in recent quarters. The net eurocurrency liabilities of BIS reporting banks, a group that includes most banks in industrial countries and many offshore centers, grew $28 billion in the fourth quarter of 1987, net of exchange rate changes, compared to $6 billion in the fourth quarter of 1986 (Table 7). In the balance of payments accounts, bank inflows were initially the major offset to the large outflows resulting from nonresident sales of equities recorded in Japan and Germany. The banking sector was also a heavy net cross-border lender to nonbanks in the fourth quarter, lending $23 billion net, twice as much as in any other quarter in the last two years. No doubt, the higher lending reflected the slowdown in the international securities markets.[13]

Capital flows were sufficiently disrupted and exchange rate expectations sufficiently changed in the weeks after the crash that central bank reserve flows also became an important channel for international capital flows. These reserve flows assisted directly—and indirectly through the banking system—in financing the U.S. current account deficit in the fourth quarter of 1987.

Cross-border portfolio investment by residents of the large industrial countries picked up strongly in early 1988, and even investments in equities began to improve late in the first quarter. Indeed, international investors on balance bought $7 billion in Japanese equities in the first quarter of 1988, the first net purchases in two years. Japanese and U.K. residents, however, did not participate in the resumption of cross-

[13]U.S. bank lending to nonfinancial corporate borrowers also increased in the fourth quarter but was not out of line with the experience in the fourth quarter of previous years, when financial flows were greatly affected by tax law changes.

border equity purchases in the first quarter. And trading of stocks outside the home market recovered even less in the first months of 1988. The value of foreign equities trading in London recovered to its year-earlier level but remained well below the mid-1987 peak. Trading of leading U.K. ADRs in New York and of foreign stocks in Tokyo was still at half the year-earlier levels.

Table 7

Selected Flows from the Balance of Payments*

Billions of Dollars Not Seasonally Adjusted; (−) = Outflow

	1987-III	1987-IV	1988-I
Nonresident portfolio investment			
Bonds			
Canada	2.0	0.7	2.7
Germany	−0.3	0.4	1.4
Japan	6.2	2.3	−1.2
United Kingdom†	3.9	0.9	0.6
United States	−2.4	1.1	6.2
Eurobonds			
Japan	14.0	5.6	8.1
United States	6.3	3.3	2.6
Resident portfolio investment abroad			
Bonds			
Canada	−0.2	0.4	−0.4
Germany	4.7	0.5	8.0
Japan‡	17.1	7.3	13.2
United Kingdom	−2.0	−5.8	5.7
United States	1.4	5.7	3.8
Net bank flows§			
Canada	0.3	1.6	1.5
Germany	3.9	3.4	2.2
Japan	−12.2	24.0	2.9
United Kingdom	−6.1	−3.3	10.0
United States	22.7	13.1	−6.7
BIS reporting area	15.9	27.9	7.4
Foreign currency reserves; (−) = increase			
Canada	−1.1	−0.6	−4.4
Germany	−1.5	−15.6	5.8
Japan	−2.8	−8.9	−3.2
United Kingdom	−0.5	−12.7	0.3
United States	−0.1	0.9	2.6

*For the United States, transactions with foreign official institutions are excluded.

†Government bonds only.

‡Excluding bonds issued by nonresidents in Japan.

§Adjusted for exchange rates.

Sources: Statistics Canada, *Quarterly Estimates of the Canadian Balance of International Payments,* Table 1; Deutsche Bundesbank, *Balance of Payments Statistics, Statistical Supplements to the Monthly Reports of the Deutsche Bundesbank,* Series 3, Table 5d; Bank of Japan, *Economic Statistics Monthly,* "Foreign and Overseas Investments in Securities"; Central Statistical Office (United Kingdom), *Financial Statistics,* Tables 3.5, 7.1, and 8.7; U.S. Department of Commerce, *Survey of Current Business,* Tables 2, 6, and 9; Board of Governors of the Federal Reserve System, *Federal Reserve Bulletin,* Table 3.24; Bank for International Settlements, *International Banking and Financial Market Developments,* August 1988; International Monetary Fund, *International Financial Statistics.*

Conclusion

Cross-border investment and 24-hour trading cannot explain the rapid worldwide spread of the stock market break in October 1987. Direct linkages among the three largest equities markets—New York, Tokyo, and London—played a role in two instances. Selling by investors outside Japan in response to the declines in London and New York appears to have helped precipitate the Tokyo decline. New York's drop and recovery were transmitted fairly quickly into the prices of leading U.K. shares traded in ADR form in New York, although the principal downward push in London came from domestic investors.

The international linkages among the three largest equities markets were not sufficiently developed to produce the simultaneous and severe downturn in stock prices worldwide, and many large international investors, particularly those in Japan, did not sell off. Domestic investors shaped the decline in the largest markets. Thus, the principal international linkage between national stock markets appears to be the unobservable and indirect one created when sharp price declines in overseas markets contribute to a panicky market psychology.

The significance and the potential force of the international transmission of disturbances are likely to grow. Even after the nonresident liquidations in October and November, the stock of cross-border equity holdings is substantial. Information links among markets are already extraordinarily good and, in the area of direct trading and clearing linkages, the connections are now in the early stages of development. At present, trading links exist between Canadian and regional U.S. exchanges. Although clearing links do not yet exist with Tokyo, they are being developed between London and New York. In time, the completion of these links and a streamlining of the international clearing and settlement mechanism for internationally-traded equities could allow price discovery to occur outside the home market time zone and thus accelerate the reaction of domestic equities prices to foreign disturbances. A hint of this potential can be seen in the large increase in the trading volume of foreign equities in London—including Japanese and European shares—during the break. The shifting of European equities trading to London with clearing through Euroclear or Cedel represents the type of mechanism that could strengthen those international linkages.

The still relatively underdeveloped state of international equities trading reflects the many practical diffi-

culties to be overcome in establishing trading and clearing links among markets. The presence of practical problems suggests that implementation of proposed measures to reduce the chance of another U.S. market break would not quickly and easily drive U.S. equities trading to offshore markets. And in an international context, reducing the chance of a market crash in the large U.S. market—or any other large market—would work to prevent the cycle of round-the-globe panic selling seen last October.

Robert Aderhold
Christine Cumming
Alison Harwood

Margin Requirements on Equity Instruments[1]

The stock market crash of October 1987 focused considerable attention on the adequacy and consistency of margin requirements on U.S. equity-related products. The analysis of these issues is difficult because of the complexity of U.S. margin rules. To help clarify the discussion, this article outlines the margin rules in the markets for stocks, stock index futures, stock options, stock index options, and stock index futures options.[2]

The general principle behind margin requirements is simple. Margin requirements oblige investors who undertake contractual obligations to deposit and maintain a minimum amount of cash or securities with their counterparties. Margin requirements in different markets serve several different goals,[3] but in all cases margin deposits reduce counterparty losses whenever contractual obligations are not fulfilled: if the investor defaults, the counterparty at the very least retains the margin deposit.

This principle applies in all markets, even though the underlying contractual obligations that create the need for margin requirements may differ. These contractual obligations are outlined in Table 1. In practice, margin requirements modify these obligations, since investors must satisfy the margin rules on a continuous basis.

As described in the table, the contractual obligations of short and long positions in the *stock index futures market* are to receive or make payments sometime in the future. Both long and short positions are required to put up and maintain minimum margin deposits with their counterparties. In *options markets,* the basic contractual obligation of the short position is to purchase or deliver the underlying security if and when the long position exercises the option. The short position is required to put up and maintain a minimum margin deposit with the counterparty. Finally, in the *stock market,* contractual obligations arise in two distinct transactions: buying stock on margin and selling stock short. Investors buying stock on margin take out a loan and use the proceeds together with their own funds to buy stock. The stock is then deposited as collateral with the lender. The basic contractual obligation of each investor is to repay the loan. Margin requirements oblige investors to deposit and maintain stock collateral at a specified minimum level above the face value of the loan. In short sales, investors sell borrowed stock, so their basic contractual obligation is to return the stock to the lender. Each short seller is required to put up a minimum deposit with the stock lender.

Describing the margin rules governing transactions in the U.S. financial markets is a difficult task. Different margin systems have developed for different markets and, even within individual markets, the rules may vary depending on the type of investor and transaction. The purpose of this article is to identify the appropriate margin-setting authorities, to sort out the rules apply-

[1]This article is intended only to provide a brief overview of margin regulations and related topics. It is not designed to be used, and should not be used, as a substitute for the appropriate regulations and published interpretations thereof. Questions concerning margin regulations should be addressed to your legal counsel.

[2]A more detailed description of margin requirements can be found in George Sofianos, "Description of Margin Requirements," Federal Reserve Bank of New York, Unpublished research paper, September 1988.

[3]See the discussion in Arturo Estrella, "Consistent Margin Requirements: Are They Feasible?" in this issue of the *Quarterly Review.*

Table 1

Summary of Basic Contractual Obligations*

Stocks

Buying stock on margin: Investors buying stock on margin take out a loan and use the proceeds together with their own funds to buy stock. The stock then serves as collateral for the loan. Such loans are known as margin loans. The basic contractual obligation of each investor is to repay the margin loan plus interest. In general, margin loans carry no stated maturity. The counterparty is the provider of the margin loan.

Selling stock short: In short selling, investors sell borrowed stock. The basic contractual obligation of each short seller is to return the stock to the counterparty, the stock lender. Stock lending agreements are usually of indefinite duration, but they are subject to call by the lender.

Stock index futures

Long positions: The contractual obligation of the long position is to receive on settlement date a multiple (usually $500) times the underlying stock index minus the futures price. (Negative receivables denote a payment.)

Short positions: The contractual obligation of the short position is to make a payment on settlement date equal to the multiple times the underlying stock index minus the futures price. (Negative payments denote receivables.)

Because all positions must be marked to market and losses and gains realized daily, the settlement date differs from other days only in that positions are marked to market for the last time and then closed.

The ultimate counterparty for both short and long positions is the clearinghouse associated with each exchange.

Stock options

Long positions: The long position in an option contract has the right to exercise the option some time in the future and purchase (call option) or sell (put option) the underlying stock at the strike price fixed when the position is opened. Because the long position has a right but not an obligation, once the option premium is fully paid, no contractual obligations remain.

Short positions: The contractual obligation of the short position is to sell (call option) or buy (put option) the underlying stock at the strike price if the long position exercises the option.

The ultimate counterparty in all stock option transactions is the Options Clearing Corporation (OCC).

Stock index options

The contractual obligations are the same as for stock options except that the underlying "security" is a multiple (usually $500) times a stock index. The ultimate counterparty is the OCC.

Stock index futures options

The contractual obligations are the same as for stock options except that underlying a stock index futures option is a stock index futures contract. The ultimate counterparty is the clearinghouse associated with each exchange.

*This table summarizes the *basic* contractual obligations in the absence of margin requirements. The presence of margin requirements changes the contractual obligations of investors because the margin requirements must be satisfied on an ongoing basis. For example, when investors buy stock on margin from broker-dealers, they are required by the margin rules to maintain a specified level of equity in the margin account at all times.

ing to particular parties in particular situations, and to outline each set of rules briefly.

In describing the rules, the article focuses on five features that together determine the amount of protection provided to counterparties:

- *Initial margin requirements* set the minimum margin deposit with which a position can be opened.
- *Maintenance margin requirements* set a floor below which margin is not allowed to fall as long as the position remains open.
- *Variation margin* refers to the flow of payments from losers to gainers that results from the daily or intraday reevaluation of positions in futures markets.
- *Posting period* is the amount of time an investor is given to satisfy the initial, maintenance, and variation margin requirements. If the investor fails to satisfy the requirements within the allowable time, the counterparty can close the undermargined position. The length of the posting period is important because as it increases, counterparty losses may cumulate. In practice, posting periods range from as many as 15 days to a few hours.
- *Allowable form of margin* refers to the type of securities other than cash that can be used as margin. In some cases only cash is allowed as margin; in other cases securities and letters of credit can also be used. The form of margin influences the cost of maintaining a margined position and determines how easily the margin deposit can be converted into cash if needed.

The following sections examine the margin requirements in each market. Table 2 lists the markets that will be discussed, the main contracts, and the various margin-setting bodies. The table also identifies the clearinghouses that play an important role in the margin process for futures and option transactions.

Throughout, the article focuses on the margin requirements imposed by the regulatory bodies cited in the table. It is important to remember that these are minimum requirements. Counterparties, such as broker-dealers, often impose more stringent requirements.

Stocks

The Federal Reserve Board divides stocks into margin and nonmargin groups. Margin stocks consist of all U.S. exchange-traded stocks and some but not all over-the-counter (OTC) stocks. Broker-dealers are not allowed to use nonmargin stock as collateral in making loans. By contrast, banks and other lenders can lend any amount they like on nonmargin stock. Both margin

and nonmargin stocks can be sold short.[4] The following sections describe the rules established by the Board and the New York Stock Exchange (NYSE) for buying margin stock using a margin loan and for short selling.[5]

[4]It is likely that some thinly traded nonmargin stocks are not sold short because no stock is available to borrow, but the Board does not prohibit such a sale.

[5]The margin rules of the various exchanges and the National Association of Securities Dealers (NASD) are similar. This is partly the result of a 1975 amendment of the Securities Exchange Act

Buying stock on margin

Margin requirements for buying margin stock using a margin loan differ depending on the source of the loan. Margin loan sources—the lenders—fall into three groups: broker-dealers, banks, and other lenders. Regulation T of the Federal Reserve Board determines the

Footnote 5 continued
of 1934, which prohibits the use of margin rules to get a competitive advantage. The rules of the various exchanges and the NASD apply to each organization's members.

Table 2

Instruments, Markets, Clearing, and Margin Setting*

Stocks

Markets	Margin-setting Bodies
New York Stock Exchange Over-the-Counter Market American Stock Exchange Midwest Stock Exchange Pacific Stock Exchange Philadelphia Stock Exchange Boston Stock Exchange Cincinnati Stock Exchange	Federal Reserve Board, Regulations T, U, G, X (initial margins†) Exchanges and the National Association of Securities Dealers (NASD) (maintenance margins) The Securities and Exchange Commission (SEC) must approve exchange and NASD margins

Stock Index Futures

Main Contracts	Markets	Clearing	Margin-setting Bodies
S&P500	Chicago Mercantile Exchange (CME)	CME Clearinghouse	Exchanges and clearinghouses
NYSE Composite	New York Futures Exchange (NYFE)	Intermarket Clearing Corp.‡	The Commodities Futures Trading Commission (CFTC) can impose emergency margins§
Major Market	Chicago Board of Trade (CBOT)	CBOT Clearing Corp.	
Value Line	Kansas City Board of Trade (KCBOT)	KCBOT Clearing Corp.	

Stock Options

Main Markets	Clearing	Margin-setting Bodies
Chicago Board Options Exchange American Stock Exchange Philadelphia Stock Exchange Pacific Stock Exchange New York Stock Exchange	Options Clearing Corp. (OCC)	Federal Reserve Board‖ Exchanges and the OCC SEC must approve exchange and OCC margins

Stock Index Options

Main Contracts	Markets	Clearing	Margin-setting Bodies
S&P 100	Chicago Board Options Exchange	Options Clearing Corp.	Same as for stock options
Value Line	Philadelphia Stock Exchange		
Major Market	American Stock Exchange		
S&P 500	Chicago Board Options Exchange		
NYSE Composite	New York Stock Exchange		

Stock Index Futures Options

Main Contracts	Markets	Clearing	Margin-setting Bodies
S&P500	Chicago Mercantile Exchange	CME Clearinghouse	Same as for stock index futures
NYSE Composite	New York Futures Exchange	Intermarket Clearing Corp.	

*For each instrument, markets are ranked according to average daily share or contract volume in March 1988 (greatest volume first).

†Although the Board has the authority to set maintenance margins, it has chosen not to exercise it.

‡The Intermarket Clearing Corporation is a wholly owned subsidiary of the Options Clearing Corporation.

§The exchanges and clearinghouses do not have to get CFTC approval for changes in the level of margin requirements. Major changes in margin systems, however, must be approved by the CFTC.

‖Since September 1985, the Board has allowed the exchanges to set their own margins. Nevertheless, the Board prohibits banks from making margin loans using options as collateral; only margin loans to specialists are exempted from this rule.

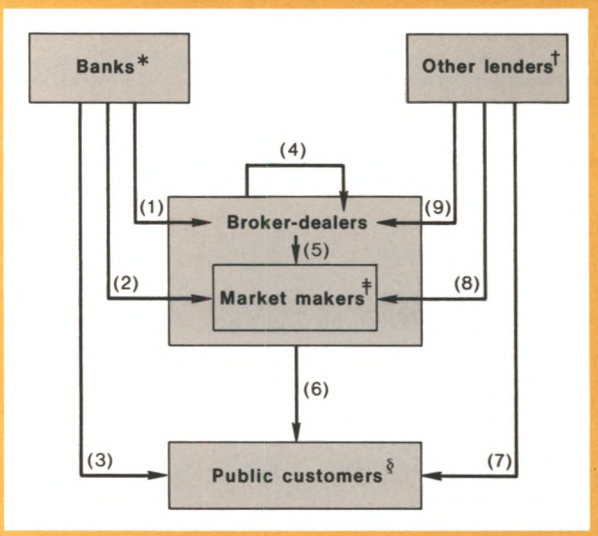
initial margin requirements on margin loans provided by broker-dealers, and the NYSE determines the maintenance margin requirements on loans provided by its members. Margin loans from banks and other lenders are regulated exclusively by the Federal Reserve Board through Regulations U, G, and X.[6]

Margin requirements also differ depending on the destination of the loan. Margin loan destinations—the borrowers—fall into three groups: public customers, market makers, and broker-dealers other than market makers.[7] Diagram 1 shows the nine resulting combinations of lenders and borrowers. Because the rules are the same for some combinations, only six distinct cases are discussed.

Margin loans from broker-dealers to public customers. A public customer wishing to borrow from a broker-dealer to buy margin stock must open a margin account with the broker-dealer. The account is debited with the face value of the margin loan and credited with the market value of the stock. The market value of the stock minus the face value of the loan is the net equity in the account. The initial margin requirement sets the minimum acceptable net equity level at the beginning of the transaction at 50 percent of the stock value.[8] Equivalently, the investor cannot borrow more than 50 percent of the market value of the stock; that is, the loan value of the stock is 50 percent.[9] To satisfy this requirement, the investor can make a cash down payment equal to 50 percent of the market value of the stock. For example, to buy a stock worth $100, the investor can put up $50 in cash and borrow $50. The margin account will be credited with $100 worth of stock and debited with the $50 margin loan.[10] Regula-

Diagram 1

Sources and Destinations of Margin Loans



*Banks include member banks of the Federal Reserve System and nonmember banks that have signed a special agreement with the Federal Reserve Board.

†Other lenders include savings and loan associations, credit unions, finance companies, insurance companies, and foreign sources of margin loans.

‡Market makers consist of specialists, odd-lot dealers, OTC market makers, third market makers, and block positioners.

§Public customers include all investors except market makers and broker-dealers.

Distinct Cases for Margin Requirements

(i) Loans from broker-dealers to public customers (arrow 6).
(ii) Loans from banks and other lenders to public customers (arrows 3 and 7).
(iii) Loans from banks and broker-dealers to market makers (arrows 2 and 5).
(iv) Loans from banks to broker-dealers (arrow 1).
(v) Loans from broker-dealers to other broker-dealers (arrow 4).
(vi) Loans from other lenders to broker-dealers and market makers (arrows 8 and 9).

[6] The Board regulations cover only those loans that are (a) extended for the purpose of purchasing, carrying, or maintaining margin stock ("purpose credit") and (b) secured by margin stock. A purpose loan secured with a bond or with a mortgage on the borrower's home is not covered. Also, a loan secured by margin stock that is used to buy a bond or a house ("nonpurpose credit") is not covered.

[7] There are no margin requirements on loans to non-U.S. borrowers outside the United States. In many cases, however, U.S. citizens are covered by the margin regulations even if they borrow offshore.

[8] NYSE rules also require that a minimum net equity of $2,000 be maintained in the account at all times.

[9] In general, the loan value of a security equals one minus the margin requirement. For example, Treasury bills are subject to a 1 percent NYSE-determined initial margin requirement and consequently have a loan value of 99 percent. Nonmargin OTC stock has zero loan value at broker-dealers.

[10] Alternatively, the investor can deposit in the margin account a fully owned security, borrow an amount equal to the loan value of the security, and use this amount as the cash down payment. For example, the investor can deposit $100 in Treasury bills, borrow $99,

Footnote 10 continued
and use this dollar amount as the cash down payment together with a $99 margin loan to buy $198 worth of stock. The margin account will have $298 in assets (bills and stock) and $198 in liabilities. Because the account also includes Treasury bills, net equity is less than 50 percent.

tion T gives investors up to seven business days to make this down payment.[11]

The initial margin requirement also determines the amount an investor can withdraw from the account. As the price of the margin stock increases, the maximum allowable margin loan (50 percent of the stock value) also increases. The difference between the outstanding margin loan and the maximum allowable loan is an unused credit line that the investor can draw down. In the example, if the stock rises to $120, the maximum allowable margin loan is $60, so with a $50 margin loan outstanding, the investor can withdraw $10.[12]

To satisfy the maintenance margin requirements, the equity in the account must not fall below 25 percent of the market value of the margin stock.[13] If equity falls below 25 percent, the broker must make a margin call asking the investor to restore the account to at least the *maintenance* level. Margin calls must be met "as promptly as possible and in any event within 15 business days."[14] If the margin call is not met, the broker must sell enough stock to restore the account to the maintenance level.

Margin loans from banks and other lenders to public customers. Loans in this category cannot exceed the maximum loan value of the margin stock securing the loan. This maximum loan value is set at 50 percent of the market value of the stock; consequently, it is equivalent to the initial margin requirements for broker-dealer loans. There is no explicit maintenance margin requirement. Margin loans to customers outside the United States, to other domestic and foreign banks, and to qualified employee stock ownership plans may be made on a good faith basis. The phrase "on a good faith basis" means that banks and other lenders, "exercising sound banking judgement," can lend any amount they like against margin stock.[15]

Margin loans from banks and broker-dealers to market makers. The Board allows banks and broker-dealers to make margin loans to market makers on a good faith basis. These loans can be made to registered exchange specialists, odd-lot dealers, and dealers certifying that they are qualified OTC-market makers, qualified third-market makers, or qualified block positioners as defined by the rules of the Securities and Exchange Commission (SEC).[16] Market makers must certify that the loans will be used solely for financing their market-making activities.

Margin loans from banks to broker-dealers other than market makers.[17] Loans in this category may be used for financing proprietary margin buying or for financing broker-dealer margin loans to customers. Regulation U treats bank loans to broker-dealers for financing proprietary margin buying the same way as bank loans to public customers: such loans cannot exceed the 50 percent loan value of margin stock. Several "special purpose loans," however, are exempted and can be made on a good faith basis. Special purpose loans include arbitrage loans, intraday loans, loans for securities in transit or transfer, temporary advances in payment-against-delivery transactions, and distribution loans.[18]

When bank loans are used to finance broker-dealer margin loans to customers, the broker-dealer acts as an intermediary between the banks providing the funds and the margin customers.[19] Regulation U allows broker-dealers to borrow from banks up to the total indebtedness of their customers on a good faith basis, pledging customers' securities. For example, a broker-dealer that provided $1 million in margin loans to its customers to buy $2 million worth of stock could use this stock as collateral to borrow at most $1 million on a good faith basis.[20]

Margin loans from one broker-dealer to another. The

[11]Broker-dealers often give investors less time to make the down payment.

[12]In general, if on day one the initial margin requirement is just satisfied and on day two the stock price increases, the investor can withdraw half of the increase.

