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Are banks using derivatives to hedge financial risks or to make speculative gambles? While data are not available to answer this question fully and directly, the relationship between bank capital and derivatives activities may provide an important clue. This study provides evidence that those banks with the highest capital cushion with which to absorb losses and potentially the lowest risk-taking incentives are the ones with the highest derivatives participation. This finding is consistent with the view that either financially strong institutions are using derivatives to hedge, or regulatory and market discipline have made higher capital levels a prerequisite for derivatives activities. Either way, a positive relationship between derivatives activities and capitalization should help ease concerns regarding bank derivatives activities.

Unanticipated increases in interest rates are often viewed as harmful to banks. This assumption arises partly from the fact that banks are frequently viewed as institutions that borrow short and lend long. Because the implementation of the Basle risk-based capital standards did not include a capital charge for interest-rate risk, banks may have been encouraged to substitute interest-rate risk for credit risk in their portfolios. Here, two approaches are used to estimate whether interest-rate risk at banks has increased significantly since the implementation of risk-based capital standards. One method relies on bank stock price data to judge the effects of interest-rate increases on banks' market value, while the other approach uses bank accounting data to infer long-run effects of interest-rate movements on bank profitability. Overall, the results provide some evidence that interest-rate risk is higher after the Basle capital standards took effect.

Who's Capitalizing On Derivatives?

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Are banks using derivatives to hedge financial risks or to make speculative gambles? This study provides evidence that those banks with the highest capital cushion with which to absorb losses and potentially the lowest risk-taking incentives are the ones with the highest derivatives participation.

Financial derivatives activity at U.S. banks, as measured by the notional value of derivatives contracts, has increased dramatically in recent years, more than doubling from roughly $7 trillion in the first quarter of 1991 to about $16 trillion by year-end 1994 (*Chart 1*). This tremendous growth, coupled with recent highly publicized derivatives-related losses, has led bank regulators and policymakers to question the potential impact of derivatives activities on the safety and soundness of the banking system.

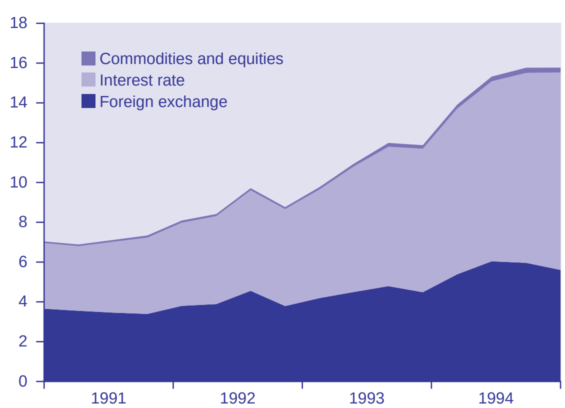
One view of these issues emphasizes the benefits of derivatives activities in helping banks manage risks and serve their financial customers. Under this view, regulatory capital standards, disclosure requirements, and supervisory guidelines are seen as sufficient controls over the generally beneficial use of derivatives instruments.[1]

But an alternative view characterizes derivatives activities as highly speculative endeavors that greatly jeopardize financial safety and soundness. The focus is placed on the potential for weak or ill-managed institutions to suffer large losses through derivatives trading, thereby endangering the safety of both the banking system and the fund that backs federally insured deposits. In this regard, some have favored restricting, or even banning, derivatives activities at insured commercial banks. In this way, the nature of proposals for the appropriate regulatory response to the recent growth in derivatives activities depends on assessments of the motivations and actions of derivatives users.[2]

The regulatory policy debate over derivatives has been accompanied by a search for evidence on the nature of the derivatives activi-

Chart 1
Growth of Financial Derivatives Activities At U.S. Insured Commercial Banks

Notional value, trillions of dollars



[1] See Siems (1994), Abken (1994), and Becketti (1993) for studies that conclude that banks can safely manage and regulators can effectively supervise bank participation in derivatives markets. Also, the Group of Thirty (1993), an international policy organization made up of representatives of central banks, international banks, securities firms, and academia, emphasizes the positive economic benefits associated with derivatives and has published a set of recommendations for users and dealers of financial derivatives.

[2] See the General Accounting Office (1994) for recommendations calling for stiffer government regulation of financial derivatives markets.

ties actually conducted by banks. Are derivatives being used to hedge or to speculate? And to what extent are banks acting in the capacity of a dealer, as opposed to taking net positions themselves?

