Bank Capital Requirements for Market Risk: The Internal Models Approach

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The increased prominence of trading activities at many large banking companies has highlighted bank exposure to market risk—the risk of loss from adverse movements in financial market rates and prices. Recognizing the importance of trading operations, banks have sought ways to measure and to manage the associated risks. At the same time, bank supervisors in the United States and abroad have taken steps to ensure that banks have adequate internal controls and capital resources to address these risks.

Prominent among the steps taken by supervisors is the development of formal capital requirements for the market risk exposures arising from banks' trading activities. These market risk capital requirements, which will take full effect in January 1998, depart from earlier capital rules in two notable ways. First, the capital charge is based on the output of a bank's internal risk measurement model rather than on an externally imposed supervisory measure. Second, the capital requirements incorporate qualitative standards for a bank's risk measurement system.

This paper presents an overview of the new capital requirements. In the first section, we describe the structure of the requirements and the considerations that went into their design. In addition, we address some of the concerns that have been raised about the methods of calculating capital charges under the new rules. The paper's second section considers the probable impact of the market risk capital requirements. After performing a set of rough calculations to show that the effect of the internal models approach on required capital levels and capital ratios will probably be modest, we identify some significant benefits of the new approach. Most notably, the approach will lead to regulatory capital charges that conform more closely to banks' true risk exposures. Moreover, the information generated by the models will allow supervisors and financial market participants to compare risk exposures over time and across institutions.

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The Structure of the Market Risk Capital Requirements

The new capital requirements for market risk have been put forward as an amendment to existing capital rules. In late 1990, banks and bank holding companies in the United States became subject to a set of regulatory capital guidelines that defined minimum amounts of capital to be held against various categories of on- and off-balance-sheet positions.[1] The guidelines also specified which debt and equity instruments on a bank's balance sheet qualified as regulatory capital. These guidelines were based on the 1988 Basle Accord adopted by the Basle Committee on Banking Supervision, a group made up of bank supervisors from the Group of Ten countries.

While the original Basle Accord and U.S. risk-based capital guidelines primarily addressed banks' exposure to credit risk, the new requirements set minimum capital standards for banks' market risk exposure.[2] Broadly speaking, market risk is the risk of loss from adverse movements in the market values of assets, liabilities, or off-balance-sheet positions. Market risk generally arises from movements in the underlying risk factors—interest rates, exchange rates, equity prices, or commodity prices—that affect the value of these on- and off-balance-sheet positions. Thus, a bank's market risk exposure is determined both by the volatility of underlying risk factors and the sensitivity of the bank's portfolio to movements in those risk factors.

Banks face market risk from the full range of positions held in their portfolios, but the capital standards focus largely on the market risks arising from banks' trading activities.[3] This focus reflects the idea that market risk is a major component of the risks arising from trading activities and, further, that market risk exposures are more visible and more easily measured within the trading portfolio because these positions are marked to market daily. Thus, under the amended capital standards, positions in a bank's trading book are subject to the market risk capital requirements but are exempt from the original risk-based capital charges for credit risk exposure.[4] In addition, commodity and foreign exchange positions held throughout the institution (both inside and outside the trading account) are subject to the market risk capital requirements.

Because the capital standards principally address the market risk arising from trading activities, only those U.S. banks and bank holding companies with significant amounts of trading activity are subject to the market risk requirements. In particular, the U.S. standards apply to banks and bank holding companies with trading account positions (assets plus liabilities) exceeding $1 billion or 10 percent of total assets. The institutions meeting these criteria, while relatively few in number, account for the vast majority of trading positions held by U.S. banks.[5] Supervisors also have the discretion to impose the standards on institutions that do not meet these criteria if such a step appears necessary for safety and soundness reasons. The rules become effective as of January 1998, although the U.S. regulation also permits banks to elect early adoption during 1997.