[13]All exchanges and the NASD impose the same 25 percent maintenance margin requirement. Broker-dealers can impose higher maintenance margins on their customers, just as they can impose higher initial margins.

[14]NYSE Rule 431(f)(6). Broker-dealers usually allow only one to two days for a call to be met. The Securities and Exchange Commission's capital rules require that broker-dealers take capital charges for any maintenance margin deficiencies (less than 25 percent equity) that persist for more than five days. Margin calls can be met by depositing cash or securities.

[15]The quotation is from Regulation U. The good faith loan should not exceed 100 percent of the value of the collateral.

[16]Only banks may provide good faith margin loans to block positioners.

[17]Margin loans to broker-dealers are not the only loans made by banks to securities firms; only margin loans, however, are subject to the Board's margin requirements. Banks regularly provide securities firms with other types of loans, including unsecured loans and loans for financing activities unrelated to the broker-dealer function.

[18]For a loan to qualify as a special purpose loan, the borrower must state in writing the purpose of the loan.

[19]The broker-dealer is not a mere pass-through between the bank and the margin customers. If a customer defaults, the broker-dealer must use its own capital to repay the lending bank.

[20]Loans to broker-dealers secured by customer securities are called hypothecation loans. Written certification of their purpose is required. SEC rules stipulate that a broker-dealer cannot pledge more than its aggregate customer indebtedness but can pledge up to 140 percent of the debit balance in an individual margin account.

Board does not allow margin loans from one broker-dealer to another for financing proprietary buying of stock. Certain other loans between broker-dealers can be made on a good faith basis. These include loans for the purchase of securities for customer accounts[21] and loans by a broker-dealer to any of its partners or stockholders for the purchase of its own stock, the stock of an affiliated corporation, or the stock of another broker-dealer.

Margin loans from other lenders to broker-dealers. The Board does not allow margin loans from other lenders to broker-dealers, including market makers.[22] The only exceptions are emergency and capital contribution loans. Unsecured loans to broker-dealers are theoretically possible.[23]

Selling stock short

In general, a short sale consists of two distinct transactions, each subject to different requirements. One transaction is between a customer and the customer's broker-dealer. In this transaction the broker-dealer provides the stock that the customer sells short. The stock comes from the broker-dealer's own inventory, from other customers of the broker-dealer, from other broker-dealers, or from other institutions.[24] If the stock does not come from the broker-dealer's own inventory, then there is a second transaction—in this case, between the broker-dealer and the stock lender.

Consider first the transaction between broker-dealer and stock lender. According to Regulation T, the broker-dealer must deposit with the stock lender cash or other acceptable collateral equal to 100 percent of the stock's current market value.[25] The broker must adjust or mark to market the amount of collateral daily so that it is at all times equal to 100 percent of the stock value at the close of the preceding business day. For example, if the stock closes $10 higher than the previous closing, the broker must deposit $10 with the stock lender by the next day's opening.

Consider next the transaction between customer and broker-dealer. The short sale must take place through a margin account. The value of the stock sold short appears as a debit in the account. The proceeds from the short sale are retained by the broker-dealer and credited to the customer's margin account. According to Regulation T, the customer then has seven business days to deposit in the account an additional amount equal to 50 percent of the value of the stock. This additional deposit need not be in cash; securities can be used instead. Once this deposit is made, the account will show a credit equal to 150 percent of the stock value, a debit equal to the market value of the borrowed stock, and net equity equal to 50 percent of the stock value.

The account is marked to market daily so that a change in the value of the stock will lead to an equal and opposite change in the account's equity position, all else equal. For example, a $10 increase in stock value will reduce the equity in the account by $10. The customer need not deposit additional funds unless the account drops below the maintenance level. The NYSE requires customers to maintain net equity at a level equal to at least 30 percent of the market value of the borrowed stock.[26] The customer must restore an undermargined account to the required level promptly, and in no more than 15 days—the same requirement that applies to customers who buy stock on margin.

Finally, two special cases must be mentioned. First, for market-maker short sales that are related to market making, only good faith margin is required. Second, because proprietary broker-dealer short sales involve a single transaction—that between the broker-dealer and the stock lender—the broker-dealer is only subject to the requirements for this transaction: 100 percent collateral marked to market daily.[27]

Stock index futures

In the stock index futures market, a clearinghouse interposes between customers with long and short positions. The clearinghouse is the ultimate counterparty in all trades and guarantees all transactions. Customer transactions entail an additional layer of intermediation: a clearing member comes between the customer and the clearinghouse. A clearing member is an exchange member firm that is also a member of the

[21] These loans are subject to the same rules as bank loans to broker-dealers used to purchase securities for customer accounts.

[22] Non-broker-dealer affiliates of securities firms are also not allowed to make margin loans to broker-dealers.

[23] Nevertheless, because virtually all of a broker-dealer's assets are securities, it is difficult to argue that any loan to a broker-dealer is not secured directly, or indirectly, by securities and hence exempt from the Board's lending restriction. One example of a permitted unsecured loan is subordinated debt that complies with SEC rules.

[24] To borrow stock from a customer, a broker-dealer must have the customer's written consent. The broker-dealer cannot borrow more than the debit in a customer's margin account.

[25] As usual, this is a minimum requirement; in practice more collateral may be put up. Acceptable collateral includes Treasury securities, negotiable bank certificates of deposit, banker acceptances, and irrevocable letters of credit.

[26] Maintenance margins for low-priced stocks are slightly higher.

[27] If the proprietary short sale has to be done through an account with another broker-dealer (because the short selling broker-dealer is not self-clearing), then it is subject to the 50 percent initial and 30 percent maintenance margin requirements.

clearinghouse. Clearing members accept financial responsibility for the performance of their customers.[28] Customers include public customers, nonclearing broker-dealers, and the floor traders or "locals." Only proprietary trades of clearing members clear directly through the clearinghouse.[29]

Customers deposit margin at clearing members, and clearing members deposit margin at the clearinghouse. Each clearing member maintains two separately margined accounts with the clearinghouse: a house account for proprietary trades and a customer account for the trades of its customers. The exchanges determine the customer margin rules, and the clearinghouses determine the rules for the deposit of margin by the clearing members in their house and customer accounts.[30]

For both customers and clearing members, there are two distinct sets of margin flows: those associated with the deposit of initial and maintenance margin and those associated with the payment of variation margin. The payment of variation margin is important because once such a payment has been made, future counterparty losses depend on the change in the value of the futures position till the next variation margin payment is due on the following day. As a result, margin deposits are required to protect counterparties against the possible *one-day* loss in the value of futures positions.

The next two sections examine the requirements for both types of margin flows, focusing on the rules of the Chicago Mercantile Exchange (CME) and its clearinghouse. The most popular futures contract, the S&P 500, trades on this exchange.

Initial and maintenance margin requirements. Initial and maintenance margin requirements are specified in fixed dollar amounts to be deposited per contract. As of August 22, 1988, customers are required to deposit with clearing members $20,000 per S&P 500 contract if they are classified as speculators, and $10,000 per contract if they are classified as hedgers.[31] These dollar figures translate to 15.6 percent and 7.8 percent, respectively, of the value of the contract on August 22, 1988. The maintenance margin is $10,000 per contract for both speculators and hedgers. To be classified as hedgers, customers must convince clearing members that they have a need to hedge. For example, customers will qualify as hedgers if they hold diversified baskets of stock and take short futures positions (so-called bona fide hedging). Customers may also qualify as hedgers if they anticipate future capital flows and want to lock in prices (anticipatory hedging). In practice, the criteria used in making the classification vary from clearing member to clearing member; the majority of customers put up hedger margins. Table 3 lists the current margin requirements for the main stock index futures contracts.

The clearinghouse requires clearing members to pass the maintenance portion of customer initial margin on to their customer accounts with the clearinghouse. For example, a speculator opening a single position will deposit at least $20,000 with the clearing member. The clearing member will then forward $10,000 to the clearinghouse and retain the balance. For a hedger, the required initial and maintenance margins are the same, so unless the clearing member asks

[28]For example, if a customer defaults, then the clearing member must use its own capital to honor the defaulter's obligations to the clearinghouse.

[29]In practice, the structure of the market is more complicated. Public customers and nonclearing broker-dealers (but not the locals) must trade through a futures commission merchant (FCM). Some FCMs are clearing members and some are not. Moreover, not all clearing members are FCMs. Nonclearing FCMs must clear both customer and proprietary trades through a clearing member—a requirement that adds an extra step in the whole process. This extra step is ignored here. For more details, see Sofianos, "Description of Margin Requirements."

[30]The CME clearinghouse simply determines what portion of the initial margin deposit required by the exchange should be forwarded to the clearinghouse and when this must be done.

[31]There are two other classifications: *intramarket* spreaders take opposite positions in contracts on the same index but with different settlement days; *intermarket* spreaders take opposite positions in contracts based on different stock indexes. Intramarket spreaders have margin requirements as low as $200 per contract.

Table 3

Margin Requirements for Stock Index Futures

(As of August 22, 1988)

	Initial		Maintenance	
	In Dollars	In Percent	In Dollars	In Percent
Chicago Mercantile Exchange (S&P 500)				
Speculators	20,000	15.6	10,000	7.8
Hedgers	10,000	7.8	10,000	7.8
Chicago Board of Trade (Major Market)				
Speculators	15,000	15.5	10,000	10.3
Hedgers	10,000	10.3	10,000	10.3
New York Futures Exchange (NYSE Composite)				
Speculators	6,000	8.2	4,000	5.5
Hedgers	4,000	5.5	4,000	5.5
Kansas City Board of Trade (Value Line)				
Speculators	7,500	6.4	7,500	6.4
Hedgers	5,000	4.3	5,000	4.3

The percent requirements are the dollar requirements as a fraction of the appropriate multiple times the August 22, 1988 value of each index (500 × 257.0 for the S&P 500, 500 × 145.9 for the NYSE Composite, 500 × 234.1 for the Value Line, and 250 × 387.4 for the Major Market).

for more than the required $10,000, the whole of the deposit must be forwarded to the clearinghouse. The total margin each clearing member must have on deposit in its customer account at the clearinghouse equals the total number of open positions it carries times the maintenance margin per position. The CME clearinghouse requires clearing members to make this deposit based on the gross positions of their customers. For example, a clearing member whose customers are long 100 positions and short 99 positions in the same S&P 500 contract must have at least $1,990,000 in its customer account at the clearinghouse.[32]

For proprietary positions, clearing members are subject only to the $10,000 maintenance margin because they clear directly through the clearinghouse.[33] Clearing members must deposit this amount in their house account at the clearinghouse. Because the maintenance level is the same for hedgers and speculators, this distinction is irrelevant for clearing member proprietary positions.

The exchange requires clearing members to collect initial margin from customers in advance of opening a position. The clearinghouse has the following timetable for collecting margin from clearing members: every day, after trading stops, it calculates the number of open positions in each clearing member's accounts, and early every morning it notifies members of their total margin requirements. If a clearing member has on deposit with the clearinghouse more margin than is required, it can withdraw the excess.[34] If the margin on deposit is not sufficient, then the system generates a cash margin call. For example, if open positions increase from 199 to 200 and only $1,990,000 is on deposit, the clearing member will get a call for an extra $10,000. By 7:00 a.m. a bank acting on behalf of the clearing member must confirm that it will meet the call within the same day.[35] In emergencies the clearinghouse may call for additional margin to be deposited, possibly within an hour.

[32]The example assumes that the maintenance margin is $10,000 for each of the 199 positions. The other three clearinghouses (see Table 2) require clearing members to forward maintenance margin based on the *net* positions of their customers. The netting is done not only for each customer (opposite positions in the same contract cancel each other out) but also across customers. In the example, clearing members would forward the maintenance margin on only one position.

[33]The required margin is lower for intermarket or intramarket spreads.

[34]An excess will occur if the clearing member experienced a net closing of positions.

[35]Even though the bank makes a commitment at 7:00 a.m. to meet the margin call, the clearing member need not put up the cash till some time later in the day.

Clearing members can accept as margin from customers cash, U.S. Treasury securities, letters of credit, and listed securities.[36] The clearinghouse, however, is more restrictive in what it accepts as margin from clearing members. The first $25,000 of margin assets per member account must be in cash, after which Treasury securities are acceptable.[37] Letters of credit can be used after $50,000 in cash and Treasury securities have been deposited. The letters of credit must be irrevocable and callable within 60 minutes. The clearinghouse does not accept listed securities.

Variation margin. After the end of the trading day, the clearinghouse marks to market each position in a member's house and customer accounts.[38] It then forwards this information to the clearing members ahead of the next day's opening. Variation margin flows between customers and clearing members and between clearing members and the clearinghouse.

Consider first the flows between customers and clearing members. Each clearing member typically has some customers that lose and some that gain on their S&P 500 futures positions. Using the information provided by the clearinghouse, each member credits the accounts of the gainers with the gain in their positions and debits the accounts of the losers with the loss. Customers whose accounts have been credited can withdraw any gains in excess of the initial margin. Customers whose accounts have been debited will get a margin call if the loss pushed the account balance below the maintenance level.[39] An investor who gets a margin call has to replenish the account, restoring it to the *initial* margin level. Consider the speculator who originally deposited $20,000—$10,000 with the clearinghouse and a $10,000 buffer with a clearing member. A $7,000 loss in the position may be met out of the buffer. No margin call has to be made, but the buffer will be reduced to $3,000. A further loss of $4,000 will leave the account undermargined by $1,000 and will lead to a margin call for $11,000 to restore the account to the initial level. Clearing members determine the time allowed customers to meet a margin call. According to the CME rules, "if within a reasonable time the customer fails to comply with such demand (the clearing member may deem one hour to be a reasonable

[36]The securities must be listed on the NYSE or American Exchange and are accepted at 70 percent of market value.

[37]Treasury notes and bonds are subject to at least a 5 percent haircut.

[38]In marking to market, the clearinghouse uses closing settlement prices.

[39]In practice investors whose accounts have been debited may get a margin call even if the account is above the maintenance level.

time), the clearing member may close out the customer's trades or sufficient contracts thereof to restore the customer's account to required margin status."[40]

The clearinghouse calculates variation margin separately for each clearing member's customer account and house account. Customer account variation margin depends on the net gains or losses of each clearing member's customers. A member whose customers experienced more losses than gains will make a cash payment to its customer account at the clearinghouse equal to the net loss. For example, a member with 10 customers losing $4,000 each and 5 customers gaining $4,000 each must pay the clearinghouse $20,000. A member that experienced net losses on its proprietary positions will have to make a payment to its house account at the clearinghouse. The clearinghouse will forward these payments to clearing members whose accounts are experiencing net gains.

Banks acting on behalf of clearing members must confirm by 7:00 a.m. that the variation margin will be posted with the clearinghouse sometime later the same day. Table 4 summarizes the timing of margin flows between clearing members and the clearinghouse. In times of extreme price volatility, the clearinghouse may ask clearing members to make intraday payments of variation margin, usually within an hour. The CME clearinghouse recently introduced a regular 2:00 p.m. intraday variation margin call.[41]

Stock options

The institutional arrangements for stock options are similar to those for futures. The ultimate counterparty in all stock option transactions is the Options Clearing Corporation (OCC). For customer transactions, a clearing member always interposes between the customer and the OCC. Only proprietary trades of clearing members clear directly through the OCC. Public customers, nonclearing broker-dealers, and market makers must clear through a clearing member.

The option exchanges determine the minimum margin to be deposited by customers to clearing members, and the OCC determines the minimum margin to be deposited by clearing members to the OCC.[42] The OCC uses a margining system that differs from the one used by the exchanges. The next two sections describe the NYSE rules for the deposit of margin by customers to clearing members[43] and the OCC rules for the deposit of margin by clearing members.

Deposit of margin by customers to clearing members.[44] Option buyers—that is, the long positions—must pay the full premium in cash; they are not allowed to buy options on margin.[45] Once the premium is paid, the

[40]CME rulebook, chap. 8, section 827(D). The clearing member may also lend the required margin to the customer.

[41]The CBOT Clearing Corporation has had a regular 2:00 p.m. intraday variation margin call since before the October 19 stock market crash.

[42]The Board has the authority to set option margin requirements. Since September 1985 the Board has allowed individual exchanges to determine the margin requirements on the options that they list. Nevertheless, the Board's Regulation U prohibits banks from making margin loans against options.

[43]The margin rules of the option exchanges are very similar. This similarity enabled the NYSE to specify a uniform set of option rules for all its members, irrespective of where options are listed. The NYSE rules cover most of the market participants.

[44]Option transactions usually, but not necessarily, take place through a margin account. Options may be both held and written in a cash account. This section describes the requirements for margin account option transactions. Writing options through a cash account is subject to a variety of restrictions: most important, the account must hold either (a) the underlying stock in the case of a call option, or (b) cash or money market instruments in the amount of the exercise price in the case of a put option.

[45]Equivalently, the loan value of options is zero. This restriction applies only to borrowing for the purpose of buying options (or stock). It is possible to use the value of long option positions as collateral to borrow for other purposes.

Table 4

Timing of Margin Flows between Clearing Members and Clearinghouse (Chicago Mercantile Exchange, S&P 500 Futures Contract)

Chicago Time	
3:15 p.m.	Trading ends.
9:00 p.m.	The clearinghouse begins final trade reconciliation. After it is completed, the clearinghouse calculates two sets of margin flows: (a) the amount of margin each member should deposit or can withdraw to keep total margin in its customer and house accounts at the required level (number of open positions times maintenance margin); (b) the amount of variation margin each member should pay or receive (the net loss or gain in each account).
Early morning	The clearinghouse informs clearing members of the two sets of margin flows.
7:00 a.m.	The clearinghouse receives irrevocable commitments from banks acting on behalf of the clearing members that both sets of margin payments will be made within the day. The timing of the actual cash flows between clearing members and their banks and between the banks and the clearinghouse varies from case to case.
8:30 a.m.	Trading in the S&P 500 futures contract begins.

Source: Chicago Mercantile Exchange, Clearing Division, "Clearing House Banking Interface," White Paper Series, December 1987.

option buyer has no remaining contractual obligations and so is not required to put up and maintain a margin deposit.

Margin requirements on option issuers—the short positions—consist of a set of basic requirements for naked (uncovered) positions. These requirements are reduced for covered positions. Table 5 summarizes the requirements.[46] For a naked position, the issuer must deposit as margin all the proceeds from the sale of the option. If the option is in the money, the issuer must also deposit extra margin equal to 20 percent of the underlying stock price. If the option is out of the money, the extra margin required is 20 percent of the stock price minus the out-of-the-money amount but no less than 10 percent of the stock price.

There are three types of covered short positions: hedges, spreads, and combinations. To hedge a short call (put), the issuer has to be long (short) in the underlying stock.[47] No margin is required for the hedged short option.[48] Spreads combine short with long positions in a given call or put option. The positions can have different expiration dates, different exercise prices, or both. Combinations consist of short puts and short calls on the same underlying stock, possibly with different expiration and exercise prices. The rules for spreads and combinations are summarized in Table 5.

Maintenance margin requirements on short options are the initial requirements marked to market daily. If stock and option prices move favorably, funds will be freed to support other investments. For unfavorable moves, additional funds will be required to support option positions. For example, if the underlying stock price increases by $5 and the premium of an in-the-money naked short call option increases by $1, the margin requirement will increase by $2.

With options, as with stock margin transactions, initial margin must be deposited within seven business days from the trade date, and margin calls must be met promptly.[49] Margin stock and U.S. government securities, valued at their loan value, can be used to satisfy option margin requirements.

The only groups exempted from the customer margin rules are stock specialists, option specialists,[50] and other registered market makers. The NYSE allows its members to carry long and short option positions of these groups on "a margin basis satisfactory to the concerned parties."[51] In the case of option market makers, this special treatment applies only to positions in the options in which they are making markets. In the case of stock market makers, the special treatment applies only to positions in options overlying the stock in which they are making markets. When market-maker positions in other options are allowed, they are subject

[46] Table 5 shows the minimum amounts that must be in deposit at clearing members for each customer short position. In all cases the out-of-pocket payment of an option issuer is the required deposit minus the proceeds from issuing the option.

[47] For example, issuers of IBM calls must hold the underlying IBM stock so that their ability to deliver the stock, whenever the calls are exercised, is assured.

[48] If the stock hedging a short call is not owned outright, it is subject to the usual stock initial and maintenance margin requirements. The same applies for stock sold short to hedge a put.

[49] As in the case of stocks, the NYSE permits members to give customers as many as 15 business days to meet a call. In practice, broker-dealers usually give much less time.

[50] In addition to the option specialists, competitive option traders who qualify as specialists under SEC rules are also exempted.

[51] NYSE Rule 431 (f)(2)(J). Moreover, the Board's Regulation U allows banks to lend against long option positions to stock and option specialists on a good faith basis. Such loans must be used to finance narrowly defined "permitted offset positions."

Table 5

Customer Margin Requirements on Stock Options

(As of July 11, 1988)

Long options:	Premium must be paid in full
Naked short options	
In-the-money:	$\pi + (0.20 \times S)$
Out-of-the-money:	$\pi + MAX[(0.20 \times S) - T, 0.10 \times S]$
Hedges	
Short call, long stock:	0 for call $0.50 \times S$ for stock
Short put, short stock:	0 for put $1.50 \times S$ for stock
Spreads	
Long expires before short:	Premium must be paid in full for long Short treated as naked
Long does not expire before short	
Call spreads:	Premium must be paid in full for long MAX[E(long) − E(short), 0] for short
Put spreads:	Premium must be paid in full for long MAX[E(short) − E(long), 0] for short
Short combinations:	The greater of the naked short put or the naked short call requirement plus π for the option with the lower requirement

Explanations:

π Option premium
S Value of underlying stock
E Exercise price of option
T Out-of-the-money amount = MAX[E − S,0] for a call
= MAX[S − E,0] for a put

to the customer margin rules.[52]

Proprietary positions of broker-dealers that are neither market makers nor clearing members of the OCC are treated like those of any other customer. The proprietary positions of OCC clearing members are only subject to the OCC requirements.

The deposit of margin by clearing members to the OCC. Each clearing member must maintain separate customer, house, and market-maker accounts with the OCC. These accounts are margined separately. Total margin for the customer account is calculated differently from total margin for the house and market-maker accounts.

The rules for the house and market-maker accounts are examined first. Within each account, the OCC pairs all long positions in an option class with short positions in the same option class.[53] Each option class now consists of some paired long and some paired short positions, and in most cases, either some unpaired long or some unpaired short positions.[54] Concentrating on the paired positions, the OCC subtracts the aggregate value of the paired long options from the aggregate value of the paired short options.[55] A positive balance is called excess short value and a negative balance is called excess long value. There are now four possibilities for each option class:

- Excess short value, unpaired short positions. Total margin is 130 percent of the excess short value plus 130 percent of the value of the unpaired short positions.[56]
- Excess short value, unpaired long positions. Total margin is 130 percent of the excess short value minus 70 percent of the value of the unpaired long positions.
- Excess long value, unpaired short positions. Total margin is minus 70 percent of the excess long value plus 130 percent of the value of the unpaired short positions.
- Excess long value, unpaired long positions. Total margin is minus 70 percent of the excess long value minus 70 percent of the value of the unpaired long positions.

If an option class ends with a margin credit, 50 percent of this credit can be applied against the margin required in other option classes within the same account.

Margin for the customer account is calculated more conservatively. All long positions in an option class are classified as unsegregated or segregated. Unsegregated positions form the long leg of an identified spread in the account of an individual customer. The OCC then follows the same procedure used for the house account, but with two differences: only the unsegregated long positions are paired with short positions,[57] and segregated long positions and excess long values are set to zero.[58] The end result is that clearing members must deposit 130 percent of the aggregate value of customer short positions, with some short positions offset by the value of unsegregated longs. Option classes never end with a margin credit in the customer's account.