Unfortunately, the information banks submit quarterly in regulatory financial statements does not specify the nature of derivatives activities at individual institutions. As a result, it often is difficult to distinguish empirically hedging from speculative activities, and a bank's derivatives involvement as a dealer also is not directly identifiable.

Nevertheless, it may be possible to address some of the concerns currently facing policymakers through an analysis of the relationship between derivatives activities and bank capital. Bank capital long has played a prominent role in the supervisory process. And that role was enhanced further with the enactment of the Federal Deposit Insurance Corporation Improvement Act of 1991, which established new policies and procedures designed to control tightly the activities of thinly capitalized banks, while expanding the options and activities open to banks that maintain relatively high capital levels. The basic philosophy underlying the capital-based supervisory approach is that banks with relatively low capital ratios have a smaller cushion with which to protect the Bank Insurance Fund from potential losses and a greater incentive to engage in high-risk activities. Such considerations suggest that tighter restrictions on thinly capitalized institutions may be appropriate.

The question then arises of whether derivatives activities, which often are more complex and somewhat more difficult for regulators to monitor than bank lending activities, have tended to be associated with high or low capital levels. If derivatives activities were concentrated at thinly capitalized banks, then that would reinforce concerns over the possible motivations and potential losses of derivatives players. Conversely, a positive capital–derivatives relationship would help ease such concerns, since greater derivatives participation at least would be associated with stronger capital positions.

To date, much of the evidence submitted on this issue has suggested an association of derivatives activities with low capitalization. However, in this article, we offer substantial evidence in the other direction. Specifically, we find that, for most size classes of banks, the intensity of derivatives activities, as measured by the notional value of derivatives contracts relative to total bank assets, is higher for banks with relatively high capital levels.

These findings have important implications for the supervision of the derivatives activities of commercial banks. If banks are using financial derivatives in a speculative or risky fashion, then the finding of a positive relationship between derivatives activities and capitalization is consistent with the view that regulatory measures have offset the incentive for thinly capitalized banks to take on increased risk. Those banks with the highest capital cushion with which to absorb losses and, as a result, the lowest risk-taking incentives, are the ones with the highest derivatives participation. These findings cast considerable doubt on the view that banks are placing large financial bets through derivatives.

If, on the other hand, banks use derivatives primarily to hedge, or reduce risk, then our findings are consistent with the view that, because well-capitalized banks have relatively low risk-taking incentives, they are more likely to hedge. Either way, the finding of a positive relationship between derivatives activities and capitalization should ease concerns that additional regulatory restrictions on bank derivatives activities are necessary at this time.

Factors potentially influencing derivatives usage

What are the determining factors that motivate banks to use derivatives? This question is complicated by the multiple uses of derivatives instruments. Individual banks can use derivatives not only to hedge, but also to speculate on changes in interest rates or exchange rates in anticipation of expected market movements. And banks can trade derivatives by serving as a dealer in helping other organizations meet their specific risk management objectives. Moreover, an additional complicating factor in analyzing bank derivative usage is the influence of regulatory and market discipline on a bank's decision to use derivatives in any of these alternative capacities.

Hedging. Perhaps one of the strongest motivations for using derivatives is their potential effectiveness in hedging financial risks. For corporations, Nance, Smith, and Smithson (1993) argue that the use of derivatives to hedge risks can increase the value of firms by reducing expected taxes, the costs associated with financial distress, and the likelihood of bond defaults. Sinkey and Carter (1994) build on this theory of hedging behavior—together with contemporary theories of banking, as discussed in Bhattacharya and Thakor (1993)—to examine empirically the determinants of the hedging and derivatives activities of U.S. commercial banks. Sinkey and Carter find that the use of derivatives is associated with smaller maturity gaps, greater liquidity, lower net interest margins, higher dividends, greater use of subordinated debt, and lower capital ratios.

Speculation. In addition to the types of motivating factors related to hedging, the existence of the federal safety net for bank deposits may give banks special reasons for using derivatives. In particular, mispriced deposit insurance can lead to risk-taking incentives.[3] When deposit insurance premiums do not fully reflect the risk of individual institutions, a bank's incentive for risk-taking tends to increase as its level of capitalization falls. Such risk-taking incentives are a particular manifestation of the general moral hazard problem, which occurs when the method of insurance alters the behavior of the insured. Because of this incentive structure, banks may attempt to exploit government subsidies by taking on increased risk during times of financial stress. Such considerations have helped generate concern among regulators and policymakers over the potential for speculative derivatives activities.