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Innovative Features

The market risk capital standards have drawn considerable attention because they differ significantly in approach from the risk-based capital rules for credit risk. The market risk standards impose a quantitative minimum capital charge that is calculated for each bank using the output of that bank's internal risk measurement model; they also establish a set of qualitative standards for the measurement and management of market risk. In both regards, the capital

standards break new ground. By substituting banks' internal risk measurement models for broad, uniform regulatory measures of risk exposure, this approach should lead to capital charges that more accurately reflect individual banks' true risk exposures. And by including qualitative standards, the approach is consistent with the shift in supervisory interest from a focus on risk measurement to a more comprehensive evaluation of banks' overall risk management.

Any bank or bank holding company subject to the market risk capital requirements must be able to demonstrate that it has a conceptually sound risk measurement system that is implemented with integrity.

The qualitative standards are designed to incorporate basic principles of sound risk management in the capital requirements. Any bank or bank holding company subject to the market risk capital requirements must be able to demonstrate that it has a conceptually sound risk measurement system that is implemented with integrity. The risk estimates produced must be closely integrated with the risk management process: for example, management could rely on daily reports from the system to assess current strategy or could base its limit structure on the risk estimates. In addition, the bank must conduct periodic stress tests of its portfolio to gauge the impact of extreme market conditions. Further, the bank must have a risk control unit that is fully independent of the business units that generate market risk exposures. Finally, internal and/or external auditors must conduct an independent review of the bank's risk management and measurement process.

The quantitative capital requirements distinguish between *general market risk* and *specific risk*. As defined in the capital standards, general market risk is the risk arising from movements in the general level of underlying risk factors such as interest rates, exchange rates, equity prices, and commodity prices. Specific risk is defined as the risk of an adverse movement in the price of an individual security resulting from factors related to the security's issuer. At one level, general and specific market risk are analogous to systematic and nonsystematic risk in a standard asset-pricing framework. Specific risk, however, is intended to cover variation both from day-to-day price fluctuations and from surprise events, such as an unexpected bond default. The following subsections provide an overview of the capital treatment of the two types of risk.

Capital Requirements for General Market Risk

The capital requirements for general market risk are based on the output of a bank's internal value-at-risk model, calibrated to a common supervisory standard. In brief, a value-at-risk model produces an estimate of the maximum amount that the bank can lose on a particular portfolio over a given holding period with a given degree of statistical confidence.[6] Although there are a variety of empirical approaches to calculating value at risk, estimates are almost always derived from the behavior of underlying risk factors (such as interest rates and exchange rates) during a recent historical observation period.

The general market risk capital requirement is based on value-at-risk estimates calibrated to a ten-day, 99th percentile standard. That is, if the ten-day, 99th percentile value-at-risk estimate is equal to $100, then the bank would expect to lose more than $100 on only 1 out of 100 ten-day periods. The common supervisory standard is imposed to ensure that the capital charge entails a consistent prudential level across banks. The value-at-risk estimates must be calculated on a daily basis using a minimum historical observation period of one year, or the equivalent of one year if observations are weighted over time. The capital charge for general market risk is equal to the average value-at-risk estimate over the previous sixty trading days (approximately one quarter of the trading year) multiplied by a "scaling factor," which is generally equal to three.[7]

Several aspects of this calculation have generated considerable discussion, and thus it is worth taking a moment to consider them further. First, the ten-day holding period has been criticized as being overly conservative, since under normal market conditions, many positions in a bank's trading portfolio could be liquidated in less than this amount of time.[8] The ten-day standard, however, also reflects the need to address the risks posed by options and other positions with nonlinear price characteristics. Because options' sensitivities to changes in market risk factors can grow at a rate that is disproportionate to the size of changes in the risk factors, a longer holding period can reveal risk exposures that might not be evident with the smaller risk factor movements associated with shorter holding periods. Thus, the choice of a ten-day holding period stems from the view that the value-at-risk estimates used in the capital calculation should incorporate the impact of instantaneous ten-day-sized price moves in the market risk factors. In the language of options, the ten-day holding period serves to calibrate the coverage of "gamma" risk.[9]