The calculations described above are repeated every day after trading stops. By 7:00 a.m. every morning, clearing members get a report stating the aggregate required margin on short positions that must be in deposit with the OCC by 9:00 a.m. Margin must be deposited in the form of cash, U.S. government securities, bank letters of credit, or margin stock at 50 percent of market value. For short calls, the clearing member can deposit the underlying security rather than deposit the margin. The OCC has the authority to change margin requirements at short notice if market conditions make this necessary.

Stock index options

The same institutional arrangements are used for stock index options as for stock options: the OCC is the ulti-

[52] Market makers' allowable option transactions are narrowly defined. Stock specialists can only hold options overlying their specialty stock, any option position established must be on the opposite side of the market from the stock position, and the range of permissible hedge ratios is limited.

[53] An option class consists of either puts or calls on the same stock, possibly with different expiration dates and strike prices. The pairing is done as follows: positions in the same option series are paired first, then the highest priced longs are matched with the highest priced shorts, and so on till either the long or the short positions run out.

[54] For example, if an option class consists of two long and three short positions, there will be two paired long, two paired short, and one unpaired short position.

[55] Values are based on the option premium at the close of trading.

[56] Consider an option class consisting of two long options—one $5 and the other $6—and three short options—one $5, one $7, and one $8. The $5 long will be paired with the $5 short (same option series) and the $6 long will be paired with the $8 short, leaving the $7 short unpaired. Subtracting the paired longs from the paired shorts will give $2 excess short value (($5+$8)−($5+$6)). Total margin will be $2.60 (130 percent of the excess short value) plus $9.10 (130 percent of the unpaired short).

[57] Moreover, unsegregated longs cannot be paired with shorts with longer expirations.

[58] Segregated long positions are set to zero because if one customer defaults, the OCC cannot seize the long positions of another customer. The customer account of a clearing member at the OCC consists of the positions of the clearing member's many customers. Even though the clearing member has a lien on the positions of each of its customers, the OCC does not have an indiscriminate lien on all the positions in the customer account.

mate counterparty but clearing members interpose between customers and the OCC. The rules for the deposit of margin by customers to clearing members are almost identical to the corresponding rules for stock options: long options cannot be bought on margin, and the margin deposit on naked short positions is calculated in the same way. For naked short positions in broad-based index options, however, the investor is required to deposit extra margin equal to 15 percent—instead of 20 percent—of the underlying index.[59] Spreads and combinations are given the same treatment as in stock options, but hedged index option positions are treated the same as naked positions. Posting periods are the same as for stock options.

The rules governing the deposit of margin by clearing members in their customer, house, and market-maker accounts at the OCC are different from the corresponding stock option rules.[60] The most interesting feature of these rules is the use of an option-pricing model to estimate the net cost (or value) of liquidating all positions in an account that belong to the same option group.[61] For each option group, the OCC has specified a range, known as the margin interval, that reflects the likely one-day change in the underlying index. Table 6 lists the current margin intervals for all stock index options. For example, the margin interval for the S&P 100 index is 16 points. Every day, after trading stops, the OCC calculates the current liquidation cost using the closing option premia and estimates the liquidation cost under the assumption that the current closing index value increases and decreases by the full margin interval. If the closing value of the S&P 100 is 250, the OCC will estimate the liquidation cost at 234 and 266.[62] The required margin is equal to the maximum of the estimated and current liquidation costs.[63] With stock index options, as with stock options, the OCC calculates margin for customer accounts more conservatively than for house accounts. The main difference is that the OCC assigns zero value to segregated long positions in a customer account. Posting periods for house, market-maker, and customer accounts are the same as for stock options.

[59]Broad-based index options include those on the S&P 500, S&P 100, Major Market, Value Line, and NYSE Composite indexes.

[60]The OCC margins all nonequity options (for example, options on government securities or foreign currencies) in the same way as index options.

[61]An option group consists of all positions (long or short, put or call, at any strike price and any expiration date) on the same underlying index. Long positions give rise to liquidation value while short positions represent a liquidation cost.

Table 6

OCC Stock Index Option Margin Intervals

(As of July 11, 1988)

Option	Margin Interval In Points	Margin Interval In Dollars	Percent of Index
S&P 100	16.00	1,600	6.19
S&P 500	16.00	1,600	5.91
AMEX Major Market	24.00	2,400	5.86
NYSE Composite	8.00	800	5.23
AMEX Institutional	16.00	1,600	5.99
PSE FNN Composite	10.00	1,000	5.34
PHLX National OTC	15.00	1,500	5.77
Value Line Composite	12.00	1,200	4.89
AMEX Computer Tech.	6.00	600	5.16
PHLX Gold and Silver	11.00	1,100	10.48
AMEX Oil	8.00	800	4.54
PHLX Utility Index	7.00	700	3.80

Source: OCC Information Memo, April 11, 1988, updated. Index percentages are based on the closing values of the underlying indexes on July 11, 1988.

Stock index futures options

Stock index futures options trade on futures exchanges and clear in the same way as futures. The most popular contract is the S&P 500 futures option. Like its underlying futures contract, this option contract trades on the CME and clears through the CME clearinghouse.[64] This section describes the rules of the CME and its clearinghouse.

The rules for the deposit of margin by customers to clearing members are similar to the corresponding stock option rules: both sets of rules are strategy-based. A set of basic requirements applies to naked short positions; these requirements are reduced for hedges, spreads, and combinations. To calculate margin, clearing members use the margin requirements for stock index futures, so the classification of customers as speculators or hedgers carries over to stock index futures options. Table 7 lists customer margin requirements for a sample of positions in the S&P 500 futures option. For example, a customer with a naked long position must pay the premium in full. A customer with a naked in-the-money short position must deposit the premium plus the margin for the underlying futures contract (either $20,000 or $10,000). If the position is

[62]The OCC also estimates the liquidation cost at all strike prices between these two extremes.

[63]This is a simplified representation of the rules. For more details, see Sofianos, "Description of Margin Requirements." Another interesting feature of these rules is that options based on broad-based indexes form a single "product group" and are margined as an integrated portfolio.

[64]One advantage of this arrangement is that it facilitates the cross-margining of S&P 500 futures option positions and S&P 500 futures positions.

out of the money, less margin is required. Customers can deposit securities and letters of credit as margin instead of cash—the same alternatives open to futures customers. Positions are marked to market daily. Customers must pay any additional required margin in cash, daily, and no later than 10 minutes before the market opens.

The clearinghouse uses a delta-based margin system to calculate the margin to be deposited by clearing members. Everyday it estimates the delta for each option position.[65] The daily margin requirement for each short position is the current option premium plus the $10,000 maintenance margin requirement for the underlying S&P 500 futures contract multiplied by the relevant delta. There is a minimum margin charge of $475 per naked short option. As in the case of futures positions, clearing members can deposit Treasury securities and letters of credit as margin. Because both the option premium and the delta can vary from day to day, the total margin that must be on deposit with the clearinghouse will change daily even if the number of open positions does not change.[66] The clearinghouse uses the same timetable for calculating and collecting margin on options that it uses for futures.

The CME is currently replacing both its strategy-based and its delta-based margin systems with a new system called Dollars-at-Risk.[67] It will use the new system to calculate the margin that must be deposited both by customers to clearing members and by clearing members to the clearinghouse. The new system is similar to the OCC margin system for stock index options. Under the new system, the CME will be using an option-pricing model to obtain daily estimates of the liquidation cost of a portfolio of positions on the S&P 500 index under a variety of assumptions about the underlying futures price and its volatility. It will set margin to cover the maximum estimated liquidation cost. The portfolio may consist of positions on S&P 500 futures and options on these futures, so that estimated gains (losses) on the futures can offset (augment) estimated losses on the options. The CME will impose additional margin charges for spread positions with different settlement dates, and there will be a minimum margin charge for short options.[68]

[65]The option delta is the rate at which the option premium changes as the underlying futures price changes. Deltas range from −1 to +1.

Table 7

Customer Margin Requirements on S&P 500 Futures Options

(Selected Positions; As of September 1, 1988)

Long options:	Premium must be paid in full
Naked short options	
In-the-money:	π + M
Out-of-the-money:	π + MAX[M−(0.5×T), 2,250]
Option-futures spreads (hedges)	
Short call/long futures Short put/short futures	π + MAX[m−(0.5×N), 2,250] on *combined* position
Long call/short futures Long put/long futures	MAX[m−π, 0] for futures Premium must be paid in full for long options
Option-option spreads	
Horizontal*	
Long expires before short:	μ + MAX[π (short)−π (long), 0] for short Premium must be paid in full for long
Short expires before long:	0 for short Premium must be paid in full for long
Short combinations	
Straddles†:	π(put) + π (call) + m

Explanations:

π	Option premium
M	Margin on S&P 500 futures contract (20,000 or 10,000)
m	Hedge margin on S&P 500 futures contract (10,000)
μ	Spread margin on S&P 500 futures contract (400)
S	Value of underlying index
E	Exercise price of option
T	Out-of-the-money amount = MAX[E−S,0] for a call = MAX[S−E,0] for a put
N	In-the-money amount = MAX[S−E,0] for a call = MAX[E−S,0] for a put

**Horizontal spreads:* one short plus one long, call or put, same exercise price, different expiration date.

†*Short straddles:* one short put plus one short call, same exercise price, same expiration date.

Summary

The differences in margin requirements examined in this article can be summarized briefly. The margin rules on U.S. equity-related products differ depending on the product and the identity of the parties in the transaction. Often, for a given product and investor, the requirements will also depend on the investor's combination of positions. Differences in margin requirements go beyond simple variations in margin levels; there are differences in the way margin is calculated, the length of the posting period, and the form margin can take.

Investors buying stock on margin face different

[66]For stock index futures contracts, the total margin that must be on deposit with the clearinghouse changes only if the number of open positions changes.

[67]The new system will be used for S&P 500 futures options and all other CME options on futures.

[68]A more detailed description of the new Dollars-at-Risk system can be found in Sofianos, "Description of Margin Requirements."

requirements depending on whether the source of the margin loan is a broker-dealer, a bank, or some other lender. The requirements also depend on whether the margin borrower is a public customer, a market maker, or a broker-dealer. For short sales, the identity of the short seller is important: the short seller may be a public customer, a market maker, or a broker-dealer, and the requirements vary in each case.

In the stock index futures market, one set of rules governs the deposit of initial, maintenance, and variation margin by customers to clearing members. Initial margin is higher if the customer is classified as a speculator rather than a hedger. Another set of rules governs the deposit of margin by clearing members to the clearinghouse. Each clearing member maintains one customer account and one house account with the clearinghouse, and the two accounts are margined separately.

For options, there are again two sets of rules: one for the deposit of margin by customers to clearing members and another for the deposit of margin by clearing members to the clearinghouse. For stock options, stock index options, and stock index futures options, customer margins are strategy-based: in all cases margins vary depending on whether short positions are naked, or whether they are hedges, spreads, or part of some other combination. For each of these three types of options, a completely different margining system is used to calculate clearing member margins. In all cases, clearing members maintain separate customer and house accounts with the clearinghouse. The two accounts are margined separately using different rules.

George Sofianos

Consistent Margin Requirements: Are They Feasible?

With the development of a wide variety of markets in equity-related financial instruments, investors have at their disposal numerous ways of investing in stock "exposure." That is, they may invest in various instruments whose returns are determined primarily by the returns on individual stocks or portfolios of stocks. For every position in each of these equity-related instruments, there are minimum margin requirements that compel the investor to maintain a specified level of equity in a margin account. This article examines the issues surrounding the consistency of margin requirements across equity-related markets, suggests methods for reducing inconsistencies, and identifies the inherent problems.

The equity-related instruments currently available are summarized in Table 1. There are three basic constructs through which new instruments are created: indexes, futures contracts, and options contracts. In addition, these techniques may be combined to produce other derivative securities, such as index futures or options on index futures. The available combinations allow investors to obtain equivalent returns in various markets and to choose the market that is most suitable for their particular needs (as regards transaction costs and the timing of the transactions, for example). The derivative markets also permit reallocations of risk-bearing among investors over time with a flexibility that would be difficult to achieve with the underlying instruments alone.

Because of the relationship between the returns on derivative assets and those of the corresponding stocks, each derivative instrument is priced in a way that is closely related to that of the underlying equity position. Otherwise, arbitrage profits would be available on an almost riskless basis to investors who assume positions in pairs of instruments that are mispriced according to the basic implicit relationships.

Two questions are examined here. First, should margin requirements be made consistent across all equity-related markets? Margin requirements serve more than one objective, and they are set by numerous institutions with different backgrounds in different markets, so they exhibit little apparent consistency across markets.[1] Second, if it is deemed advisable to make margin requirements more consistent, how does one go about this task? The analysis that follows concludes that it is desirable to have a degree of consistency across markets, but not necessarily identical requirements. On the other hand, the opportunities for fine tuning are limited by the uncertainty that prevails as to the exact results of applying margin requirements. The lesson is that a healthy dose of good judgment is essential in the setting of margin requirements.

Why impose margin requirements?

Before proceeding to the questions regarding the consistency of margin requirements, it is necessary to consider the ultimate objectives of such requirements. Only in that context will the appropriate criteria for consistency become clear.

At no point in time has there been a clear consensus about the rationale for imposing margin requirements.

[1]George Sofianos, "Margin Requirements on Equity Instruments," this issue of the *Quarterly Review*, provides a detailed summary of the margin requirements on equity-related instruments for various investor categories.

As expertise has developed in this area, some of the proposed motivations have lost most of their support. For example, the argument has been advanced that margin requirements reduce the diversion of funds from productive uses (such as physical investment) to speculative uses. Real resources, however, are not in general used up by margin loans, which represent the insertion of an additional instrument in the chain of financial intermediation channeling savings into investment. It is possible, however, that margin requirements could be used to deal with market imperfections.

Another formerly popular claim is that margin requirements protect unwise small investors from themselves by limiting the amount of risk they can incur. Margin requirements apply to broad classes of investors and thus are, at best, a blunt instrument for weeding out these problem cases. In addition, they only restrict the credit that may be obtained directly by using the securities purchased as collateral and take no account of the investor's overall leverage.

Table 1

Menu of Available Equity Instruments

Instrument	Representative Exchanges	Underlying Security
Individual stocks	NYSE, AMEX, NASDAQ	—
Futures on stocks	NA	—
Options on stocks	CBOE, AMEX, PHLX, PSE, NYSE	Individual Stocks
Options on futures	NA	—
Indexes	NA (proposed for AMEX, NYSE, PHLX)	—
Index futures	CME	S&P 500
	NYFE	NYSE Composite
	CBT	Major Market Index
	KC	Value Line
Index options	CBOE	S&P 100, S&P 500
	AMEX	Major Market Index
	NYSE	NYSE Composite
	PHLX	Value Line, OTC Composite
	NASDAQ	NASDAQ 100
Options on index futures	CME	S&P 500
	NYFE	NYSE Composite

Key:
- AMEX — American Stock Exchange
- CBOE — Chicago Board Options Exchange
- CBT — Chicago Board of Trade
- CME — Chicago Mercantile Exchange
- KC — Kansas City Board of Trade
- NYFE — New York Futures Exchange
- NYSE — New York Stock Exchange
- NASDAQ — National Association of Securities Dealers Automated Quotation System
- PSE — Pacific Stock Exchange
- PHLX — Philadelphia Stock Exchange
- NA — Not available

Only two motivations seem to have withstood the test of time, although the issue of their validity is by no means completely settled. The first of these is the protection of the integrity of the markets. In practice, this involves limiting the degree of credit risk to which market participants are exposed so that, in a period of adverse events, defaults do not cumulate to cause a breakdown in the market as whole. In the absence of dictated margin requirements, creditors would be expected to protect their own interests by requiring prudent margin levels. But they would focus on their own perception of their own risks—not the risks to the system—and they might be subject to competitive pressures. Thus, the proximate objective of margin requirements may be to protect the creditors from the risk of default, but this objective serves the ultimate goal of protecting the system.

The other side of the tradeoff in setting margin levels under this criterion involves the liquidity of the market. It is generally possible to reduce credit risk to arbitrarily low levels by imposing very strict margin requirements. A side effect of this strategy, however, is to exclude from the market certain investors who, given sufficient potential for borrowing, would take positions that would enhance the liquidity of the market. With extreme margin requirements, the whole market might be stifled.

Initial margins are usually emphasized in considering the effects of high margin requirements on liquidity. Large margin calls, however, which might result from strict maintenance or variation margin requirements, could be just as disruptive to the markets as strict initial requirements. A significant cushion between initial and maintenance margins, such as exists for individual stocks, allows for the possibility of major price changes without an accompanying unexpected strain on the demand for short-term liquidity.

A second motivation behind the establishment of margin requirements may be the control of excessively speculative activity, which could exacerbate the deviations of actual stock prices from the values implicit in the fundamental information on the corporations issuing the securities. These deviations may be in the form of increased volatility in stock price movements or they may involve persistent discrepancies between the actual and fundamental stock prices, as in the phenomena known as "bubbles" and "fads."[2] Once again, the drawback in setting higher margin requirements is the possible loss of liquidity.

[2]See Gikas Hardouvelis, "Margin Requirements and Stock Market Volatility," in this issue of the *Quarterly Review.* Earlier empirical work had not found persuasive evidence that margin requirements curb speculative activity. Using different statistical methods, Hardouvelis

This second motivation for margin requirements is not altogether distinct from the first. If margin requirements are effective in reducing excessive price volatility by controlling speculation, some of the price uncertainty that contributes to credit risk will be eliminated. Indeed, experience has shown that the most significant threats of credit disturbances to the stock markets occur during episodes of excessive volatility. Thus, reducing the likelihood of such volatility may be an important channel through which margin requirements protect the integrity of the markets.

Running parallel to the two basic motivations for imposing margin requirements is the notion that the stock market is special in that it involves the trading of claims in the ownership of the productive resources of the economy. In a market-oriented democracy, broad involvement in such activities on the part of individual investors is usually considered a desirable objective. Any development that would tend to chase these investors away from the market (such as unwarranted volatility, systemic risk, or manipulation) should, in this view, be vigorously avoided.

Perhaps because few instances of severely destabilizing volatility have been experienced in the U.S. stock markets, the empirical evidence supporting the use of margin requirements either for protecting market integrity or for curbing excessive speculation is technically not very strong. Conversely, the results of the technical studies have not rejected the usefulness of margin requirements as an instrument for protecting the markets or guarding against excessive speculation.

General considerations in the setting of margin requirements

The general principles to be followed in setting margin requirements, as well as the final results, will differ according to the particular goals pursued by regulators. In this section, a basic course of action is laid out for each of the two major objectives identified earlier. Most of the issues raised here are examined in greater detail in subsequent sections.

In the case of the market integrity motivation, there are three questions to investigate in trying to determine what level of margin requirements would provide a given level of systemic protection. The first concerns the accuracy of knowledge about the probability distribution of future price movements in the underlying security. Simply looking at the past or making some theoretical assumption may not be sufficient to obtain a precise representation of future price movements. This is particularly true for worst case scenarios, which may not seem plausible or even conceivable until after the fact.

The second question concerns the relationship between the movements in the prices of the underlying equity security and the price of a particular derivative instrument. Important strides have been made in the last two decades in working out the mathematics of the appropriate pricing of derivative securities, such as options and futures, under given conditions. The pricing relationships developed, however, apply only to some types of instruments, involve substantial complications, and may produce results that differ consistently from observed prices. The difficulties vary from instrument to instrument but are most severe in the case of options.

The third question is probably the hardest. Once the credit risk in an individual transaction or position has been analyzed, what are the implications for the market as a whole? A liquid market may be able to absorb a number of delinquencies, but how many defaults would cause a serious market failure? Are several small defaults worse than a large one? What is the interaction among different market participants in the event of defaults? Does this interaction tend to accelerate the collapse of a market, and by how much? In view of these uncertainties, the setting of margin requirements to protect the integrity of the markets can hardly be approached as a simple academic exercise in measuring the credit risk associated with a range of potential price movements.

The use of margins to control speculation raises equally daunting questions. One must ask whether it is desirable to control speculation at all, and whether margin requirements are an adequate means of achieving that objective. Even if they do contain speculation in one market, high margin requirements may drive speculators to other markets. The empirical evidence in this respect is far from clear cut, but there are reasons to believe that the control of some types of speculative activity is a valid concern of regulators and that margins may be useful for that purpose.[3]

Finally, the consistency of the two regulatory objectives poses a potential problem. If the objectives of protecting financial integrity and limiting speculation have different implications for the level of margin requirements, what relative weight should be assigned to each objective? All of the foregoing difficulties are encountered for each individual instrument even before considerations of consistency across different instruments are entertained.

Footnote 2 continued
presents evidence that when margin requirements are higher, stock price volatility is lower. For an examination of the possibility of "bubbles" in stock prices, see Hardouvelis, "Evidence on Stock Market Speculative Bubbles: Japan, United States, and Great Britain," in this issue of the *Quarterly Review*.

[3]For a discussion and some evidence, see Hardouvelis, "Margin Requirements."

Margin requirements and the integrity of the markets

This section outlines the analytical process by which margin requirements may be used to control credit risk as a means of protecting the integrity of the markets. The process is described separately for stocks, futures, and options.[4] The same kind of analysis is performed in the next section for the alternative objective of controlling speculative activity.

In general, the procedure involves determining the probability of an exposure to credit loss that is associated with each margin level, and choosing the level that produces an acceptable amount of risk for the creditor. The first step is to identify the potential credit risks. In the case of stocks bought on margin, a loan to the investor is collateralized by the stocks purchased. The danger to the creditor is that the value of the security may fall to levels that would be insufficient to cover the amount of the loan. Even though the debtor would still have a legal obligation to repay the loan in full, the practical likelihood of a default is clearly greater if some or all of the loan is unsecured by the assets in the margin account.

Suppose a margin of 25 percent is required on the purchase. Equivalently, the amount of the loan may not exceed 75 percent of the initial value of the security. If no further margin calls are made, the stock price may fall by as much as 25 percent before the lender is exposed to any actual credit risk.

Given a set of precise—though probabilistic—assumptions about the future behavior of the price of the stock, the probability of developing an exposure to credit risk during the period allowed for the posting of margin may be computed. The same may be done for other proposed margin levels from zero to 100 percent. The level selected would then be the lowest that would keep the probability of credit exposure within acceptable limits. It should be noted, however, that there is no objective way of selecting the acceptable level of risk, so that ultimately judgment is the only available guide.

The foregoing example applies to a long position in stocks. Similar principles apply to the short sale of stocks, but with short sales, the risk is related to a rise, as opposed to a decline, in the price of the securities.

In the case of futures contracts, credit risk exists whenever the futures price, which is determined at the outset of the contract, differs from the value of the underlying stock portfolio at maturity. Either side may show a deficiency at that time, depending on who is long and short and on the realized price of the security. Thus, each side is a potential credit risk and margin must be required from both sides. In general, the long side profits from upward movements in the stock price and loses if the price declines, while the opposite is true for the short side of the contract. The relevant probability is that of the event that the amount at risk over the margin-posting period—the current shortfall for a given party, if any—exceeds the total margin that has been collected from that party, either as initial or variation margin.

Once the probability is calculated for each set of margin requirements,[5] one proceeds as before to choose a combination of margin requirements that keeps the probability within acceptable bounds.

With options contracts, the fundamental asymmetry of returns relative to those of the underlying asset means that the level of credit risk is dramatically different for the buyer and the writer. The buyer of an option—be it a put or a call—obtains exposure to each share of the underlying stock for a premium that is generally considerably less than the stock's price per share. Unlike a futures contract, the long side of an option poses no credit risk once the premium is paid in full, since no further payments are ever required from that party. If the option expires (or is exercised) in the money, a credit accrues to the long side. If on the other hand the option expires out of the money, there is no obligation to exercise it and, hence, no further loss. For this reason, there is no need to require margin from the buyer beyond the premium itself.