To the extent that derivatives are used to speculate, the moral hazard hypothesis would predict that derivatives usage should increase as capitalization falls. Conversely, if derivatives are used mainly to hedge, the moral hazard hypothesis would suggest that derivatives activities should be greater at relatively well-capitalized institutions. Intuitively, such banks should be more likely to hedge unwanted risks because more of the banks' own capital is at stake.

Regulatory discipline. The existence of federal deposit insurance is a key motivating factor behind the existence of federal bank supervision and regulation. Because the government has guaranteed the safety of most bank deposits, the responsibility for monitoring and disciplining bank behavior essentially has devolved from depositors to the regulatory agencies. Under this type of system, Buser, Chen, and Kane (1981) describe the way in which regulatory and supervisory restrictions might increase as bank capital levels fall. Similarly, Merton and Bodie (1992) argue that the appropriate regulatory response to potentially excessive bank risk-taking might include monitoring, risk-based deposit insurance premiums, cash-asset reserve and capital requirements, portfolio restrictions, and limits on discount window borrowing.

To the extent that these regulatory measures are effective, the negative relationship between bank capital levels and risk-taking predicted by moral hazard considerations might be offset or even reversed. If derivatives are used for speculative purposes, then these considerations suggest derivatives participation should fall as capital levels decline.

Table 1
The Capital–Derivatives Relationship

Relationship to capitalization	Derivatives usage: Hedging	Derivatives usage: Speculating
Positive	**Box A** Moral hazard	**Box B** Regulatory and market discipline
Negative	**Box C** Regulatory and market discipline	**Box D** Moral hazard

Market discipline. Although the existence of federal deposit guarantees reduces the potential disciplinary role of depositors, certain peculiarities of derivatives instruments suggest that market forces may still play a role in disciplining bank derivatives activities. In particular, since many derivatives contracts are made over the counter without the benefit of a third-party guarantee, low capital levels may reduce access to the derivatives markets. Perhaps more importantly, to the extent that banks use derivatives to speculate, the monitoring and disciplining activities of uninsured bank creditors also would be expected to result in a positive relationship between bank capitalization and derivatives participation.

Dealing. Finally, as financial intermediaries, banks can use derivatives to help financial customers manage their own risk positions. In this capacity, banks manage an entire derivatives portfolio, with specific contracts linked to the special needs of individual customers. However, while derivatives are easily accessible, successful derivatives trading requires a substantial investment in intellectual and reputational capital.[4] The time and resources required to understand and monitor derivatives activities may make some banks reluctant to participate in the derivatives markets, particularly in the capacity of a dealer. Typically, large banks are able to develop derivatives expertise and exploit innovations more efficiently because of size and technical efficiencies.[5] In particular, Booth, Smith, and Stolz (1984) and Block and Gallagher (1986) assert that informational and transactional scale economies can promote increased derivatives usage for dealing.

Implications of the capital–derivatives relationship

In light of these arguments, the relationship between bank capital ratios and derivatives activities is particularly important, as shown in Table 1. If banks use derivatives to hedge against unwanted risks and to maintain their capital base, then, under the moral hazard hypothesis,

[3] See, for example, Merton (1978, 1977); Kareken and Wallace (1978); Buser, Chen, and Kane (1981); Marcus (1984); Kane (1989, 1985); and Short (1987).

[4] See Hu (1993) for a review essay that traces the history of the development of derivatives and the emergence of the new "financial science," which integrates mathematical sophistication and economics into finance and raises the level of conceptualization in financial methodologies. In addition, Bernstein (1992) provides a comprehensive history of modern finance recounted with wit and elegance that should be useful to academics and interested lay readers alike.

[5] Hunter and Timme (1986) argue that large banks have used their operating efficiencies as a means of remaining competitive in deposit markets.

capital levels should be positively associated with derivatives usage, as shown in Box A. Conversely, if derivatives are used primarily to speculate, then the moral hazard hypothesis would predict a negative relationship between bank capital levels and derivatives activities, as shown in Box D.

The regulatory and market discipline hypotheses produce the opposite predictions. If banks use derivatives to speculate, regulatory discipline, and possibly market forces, might counter any existing moral hazard incentives and give rise to a positive capital–derivatives relationship, as shown in Box B. On the other hand, to the extent that derivatives are used to hedge, regulatory and market discipline might motivate thinly capitalized banks to make the greatest use of derivatives instruments, as shown in Box C.[6]

From a policy perspective, the finding of a positive relationship between bank capitalization and derivatives activities would be the most comforting, since such a result would rule out the combination of speculation and moral hazard shown in Box D.