Second, the minimum historical observation period has come under question. Critics characterize the year-long minimum as intrusive and argue that longer observation periods have not been shown to result in more accurate value-at-risk estimates. In fact, however, the minimum historical observation period requirement primarily reflects concerns about the variability of the capital requirement across institutions, rather than a judgment by supervisors about the historical observation period likely to produce the most accurate value-at-risk estimates for capital or risk management purposes.[10]

The basic idea behind this requirement is that banks with similar risk exposures should face similar capital charges. In this regard, empirical evidence suggests that shorter observation periods tend to generate value-at-risk estimates that are more volatile over time (Hendricks 1996). Thus, for a set of banks with similar risk exposures, this result implies that the dispersion of value-at-risk estimates across banks will tend to be greater when some of the banks are using short observation periods. The minimum one-year historical observation period is an attempt to limit this disparity.

A third element of the new capital requirements that has proved controversial—indeed, more controversial than any other element—is the scaling factor. The scaling factor has been criticized as an ad hoc supervisory adjustment that undercuts the benefits of basing a capital charge on banks' internal models. In this view, the key advantage of using internal risk measurement models is that they provide more accurate measures of an individual bank's risk exposure than do broad supervisory measures. Accordingly, some have argued that a bank that can demonstrate convincingly that its model is accurate should be subject to a scaling factor of one.

By itself, even a perfectly measured ten-day, 99th percentile value-at-risk figure may not provide a sufficient degree of risk coverage to serve as a prudent capital standard.

In considering this argument, however, it is important to recognize that the overall purpose of the scaling factor is to produce the desired degree of coverage for the market risk capital charge. The market risk capital requirements are intended to ensure that banks hold sufficient capital to withstand the consequences of prolonged and/or severe adverse movements in the market rates and prices affecting the value of their trading portfolios. The key assumption behind the internal models approach is that a value-at-risk estimate calibrated to a ten-day, 99th percentile standard is well correlated with the degree of such risk inherent in the portfolio, and thus is a reasonable base for a minimum capital standard.

Nonetheless, by itself, even a perfectly measured ten-day, 99th percentile value-at-risk figure may not provide a sufficient degree of risk coverage to serve as a prudent capital standard. For one, such a standard implies that a bank is expected to have trading portfolio losses that exceed its required capital in one ten-day period out of a hundred, or about once every four years. An environment

in which banks depleted their market risk capital so frequently could be highly unstable, particularly if such events happened to many banks at the same time (which could occur if banks adopted similar trading strategies). Further, value-at-risk estimates based only on recent historical market data may not incorporate the possibility of severe market events. Thus, a capital standard based on unadjusted value-at-risk estimates might not provide sufficient capital for a bank to withstand the effects of market breaks or unanticipated regime shifts.

The role of the scaling factor is to translate the value-at-risk estimates into an appropriate minimum capital requirement, reflecting considerations both about the accuracy of a bank's value-at-risk model and about prudent capital coverage. The capital cushion should cover possible losses due to market risk over a reasonable capital planning horizon—which is generally seen to reflect a period between one quarter and one year—while at the same time reflecting the fact that banks' trading positions change rapidly over time. As an alternative to the scaling factor, supervisors could have based the capital charge on value-at-risk estimates calibrated to a very stringent prudential standard (for example, a one-year holding period or a 99.999th percentile standard). In practice, however, it is very difficult to derive reliable and verifiable value-at-risk estimates for such extreme parameter values. Actual observations of such "tail events" are few, greatly complicating the task of verifying that any model is accurately measuring the probability of these occurrences. Thus, instead of representing a more "scientific" alternative to the scaling factor, a requirement of this kind would simply introduce a false sense of precision into the capital standards.

By contrast, the scaling factor has the advantage of being simple and easy to implement. It does not require banks to make (or supervisors to evaluate) complex calculations intended to model rare or as yet unobserved events, such as regime shifts or market breaks. At the same time, however, it does seek to provide a capital cushion against such incidents. In addition, it is similar to the techniques used by some banks for internal capital allocation, in which one-day value-at-risk estimates are extrapolated to a much longer holding period (for example, six months or one year) by multiplying by the square root of time (in the case of ten-day value-at-risk estimates, this calculation for a one-year holding period implies a multiplication factor of five). Moreover, comparisons of ten-day, 99th percentile value-at-risk estimates with banks' actual daily trading results suggest that the scaling factor of three provides an adequate level of capital coverage. The results of bank stress-testing programs were also a key input in the decision to use a scaling factor of three.