For the writer, quite the opposite is true. The writer makes no initial payment other than the posting of margin and is subject to adverse changes in the price of the underlying security that may cause the option to move far into the money. Traditionally, margins on written options have implicitly included components reflecting expected movements in stock prices as well as the volatility or uncertainty of future price movements. In the margin formulas, these parameters are represented by proxies—for example, the amount by which an option is in or out of the money, or a percentage of the current market price of the underlying asset. The requirements are marked to market daily, and additional margin calls or withdrawals are made accordingly.

As with futures, the margin regulator starts with a given structure of margin requirements and, using a model of stock price movements, calculates the probability of any remaining credit risk. This is then done for other conceivable levels of margin requirements, whereupon a structure with an acceptable probability level is selected.

[4]The technical analysis that underlies the procedures described in this section is illustrated in Appendix B.

[5]Margins in the futures markets have traditionally included variation margin as well as initial margin. The variation margin requirement for stock index futures is 100 percent, but there is no conceptual difficulty in having a variation rate other than zero or 100 percent.

Traditionally, margin requirements have been applied separately to the positions held by an investor with different brokers, in different markets, or through different clearing corporations. With cooperation and coordination among brokers, exchanges, and clearing houses, it would be possible to apply margin requirements to an individual's consolidated overall position. Such "cross margining" currently exists to a limited degree, and further initiatives are in progress among several exchanges and clearing corporations.

For each instrument or combination of instruments considered above, the setting of margin requirements to control credit risk requires precise knowledge about the instruments, the markets, and the probability distributions of price movements. The structure of the market is taken as given, and it is assumed that changes in margin requirements do not affect the fundamental pricing of the underlying securities.

Margin requirements and speculative activity

A widely accepted principle of financial theory states that stock prices should reflect all the available and relevant information about the issuing firm's fundamentals. This is not a statement of the "efficient markets hypothesis,"[6] but a prescriptive statement to the effect that an investor should be able to determine and pay a fair price for a share in the ownership of a corporation. Most would agree that the stock market should be used by corporations to raise capital, but not by speculators to place uninformed bets that could drive prices away from their fundamental values.

If making stock prices conform to fundamentals is the ultimate objective, why use margin requirements, which control the degree of leverage available to investors? One argument might be that speculators tend to be risk-takers and find leveraged positions, which involve greater risk than their unleveraged counterparts, attractive. In addition, leverage allows an investor to control a greater amount of shares with a given dollar amount of initial capital. To the extent that long-term fundamental investors are not heavily leveraged, the relative influence of speculators may increase as the maximum permitted leverage increases.

As an illustration, consider a speculator who tends to overreact to news. With $100,000 of capital and a 100 percent margin requirement, he would be able to purchase only $100,000 worth of stocks. If the required margin were only 10 percent, however, he would be able to buy $1,000,000 of stocks, a purchase that would have a much greater effect on stock prices. Other investors with longer-term objectives would be subject to excessive price volatility resulting from the greater purchasing power of the overreacting speculator.

The statistical relationships between margin requirements, speculation, and volatility are not well established. Hence, there is no precise way of determining the degree of allowable leverage that would reduce the volatility associated with speculation to acceptable proportions, just as there is some fuzziness in the relationship between individual credit risk and the integrity of the market. In this case, it is necessary to identify the parties whose activities should be controlled and to understand the nature and magnitude of their operations. Because many important market participants (such as pension funds) typically want to hold long unleveraged positions on balance, they need not be significantly affected by stricter margin requirements.

How could margin requirements be used to limit leverage in the futures market? A futures position in stocks is economically equivalent to a fully leveraged position in the underlying securities over the term of the futures contract. In both cases, there is no initial cash outflow. At the futures maturity date, the long party in the futures has the value of the stock minus the initial futures price, while the long leveraged position has the stock minus the amount owed on the loan. The similarity of these positions causes the market to set the futures price at inception to the amount owed on the loan, including interest, at the futures maturity date. Otherwise, arbitrageurs could obtain riskless profits by shorting the position with the higher price (futures or loan price) and buying the other. The difference between the spot and futures prices thus tends to be the interest cost of the loan.[7]

Thus, in terms of the amount of leverage permitted, a zero initial margin requirement on the futures would be equivalent to a zero initial margin requirement on the underlying stock in the cash market. Similarly, an initial margin requirement on the futures of any magnitude between zero and 100 percent is equivalent in terms of leverage to an initial margin requirement of the same magnitude on the underlying stocks.

The implicit leverage in an options position is more difficult to determine because of the complexity of options pricing. For options on relatively simple assets, fairly accurate pricing formulas have been developed.[8]

[6] One form of the efficient markets hypothesis states that security prices reflect all available information. This is a (perhaps) testable empirical proposition, as opposed to a normative statement such as the one in the text.

[7] The futures prices predicted by these arbitrage relationships do not in general coincide with observed prices, in large measure due to institutional factors. These factors include transactions costs, dividend payments, different settlement practices in the spot and futures markets, and the fact that the futures apply to an index, whereas only individual stocks are traded in the spot market.

[8] As in the case of a non-dividend-paying stock studied by Fischer Black and Myron Scholes in "The Pricing of Options and Corporate

In these cases, it is possible to construct a "hedge portfolio" that consists of time-varying proportions of cash and the underlying stocks and that replicates the option returns. The resulting hedge portfolio for a call option normally consists of a long position in the stock and a short cash position (a loan), so that an implicit leverage ratio may be easily computed from the pricing formula. This implicit leverage is the ratio of the value of the loan to the value of the stocks in the hedge portfolio.

Table 2 presents the implicit leverage ratios for long positions in various call options, as calculated using the Black-Scholes option pricing formula. The implicit leverage is quite substantial, particularly for options that are around the money or out of the money. The additional margin that would be necessary to bring the leverage down to 50 percent, as required for stocks in the spot market, is also shown in Table 2. This amount may be several times the option premium. A similar exercise may be performed for a short call or a put option, with similar results.

Footnote 8 continued
Liabilities," *Journal of Political Economy,* May-June 1973.

Table 2

Implicit Leverage for a Long Call Option

Volatility (Percent Per Annum)	Exercise Price (In Dollars)	Implicit Leverage (Percent)*	Call Premium (In Dollars)†	Additional Margin (In Dollars)‡
20	70	68	32.42	17.47
20	100	88	7.43	23.81
20	130	94	0.36	2.75
40	70	64	33.28	13.54
40	100	79	12.86	17.37
40	130	85	3.76	8.93
60	70	59	35.72	7.88
60	100	70	18.29	12.51
60	130	76	8.78	9.87

Assumptions:
Underlying stock price = $100
Maturity = 6 months
Interest rate = 7 percent per annum

*Black and Scholes (see footnote 8 in text) have shown that a call option may be replicated with a continuously rebalanced portfolio consisting of a long stock position and a short cash position (a loan). At time t, the values of these two positions should be:

A_t = stocks = $S_t N(h_t)$,

L_t = loan = $e^{-rT} K N(h_t - \sigma T)$,

where S_t is the value and σ is the volatility of the underlying stocks, K is the exercise price, T is the time to maturity of the option, r is the risk-free interest rate, $N(\cdot)$ is the standard Gaussian cumulative distribution function, and

$h_t = [\log(S_t/K) + (r + .5\,\sigma)T)]/\sigma T$.

The implicit leverage is L_t/A_t.

†The Black-Scholes premium is $A_t - L_t$.

‡Margin required to bring implicit equity proportion to 50 percent, that is, $\max[0, L_t - .5\,A_t]$.

It should be clear from the foregoing discussion that using margin requirements to control the leverage obtained with options is a difficult task. The rules based on implicit leverage are complex, even in the basic Black-Scholes case discussed above. For some options, there are no explicit pricing formulas on which to rely.

Another complication that arises in the context of margins on options is the wide discrepancy that may result from applying the two objectives for margin requirements. It has been previously argued that if credit risk is the major concern, there is no need for margin beyond the option premium for a long call, since the credit risk posed by the long side is then zero. A glance at Table 2, however, shows that implicit leverage in excess of 80 or 90 percent is possible with option positions even if they involve no credit risk. A speculator who prefers the return patterns arising from a highly leveraged stock position could bypass the requirements of the spot market by investing in an option position with very high implicit leverage. Under most circumstances, this strategy would produce essentially the same investment results as investing in the corresponding leveraged position in the spot market. Through arbitrage, such activities would ultimately affect pricing in the spot market.

Why make margins consistent?

The question whether margins should be consistent across markets must be considered within the context of the basic objectives for margin requirements. It is not clear a priori that the two objectives would produce the same results. In some cases, similar margin requirements may be used to satisfy both goals at once. For some instruments, notably options, the solution is dramatically different depending on which of the two objectives is given priority.

Furthermore, the structure of each of the various equity-related markets is so unique in ways that are fundamental to the problem at hand that, in addition to the margin rates, a whole series of other parameters must be considered in the context of margin requirements. Before going into the consistency question in detail, it is useful to list the parameters that are potentially under the regulators' control. Not all of the following have been explicitly utilized in all markets.

Initial margin. Initial margin requirements for individual stocks are set by the Federal Reserve Board (they are currently 50 percent). The Board also controls initial margins on stock options and stock index options but has left the details to the appropriate exchanges subject to the approval of the Securities and Exchange

Commission. For stock index futures and options on index futures, initial margins are set by the exchanges and by the self-regulatory organizations.

Maintenance margin. Some form of maintenance margin requirement is found in virtually all markets. In the markets for individual stocks, there is a large gap between the initial (50 percent) and the maintenance (25 percent) requirements, and there is no obligation to issue margin calls before the maintenance level is hit. However, whenever the equity in a margin account falls below the maintenance level, new cash or securities must be deposited to bring it back up to that level (or to the initial level, as in the index futures market). The level of the requirement is generally set by the exchange. With options, maintenance margins are based on current market premiums and are used as a means of marking positions to market.

Variation margin. The concept of variation margin is used primarily in the futures markets. Investors are required to mark their positions to market (on a daily or intraday basis for stock index futures) and to post an amount corresponding to any adverse change in the futures price. While variation margin has traditionally been set at 100 percent in the futures markets and not required in the cash markets, it is conceptually possible to set this requirement at fractional values of the change resulting from marking to market.

Posting period. The length of the period allowed for the posting of margin calls is of the utmost importance for the credit risk control objective. Risk and uncertainty are clearly greater if investors are allowed up to 15 business days to post margin (as in the spot market, in principle) than if they are allowed no more than one day (as in the index futures market). The length of the posting period bears a direct relationship to the clearing and settlement practices of the individual markets.

Form of margin. The types of securities accepted to cover margin requirements differ from market to market. In the various markets, these may include cash, Treasury securities, and nonpublic instruments, including credit lines.

Explicit exemptions. Different types of investors have different margin requirements in each market. A broker-dealer, for example, will generally have more flexibility than a customer. The same applies with greater force to a market maker in the security. In some cases, customers are classified as hedgers or speculators for the purpose of applying different margin requirements.

Degree of discretion. In some cases, the regulatory authority may grant specific exemptions to investors on a discretionary basis. For example, the Options Clearing Corporation may reduce overall margin require-

Table 3

Margin Simulation Statistics for Spot and Futures Markets over One Year

	Stocks (Five-Day Periods)		Futures (One-Day Periods)	
Volatility (Percent Per Annum)	60	40	40	20
Equity				
Average	40.2 percent	42.1 percent	15.2 percent	14.7 percent
Probability of negative equity	0.002 percent	0 percent	0.01 percent	0 percent
Margin Calls				
Minimum	−$53.44	−$23.04	−$28.31	−$7.60
Maximum	$40.76	$11.69	$28.35	$7.51
Average positive call	$ 0.26	$ 0.08	$ 1.05	$0.51
Probability of:				
positive call	8.4 percent	3.9 percent	49.7 percent	49.2 percent
call of at least $1	6.4 percent	2.6 percent	34.1 percent	21.4 percent

Assumptions:
- Initial value of security = $100
- Instantaneous expected return = 7 percent per annum
- Margins on stocks:
  - Initial margin = 50 percent
  - Maintenance margin = 25 percent
  - Posting period = 5 days
- Margins on futures:
  - Initial margin = $15
  - Variation margin = 100 percent
  - Posting period = 1 day
- Number of iterations = 2000

ments for its members on a discretionary basis when options held long by the members are substantially in the money.

The implications—in terms of the likelihood of negative equity and of margin calls—of recent choices as to margin parameters in the stock market and in the stock index futures market are illustrated by the simulation statistics presented in Table 3. The basic assumptions for the simulations are intended to be generally representative of conditions in the New York Stock Exchange for the stock market and in the Chicago Mercantile Exchange for the futures market. Price movements are represented by a mathematical formulation (the Wiener process) widely used in the context of stock prices and derivative instruments.

Two different volatility assumptions are examined in each market. In general, a diversified portfolio of stocks will experience lower price volatility than an individual issue. Since index values correspond to the prices of such a diversified portfolio, a relatively low volatility is assumed for index futures (20 percent). For the stock market, higher values are used (40 and 60 percent). The case of index futures with a volatility of 40 percent is included for the purpose of comparison with the stock market.

The results in Table 3 indicate that the requirements in the spot and futures markets are roughly equivalent in terms of the probability of exposure to credit risk (probability of negative equity). A range of volatilities has to be considered for the spot market, but the probabilities tend to be quite low for most reasonable values, as they are for the index futures. Nevertheless, other statistics vary markedly across markets.

In the stock market, initial margins are relatively high, and there is a built-in buffer against margin calls provided by the difference between initial and maintenance margins. In the futures market, initial margins are lower, but additional margin is required any time prices change. The effects are noticeable in the relationship between equity levels and margin calls.

Equity in the spot market is on average between two and three times higher than in the futures market. A large portion of this difference is attributable to the buffer against calls. As a result, both the incidence and magnitude of positive margin calls (in contrast to negative calls, or allowable margin withdrawals) are much lower in the stock market. The chances of a margin call are about even in the futures market, and a call of 1 percent or more of the original stock price occurs about one-fifth of the time. The dollar value of the average call in the futures market is about twice that corresponding to a stock whose volatility (60 percent) is three times that of the index. These figures provide a clear illustration of the tradeoff between high initial margins and frequent large margin calls.[9]

Consistent margins and the integrity of the markets

All of the parameters identified in the previous section affect the expectations and probability distributions associated with credit risk for each of the equity-related instruments. A simple rule of thumb to make margins consistent is to set the parameters so that the probability of an equity deficiency in an investor's position is the same for all instruments. This ignores the distinct possibility that the relationship between individual default and the overall integrity of the market may vary from one market to another. A system with many essentially independent intermediaries is more resilient than one in which intermediation takes place in several steps with the potential of a chain reaction of defaults. Alternatively, the netting out of positions may be different from market to market. A large volume of open positions on either side is not necessarily risky if the holdings of individual investors are hedged for the most part. In any case, the rule of thumb described above is a useful first step.

More specifically, the regulator would proceed with the analysis described earlier for controlling credit risk in each particular instrument. Consistency would require that the acceptable probability level selected be the same for each instrument.

Conceptually, the application of this method is not

[9]Note that the figures reported in Table 3 are based on a mathematical simulation and not on historical data. The mathematical techniques have been used elsewhere to calculate the probability of negative equity during a single posting period, starting from the maintenance level (for example, *Interim Report of the Working Group on Financial Markets*, Washington, D.C., May 1988). The simulation in Table 3 is more general in that it covers all the events that may develop over the course of a year, incorporating initial, maintenance, and variation margin requirements, as well as an explicit posting period.

Table 4

S&P Composite Index: Frequency of Extreme Monthly Returns

(Percent of Observations within Period)

Period	Loss of More Than 8.5 Percent	Gain of More Than 8.2 Percent
1930-39	18.3	15.8
1940-49	2.5	0.8
1950-59	0.0	1.7
1960-69	0.8	0.8
1970-79	4.2	4.2
1978-87	4.2	5.0
1926-87	5.0	5.0

Source: Ibbotson Associates, SBBI/PC data base.

difficult in the context of the spot and futures markets where, because of arbitrage pricing, the relevant events are essentially the same.[10] A simple way to impose consistent margins would be to make them *uniformly equivalent,* that is, to set every parameter—initial, maintenance, and variation rates; posting period; exemptions; and so forth—at the same level in each market. While theoretically attractive, this requires very fundamental changes in the way these markets presently operate. Virtually every one of the parameters described above varies significantly from market to market. Since some of these differences—such as the margin posting period—arise from operational features of the markets, regulators contemplating a change must consider the potential disruption.[11]

Another less disruptive way to deal with the problem is to make the requirements *dynamically equivalent,* that is, to allow for the possibility of setting the parameters at different levels in the spot and futures markets, but in such a way that the resulting probabilities of equity deficiencies are the same across markets. For example, if the initial margin requirement were lowered in the spot market, the probability of deficiencies would increase. To lower the probability to the original level, some fractional variation margin requirement might be imposed. Alternatively, the posting period might be shortened, and so on.

While the calculation of these tradeoffs is theoretically feasible, it is by no means an easy task in practice. It requires detailed knowledge of the probability distribution of movements in the price of the underlying security, as well as a clear representation of the relationship between the pricing of futures and the pricing of the underlying security.

To illustrate the problems, Table 4 presents the frequency of unusually large positive or negative price movements in the S&P Composite index for the period from 1926 to 1987 and for a series of 10-year periods within those years. The results indicate that the assumption that future volatility will resemble past volatility is highly suspect, even though some stability is imposed by the substantial length of the periods considered.

Option returns bear a complicated relationship to those of the underlying asset, and the problems they create in the context of consistent margins are even greater. The use of uniform equivalence is out of the question. It is still possible to impose dynamic equivalence, though the complexity of the pricing relationship makes this even harder than in the case of futures.

In general, theoretical analysis along these lines may provide regulators with some guidelines for the establishment of consistent margin requirements. It is clearly not an exact science, however, and substantial judgment is required.

Consistent margins and speculation

Initial margin is the most important parameter in the setting of margin requirements if the control of speculation *qua* leverage is the objective. The goal is to make it harder for pure speculators to borrow a large proportion of the amount that they invest in equity securities, and thus lower their chances of affecting trading volume and market prices.

Once again, the equivalence between spot and futures markets is not conceptually difficult because of the close relationship between their returns. The practical problem is that in each market, initial margin has been set in conjunction with all the other parameters. If the markets have dynamically consistent margin requirements (that is, if the exposure to credit risk is the same in each market), it may be inadvisable to change the initial margin requirement without making offsetting changes in at least some of the other parameters.

Options again present a greater challenge, since an implicit leverage level must be computed as in Table 2, and it is quite difficult to come up with precise values, especially if no theoretical representation exists for the price of a particular option.

The natural tendency is that speculators will shift to markets where initial margin requirements are effectively lower. That is, they will move to markets where a position with a large degree of actual or implicit leverage is permitted. Because of strong interconnections among markets, however, those markets with high margin requirements are not immune to the actions of speculators in other derivative markets. Excessive volatility, as well as nonfundamental pricing, may be transmitted from one market to another. Thus, if speculation is a real issue, the consistency of initial margins should be seriously considered.

Conclusion

The results of this article are perforce not a neat set of rules, but a series of guidelines to be considered by regulators. Making margins consistent across markets demands some serious thought about why there are margin requirements at all; it also confronts regulators

[10] Margin requirements in the spot and futures markets are analyzed graphically in Appendix A.

[11] As markets evolve in response to generally available technical advances, their operational features may converge and thus simplify the establishment of cross-market consistency. For example, the New York Stock Exchange and the American Stock Exchange are currently moving towards a one-day clearing system for all listed equity trades. This development would facilitate the use of shorter margin-posting periods (closer to those in the futures markets), if such a move seems desirable.

with difficult technical problems. Since the mathematical accuracy of the available methods is limited, it is necessary for those regulators to exercise a great deal of judgment in the process.

Even if the technical problems are adequately handled, there are still significant difficulties in bringing together markets that have developed operationally in dramatically different ways. Massive changes would be necessary to equalize each parameter across all markets, even if that were mechanically feasible.

Nevertheless, the concerns about the integrity of the markets and about the dangers of destabilizing speculation are genuine. Dealing with them in only some markets, or in a piecemeal fashion, does not adequately confront the issue. In seeking to adjust margin requirements to meet these objectives, regulators can look to technical studies for guidance but must rely on their good judgment as the ultimate tool.

Arturo Estrella

Appendix A: Graphical Analysis of the Spot and Futures Markets*

The basic diagram

The elements of margin requirements may be compared graphically across markets in the cases of individual stocks and index futures. Because of the simplicity of the arbitrage pricing relationship between spot and futures markets, margin requirements apply in much the same way in the two markets. As argued in the text, options present a greater challenge in terms of comparative analysis and do not easily lend themselves to this type of graphical exposition.

Chart 1 illustrates the three basic types of margin requirements in a single diagram. The investor's equity in a stock position is graphed on the vertical axis against the price of the stock on the horizontal axis. The 45-degree line, OG, shows the equity that would exist in an unmargined account, namely, 100 percent of the stock value. If the initial price of the shares is S_0, then the unmargined investor has initial equity of exactly S_0. In the absence of margin calls, account equity increases or decreases by a dollar for every dollar change in the price of the stock.

If the stock is subject to an initial margin requirement of m_I, then account equity must at least equal $m_I S_0$ at the time the stock is purchased (point A). The line OB, which has slope m_I, demonstrates this constraint. By choosing to borrow less than the maximum allowable amount, the investor could initially lie anywhere between A and G.

A maintenance margin requirement of m_M restricts the position equity to be at all times in excess of $m_M S_t$, or above the line OD, whose slope is m_M. As long as the maintenance margin is less than the initial margin, the line OD will lie everywhere beneath OB.

If the variation margin requirement is m_V, the one-for-one change in the account equity given a change in the stock price is offset by the amount m_V. Thus, equity will change by $1 - m_V$ for each dollar change in the price of the stock. Consequently, a line such as AF, passing through point A with slope $1 - m_V$, demonstrates this type of margin requirement. In contrast to the lines demonstrating the other two types of margin requirement, the variation margin line may shift as the stock price moves if the upper and lower bounds for required margin are binding. This phenomenon is illustrated below in the discussion of spot market requirements.

Two extreme cases help to illustrate the effects of variation margin. If there is a 100 percent variation margin, the variation margin line will be horizontal. In other words, account equity is restricted to remain constant—each dollar change in the underlying price will be fully passed through to the investor. By contrast, if the variation margin is zero, the slope of the line will be unity because account equity changes dollar-for-dollar with every change in the underlying price.

An interesting case arises if the sum of the initial and variation margin requirements is exactly 100 percent. This is equivalent to setting the margin requirement to be at all times a constant proportion of the current stock value. Under these circumstances, the line AF in Chart 1 coincides with AB. They intersect the schedule AD of maintenance requirements only at the origin, so that the concept of maintenance margin is essentially irrelevant.

Both the stock and futures markets in the United States have, in some form, initial, maintenance, and variation margins, although variation margin is somewhat disguised in the stock market and prominent in the futures market.