For additional protection, the market risk capital requirements incorporate a feature intended to ensure that models that systematically underestimate risk exposures are subject to a higher multiplication factor. This feature is the so-called backtesting requirement. Backtesting is a process of confirming the accuracy of value-at-risk models by comparing value-at-risk estimates with subsequent trading outcomes. For instance, an accurate model will produce one-day, 99th percentile value-at-risk estimates that are exceeded by actual trading losses only 1 percent of the time.

The backtesting procedures in the market risk capital requirements use a very simple statistical test based on the number of times during a year that trading losses exceed value-at-risk estimates. For purposes of the backtest, banks will compare daily end-of-day value-at-risk estimates calibrated to a one-day, 99th percentile standard with the next day's trading outcome. Each instance in which a trading loss exceeds the value-at-risk estimate is termed an exception. Since it is unlikely that an accurate model would produce a large number of exceptions, banks with five or more exceptions over a one-year period are subject to a higher scaling factor. The increase in the scaling factor is as large as 33 percent (from three to four) for banks with a very large number of exceptions.

The introduction of the higher scaling factor for banks experiencing five or more exceptions is based on a simple statistical technique that calculates the probability that an accurate value-at-risk model would generate a given number of exceptions during a year of trading days. In theory, these probabilities are independent of the design of any particular model, so the same number of exceptions

is used as the starting point for the higher scaling factor across all banks. Overall, the backtest is calibrated to ensure that a bank with an accurate value-at-risk model is very unlikely to face an increased scaling factor. The relationship between the number of exceptions and the scaling factor is reported in Table 1.[11]

For technical reasons, the backtests conducted by banks may deviate from the ideal conditions assumed in the statistical derivation. For one, the trading gains and losses used in the backtest calculation may be based on the actual trading outcomes booked by the bank, and in that case will include fee income and the profits and losses from intraday trading. This means that the profit and loss figures used in the backtest could reflect influences not incorporated into the value-at-risk model, potentially introducing bias into the backtest results. The direction of the bias is not clear, however. On the one hand, including fee income in the profit and loss figures will tend to reduce the number of exceptions identified. On the other hand, the impact of intraday trading will likely increase the volatility of the daily profit and loss figures relative to the value-at-risk estimates, increasing the probability of an exception.

One possible response would be to require banks to calculate hypothetical profit and loss figures by holding end-of-day positions constant and excluding fee income. This calculation could become quite burdensome, however. For this reason, and because the use of actual profit and loss figures in the backtest does not produce a clear bias in the test, banks are allowed to use the profit and loss information already at hand.

Finally, the backtest is calibrated to a one-day standard, whereas the value-at-risk estimates used for capital purposes are calibrated to a ten-day standard. Many commentators have pointed out that this difference introduces a discrepancy between the value-at-risk estimates validated in the backtest and the estimate actually used for capital purposes. Once again, the reasoning behind this specification reflects the practical limitations of testing value-at-risk estimates calibrated to a ten-day standard: backtesting such estimates would require a significant amount of historical data to generate a series of independent ten-day profit and loss figures. With only a limited number of such observations—just twenty-six over a one-year horizon—the power of the backtest to distinguish between accurate and inaccurate models is very limited. Thus, the supervisory backtest is calibrated to a one-day standard to strike a balance between the need to have a sufficient amount of data to give the backtest statistical power and the desire to determine the accuracy of the value-at-risk model used in the capital calculations.