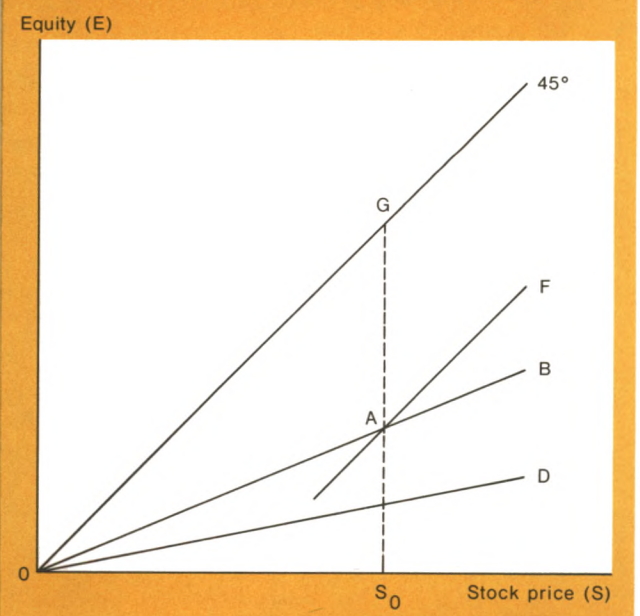
Current institutional framework: a stylized summary

The stock market (New York Stock Exchange). To purchase stock on margin at the New York Stock Exchange (NYSE), a retail investor must put down cash for at least 50 percent of the value of the stock at the time of the purchase.† This minimum initial margin requirement

†In addition, a margin account must be opened with at least $2,000.

Chart 1

Initial, Maintenance, and Variation Margins



*Stephen R. King made valuable contributions to the writing of this appendix.

Appendix A: Graphical Analysis of the Spot and Futures Markets *(continued)*

is set by the Federal Reserve Board's Regulation T. In addition, the NYSE requires that a retail customer's equity must at all times exceed 25 percent of the current value of the stock (the so-called 25 percent maintenance margin).‡ The equity in the stock position may only be reduced from 50 to 25 percent as a result of declines in the stock price, not by additional borrowing. On the other hand, if the price of the stock were to rise, the investor would be entitled to increase the size of the margin loan to 50 percent of the current stock price.§

The margin requirements in the stock market are illustrated diagrammatically in Chart 2, which follows the same basic construction as Chart 1. Once again, the investor starts at point A, which represents a margin of m_1S_0 on a position worth S_0. In this case, equity must exceed the line OGAB, where the slopes of the line segments OG, GA, and AB are 0.25, 1, and 0.5, respectively. The segment OG is simply the maintenance margin requirement. GA is determined by a variation margin requirement of zero—position losses can be fully subtracted from account equity. Although AB is defined by the initial margin requirement, it also performs the role of a variation margin applied at the initial rate, because it specifies that the investor can withdraw 50 cents for each dollar by which the stock price rises above its initial value.

As a numerical example, consider a customer who buys 100 shares for $1 each, financing the purchase by borrowing $50 from a broker. If the price of the shares rises to $1.50, the customer's equity rises to $100, or two-thirds of the current value of the investment. The margin requirements would allow borrowing of up to $75 (50 percent of the current share value), so the customer would be entitled to withdraw $25 from the broker. Note that this is also 50 percent of the rise in value.

If, instead of rising, the price had fallen from its initial $1.00 to $0.50, the customer's equity would have evaporated (the value of the stock would exactly equal the $50.00 debt to the broker). The NYSE maintenance requirements demand that the customer's equity be at least 25 percent of the current value of the stock ($12.50, in this case), so the customer would have to post this amount to avoid being sold out.

Since margin may be removed from the account if it exceeds 50 percent, and since there are margin calls whenever equity drops below 25 percent, the line segment AG in Chart 2 may shift as stock prices move through time. For example, if the stock price rises to S_1, then the investor will be faced with a new variation margin line, A'G', showing the allowable decline in account equity should the stock price subsequently decline. Similarly, if equity drops to the line segment OG following a price decline, any subsequent increases would be along a line parallel to AG, but not necessarily along AG itself.

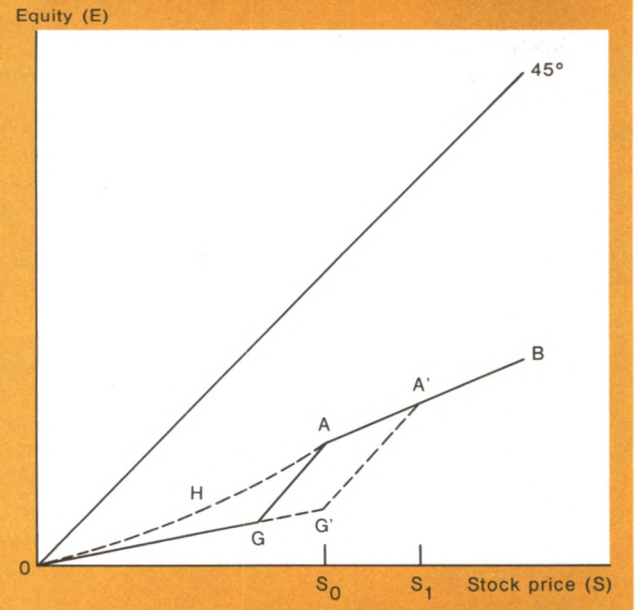
This shifting makes it difficult to anticipate the exact relationship between the uncertain stock prices and the minimum required equity. Point G', for instance, which represents a level of equity lower than the initial amount at A, is attainable only if prices and equity first move up to point A'. In general, knowing the value of the stock at the end of a given period (or equivalently, the average return over the period) is insufficient to determine the required equity at that time because the whole path of stock prices over the period must be taken into consideration.

This phenomenon may be illustrated using the numerical examples given earlier. Suppose that the stock price goes from $1.00 to $1.50, and then back to $1.00. As shown above, the margin requirement after the first price movement is $75. After the price drops back to $1.00, the value of the portfolio is $100 once more, but equity is allowed to fall by the full price drop of $50 to the maintenance level of $25.

Alternatively, suppose that the price first falls to 50

Chart 2

Stock Market



‡The same regulations do not necessarily apply to specialists or some other professional organizations. Cf. *The Report of the Presidential Task Force on Market Mechanisms,* January 1988, p. VI-15.

§In other words, to withdraw equity from the account.

cents and then rebounds to $1.00. The maintenance margin requirement, as calculated above, would be binding at $12.50 after the initial drop. When the price rises again to $1.00, equity increases to $62.50, but the excess over 50 percent may be withdrawn so that the required level is $50. Thus, we have two situations in which the value of the portfolio starts and ends at $100, but the margin requirement at the end of the period is either at the minimum or at the maximum rate (25 and 50 percent, respectively).

Another complication arises from the length of the period allowed for the posting of margin calls. In the stock market, margin calls may be satisfied by a deposit of cash into an investor's margin account, typically within five days. In the intervening time, the stock price might move adversely, lowering the customer's equity. Partly as a response to the delayed payment, brokers generally make margin calls before the customer reaches the margin limit. Diagrammatically, this would imply that the path OGA would contain some curvature. If price moves are gradual, then a curve such as OHA might capture the effective requirement. However, if prices were to drop very sharply, OHA could actually dip below OGA before margin payments were made.

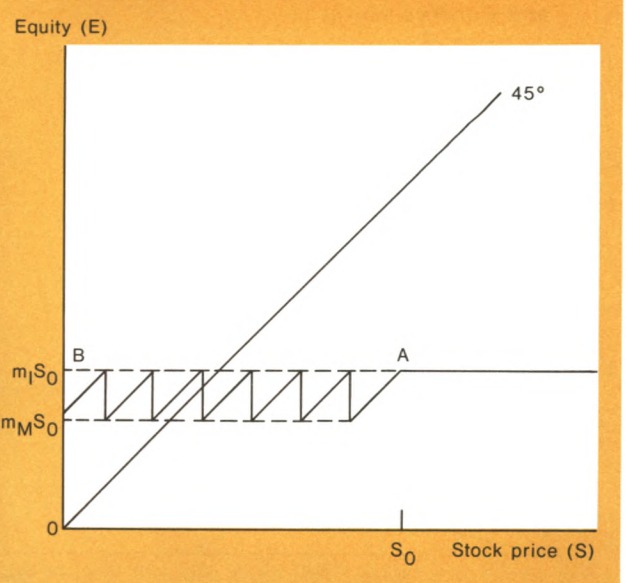
The Futures Market (Chicago Mercantile Exchange). Customer margins in the futures markets perform essentially the same function as margins in the cash market, but they do differ in some important institutional respects. As in the spot market, futures market customers are constrained by both initial and maintenance margins. At the end of 1987, initial margins for a speculator on an S&P 500 futures contract were $20,000, or about 16 percent of the price of the contract. Maintenance margins were $15,000, or 12 percent.‖ For a hedger, margins are considerably lower. In contrast to the spot market, variation margins are 100 percent of price movements. They must be posted by the beginning of the following trading day, and in some instances there may be intraday margin calls.

Futures margins are diagramed in Chart 3.¶ This formulation is particularly simple if the futures price rises. In this case, the 100 percent variation margin allows the investor to withdraw all equity in excess of the initial margin. If the price falls, then the equity in the account may be reduced by that amount to pay for the variation call, unless the balance in the equity falls below the maintenance level. If that occurs, then equity must be raised to its initial level. Consequently, the constraint on the investor may exhibit a sawtooth shape to the left of the initial price. In practice, additional margin may be required from the customer at the broker's discretion so that the actual minimum equity may be closer to the horizontal line BA.

For comparison with the numerical example in the previous section, we can consider the situation of an investor purchasing a hypothetical $100 futures contract with initial margin of $16 and maintenance margin of $12. Before undertaking the transaction, the investor will be required to have $16 in a margin account. At no stage is credit actually extended in a futures transaction, but the investor's initial equity is the $16 down payment. If the contract rises in value to $150, the investor will have an equity of $66 (the initial $16 plus the increase of $50 in the value of the contract). Because the contracts are marked to market each business day, the investor would receive the increase in the value of the contract ($50) at that time and could withdraw the full amount of this increase in value as cash. However, the investor can never withdraw an amount that would reduce the position's equity beneath its initial margin amount.

Chart 3

Futures Market



‖All institutional details on futures in this appendix relate to contracts on the S&P 500 on the Chicago Mercantile Exchange. These contracts are for $500 multiplied by the value of the S&P 500 index, or about $125,000 per contract at year-end 1987 prices. Initial margins have been reduced somewhat since that time, to $15,000.

¶No distinction between spot and futures prices is made here or in Appendix B. It is assumed that the futures price is adjusted for interest costs (which are known contemporaneously) and dividend payouts (which are highly predictable).

Appendix A: Graphical Analysis of the Spot and Futures Markets *(continued)*

If, instead of rising, the value of the contract had fallen to $50, the investor's equity would drop from $16 to −$34 (a capital loss of $50 on the contract). The exchange requires that if the margin account drops below its maintenance value ($12), it must be increased by the start of the next day's trading to the full initial amount. Consequently, the investor would be required to put $50 into the account.

Had the price decline been less severe—for example from $100 to $97—the situation would be somewhat different. In this case, account equity would have shrunk from $16 to $13. Since the margin account would still exceed the minimum maintenance amount ($12), the broker would not be required to demand a margin payment from the customer. Instead, the broker could simply forward the $3 of variation margin to the clearing house, debiting the customer's margin account by the same amount.

Differences between the two markets. Chart 4 combines the analysis from Charts 2 and 3 to show the relationship between margins in the stock and futures markets in a single figure. For clarity, it is assumed that customers in the futures market are required to keep their equity at the minimum maintenance level.** The diagram immediately reveals the high initial burden placed on an investor purchasing an instrument on the cash market rather than the futures market. However, it also reveals that in a severe market decline, when prices fall by more than one-half of their initial levels, the minimum equity in the futures market would exceed that in the cash market. The reason for this difference is that the futures margins are specified in absolute dollar terms, whereas cash market maintenance margin is stated as a percentage of the current stock price. As prices decline, the required margin rate on the futures market investor increases, unless the requirements are modified on an ad hoc basis.††

The same information can be displayed in terms of marginal and average margin requirements in the cash and futures markets, as in Charts 5 and 6. The marginal rate (Chart 5) is simplest in the futures market since it is constant at 100 percent—the investor's margin calls increase dollar-for-dollar with a decline in the price of

**As they would be permitted to do in principle if they kept their balance one cent above the minimum maintenance level. While in practice the minimum may be closer to the initial dollar level, the maintenance requirement represents the lowest possible—if not typical—level.

*Footnote ** continued*

††The futures exchanges can and do adjust margin levels on current and existing contracts in response to changed market conditions, principally to variations in volatility. If prices move downwards sharply, with an apparent increase in volatility, then the exchanges would likely increase margin requirements. If they fell gradually without an increase in volatility, then it is uncertain whether margin levels would be reduced.

Chart 4

Comparison of Stock and Futures Markets

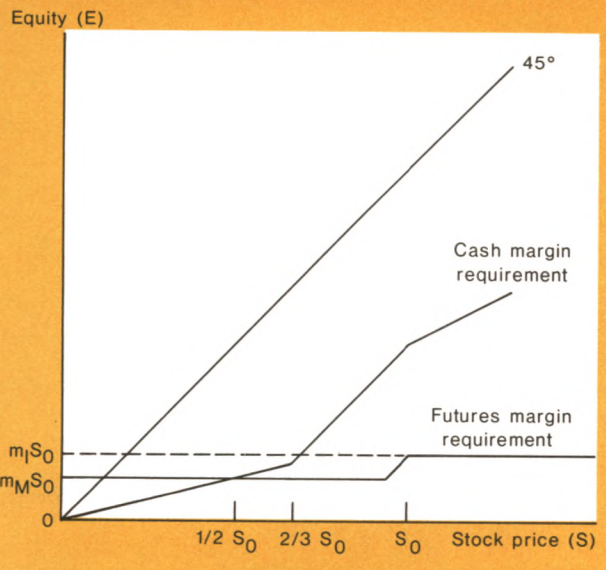
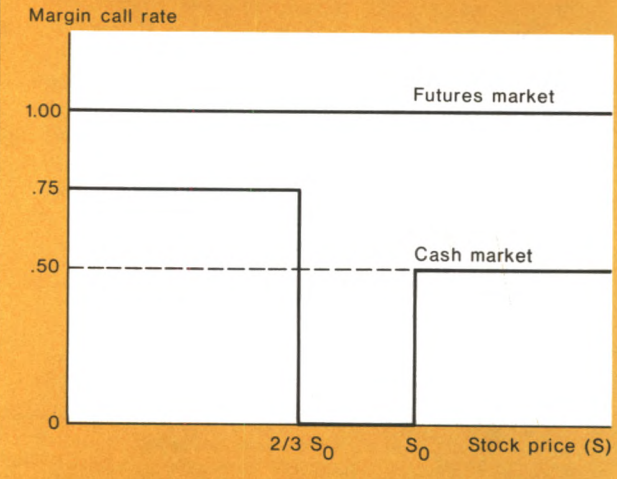


Chart 5

Marginal Margins



Appendix A: Graphical Analysis of the Spot and Futures Markets *(continued)*

the contract.

There are three different marginal margin rates in the cash market, depending on the relationship between the initial price and the current price of the stocks. If the price of the stock rises from its initial value, the investor may withdraw 50 cents for each dollar of price change. If the price falls from its initial value, no additional equity need be added until the 25 percent maintenance level is hit. In this range, therefore, the marginal margin is zero. Once the maintenance level is hit, however, the investor must deposit 75 cents for each dollar by which the price falls. As indicated earlier, the position of the middle range over which there are no margin calls may change if the initial or maintenance margin rates become binding. This corresponds to the shifting of line segment AG in Chart 2.

The average margin rate is computed by dividing total required equity by the price of the underlying investment. The average rates for the cash and futures markets are plotted in Chart 6. In the cash market, the average rate is 50 percent above the initial price and 25 percent once the maintenance level is hit. The futures margin rate is always decreasing because the requirement is fixed in dollar terms. As the contract price rises, the average margin drops towards zero, and as the price falls, the average margin increases indefinitely. If the value of the contract falls beneath the initial margin, the average margin rate can exceed 100 percent.

An important difference between the spot and futures

Chart 6

Average Margins

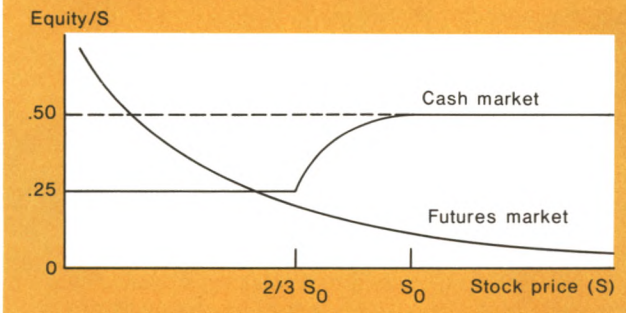


Chart 7

Sample Realization (Bull Market)

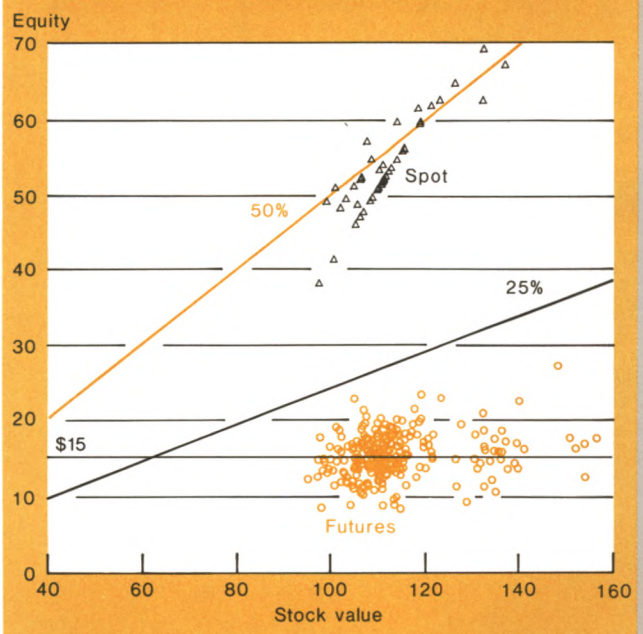
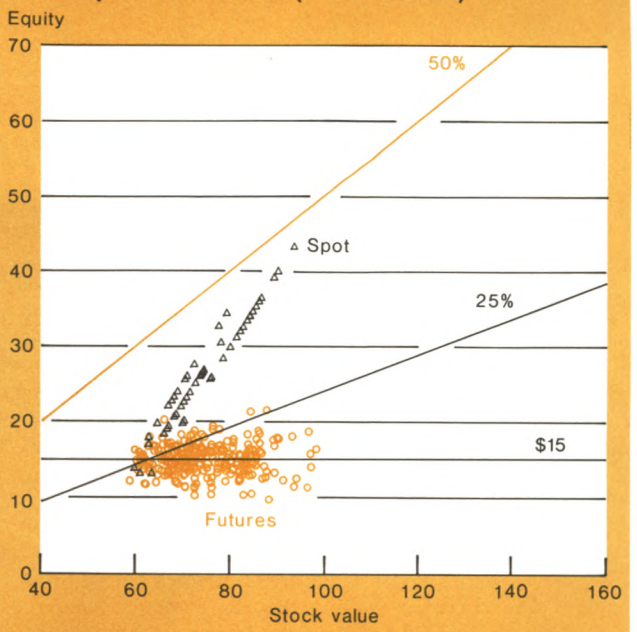


Chart 8

Sample Realization (Bear Market)



Appendix A: Graphical Analysis of the Spot and Futures Markets *(continued)*

markets concerns the length of time that customers have to post margin calls with their brokers. This is technically 15 days in the spot market, as compared with at most one trading day in the futures market. These numbers overstate the actual difference, however, since brokers in the spot market have the right to be more demanding, and usually are.

Simulation analysis

To provide a more specific illustration of how required margins in the spot and futures markets vary over time in relation to the value of the underlying stocks, Charts 7 and 8 present the results of a simulation of margin requirements for a stock or futures portfolio over a period of a year. The underlying stock prices are drawn randomly from a distribution with a mean return of 15 percent and a volatility (standard deviation) of 40 percent.‡‡ For the spot market, the requirements are those described earlier, with initial margin of 50 percent and maintenance margin of 25 percent. For the futures market, it is assumed that required margin is always 15 percent of the original value of the stocks.

The value of each point on the vertical axis represents the dollar value of equity in a customer's margin account just before a margin call is posted, with the corresponding value of the stocks on the horizontal axis. Because of the different periods allowed for posting margin calls in the two markets, it is assumed that the time between two consecutive observations is one trading day in the futures market and five trading days in the spot market. Hence, there are 250 and 50 points, respectively, for the futures and spot markets.

Each chart starts with a stock value of $100 and presents a particular realization (series of randomly generated values) of the stock value process over the course of a year. The same realization is used in each chart for both the spot and futures markets. In Chart 7, daily returns were generally positive over the course of the year and a wide discrepancy developed between the margin levels in the two markets. Some equity was removed from the spot market account when the level exceeded 50 percent, but the maintenance level was not tested. The realization of Chart 8 is essentially a bear market, and the margin levels are much more comparable across markets, especially when stock prices fell to 60 percent or less of their original levels.

Broadly speaking, margin requirements in both markets perform a similar role, restricting the investor's exposure in the instruments and the creditor's risk. Because of the daily and intraday marking to market for futures positions, futures exchanges set their initial and maintenance margin requirements considerably lower than those set in the cash market. This represents a rational response to the lower risk exposure that results from frequent marking to market.

‡‡The S&P 500 index, which corresponds to a well-diversified stock portfolio, has a historical volatility of about 15 to 20 percent. Volatilities for individual stocks vary substantially, but most would be greater than that of the index as a whole, some significantly so.

Appendix B: Calculation of Credit Risk for Equity-Related Instruments

This appendix provides specific illustrations of the procedures described heuristically in the text for calculating the likelihood of an equity deficiency in a margin account. A model of margin requirements and position equity is developed along the lines of the graphical analysis of Appendix A. For stocks, options, and index futures, the events that correspond to negative equity positions within a margin-posting period are identified. Numerical examples are also provided, based on a theoretical Wiener process distribution for stock price movements.

The model

The following basic definitions (consistent with those of Appendix A) are used in the subsequent discussion:

S_t = value of the underlying stocks at time t,
x_t = $\log(S_t/S_o)$ = return from time 0 to time t,
E_t^r = required equity at time t,
m_I = initial margin requirement (proportion),
m_M = maintenance requirement (proportion).