Table 1
BACKTESTING AND THE SCALING FACTOR

Number of Exceptions (Out of 250 Trading Days)	Scaling Factor	Cumulative Probability (Percent)
0 to 4	3.00	10.78
5	3.40	4.12
6	3.50	1.37
7	3.65	0.40
8	3.75	0.11
9	3.85	0.03
10 or more	4.00	<0.01

Note: The "cumulative probability" column reports the probability that an accurate model would generate more than the number of exceptions reported in the first column. These figures are generated using a binomial distribution, assuming a sample size of 250 trading days. For the purpose of the backtest, an accurate model is one that produces an accurate estimate of the 99th percentile of the distribution of one-day trading gains and losses. Thus, an accurate value-at-risk model will produce more than five exceptions over a 250-day trading period 4.12 percent of the time.

CAPITAL REQUIREMENTS FOR SPECIFIC RISK

As noted earlier, the capital requirements for specific risk are intended to cover the risk of adverse price movements stemming from factors related to the issuer of an individual security. Thus, debt and equity positions in bank trading portfolios are assumed to be subject to specific risk. Under the original risk-based capital guidelines put forth in 1988, long debt and equity positions in a trading portfolio were subject to capital charges ranging from 0 percent (for government securities) to 8 percent (for corporate debt and equity) of the book value of the positions. Under the amended guidelines, both long and short debt and equity positions are covered by the market risk capital requirement for specific risk.

Banks whose value-at-risk models incorporate specific risk can use the specific risk estimates generated

by their models.[12] Under the most recent announcement by the Basle Committee on Banking Supervision (1997), these model-based specific risk estimates are subject to a scaling factor of four until market practice evolves and banks can demonstrate that their models of specific risk adequately address both idiosyncratic risks and "event risks"

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that might not be captured in a value-at-risk model.[13] This provision holds out the prospect of harmonizing the specific risk capital requirements fully with the general market risk requirements as market practices with respect to positions subject to significant event risks become clearer. This approach is consistent with the view that there is no compelling conceptual reason to separate market risk into a general and a specific portion in a value-at-risk model, or to apply different standards to one portion than to another.

Impact of the Capital Requirements

Effect on Capital Levels and Capital Ratios

How the market risk requirements will affect banks' required capital ratios is difficult to calculate precisely with the data currently in the public domain. Such calculations require both information on banks' value-at-risk estimates—calibrated to the ten-day, 99th percentile supervisory standard—and information about the distribution of trading assets and liabilities among various specific risk categories. Despite the lack of such data, however, it is possible to make a rough estimate of the impact of the capital charge by using information reported in banks' annual reports.

Table 2 reports 1996 average value-at-risk estimates for a sample of large bank holding companies that presented annual average value-at-risk estimates in their 1996 annual reports along with sufficient descriptive detail to identify the holding period and percentile underlying the estimate.[14] As indicated in Table 2, all of the estimates were based on a one-day holding period, with percentiles ranging from the 95th to the 99th. The divergence in these parameters, as well as in other aspects of the estimates such as correlation assumptions, makes direct comparisons of these figures across institutions difficult.

Nevertheless, these figures suggest that the impact of the market risk capital charge on required capital levels and capital ratios is likely to be quite small. Using these numbers, we calculate that the estimated increase in the level of required capital from the general market risk component of the new capital charge ranges roughly between 1.5 and 7.5 percent for these banking companies. We find that the impact on the capital ratios is also fairly modest, with an average decline of about 30 basis points and 40 basis points in the tier 1 and total capital ratios, respectively. These calculations are at best rough estimates, however, and could differ significantly from the actual impact of the capital charge at the time it becomes effective. Such differences would reflect both estimation error in translating the reported figures to the supervisory stan-

Table 2
1996 Annual Average Value-at-Risk Estimates for Selected U.S. Bank Holding Companies

Bank Holding Company	1996 Average Daily VAR (Millions of Dollars)	Percentile Basis	Holding Period
BankAmerica	42[a]	97.5	1 day
Bankers Trust	39	99.0	1 day
Chase Manhattan	24[b]	95.0	1 day
Citicorp	45[c]	2σ	1 day
J.P. Morgan	21	95.0	1 day

Note: The average 1996 value-at-risk (VAR) figures are drawn from the companies' 1996 annual reports.

[a] Figure assumes a correlation of one between broad risk categories. The comparable figure assuming a correlation of zero is $18 million.

[b] Figure is based on the volatility of actual daily trading results, as reported in the 1996 annual report.

[c] The 2σ VAR figure is equivalent to the 97.7th percentile under a normal distribution.

dards and changes in the bank holding companies' portfolios over time.

Once we account for the capital treatment of specific risk, the overall impact of the market risk capital charge is likely to be even smaller than our calculations suggest. As noted earlier, many traded debt and equity positions subject to the credit risk capital requirements under the original capital guidelines are now subject to specific risk capital requirements based on the output of banks' internal models. This "specific risk carve-out" will offset the impact of the additional general market risk capital charge, possibly to a considerable degree. Unfortunately, the data needed to make reasonably precise estimates of this effect are not currently available. However, given the significant positions that some institutions hold in instruments that will become subject to the specific risk capital requirements, this carve-out may well result in a net *reduction* in required capital levels for some institutions.

Advantages of the Internal Models Approach

Whatever the effect of the new standards on the level of overall required capital, capital requirements based on internal models should produce minimum regulatory capital charges that more closely match banks' true risk exposures. This closer relationship is important not only for determining the risk facing an institution at a particular moment in time, but also for tracing the evolution of risk over time. That is, while the value-at-risk estimates underlying the market risk capital charge are useful for assessing the *level* of risk undertaken by a bank or bank holding company at a given moment, they are potentially even more beneficial for understanding *changes* in risk exposure over time. By extension, the key benefit of the market risk capital charge is that the required capital levels will evolve with risk exposures over time.

In addition to tightening the link between risk exposures and capital requirements, a capital charge based on internal models may provide supervisors and the financial markets with a consistent framework for making comparisons across institutions. As the information in Table 2 makes clear, the value-at-risk figures presented in the annual reports of various bank holding companies are calculated using different parameters, especially the percentile of the loss distribution. These differences make comparisons across institutions difficult without additional calculations to convert the figures to a common basis. Typically, these calculations require assumptions that may be only approximately correct, introducing additional noise in the comparisons.

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By contrast, the market risk capital charge provides a common standard for value-at-risk estimates that makes comparisons across institutions easier and more reliable. The value-at-risk estimates underlying banks' capital charges will be based on a uniform set of prudential parameters and will accurately reflect the assumptions and specifications of each bank's internal model (rather than an external approximation). Further, the financial markets may gain information about the performance and accuracy of these models over time if banks make public the results of their backtests. While disclosure of the details of these results is purely discretionary, this backtesting information is consistent with the type of disclosures about market risks advocated in several recent discussion papers (see Bank for International Settlements [1994] and Federal Reserve Bank of New York [1994] for two examples).

Challenges for Supervisors

The actual benefits to be derived from the value-at-risk estimates depend crucially on the quality and accuracy of

the models on which the estimates are based. To the extent that these models are inaccurate and misstate banks' true risk exposures, then the quality of the information derived from any public disclosure will be degraded. More important, inaccurate value-at-risk models or models that do not produce consistent estimates over time will undercut the main benefit of a models-based capital requirement: the closer tie between capital requirements and true risk exposures. Thus, assessment of the accuracy of these models is a key concern for supervisors.

The discussion of value-at-risk models in this paper might suggest that supervisory evaluation of banks' internal models is a daunting task, necessitating the hiring of large numbers of new staff with the same degree of technical and market expertise as the bank personnel responsible for developing and implementing the models. This interpretation is somewhat mistaken, however. Although the task of assessing value-at-risk models requires supervisors to maintain staff with a high degree of technical skill and experience in reviewing banks' trading operations, it is largely an extension of the activities routinely performed by U.S. bank supervisors in overseeing the trading operations of major banks. These activities have typically entailed review and assessment of the accuracy and appropriateness of the models used by banks for pricing, risk management, and general ledger profit and loss calculations. Thus, the basic procedures for evaluating value-at-risk models are similar to those that have been used by U.S. supervisors for some time in reviewing banks' trading activities. The procedures followed by examiners are also quite similar in spirit to the techniques used by auditors and accountants to assess the accuracy of the books and records of a banking institution.