For long *stocks,* the initial required equity is given by

$$E_t^r = m_I S_o.$$

Thereafter, equity is allowed to change by any movement in stock prices,

$$E_t^r = E_{t-1}^r + S_t - S_{t-1},$$

except that E_t^r is constrained above and below by:

$$m_M S_t \leq E_t^r \leq m_I S_t.$$

Thus,

$$E_t^r = \min\,[\max[E_{t-1}^r + S_t - S_{t-1},\ m_M S_t],\ m_I S_t].$$

Appendix B: Calculation of Credit Risk for Equity-Related Instruments *(continued)*

In the NYSE, the current requirements are $m_I = .5$ and $m_M = .25$. The maximum period for posting margin calls is officially 15 business days, but in practice brokers rarely allow more than 5 days, usually just 1 or 2 days.* Since position equity must in principle always be above m_M, the key question from a credit risk point of view is whether, starting from m_M, equity will become negative at any time during the posting period. This event may be represented as:

$$\min_{T \leq t \leq T+H} m_M S_T + S_t - S_T < 0,$$

where H is the length of the posting period. This condition may be restated in terms of returns (using the earlier definition for x_t) as:

$$\min_{T \leq t \leq T+H} (x_t - x_T) < \log(1 - m_M).$$

If the distribution of price movements is stationary, as is the case for a Wiener process, the last condition is equivalent to:

$$(1) \qquad \min_{0 \leq t \leq H} x_t < \log(1 - m_M).$$

In the market for *index futures,* initial margin is stated in dollar terms, so in proportional terms m_I varies inversely with the level of the index:

$$E_o^r = D,$$
$$m_I = D/S_o,$$

where D is the required dollar amount.† There is a variation margin requirement of 100 percent of movements in the futures price, that is, positions must be marked to market. Any additional margin must be posted within 1 business day, but when large sudden price movements occur, there may be intraday margin calls. Thus, at the start of every business day, the position equity should equal D. A further complication is that brokers are allowed to let their clients' equity positions fall to a maintenance level that is about 75 percent of the initial requirement. In practice, however, the effective requirement is probably closer to D.‡ Thus,

$$m_M = pD/S_t,$$

where $.75 \leq p \leq 1$. Negative equity is observed within the posting period if

$$\min_{T \leq t \leq T+H} pD + S_t - S_T < 0.$$

In terms of returns, this is

$$\min_{T \leq t \leq T+H} (x_t - x_T) < \log(1 - pD/S_T)$$

or, if stationarity holds,

$$(2) \qquad \min_{0 \leq t \leq H} x_t < \log(1 - pD/S_T).$$

For a written *call option* on an individual stock, the NYSE margin requirement is

$$E_T^r = \pi_T + \max[.15\ S_T - \max[K - S_T, 0],\ .05\ S_T],$$

where π_T is the current call premium and K is the exercise price. This formula applies to both initial and maintenance requirements with the π_T and S_T marked to market daily.§

Here, negative equity results within the posting period (the buyer of the call is exposed to credit risk) if the intrinsic value of the option exceeds the margin, that is, if

$$\max_{T \leq t \leq T+H} S_t - K > E_t^r$$

Based on returns, this expression becomes

$$\max_{T \leq t \leq T+H} (x_t - x_T) > \log((E_T^r + K)/S_T)$$

or, if stationary,

$$(3) \qquad \max_{0 \leq t \leq H} x_t > \log((E_T^r + K)/S_T).$$

An illustrative probability distribution: the Wiener process

Once the types of events that concern creditors and regulators are identified, the likelihood of those events can be evaluated. In this section, a Wiener process is used to represent the distribution of future price movements, as is the case in much of the theoretical stock market literature. The parameters of the process (instantaneous mean and variance) are chosen on the basis of empirical evidence, but the shape of the probability distribution is constrained to a Gaussian or normal form. An alternative is to use actual empirical distributions from the past. Such distributions, however, vary substantially over time and do not lend themselves to accurate measurement and prediction.‖ The Wiener formulation, while certainly imperfect, is roughly representative of actual movements and is useful for sensitivity analysis.

The basic definition of a Wiener process for logarithmic changes in stock prices, that is, for

*Details about the rules and practices regarding margin posting periods in the stock market are found in: *New York Stock Exchange Guide*, Rule 431, Paragraph (6); Robert P. Rittereiser and John P. Geelan, *Margin Regulations and Practices,* 2d ed. (New York Institute of Finance, 1983); and Richard J. Teweles and Edward S. Bradley, *The Stock Market,* 5th ed. (Wiley, 1987).

†As explained in Appendix A, no distinction is made between spot and futures prices.

‡Margins on index futures are discussed in John L. Maginn and Donald L. Tuttle, eds., *Managing Investment Portfolios: A Dynamic Process,* 1985-1986 Update, chap. 16.

§See Sofianos, "Margin Requirements."

‖See Table 4 in the text, as well as the discussion there.

Appendix B: Calculation of Credit Risk for Equity-Related Instruments *(continued)*

$$x_t = \log(S_t/S_o),$$

is given by the stochastic differential equation:

$$dx = \mu dt + \sigma dz,$$

where dz represents driftless unit-variance Brownian motion. Given this process, it may be calculated that

$$P[x_H < a] = N\left(\frac{a}{\sigma\sqrt{H}} - \frac{\mu\sqrt{H}}{\sigma}\right),$$

where N(•) is the standard Gaussian distribution, and, more importantly for present purposes,

(4)
$$P\left[\min_{0 \le t \le H} x_t < a\right] = N\left(\frac{a}{\sigma\sqrt{H}} - \frac{\mu\sqrt{H}}{\sigma}\right) + e^{2\mu a/\sigma^2} N\left(\frac{a}{\sigma\sqrt{H}} + \frac{\mu\sqrt{H}}{\sigma}\right).$$

Since the Wiener process is stationary,

$$P\left[\min_{T \le t \le T+H} (x_t - x_T) < a\right]$$

has the same value as (4) above.¶ Also,

$$P[\max x > a] = P[\min -x < -a],$$

which leads to expression (4) with the signs reversed for the arguments of the function N (since μ becomes $-\mu$ and a becomes $-a$ in equation (4)).

The right hand side of equation (4) is a function of four parameters:

$$a,\ H,\ \mu,\ \sigma.$$

Only the first two of these parameters depend on the particular type of instrument, the last two being determined by the characteristics of the underlying asset. In order to apply expression (4) to the events defined in

¶For a discussion of Wiener processes, including the calculation of these expressions, see D.R. Cox and H.D. Miller, *The Theory of Stochastic Processes* (Chapman and Hall, 1980), chap. 5.

Probability of Negative Equity within Posting Period

Instrument	Exercise Price ÷ Value (Percent)	Maintenance Margin (Percent)	Posting Period (Days)	Volatility 20 Percent	Volatility 40 Percent	Volatility 60 Percent
Stocks	—	25	2	—	0	0
			3		0	.000011
			5		0	.000634
			15		.002672	.045657
Options	70	(18.3, 20.7)	2	—	.000003	.000485
			3		.000142	.004475
			5		.003367	.028321
			15		.097719	.213326
	100	(27.9, 33.3)	2	—	0	0
			3		0	.000013
			5		.000016	.000776
			15		.014426	.055525
	130	(38.8, 43.8)	2	—	0	0
			3		0	0
			5		0	.000021
			15		.001045	.015167
Index futures	—	7.5	1	0	—	—
		6.0	1	.000001		
		4.5	1	.000237		
		7.5	2	.000010		
		6.0	2	.000450		
		4.5	2	.008747		

Notes:

(1) It is assumed that the underlying stocks follow a Wiener process with an expected return of 12 percent per annum and a volatility as indicated in the table. There are 250 trading days per year.

(2) An entry of "0" denotes a probability of less than .0000005.

(3) For stocks and options, some parameter values are based on NYSE rules and praxis; for index futures, on the CME. Further values are included to illustrate the sensitivity of the results to these parameters and to aid in intermarket comparisons.

(4) Options are priced using the Black-Scholes formula with no dividends and a riskless interest rate of 7 percent per annum. The maintenance margins given are based on the NYSE rules for options on individual stocks and correspond to volatilities of 40 and 60 percent, respectively.

Appendix B: Calculation of Credit Risk for Equity-Related Instruments *(continued)*

(1)-(3) of the preceding section, values of μ, σ, and H must be determined, and the specific form of parameter a must be obtained from the appropriate expression in (1)-(3). The parameter a is

$$\log(1-m_M)$$

for stocks,

$$\log(1 - pD/S_T)$$

for futures, and

$$\log((E_t^r + K)/S_T)$$

in the case of options.

Numerical examples based on the Wiener process

The accompanying table provides numerical estimates of the probability of negative equity based on the Wiener process. These figures illustrate the range of probabilities that correspond to parameter values roughly representative of those currently observed in the markets. Stocks and options are assumed to correspond to individual securities, while index futures are based on a broad index such as the S&P Composite. For this reason, the volatility of the latter is taken to be lower than those of the individual instruments.

Almost all the probabilities based on realistic parameters are less than 1 percent, in most cases significantly so. An exception is the in-the-money option (K=70) on a stock with a volatility of 60 percent, for which the probability of an equity deficiency within five days is 2.8 percent. Creditors would presumably be aware of the reduced margin protection on options that are well into the money and would accordingly reduce the posting period for margin calls. The probabilities in the table seem in general to be quite low. Any such appraisal, however, is of necessity subjective.

Margin Requirements and Stock Market Volatility

Margin requirements in the stock market restrict the amount of credit that brokers and dealers can extend to their customers for the purpose of buying stocks. The current initial margin requirement of 50 percent implies that at least 50 percent of the value of a new stock purchase should come from investors' own capital. If the stock price rises after the initial purchase, investors can withdraw the differential from their margin account or can use it to buy additional stock on 50 percent margin. If the price declines after the initial purchase, investors are not required to add funds to their margin account unless their equity position falls below the so-called maintenance margin, which is currently 25 percent.[1]

Federal regulation of securities margins was mandated by Congress in the Securities Exchange Act of 1934. The stock market experience of the late 1920s led Congress to conclude that credit-financed speculation in the stock market might create excessive market volatility: In the absence of adequate margin requirements, optimistic investors with relatively low degrees of risk aversion might borrow large amounts of funds to buy stocks, causing a price rise that could not be justified by economic fundamentals. The price rise might then feed on itself; the speculators could use their increased wealth to borrow more funds and purchase more stock, thus driving prices even higher. This pyramiding effect could in turn be followed by a market collapse if less optimistic investors began to sell in the belief that the market had been overbought. As the price declined, brokers and other creditors would ask for more collateral on their loans to speculators. If some speculators could not provide the additional collateral, creditors would sell the stocks they kept as collateral, forcing prices still lower. This outcome would generate further calls for collateral, more liquidations, and additional price declines. Congress reasoned that the imposition of margin requirements could prevent the excessive volatility caused by this process of pyramiding and depyramiding and gave the Federal Reserve jurisdiction over the level of initial margin requirements.[2]

Do initial margin requirements curb speculative excesses in the stock market and reduce stock price volatility? This question has gained new importance among regulators and students of financial market developments following the sudden collapse of stock prices in October 1987.[3] Clearly, theory alone cannot provide a definite answer. Those who believe that speculation is stabilizing because it deepens the market and increases liquidity are likely to view margin requirements as harmful. Those who believe that an

[1]Note that brokers themselves set maintenance margins higher than 25 percent and vary them across customers and across time.

[2]For a review of the pyramiding-depyramiding process, see Kenneth D. Garbade, "Federal Reserve Margin Requirements: A Regulatory Initiative to Inhibit Speculative Bubbles," in Paul Wachtel, ed., *Crises in the Economic and Financial Structure* (Lexington, Massachusetts: Lexington Books, 1982). Garbade also discusses Congress' related objectives in imposing margin requirements, such as protecting small investors and inhibiting the diversion of credit to unproductive speculative activities.

[3]See, for example, the "Interim Report of the Working Group on Financial Markets," submitted to the President of the United States, May 1988. See also Arturo Estrella, "Consistent Margin Requirements: Are They Feasible?" in this issue of the *Quarterly Review*.

unchecked market is often subject to destabilizing speculation are likely to think that margin requirements could prevent speculative excesses. The question can only be resolved empirically.

This article examines the empirical relationship between initial margin requirements and the volatility of stock prices in the cash market. Since 1934, the Federal Reserve has changed the initial margin requirement in stocks 23 times (Table 1). The different levels of initial margin requirements during the last 50 years make it possible to analyze the presence or absence of an association between initial margin requirements and volatility. Certainly, stock market volatility can also vary over time for reasons unrelated to margin requirements and the unrestrained behavior of speculators. For example, in an environment with more volatile interest rates or cash flows, one expects to find more volatile stock prices. Thus the present study also takes into consideration economic factors that may influence stock price volatility.

The empirical evidence reveals an economically and statistically significant negative relationship between initial margin requirements and stock market volatility. Higher initial margin requirements are associated with a reduction in both actual stock market volatility and excess stock market volatility, that is, volatility which is over and above the volatility caused by the variability of the economic environment.

Margin requirements and destabilizing speculation: the theoretical connection

The proposition that margin requirements help curb destabilizing speculation is based on two implicit claims. The first claim is that speculation by some groups of investors can be destabilizing. The second claim is that margin requirements can impose an effective constraint on the market activities of speculators. The first claim is plausible but is not accepted by all economists. For example, Milton Friedman argues that speculation is destabilizing only if speculators on the average lose money by selling when assets are low in price and buying when assets are high.[5] Although Friedman's position is shared by many economists, increasing numbers of market professionals and academic economists believe that the high daily and monthly volatility of stock prices may be the result of asset churning by speculators who have very short-term investment horizons. Furthermore, economists have constructed theoretical models of destabilizing speculation featuring speculators who do not lose money. These models show that speculation can destabilize prices in an efficient market, but they do not claim to show that speculation will necessarily destabilize prices. The effect of speculation on price volatility is an empirical question.[6]

The claim that margin requirements can impose a binding constraint on the behavior of destabilizing speculators is also plausible. Finance theory predicts that the less risk-averse investors, that is, the potential speculators, hold more stocks and less cash in their portfolios and are therefore more likely to be constrained by margin requirements than the more risk-averse and conservative investors.[7]

Although there is a theoretical connection between margin requirements and destabilizing speculation, the connection would be uninteresting if its quantitative magnitude were trivial or nonexistent. Thus at the

Table 1

Initial Margin Requirements

(In Percent)

Effective Date	Rate	Effective Date	Rate
10/15/34	45	01/16/58	50
02/01/36	55	08/05/58	70
11/01/37	40	10/16/58	90
02/05/45	50	07/28/60	70
07/05/45	75	07/10/62	50
01/21/46	100	11/06/63	70
02/01/47	75	06/08/68	80
03/30/49	50	05/06/70	65
01/17/51	75	12/06/71	55
02/20/53	50	11/24/72	65
01/04/55	60	01/03/74	50
04/23/55	70		

Sources: New York Stock Exchange *Fact Book*, 1987, p. 54; and Board of Governors of the Federal Reserve System, *Annual Report*, various issues.

[5]Milton Friedman, "The Case for Flexible Exchange Rates," in *Essays in Positive Economics* (Chicago, Illinois: University of Chicago Press, 1953).

[6]See Oliver D. Hart and David M. Kreps, "Price Destabilizing Speculation," *Journal of Political Economy*, vol. 94 (October 1986), pp. 927-52. A step towards modeling destabilizing speculation is also taken by Bradford J. DeLong, Andrei Shleifer, Lawrence H. Summers, and Robert J. Waldman, "The Economic Consequences of Noise Traders," National Bureau of Economic Research, Working Paper no. 2395, October 1987.

[7]Dudley G. Luckett, "On the Effectiveness of the Federal Reserve's Margin Requirements," *Journal of Finance*, vol. 37 (June 1982), pp. 783-95, utilizes data on investors' equity positions in margin accounts and finds that margin requirements constrain investment in the stock market. Another piece of evidence consistent with the claim that margin requirements constrain investment in the stock market is the fact that total margin borrowings as a fraction of the value of the New York Stock Exchange stocks decrease after an increase in margin requirements; see Gikas A. Hardouvelis, "Margin Requirements, Volatility, and the Transitory Component of Stock Prices," Federal Reserve Bank of New York, Research Paper no. 8818, July 1988.

present stage, the key research question is empirical in nature.

The Federal Reserve's reaction function

One factor complicating the empirical analysis of margin requirements and their effects on market volatility is the behavior of the Federal Reserve as a regulator of margins. Thus before we turn to the effects of margin requirements on stock price volatility, a rough characterization of the Fed's behavior is in order. Recall that the Federal Reserve has changed the initial margin requirements 23 times since 1934. Increases in margin requirements were presumably initiated during periods when stock prices were perceived to be influenced by excessive speculation, while decreases in margin requirements were initiated during calmer times, perhaps in order to enhance participation in the market and increase liquidity.[8]

[8]The following excerpt from the 1951 *Annual Report* of the Board of Governors is representative of the Fed's explanations of margin requirement changes: "Although the total amount of credit in use in the stock market had not assumed heavy proportions, there had been some increase during the preceding months, together with increases in the volume of trading and in prices of securities. The expanding business and economic situation appeared to be encouraging stock market activity and speculation, and the Board of Governors believed that in the existing circumstances a further substantial price advance supported by a rapid expansion of stock market credit was a distinct possibility. The increase in margin requirements was effected as a preventive measure" (p. 81). Also

Table 2

The Federal Reserve's Reaction Function

$$M_t = \underset{(.008)}{-0.001} + \underset{(.014)}{0.956^*}\, M_{t-1} + \underset{(.007)}{0.024^*}\, (P_{t-1}/\overline{P}) - \underset{(.251)}{0.274}\, MCREDIT_{t-1} + u_t$$

$\overline{R}^2 = 0.95$, SEE = .034, $\overline{M} = 0.59$

Sample: November 1934 to December 1987

*Statistically significant at the 5 percent level.

M_t	= Official margin requirement (in decimals).
$MCREDIT_{t-1}$	= Ratio of broker margin credit to the total value of the New York Stock Exchange stocks at the end of month t-1.
$P_{t-1}/\overline{P}$	= S&P Composite index (including dividends) at the end of month t-1 divided by the average S&P Composite of the previous five years.
$\overline{R}^2$	= Coefficient of determination adjusted for degrees of freedom.
SEE	= Regression standard error.
$\overline{M}$	= Sample average of M_t.

Note: Numbers in parentheses are standard errors adjusted for conditional heteroskedasticity. When the sample period ends in 1974, the regression results are similar. When an index of small stocks is substituted for the S&P Composite, the results are also similar.

Two indicators of speculative excesses are the level of stock prices relative to trend and the amount of margin credit. Both variables are prominent in the explanations given by the Fed after changes in margin requirements. A regression of the level of margin requirements on lagged values of these indicators may provide a characterization of the Fed's regulatory response to speculative excesses. Table 2 presents the regression results. Observe that the Fed's setting of margin requirements is not very sensitive to the amount of broker and dealer credit, but it is sensitive to the level of stock prices relative to trend.[9] When stock prices rise above trend, indicating that excessive buying may be present, the margin requirement tends to increase.

The tendency of the Federal Reserve to raise margin requirements when stock prices are high relative to trend and lower them when stock prices are low relative to trend may create a spurious negative correlation between margin requirements and stock market volatility. This spurious relationship should be taken into account if the true relation between margin requirements and volatility is to be assessed correctly. The spurious relation arises as follows: Finance economists have found a negative relationship between stock prices and stock price volatility. During periods of high stock prices, the debt-to-equity ratio of firms that are publicly traded is low and, consequently, stock price volatility is low.[10] Since high stock prices cause both an increase in margin requirements and a decrease in stock price volatility, they may result in a negative correlation between margin requirements and stock price volatility. This correlation could be falsely interpreted as evidence that higher margin requirements cause a decrease in volatility. The empirical work of the following section avoids such a false interpretation by including stock prices relative to trend as an extra explanatory variable in the regressions.

Margin requirements and volatility

There is an extensive empirical literature on the effects

Footnote 8 continued
characteristic is the Board's explanation after a decrease in margin requirements in 1962: "In making this change, the Board noted that there had been a sharp reduction in stock market credit in recent weeks, with an abatement in speculative psychology" (*Annual Report*, 1962, p. 113).

[9]More involved "Granger causality" tests show that margin requirements Granger cause (are temporally prior to) margin borrowings, but margin borrowings do not Granger cause margin requirements.

[10]This phenomenon is theoretically plausible and is observed in practice. See Andrew A. Christie, "The Stochastic Behavior of Common Stock Variances: Value, Leverage and Interest Rate Effects," *Journal of Financial Economics*, vol. 10 (December 1982), pp. 407-32.

of margin requirements but, surprisingly, empirical work on the influence of margin requirements on stock market *volatility* is scarce. Thomas Moore contends that margin requirements are an ineffective tool for controlling volatility because the volatility of stock prices has remained relatively stable despite several changes in margin requirements since 1934.[11] James O'Brien takes a similar position, arguing that short-term speculative excesses have not been a characteristic of the post-1929 period.[12] A detailed study by the Board of Governors of the Federal Reserve System is more cautious, concluding only that the evidence is insufficient for a definite answer on the effectiveness of margin requirements.[13] The studies by O'Brien and the Board of Governors are very careful and quite extensive, but they focus on the relationship between margin requirements and the level or the rate of change of stock prices rather than the volatility of stock prices. Moore does not provide any regression evidence whatsoever. Nevertheless, the relationship between margin requirements and stock price volatility was studied by George Douglas and by R. R. Officer, and both authors found a negative association between the two variables. This section complements their work and seeks to sharpen their empirical analysis by using more available data and running a more complete set of regressions with variables that these authors excluded from their analyses.[14]

Because theory does not provide any guidance on the use of real or nominal stock prices, both measures are used. Specifically, monthly realized real rates of return and realized excess nominal rates of return are used to calculate the volatility measures. Real rates of return are constructed from a nominal stock price index that includes dividends, deflated by the consumer price index (CPI). Excess nominal rates of return are nominal returns minus the known one-month Treasury bill rate at the beginning of the one-month holding period.[15] It turns out that the volatility measures based on real rates of return are very similar to the volatility measures based on excess nominal rates of return. The reason for the similarity is that the monthly volatility of stock prices overwhelms the volatilities of the CPI and the Treasury bill rate.

The volatility measure used in this study is the standard deviation of monthly returns calculated over 12 consecutive months. This appears to be the best measure for capturing the possible presence of a pyramiding and depyramiding process in stock prices, a process likely to last more than a few months. Furthermore, this volatility measure focuses the analysis on longer-run volatility.[16]

The empirical analysis utilizes both large and small stocks. Large stocks are represented by the Standard and Poor (S&P) Composite index, and small stocks are represented by an index that consists of the ninth and tenth deciles of the New York Stock Exchange when its stocks are ranked by their capitalized values. For each month in the sample, a standard deviation is constructed from the data of that month and the previous 11 months. Chart 1 plots the standard deviations of the S&P Composite and of small stocks together with the official margin requirement. Observe that small stocks are more volatile than the large stocks in the S&P Composite and that the early 1930s are characterized by unusually high volatility.[17]

Chart 1 brings out a crucial point: the monthly sample from the early 1930s to the present is long but, for the purposes of this analysis, it is effectively very small because margin requirements did not change often. The small effective sample size requires more refined statistical techniques and more caution in interpreting all empirical results. A casual examination of the data would not be informative. For example, if investigators simply scanned the chart, they might falsely conclude that no relationship existed between margin requirements and volatility after 1934 and, for this reason, forgo a more detailed analysis of the data. Thus the

[11] Thomas G. Moore, "Stock Market Margin Requirements," *Journal of Political Economy*, vol. 74 (April 1966), pp. 158-67.

[12] James M. O'Brien, "Speculative Bubbles in Stock Prices and the Need for Margin Regulation," Unpublished Working Paper, Board of Governors of the Federal Reserve System, December 1984.

[13] Board of Governors of the Federal Reserve System, *A Review and Evaluation of Margin Requirements*, Staff Study, December 1984.

[14] See George W. Douglas, "Risk in the Equity Markets: An Appraisal of Market Efficiency," *Yale Economic Essays*, Spring 1969, pp. 3-45; and R. R. Officer, The Variability of the Market Factor of the New York Stock Exchange," *Journal of Business*, vol. 46 (July 1973), pp. 434-53.

[15] The purpose of subtracting the one-month Treasury bill rate from realized nominal stock returns is to construct a measure of stock

Footnote 15 continued
return volatility that is over and above the normal volatility of monthly interest rates. Note that if inflationary expectations are incorporated into the one-month Treasury bill rate, then excess nominal returns are similar to real rates of return and have an advantage: the data series on both stock prices and Treasury bill rates refer to the last trading day of the month and are, therefore, matched exactly. In contrast, data on the consumer price index refer to days within the month and are announced much later.

[16] Thus the empirical evidence in this study complements the evidence provided by the studies of O'Brien and the Board of Governors because that evidence could be interpreted as referring to short-run volatility.

[17] The standard deviations in Chart 1 are based on real rates of return. When excess nominal rates of return are used to construct volatility measures, the new chart is very similar.

limitations of the sample may explain why previous studies have neglected to undertake a rigorous examination of the correlation between margin requirements and volatility.