As a first step, supervisors can turn to the internal auditing and certification processes used by the banks to validate the accuracy and performance of their models. The qualitative standards imposed by the market risk capital guidelines require independent validation of any models used to value positions or to measure the sensitivity of portfolios to market risk. As we have seen, the standards also call for an independent risk management unit and an independent internal or external audit of a bank's risk management processes. The results of these internal reviews provide supervisors with a valuable starting point for their own evaluation. The standards also mandate that the models be used as an integral part of a bank's risk management process—for instance, as part of daily management reports or as the basis of the bank's limit system. Because the models are used for purposes that go well beyond calculating regulatory capital levels, the interests of bank management in obtaining accurate value-at-risk estimates may be more closely aligned with the interests of supervisors.

Backtesting results—both those generated as required for supervisory capital purposes and additional results generated by institutions for internal validation and calibration—also provide supervisors with important information about the accuracy of value-at-risk models. Although the backtesting procedures incorporated in the market risk capital requirements are based on relatively simple statistical tests, researchers at the banks and elsewhere are actively investigating how to use ex post trading results to draw inferences about the accuracy and performance of value-at-risk models (see Kupiec [1995], Crnkovic and Drachman [1996], and Lopez [1997]). This work may lead to better and more powerful techniques for using these data to assess the accuracy of value-at-risk models.

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In addition to drawing on these resources, supervisors rely on a dialogue with risk management staff at the bank in question and on a process of evaluating key assumptions and parameters of the models. Both the dialogue with the banks and the evaluation of the model parameters depend on having supervisory staff that can assess the technical work performed by a bank's risk management and trading staff. But while developing and retaining examiners with these skills is a key challenge for supervisors, the task is likely to become easier over time. Basic information about the structure and theoretical underpinnings of value-at-risk models is spreading, and the models are quickly becoming commonplace at financial (and nonfinancial) institutions. An understanding of these models is also emerging as a standard part of the skills acquired through academic and on-the-job training in finance and risk management. Thus, value-at-risk modeling is becoming a significantly less arcane area of both risk management and supervisory oversight.

Taken together, these factors suggest that supervisors have a broad arsenal of approaches to use in evaluating value-at-risk models. While experience over time will determine whether the information generated by these models is consistent and reliable, there is good reason to believe that the market risk capital requirements will yield information that is useful to both supervisors and market participants.

Implications for the Future

Market risk capital requirements based on internal models have drawn considerable attention since the initial proposal for these requirements was released in 1995. During this time, supervisory interest in value-at-risk models has encouraged banks in the United States and abroad to direct resources and attention toward the further development of these models and their fuller integration with the risk management process.

In the coming years, some of the key issues facing banks in value-at-risk modeling—and in risk management more generally—will concern the extension of these models to cover a broader range of the risks facing banking institutions. For example, can quantitative risk models be applied to credit, operational, and legal risks? And if so, should supervisors expand the use of their internal models to derive capital charges for these exposures? Interestingly, these issues have already surfaced in banks' efforts to model specific risk. Specific risk incorporates elements of both market risk and credit risk. In measuring specific risk, banks face a number of difficult technical and conceptual problems—how to measure the probability and likely impact of events that occur infrequently and how to quantify the effects of complex events that depend on the interrelated actions of many parties. These problems, which are at the frontier of thinking about regulatory capital and banks' internal capital allocation, will need to be resolved if quantitative risk models are to be used systematically to gauge other forms of risk.

At present, banks and other financial institutions are still in the early stages of developing methods for quantifying other types of risk and for integrating these risks into a unified capital allocation framework. Understanding the ways that risk models can and cannot be used is clearly one of the most significant challenges facing financial institutions and their supervisors today. The market risk capital requirements may further this understanding by providing a test case for the supervisory use of internal models.

ENDNOTES

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1. See Board of Governors of the Federal Reserve System (1994) for a description of the risk-based capital standards that apply to state member banks and bank holding companies. The standards for state nonmember banks and for national banks (administered by the Federal Deposit Insurance Corporation and the Office of the Comptroller of the Currency, respectively) are essentially identical.