The regression analysis uses all the available monthly observations from the late 1920s through 1987. As noted earlier, for every month in the sample, a standard deviation is calculated using the returns of that month and the previous 11 months. This standard deviation is matched with an average official margin calculated over the same 12 months. The use of overlapping data provides more statistical power but also creates some technical difficulties.[18]

Tables 3 and 4 present the regression results. Table 3 refers to real rates of return and Table 4 refers to excess nominal rates of return. Two types of regressions are run: the first includes the official margin requirement as the only explanatory variable, and the second includes additional explanatory variables that characterize the changing economic environment. Let us examine the simple set of regressions first. Observe that there is a statistically significant negative association between the official margin requirement and stock market volatility. This is true for both large and small stocks and for volatility measures based on either real or excess nominal stock returns. The negative association is present over the entire sample period and over the sample period that begins in November 1934, after the imposition of official margin requirements.

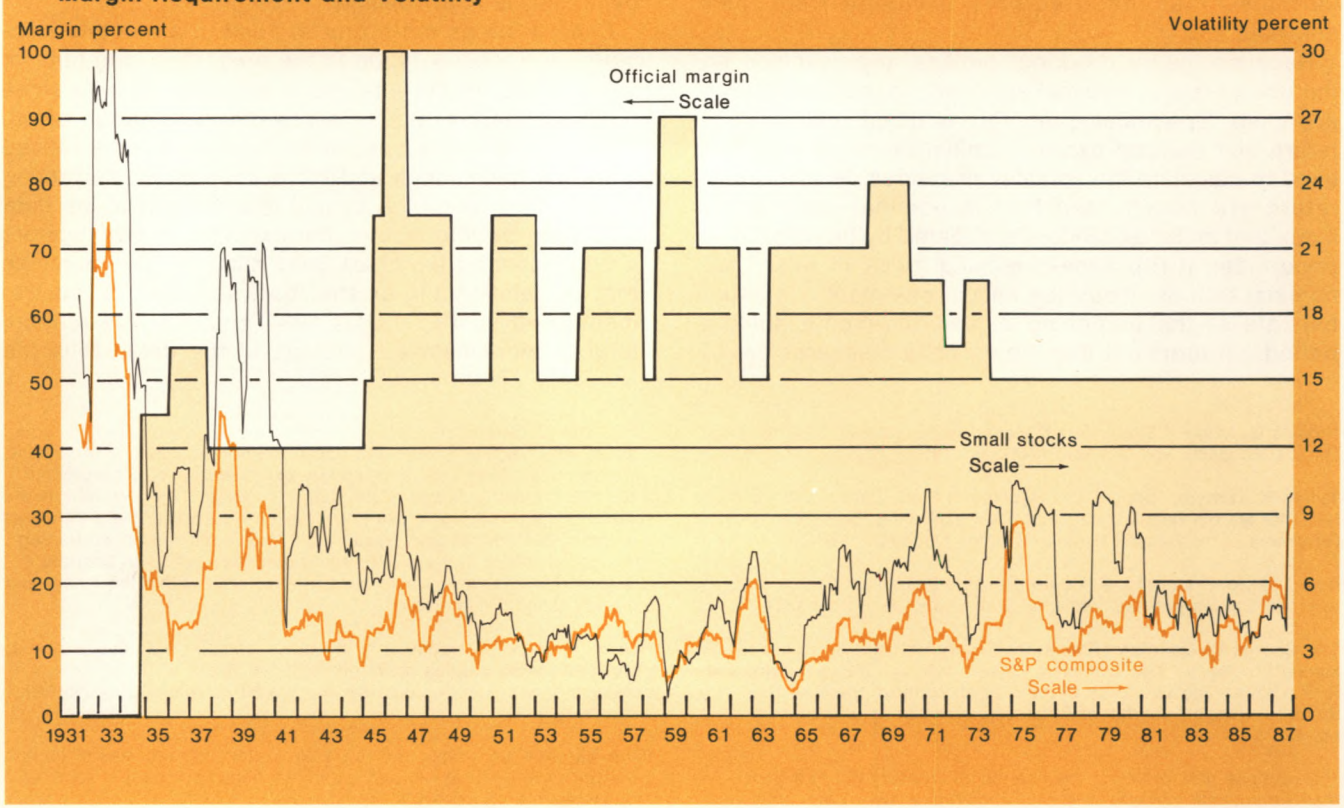
The magnitude of the effect of margin requirements on volatility is economically significant. For example,

[18]The use of rolling 12-month periods generates a moving average process of order 11 in the error term. In this case, OLS standard errors are biased estimates of the true standard errors and lead to incorrect inferences. Thus a modification of the OLS variance-covariance matrix is used, providing asymptotically consistent standard errors. See Lars P. Hansen, "Large Sample Properties of Generalized Methods of Moments Estimators," *Econometrica*, vol. 50 (July 1982), pp. 1029-54. An alternative setup would be a nonoverlapping annual sample with both stock return volatility and

Footnote 18 continued
the average margin calculated from January to December.

Chart 1

Margin Requirement and Volatility



the estimated coefficient −0.110 in Table 3 shows that over the entire sample an increase in the margin requirement by 10 percentage points from, say, 50 percent to 60 percent decreases the monthly volatility of large stocks by 1.10 percentage points. The effect of margin requirements on small stocks is even greater (1.91 percentage points). To put these numbers in perspective, observe that the average monthly volatility of large stocks, $\bar{\sigma}$, is 4.8 percentage points and of small stocks, 7.4 percentage points. Thus a 10 percentage point increase in margin requirements decreases volatility by approximately one-quarter its average value.

The results from the entire sample could overestimate the effect of margin requirements on volatility. Recall that our measure of margin requirements is the official measure, tabulated in Table 1. The effective margin requirements, however, are those set by brokers and dealers who may add a spread over the official margin for certain customers and during certain time periods. The official margin requirement thus equals the unknown effective margin plus an error. This error causes a bias in the estimated coefficients.[19] Observe now that before October 1934 the official margin is zero, which is a more severe underestimate of the true effective margin of the pre-1934 period than the official margin of later dates. Recall also that the same pre-1934 period is characterized by unusually high volatility. Thus the combination of a downward-biased proxy of the true margin and an unusually high vol-

[19]See the discussion in G. S. Maddala, *Econometrics* (New York: McGraw-Hill Book Company, 1977), pp. 292-94.

Table 3

Margin Requirements and the Volatility of Monthly Real Stock Returns

Regression Equation: $\sigma_t = \beta_0 + \beta_1 \sigma_{t-12} + \beta_2 \sigma(y_t) + \beta_3 \sigma(r_t^{CB}) + \beta_4 (P_t/\bar{P}) + \beta_5 m_t + \epsilon_t$

Sample	Estimated Regression Coefficients β_0	β_1	β_2	β_3	β_4	β_5	$\bar{R}^2$	SEE	$\bar{\sigma}$	N
S&P Index‡										
December 1931 to December 1987	.110* (.015)					−.110* (.025)	.43	.024	.048	673
	.091* (.022)	−.020 (.125)	1.003* (.186)	.358* (.125)	−.024* (.010)	−.057* (.017)	.63	.019		
October 1935 to December 1987	.067* (.010)					−.043* (.016)	.10	.017	.042	627
	.050* (.012)	.183* (.074)	.897* (.267)	.266* (.092)	−.011† (.007)	−.027* (.011)	.40	.014		
Small Stocks‡										
December 1931 to December 1987	.179* (.019)					−.191* (.032)	.47	.039	.074	673
	.095* (.022)	.234* (.119)	1.427* (.290)	.361* (.173)	−.015* (.005)	−.079* (.025)	.68	.030		
October 1935 to December 1987	.131* (.020)					−.114* (.031)	.18	.033	.064	627
	.055* (.015)	.470* (.092)	1.393* (.378)	.242† (.134)	−.009† (.005)	−.048* (.019)	.57	.024		

*Statistically significant at the 5 percent level.

†Statistically significant at the 10 percent level.

‡Inside the parentheses are standard errors corrected for conditional heteroskedasticity and the MA-11 process of the error term.

σ_t = Standard deviation of the monthly real rate of return of stocks (nominal rate of return including dividends minus the CPI inflation rate), calculated from t-11 to t (in decimals).

$\sigma(y_t)$ = Standard deviation of the monthly percentage change in the industrial production index from t-11 to t (in decimals).

$\sigma(r_t^{CB})$ = Standard deviation of the monthly real rate of return on corporate bonds from t-11 to t (in decimals).

$P_t/\bar{P}$ = Average stock price from t-11 through t, divided by the average stock price from t-71 through t-12.

m_t = Average official margin requirement from t-11 to t (in decimals).

$\bar{R}^2$ = Coefficient of determination adjusted for degrees of freedom.

SEE = Regression standard error (in decimals).

$\bar{\sigma}$ = Sample average of σ_t (in decimals).

N = Total number of overlapping observations.

atility during the pre-1934 period causes the estimated coefficient to be more negative than the true parameter. For this reason, Tables 3 and 4 rerun the regressions starting in November 1934. Of course, now the new and less negative coefficient estimate is biased in the positive direction because a zero weight is assigned to the low margin/high volatility pre-1934 sample period. Clearly, the coefficient that captures the influence of effective margins on volatility lies between the two estimates from the two different sample periods. It is reassuring that the post-1934 set of estimates are qualitatively similar. The estimated coefficient drops in magnitude but remains statistically significant. Actual stock return volatility also drops in magnitude. Thus an increase in margin requirements by 10 percentage points during the later sample decreases volatility by approximately 10 to 18 percent its average value.

Charts 2 and 3 present scatterplots of the relationship between volatility and margin requirements for the post-1934 period. Unlike Chart 1, the scatterplots show a clear negative relationship between volatility and margin requirements for both the S&P Composite and small stocks. The line through the cloud of data points is the regression line. The regression line has a negative slope and is steeper for small stocks, characteristics that are consistent with the results of the tables. Observe that in the case of the S&P Composite, the negative slope is primarily driven by observations that belong to the 1930s and 1940s. In the case of small

Table 4

Margin Requirements and the Volatility of Monthly Excess Nominal Stock Returns

Regression Equation: $\sigma_t = \beta_0 + \beta_1 \sigma_{t-12} + \beta_2 \sigma(y_t) + \beta_3 \sigma(i_t^{CB}) + \beta_4 (P_t/\overline{P}) + \beta_5 m_t + \epsilon_t$

Sample	Estimated Regression Coefficients β_0	β_1	β_2	β_3	β_4	β_5	$\overline{R}^2$	SEE	$\overline{\sigma}$	N
S&P Index‡										
December 1931 to December 1987	.112*					−.112*	.44	.024	.048	673
	(.015)					(.024)				
	.094*	−.036	1.013*	.331*	−.023*	−.060*	.63	.020		
	(.022)	(.127)	(.191)	(.120)	(.010)	(.017)				
October 1935 to December 1987	.069*					−.046*	.12	.017	.042	627
	(.010)					(.015)				
	.051*	.186*	.890*	.244*	−.011†	−.029*	.40	.014		
	(.013)	(.078)	(.274)	(.090)	(.007)	(.011)				
Small Stocks‡										
December 1931 to December 1987	.180*					−.192*	.47	.039	.074	673
	(.019)					(.031)				
	.097*	.229†	1.432*	.300†	−.015*	−.081*	.68	.030		
	(.022)	(.120)	(.291)	(.163)	(.005)	(.025)				
October 1935 to December 1987	.134*					−.118*	.18	.034	.064	627
	(.020)					(.031)				
	.058*	.463*	1.389*	.205	−.009†	−.051*	.57	.025		
	(.016)	(.099)	(.387)	(.133)	(.005)	(.019)				

*Statistically significant at the 5 percent level.

†Statistically significant at the 10 percent level.

‡Inside the parentheses are standard errors corrected for conditional heteroskedasticity and the MA-11 process of the error term.

σ_t = Standard deviation of the monthly excess nominal rate of return of stocks (nominal rate of return minus the one-month T-bill rate at the end of the previous month), calculated from t-11 to t (in decimals).

$\sigma(y_t)$ = Standard deviation of the monthly percentage change in the industrial production index from t-11 to t (in decimals).

$\sigma(i_t^{CB})$ = Standard deviation of the monthly nominal rate of return on corporate bonds from t-11 to t (in decimals).

$P_t/\overline{P}$ = Average stock price from t-11 through t, divided by the average stock price from t-71 through t-12.

m_t = Average official margin requirement from t-11 to t (in decimals).

$\overline{R}^2$ = Coefficient of determination adjusted for degrees of freedom.

SEE = Regression standard error (in decimals).

$\overline{\sigma}$ = Sample average of σ_t (in decimals).

N = Total number of overlapping observations.

stocks, the negative slope is a characteristic of the entire sample period.[20]

Let us turn now to the more complicated regressions that include additional explanatory variables. The additional variables are lagged volatility, the standard deviation of the monthly growth rate of the industrial production index, the standard deviation of the monthly rate of return of a five-year corporate bond, and stock prices relative to trend. A standard deviation is again computed from variables over the current and previous 11 months. The price relative to trend is the average price of the stock over the current and previous 11 months divided by the average price over an earlier 60-month period. The volatility of the industrial production index serves as a proxy for the volatility of dividends, and the volatility of the corporate bond return as a proxy for the volatility of discount rates. The price relative to trend is included in order to disentangle the direct effect of margin requirements on volatility from the possible spurious correlation arising from the effects of stock prices on both margin requirements and stock volatility. Finally, lagged volatility is included in order to capture other variables that may affect stock market volatility with a delay.

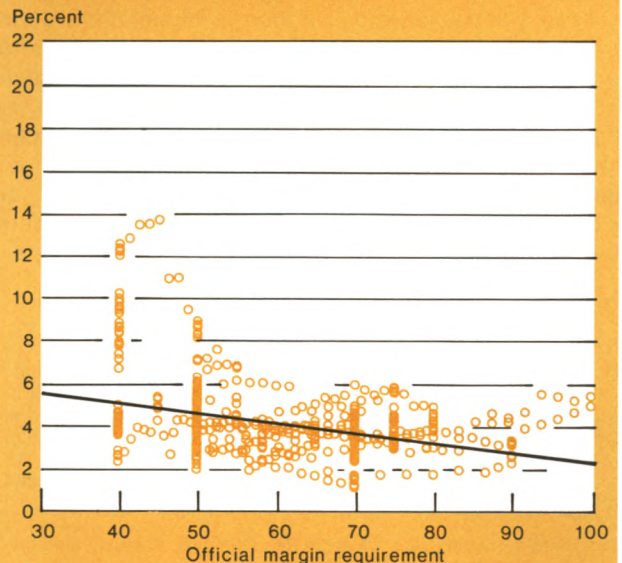
The inclusion of additional explanatory variables does not affect the qualitative results from the earlier simple regressions. Margin requirements continue to have a negative and statistically significant effect on stock market volatility. For example, Table 4 shows that over the post-1934 sample period, when other variables are kept constant, an increase in margin requirements by 10 percentage points decreases the volatility of large stocks by 0.29 percentage points and the volatility of small stocks by 0.51 percentage points, or by 7 to 8 percent of their average sample values. The effect of margin requirements may appear economically small, but note that since volatility is positively related to lagged volatility, the long-run effect of margin

[20]The scatterplots also reveal considerable heteroskedasticity. The estimation procedure automatically corrects for an unknown form of heteroskedasticity, as in Harbert White, "A Heteroscedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroscedasticity," *Econometrica*, vol. 48 (May 1980), pp. 817-38.

Chart 2

S&P Composite Volatility Regressed on Official Margin Requirement

September 1935-December 1987

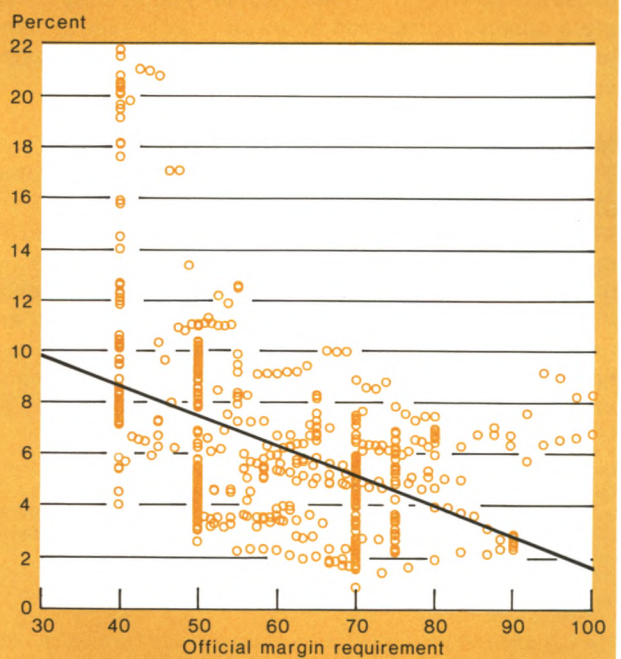


Notes: Stock volatility is the standard deviation of monthly excess nominal rates of return during the last 12 months. Official margin requirement is the average official margin requirement over the same 12-month period.

Chart 3

Small Stock Volatility Regressed on Official Margin Requirement

September 1935-December 1987



Notes: Stock volatility is the standard deviation of monthly excess nominal rates of return during the last 12 months. Official margin requirement is the average official margin requirement over the same 12-month period.

requirements is larger.[21]

The estimated coefficients of the additional explanatory variables in Tables 3 and 4 confirm intuition and our earlier discussion. Stock prices are more volatile when economic output is more volatile, when interest rates are more volatile, and, as finance economists have found, when stock prices are relatively low.[22]

Finally, note that a negative correlation between margin requirements and volatility does not necessarily imply causation from margin requirements to volatility. A third, unknown variable may have caused both volatility and margin requirements to move in opposite directions. However, the regression equations of Tables 3 and 4 take most plausible third variables into account. First, the regression controlled for the variable that entered significantly in the Fed's reaction function, namely, the level of stock prices relative to trend. Second, the regression controlled for lagged volatility and thus for possible delayed responses by the Federal Reserve to volatility changes. Third, although there is no presumption that the Fed responded to volatility, if it had, it probably would have raised rather than lowered margin requirements following an increase in volatility. Thus the Fed's possible contemporaneous response to stock market volatility itself (as opposed to those other indicators of speculative excesses already taken into account) could only generate a positive correlation between margin requirements and volatility and work against the finding of a negative correlation.

Margin requirements and excess volatility

The previous section showed that an increase in margin requirements tends to mitigate stock market volatility. However, volatility in itself is not a direct measure of speculative excess. A more direct measure of speculative excess is excess volatility, or volatility that cannot be explained by the variation of current and expected future dividends and discount rates. This section treats the relation between margin requirements and excess volatility.

One could interpret the expanded regression results in Tables 3 and 4 as evidence of the effect of margin requirements on excess volatility. The reason is simple: the regression equations include measures of the volatility of the fundamental determinants of stock prices such as dividends and discount rates, and thus the estimated effects of margin requirements on volatility are not effects that work their way through the included measures of the volatility of the fundamental determinants of stock prices. The estimated coefficients reflect the effect of margin requirements on the unexplainable component of volatility. The unexplainable component of volatility is a rough proxy of excess volatility.[23] However, unexplainable volatility is only a proxy of excess volatility because the regressions do not control perfectly for the variability of fundamental factors, particularly expected future dividends and discount rates. Furthermore, the regression equations do not take into consideration the precise theoretical relation of dividends and discount rates to stock prices, that is, the present value model.

Further analysis of the effects of margin requirements on excess volatility is beyond the scope of this article. A more technical research paper that served as the basis of this article develops a precise measure of excess volatility and examines alternative evidence of excessive speculation in the form of long-run deviations of stock prices from their fundamental values.[24] One of the major findings of that paper is that during periods of low or decreasing margin requirements, excess volatility of stock prices is higher than during periods of high or increasing margin requirements. Another finding is that "fads," that is, long-term deviations of stock prices from their fundamental values, are more prevalent during periods of low or decreasing margin requirements than in periods of high or increasing margin requirements. Again, this evidence is consistent with the hypothesis that margin requirements help curb speculative excesses.[25]

[21]The slope coefficient of lagged volatility is .186 for the S&P Composite and .463 for small stocks. Thus the effects of margin requirements cumulate as time goes on and, in the long run, they are 1.23 to 1.86 times larger than the short-run effects. The multiplicative factors of 1.23 and 1.86 can be derived by iterative forward substitution. They are equal to $1/(1-0.186)$ and $1/(1-0.463)$, respectively.

[22]The size and statistical significance of lagged volatility conflict with an assertion made recently by James M. Poterba and Lawrence H. Summers in "The Persistence of Volatility and Stock Market Fluctuations," *American Economic Review*, vol. 76 (December 1986), pp. 1142-51, that shocks to volatility dissipate quickly. Poterba and Summers use a slightly different volatility measure based on daily observations of the S&P Composite. They also run simple autoregressive models with no additional explanatory variables.

[23]In "The Persistence of Volatility," Poterba and Summers argue that volatility is well approximated by an AR(1) process. In this article's specification, volatility is calculated over a one-year interval, and thus the lagged volatility of 12 months earlier is similar to an AR(1) term. The inclusion of a lagged volatility measure in addition to the other contemporaneous variables sharpens the claim that the unexplainable volatility is a proxy of excess volatility.

[24]See Gikas A. Hardouvelis, "Margin Requirements, Volatility, and the Transitory Component of Stock Prices."

[25]For an exposition of the fads hypothesis, see Lawrence H. Summers, "Does the Stock Market Rationally Reflect Fundamental Values?" *Journal of Finance*, vol. 41 (July 1986, Papers and Proceedings of the 44th Annual Meeting of the American Finance Association), pp. 591-600.

Conclusion

Higher initial margin requirements in the cash market are statistically associated with a reduction in both actual and excess stock price volatility. The evidence should be interpreted with caution, however, because it is based on a small number of effective observations. Margin requirements have changed only 23 times since 1934. Furthermore, the last change in margin requirements occurred almost 15 years ago, in January 1974. Since that time, financial markets have changed drastically, especially with the introduction of derivative markets and the globalization of capital flows. Thus one can not use this article's findings to support specific policy changes in the cash market in full confidence that the article's predicted effects will be realized with great precision. But the results do support the contention that increases in margin requirements reduce market volatility. At a minimum, the evidence shows that the presence of margins contributes to a more stable market.

Since the stock market crash of October 1987, the role of derivative markets in index-based contracts has become a major topic in the public policy debate. Futures and options markets in stock indexes are praised for providing liquidity and hedging capabilities to large institutional investors, but the same markets are also accused of contributing excessive volatility that spills over to the cash market. To date, the primary aim of margins in derivative equity markets has been to reduce the probability of contractual defaults and the risk of a derivative market breakdown, under the assumption that the volatility of stock prices is a given exogenous factor.[26] The results of this article suggest, however, that margins may play an additional role by affecting market volatility itself. The evidence from the cash market experience with different margin requirements over the last 50 years should be taken into account in assessing the adequacy of margins in derivative equity instruments.

Gikas A. Hardouvelis

[26] Another aim is the harmonization of margins in derivative markets with the margins in the cash market. The feasibility of such harmonization is examined by Arturo Estrella in "Consistent Margin Requirements," in this issue of the *Quarterly Review.*

Appendix: Data and Sources

The primary data source is the 1988 yearbook of the Ibbotson Associates, which contains end-of-month data from 1926 through 1987. Two aggregate stock price indexes are used. The first is the Standard and Poor's Composite index. Currently, the S&P Composite includes 500 of the largest stocks, but before March 1957 it consisted of 90 of the largest stocks. The second index covers small capitalization stocks. It is composed of stocks making up the ninth and tenth smallest deciles of the New York Stock Exchange. The data on the one-month Treasury bill rate and the five-year corporate bond yield also come from Ibbotson Associates.

Data on the consumer price index were taken from Ibbotson Associates, and on the industrial production index, from the following sources: (i) for the period 1926-46, from *Industrial Production,* Board of Governors of the Federal Reserve System, 1986; (ii) for the period 1947-October 1987, from Citibase data banks; (iii) for November and December 1987, from *International Financial Statistics,* April 1988.

Data on broker and dealer margin credit come from: (i) the series entitled "Customer Net Debit Balances," which appears in *Banking and Monetary Statistics,* Board of Governors of the Federal Reserve System, 1943, Table 143; and *Banking and Monetary Statistics: 1941-1970,* 1976, Table 12.23; and (ii) the series entitled "Credit Extended to Margin Customers," which appears in various issues of the *Federal Reserve Bulletin* under the "Stock Market Credit" table. The first series runs from November 1931 through June 1970; the second series, from March 1967 through December 1987. The two series are not identical. To avoid an abrupt jump in July 1970, the second series was multiplied by the factor of 1.43, which is the average ratio of the first to the second series during the overlapping interval from March 1967 through June 1970. Data on the value of all New York Stock Exchange Stocks are end-of-month and come from New York Stock Exchange publications.

Treasury and Federal Reserve Foreign Exchange Operations

May-July 1988

Market sentiment toward the dollar turned strongly positive during the three months ending in July, and the dollar moved higher for most of the period. On balance, the dollar rose 9½ percent in terms of the other Group of Ten currencies on a trade-weighted basis (Federal Reserve Board of Governors staff index). But the increase against individual currencies varied considerably. The dollar rose approximately 12 percent against the German mark and most Continental currencies, returning close to its level against the German mark of a year ago. It advanced a more modest 6½ percent and 9¾ percent, respectively, against the Japanese yen and British pound, remaining well below its levels of a year ago. Against the Canadian dollar, the dollar declined 1½ percent.

In keeping with the Group of Seven (G-7) understandings about fostering exchange rate stability—most recently reiterated in the June Toronto Summit Economic Declaration—the U.S. authorities entered the market at times to counter the dollar's rise, operating in coordination with other central banks. Market sales of dollars by the U.S. authorities between late June and the end of July totaled $2.9 billion, all against German marks.

Throughout the period, the dollar was buoyed by any new signs of strength in the U.S. economy, which were thought likely to lead to a tighter monetary policy and higher interest rates. With statistics measuring U.S. economic growth continuing to point to greater gains than had previously been expected, market participants recognized that the focus of policy attention had shifted from concerns about recession to concerns about inflation. Statements by several Federal Reserve officials had conveyed uneasiness about the potential risks for inflation of relatively tight labor markets and capacity constraints in some industries. As it was, short-term interest rates in the United States had already firmed somewhat between mid-March and the beginning of May, maintaining and in some cases increasing interest differentials favoring investment in dollar-denominated assets.

Until mid-June, the factors supporting a higher dollar were partially counterbalanced by uncertainty about the sustainability of external adjustment and about official reactions to any rise in dollar exchange rates. Thus, the dollar's rise early in the period was relatively modest. The dollar strengthened more decisively after mid-June with market participants increasingly perceiving that international adjustment was indeed proceeding and that major industrial nations might tolerate some further increase in the dollar.

For the period as a whole, the dollar's upward movement against the mark was especially pronounced. There were questions about the longer-term prospects for investment in the German economy, in part stemming from labor costs, and continued concern over the government's intended imposition of withholding taxes on foreign investments in Germany. In these circumstances, there were heavy flows of capital out of Germany, amounting in the first half of 1988 to a record DM 50.6 billion.

The dollar's relative stability against the yen in part

A report presented by Sam Y. Cross, Executive Vice President in charge of the Foreign Group at the Federal Reserve Bank of New York and Manager of Foreign Operations for the System Open Market Account. H. Randi DeWitty was primarily responsible for preparation of the report.

reflected favorable assessments of the outlook for the Japanese economy. In particular, market participants were impressed with the extent to which the Japanese economy appeared to be adjusting to its external imbalances and experiencing vigorous increases in domestic demand.

May to mid-June

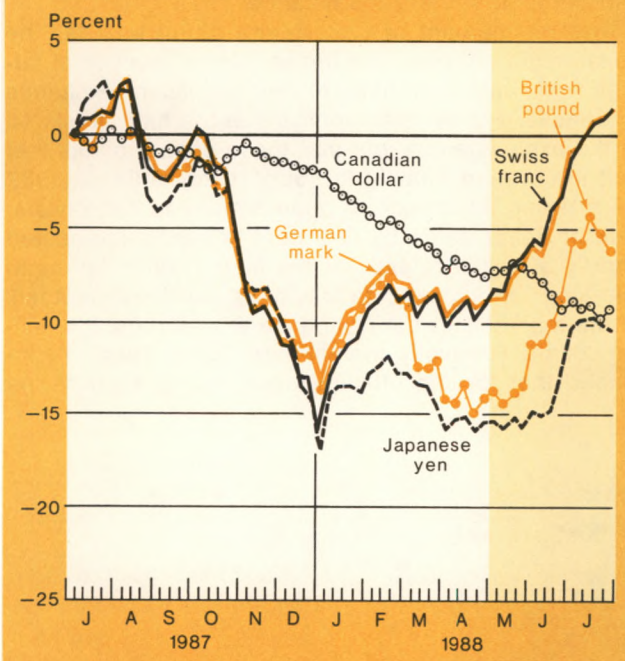
The dollar rose gradually against the mark from May until the middle of June. From its opening of DM 1.6775, it moved irregularly higher, breaking through the DM 1.70 level by mid-May and reaching DM 1.7224 by mid-June. It showed little increase on balance against the yen, however.

The dollar's rise partly reflected a widening perception that U.S. economic growth continued to be buoyant and that the Federal Reserve's policy stance might be tightened if pressures on capacity became troublesome. The report, in early May, of a decline in U.S. civilian unemployment to its lowest level in 14 years and of strong gains in manufacturing employment, together with a larger-than-expected upward revision in first-quarter GNP figures later that month, provided further evidence that economic activity was expanding rapidly. The fact that the country's export sector and manufacturing industries were contributing strongly to the economy's improved performance provided reassurance that adjustment was well underway. Moreover, market participants detected that the Federal Reserve had adopted a firmer policy stance. With financial markets generally reassured by the authorities' concern about inflation, U.S. long-term interest rates eased somewhat, and long-term interest rate differentials favoring the dollar generally narrowed, though they remained strongly positive. But as U.S. short-term interest rates rose, short-term differentials favoring the dollar widened between the beginning of May and mid-June, especially against the European currencies.

In addition, confidence in the efforts of G-7 authorities to foster exchange rate stability had increased as

Chart 1

After trading within a relatively narrow range against most major foreign currencies throughout the spring, . . .

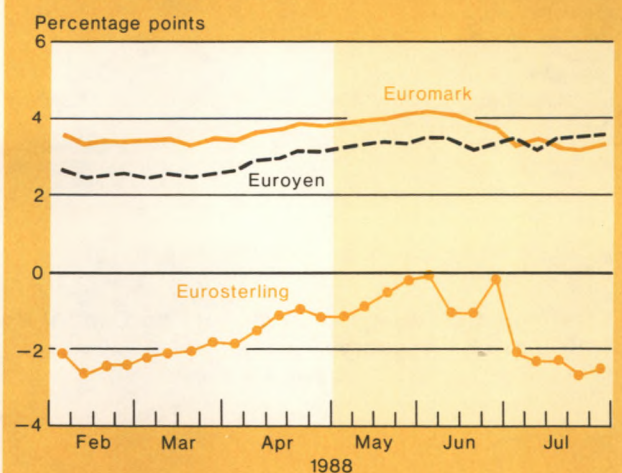


the dollar rose by varying amounts against several major currencies, especially in the second half of the May-July 1988 period.

The chart shows the percent change of weekly average rates for the dollar from July 3, 1987. All figures are calculated from New York noon quotations.

Chart 2

Short-term interest rate differentials favoring the dollar widened from May through mid-June, especially against the European currencies.



The chart shows weekly average interest rate differentials between three-month Eurodollar rates and three-month Euromarket deposit rates for German marks, Japanese yen, and British pounds.

the dollar traded in a relatively narrow range throughout the spring and U.S. export performance improved. As a consequence, concerns about exchange rate risk diminished, and investors became more confident about investing in dollar-denominated assets to take advantage of the relatively high yields on fixed-income securities available in the United States.

Moreover, reports circulated in the market of increased demand for dollars by banks' customers. Many firms had previously established short-dollar positions in the expectation that the dollar's three-and-one-half-year decline would continue well into 1988. When instead the dollar firmed, a number of corporations and financial institutions began to consider that the dollar's long decline had bottomed out. These market participants reportedly purchased dollars to avoid losses that might result from having to convert foreign currency receivables at still higher dollar levels. In this environment, market professionals perceived that a large magnitude of dollar buying might come into the exchange market if exchange rate expectations were to shift in favor of the dollar, and a sense of upside risk for the dollar began to emerge.

Under these circumstances, the market's longstanding bearish sentiment toward the dollar lessened, but was not eliminated. One concern was that tightening labor markets and capacity constraints in the United States might undermine further adjustment as well as lead to a buildup of inflationary pressures. This concern was reflected in the exchange markets when, on May 17, the dollar gained only modest ground from the announcement of an unexpected improvement in the U.S. trade deficit for March. This muted response occurred, in part, because the data recorded a sharp rise in imports that, if continued, might hinder further improvement in the trade balance.

Another element of uncertainty about how far the dollar might advance was the presumed reaction of foreign monetary authorities to any significant exchange rate move. For several months, rumors had circulated in the exchange markets that those central banks that had intervened heavily to support the dollar in 1987 were taking advantage of opportunities to sell dollars. Talk of dollar sales by G-7 central banks intensified shortly after the release of the March trade figures in mid-May. Throughout late May there was persistent talk in the market that the Bundesbank was regularly selling dollars. Gradually, market participants became convinced that foreign officials would act to contain the

Table 1

Federal Reserve Reciprocal Currency Arangements

In Millions of Dollars

Institution	Amount of Facility July 31, 1988
Austrian National Bank	250
National Bank of Belgium	1,000
Bank of Canada	2,000
National Bank of Denmark	250
Bank of England	3,000
Bank of France	2,000
German Federal Bank	6,000
Bank of Italy	3,000
Bank of Japan	5,000
Bank of Mexico	700
Netherlands Bank	500
Bank of Norway	250
Bank of Sweden	300
Swiss National Bank	4,000
Bank for International Settlements:	
Dollars against Swiss francs	600
Dollars against other authorized European currencies	1,250
Total	30,100

Table 2

Drawings and Repayments by Foreign Central Banks under Special Swap Arrangements with the U.S. Treasury

In Millions of Dollars; Drawings (+) or Repayments (−)

Central Bank Drawing on the U.S. Treasury	Amount of Facility	Outstanding as of May 1, 1988	May	June	July	Outstanding as of July 29, 1988
Central Bank of the Argentine Republic	550.0	160.0	−160.0	0	0	*
National Bank of Yugoslavia	50.0	*	0	+50.0	−16.1	+33.9
Central Bank of Brazil	250.0	*	0	0	+232.5	+232.5

Data are on a value-date basis.
*No facility

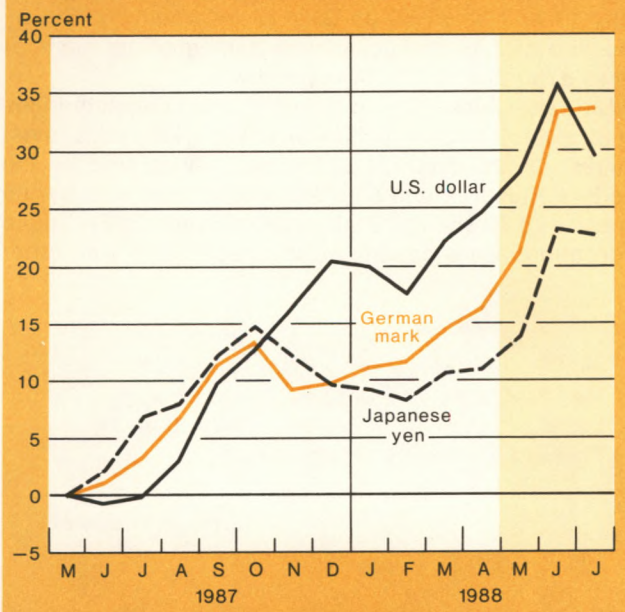
dollar's rise through intervention. At the end of May, the Bundesbank began selling small amounts of dollars openly at the Frankfurt fixing. On June 3, the Bundesbank reported sharp declines in its net monetary reserves, particularly in the foreign currency reserves component. From late May through mid-June, these declines, attributed by the market largely to dollar sales, amounted to DM 7.4 billion. Press reports indicated that other G-7 countries might also seek to reduce their dollar holdings.

Market participants also began to anticipate that foreign monetary authorities would take advantage of any increases in U.S. interest rates to increase their own interest rates. Monetary aggregates were growing relatively rapidly in a number of countries. Also, during the first week of June, officials of a number of industrial countries openly expressed concerns about a potential rise in inflation worldwide against a background of rising commodity prices. German and Japanese officials also noted the inflationary impact of the dollar's rise and underscored the importance of maintaining domestic price stability.

In these circumstances, the dollar fluctuated irregularly upward, as market participants adjusted their evaluations of official attitudes toward exchange rate movements. In the middle of June, the dollar was trading about 2½ percent higher on balance against the mark and other European currencies and was unchanged on balance against the yen from the beginning of the period.

Chart 3

Rising world commodity prices . . .



added to concerns about inflationary pressures in a number of industrialized countries.

The chart shows monthly changes in world commodity prices as reported in the International Monetary Fund's International Financial Statistics and as converted into German marks and Japanese yen.

Mid-June through July

As time passed, market participants became increasingly impressed with the dollar's resilience. They noted that the dollar had shrugged off both intervention and statements by foreign officials aimed at resisting the declines of their own currencies. They also watched for reactions to the Bundesbank's June 21 decision to increase the interest rate on its repurchase agreements and looked to the upcoming communiqué from the Summit meeting in Toronto for further indications of policy actions that might affect exchange rates.

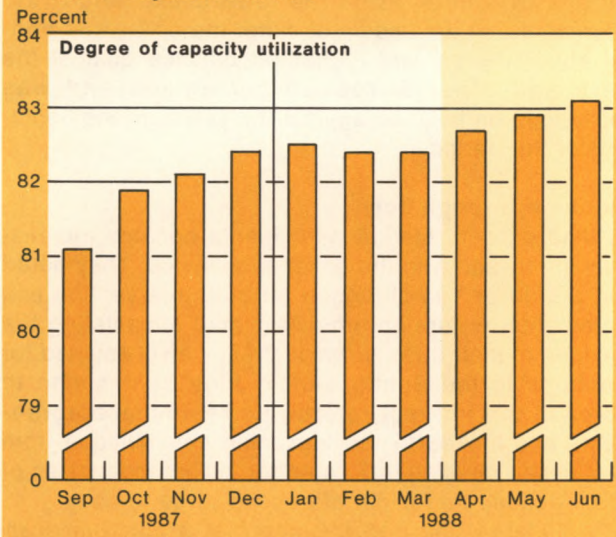
On June 14, the announcement of a much smaller-than-expected U.S. trade deficit for April reassured market participants that the correction of global imbalances was continuing, even in the face of a relatively robust U.S. economy. The market's concerns that strong domestic demand and capacity constraints would limit the scope for further trade adjustment were diminished by the data for April, which showed a decline in imports. The dollar's reaction to this set of trade figures was stronger than that of the previous month, with dollar exchange rates moving up sharply to trade at DM 1.7450 and Y 126.50 soon after the trade figures' release.

Later in June, the Economic Declaration issued after the Toronto Summit left the market with the impression that the G-7 monetary authorities would tolerate a further rise of the dollar. Although the Declaration repeated the precise words of the December 1987 G-7 statement, the dollar was already 8 percent higher in terms of the mark than at the time of the December statement. This different market environment, together with comments by several officials following the Toronto meetings, led to an interpretation that some further rise was acceptable.

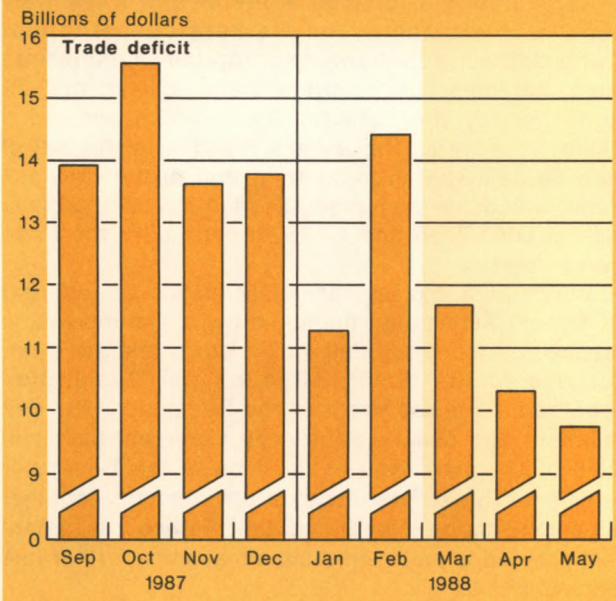
As a result of these developments, the dollar began to rise more quickly in late June. As the dollar broke through DM 1.80 and higher levels not previously anticipated, there were reports of corporations and financial institutions moving to reduce their short-dollar positions. There were also dollar purchases associated with the covering of options positions that had been established in anticipation of a continued dollar

Chart 4

Rising capacity utilization raised concerns that capacity constraints would limit trade adjustment . . .



but did not keep the U.S. trade deficit from narrowing during the period.



The top chart shows the degree of capacity utilization in U.S. industry. Capacity utilization data for April, May, and June were released on May 17, June 16, and July 18, respectively. The bottom chart shows the monthly U.S. merchandise trade balance, seasonally adjusted and reported on a census basis. The U.S. trade figures for March, April, and May were released on May 17, June 14, and July 15, respectively.

decline.

In these circumstances, the U.S. authorities entered the market for the first time during the period on June 27. The authorities continued to operate, intervening on 15 of the remaining 23 business days through the end of July and working closely in coordination with other central banks to foster exchange rate stability.

There were several occasions during July when upward pressure on dollar rates was considerable. Some of these occurred when new economic statistics were released confirming the buoyancy of the U.S. economy. The dollar was especially well bid, for example, after the July 8 report of a further decline in U.S. civilian unemployment and after the July 27 release of GNP data pointing to a 3.1 percent seasonally adjusted rate of growth for the second quarter. The dollar also came into demand after the report on July 15 of May trade figures that reassured market participants that U.S. trade adjustment remained on track. Meanwhile, press coverage of Chairman Greenspan's congressional testimony reinforced the expectation that the U.S. authorities stood ready to counter inflationary pressures. Under these circumstances, the dollar generally moved up during early July, reaching its highs of the period against the mark and the yen at DM 1.8925 on July 18 and Y 135.55 on July 15, respectively. But by the end of July, the dollar was trading off its highs at DM 1.8780 and Y 133.15, respectively.

Between June 27 and July 29, the U.S. authorities sold a total of $2.9 billion in the market, all against marks. Of the total, $1,317.5 million was sold by the Federal Reserve and $1,612.5 million was sold by the Treasury's Exchange Stabilization Fund (ESF). These operations were conducted in cooperation with other

Table 3

Net Profits (+) or Losses (−) on United States Treasury and Federal Reserve Foreign Exchange Operations

In Millions of Dollars

Period	Federal Reserve	United States Treasury Exchange Stabilization Fund
May 1, 1988 to July 31, 1988	0	0
Valuation profits and losses on outstanding assets and liabilities as of July 31, 1988	+1,101.2	+856.7

Data are on a value-date basis.

central banks.

In other industrialized countries, the authorities also intervened to sell dollars, on occasion in substantial amounts. In addition, interest rates in a number of foreign countries increased as the authorities sought to limit the decline of their currencies against the dollar or otherwise respond to signs of quickening price pressures.

In other operations, the U.S. authorities increased holdings of foreign currencies by $1,282.3 million equivalent through sales of Special Drawing Rights (SDRs) and dollars to other official institutions and through receipt of principal repayments and interest payments due to the United States under the Supplementary Financing Facility of the International Monetary Fund.

As of end July, cumulative bookkeeping or valuation gains on outstanding foreign currency balances were $1,101.2 million for the Federal Reserve and $856.7 million for the ESF. These valuation gains represent the increase in the dollar value of outstanding currency assets valued at end-of-period exchange rates, compared with the rates prevailing at the time the foreign currencies were acquired.

The Federal Reserve and the ESF regularly invest their foreign currency balances in a variety of instruments that yield market-related rates of return and that have a high degree of quality and liquidity. A portion of the balances is invested in securities issued by foreign governments. As of end July, holdings of such securities by the Federal Reserve amounted to $1,408.2 million equivalent, and holdings by the Treasury amounted to the equivalent of $1,604.8 million.

During the period under review, the U.S. Treasury, through the ESF, received repayment of its financing facility for Argentina and participated in multilateral financing facilities for Yugoslavia and Brazil.

Argentina. On May 31, the Central Bank of the Argentine Republic fully repaid the $160 million second drawing of a $550 million short-term financing facility provided by the U.S. Treasury through the Exchange Stabilization Fund, thereby fully liquidating the facility.

Yugoslavia. On June 10, the U.S. Treasury, through the ESF, together with the Bank for International Settlements (BIS) acting for a number of central banks, agreed to provide $250 million in short-term financing facilities to the National Bank of Yugoslavia. On June 15, the National Bank of Yugoslavia drew the full $50 million of the ESF facility. On July 1, $16.1 million was repaid.

Brazil. On July 27, the U.S. Treasury, through the ESF, together with the BIS acting for a number of central banks, agreed to provide $500 million in short-term financing facilities to Brazil. The ESF's facility was $250 million. On July 29, the Central Bank of Brazil drew $232.5 million from the ESF facility.

Recent FRBNY Unpublished Research Papers*

8813. McCauley, Robert N., and Christopher Maxwell. "Price Discrimination in Hotelling's Duopoly Model: Equilibrium and Efficiency." April 1988.

8814. Klitgaard, Thomas. "Managing Exchange Rates: The Experience of the European Monetary System." May 1988.

8815. Ceglowski, Janet. "Intertemporal Substitution in Import Consumption." June 1988.

8816. Hirtle, Beverly. "Default and Liquidity Risk in the Junk Bond Market." June 1988.

8817. Harris, Ethan S. "A Reexamination of the Inventory Buffer Effect with Disaggregated Data." July 1988.

8818. Hardouvelis, Gikas. "Margin Requirements, Volatility, and the Transitory Component of Stock Prices." July 1988.

8819. Bell, Linda A., Elizabeth Hall, and Daniel R. Hayes. "The Incidence of Union Concessions in the 1980s: What, Where, and Why?" August 1988.

8820. Donahoo, Kathleen, and Sherrill Shaffer. "The Impact of Capital Requirements on the Securitization Decision." August 1988.

8821. Sofianos, George. "A Comparison of Market-Making Structures." September 1988.

*Single copies of these papers are available upon request. Write to Research Papers, Room 901, Research Function, Federal Reserve Bank of New York, 33 Liberty Street, New York, NY 10045.

Single-copy subscriptions to the *Quarterly Review* (ISSN 0147-6580) are free. Multiple copies are available for an annual cost of $12 for each additional copy. Checks should be made payable in U.S. dollars to the Federal Reserve Bank of New York and sent to the Public Information Department, 33 Liberty Street, New York, N.Y. 10045. (212-720-6134). Single and multiple copies for United States and for other Western Hemisphere subscribers are sent via third- and fourth-class mail, respectively. All copies for Eastern Hemisphere subscribers are airlifted to Amsterdam and then forwarded via surface mail. Multiple-copy subscriptions are packaged in envelopes containing no more than 10 copies each.

Quarterly Review subscribers also receive the Bank's Annual Report.

Library of Congress Catalog Card Number: 77-646559

Federal Reserve Bank of New York
33 Liberty Street
New York, N.Y. 10045

Return Postage Guaranteed