2. Readers interested in the details of the market risk capital requirements should see Basle Committee on Banking Supervision (1996a) and U.S. Department of the Treasury, Federal Reserve System, and Federal Deposit Insurance Corporation (1996). The amended Basle Accord contains a second method for calculating market risk capital requirements that is not included in the U.S. guidelines. This second approach—the "standardized approach"—requires an institution to apply certain uniform techniques to calculate the capital charge for market risk. It is also important to distinguish the internal models approach contained in the U.S. guidelines from the so-called precommitment approach, which has been released for discussion by the Board of Governors of the Federal Reserve System and is being explored in a pilot project by the New York Clearing House (see Board of Governors of the Federal Reserve System [1995]). Under the precommitment approach, banks would have latitude to specify the amount of capital they wished to allocate to market risk, subject to penalties if subsequent trading losses exceeded this precommitted amount. This approach is one of several alternative methods that have been suggested for determining banks' capital requirements. For another, see Estrella (1995), who proposes capital supervision based on banks' internally determined "optimal" capital levels, in combination with a simple supervisory minimum.

3. The U.S. capital standards have recently been amended to require that a bank's capital be adequate to cover its overall exposure to interest rate risk. This determination is made as part of a bank's supervisory examination, rather than through a formal minimum capital requirement.

4. The exceptions are derivative positions, which continue to be subject to counterparty credit risk capital requirements.

5. As of the end of 1996, seventeen commercial banks met these criteria. These seventeen banks held nearly 98 percent of the trading positions (assets plus liabilities) held by all U.S. commercial banks. In addition, seventeen bank holding companies met the criteria, including the holding companies associated with fourteen of the seventeen banks. The actual number of institutions that are ultimately subject to the market risk capital requirements may differ from these figures, for two reasons: supervisors can, at their own discretion, include or exclude particular institutions, and institutions have the option to become subject to the capital requirements with supervisory approval.

6. See Jorion (1996) for a more detailed discussion of value-at-risk models. Hendricks (1996) compares the performance of several types of value-at-risk models.

7. To be precise, the capital charge for general market risk is equal to the greater of the sixty-day average value-at-risk estimate times the scaling factor *or* the previous day's value-at-risk estimate. As a practical matter, the previous day's value-at-risk estimate should rarely, if ever, exceed the sixty-day average times three.

8. Of course, some positions could take longer than ten days to liquidate. The extent to which a ten-day holding period is a suitable average would obviously depend on the characteristics of an individual portfolio.

9. Gamma risk arises from the fact that the sensitivity of an option's value to changes in the value of the option's underlying instrument will vary as the value of the underlying instrument changes.

10. Note, however, that the existing empirical evidence does not suggest substantial differences in the performance of value-at-risk models with varying observations periods.

11. For a full discussion of the use of backtesting in the market risk capital requirements, see Basle Committee on Banking Supervision (1996b). For a discussion of the statistical properties of backtesting and other methods of evaluating the accuracy of value-at-risk models, see Kupiec (1995) and Lopez (1997).

12. For banks whose value-at-risk models do not adequately incorporate specific risk, debt and equity positions in the trading portfolio are subject to a set of standardized specific risk charges, which apply to both long and short positions. These charges are added to the value-at-risk-based general market risk charge. The standardized charges are in many cases significantly lower than the original credit risk capital charges. For instance, an investment-grade corporate bond, which would have been subject to an 8 percent credit risk capital charge under the earlier guidelines, is now subject to a 1.6 percent specific risk charge.

13. There is a concern that measures of recent price variability may not provide a complete guide to the potential risk inherent in some positions—for example, illiquid positions that trade infrequently. This concern, together with the existence of differing market practices in this regard, has been a factor in shaping the interim approach to specific risk.

14. The institutions cited in Table 2 are used for illustrative purposes only. They do not represent an exhaustive list of the bank holding companies that reported value-at-risk estimates in their 1996 annual reports.

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