Evidence from the early 1990s

Currently, regulatory financial statements give little information to identify directly the nature of derivatives activities at individual institutions. However, despite the interpretative difficulties inherent in current derivatives data, several researchers have attempted to infer the motivations for derivatives usage by analyzing the relationships between derivatives participation and various potential explanatory variables.

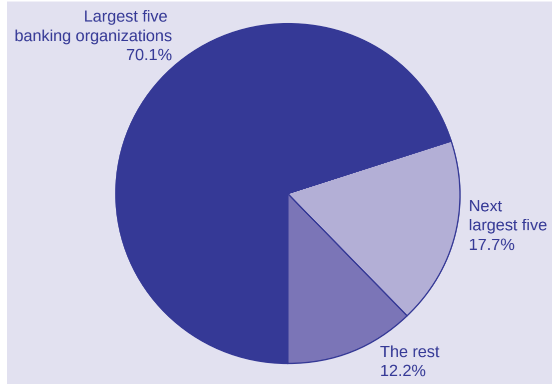
Clear evidence exists to support the notion that scale economies in derivatives activities favor large banks. Based on the reported notional value of derivatives contracts at year-end 1994, the ten largest commercial banks account for more than 87 percent of total derivatives activity in the U.S. banking industry (*Chart 2*). The high market share of these large institutions mostly reflects their dominance as derivatives dealers.

But beyond such obvious factors, relatively little is known concerning the nature of bank derivatives activities. The few studies conducted to date have tended to suggest a negative relationship between bank capitalization and derivatives.[7]

In this study, we examine the year-end financial reports submitted to regulators by individual banks over the period from 1991 through 1994 to assess the relationship between bank capitalization and derivatives activities. For each time period, banks that reported having derivatives contracts are divided into five asset size groups and also three capitalization groups.[8] Each asset size group contains 20 percent of the banks, with the first group containing the first 20 percent of the banks, as ranked from the smallest to largest, while the fifth asset size group contains the largest banks. Similarly, each capitalization group contains one-third of the banks, with the first group containing the first third of the banks, as ranked from the weakest to the strongest capitalization, while the banks with the highest capital ratios are placed in the third capitalization group. For each asset size group, we calculate, by level of capitalization, the median value of the intensity of derivatives participation, which is measured by the notional value of derivatives contracts relative to total bank assets.[9]

Chart 2
Distribution of Derivatives Activities Across U.S. Insured Commercial Banks

(Notional value, fourth-quarter 1994)



Based on data for the period from 1991 through 1994, Chart 3 shows the median notional value of derivatives relative to total assets for each asset size category and capitalization level. In each of the four years, the largest banks are the most active derivatives participants, as expected. Informational and transactional scale economies allow the largest institutions to exploit most efficiently the newest innovations and establish extensive dealer activities.

More importantly, the figures also reveal a strong relationship between bank capital levels and derivatives activity. For virtually every size group and year, derivatives participation increases with capitalization, as measured by the ratio of equity capital to total assets. In particular, the highly capitalized banks have a greater intensity of derivatives participation than banks with low capital for eighteen of the twenty

6 This prediction is complicated, however, by the frequent lack of precise information on the nature of banks' derivatives activities. For example, if derivatives were used to hedge and reduce overall risk, regulatory factors may still work to restrict derivatives activities if the risk-reducing nature of the activities was not revealed.

7 Sinkey and Carter (1994) find that banks using derivatives have weaker capital positions, smaller maturity gaps, lower net interest margins, more notes and debentures in their capital structures, higher dividend payout rates, and greater liquidity. Kim and Koppenhaver (1992) provide evidence that the ratio of the notional value of interest-rate swaps to total assets is reduced for banks with capital close to or below regulatory minimums. However, for banks in general, they find that swap exposure is negatively related to capital ratios.

8 Only a small proportion of banks actually engage in derivatives activities. Of the 10,432 insured commercial banks in the United States at the end of 1994, only 624, or 6 percent, reported any derivatives-related activities.

9 The notional value of derivatives contracts is an imprecise measure of derivatives activities. For example, the notional value of an interest-rate swap represents the principal upon which the traded interest payments are calculated, and a bank that serves merely as an intermediary in a swap transaction reports the same notional value twice, once for each side of the swap. However, due to data limitations, most previous studies of derivatives activities also are based on notional values.

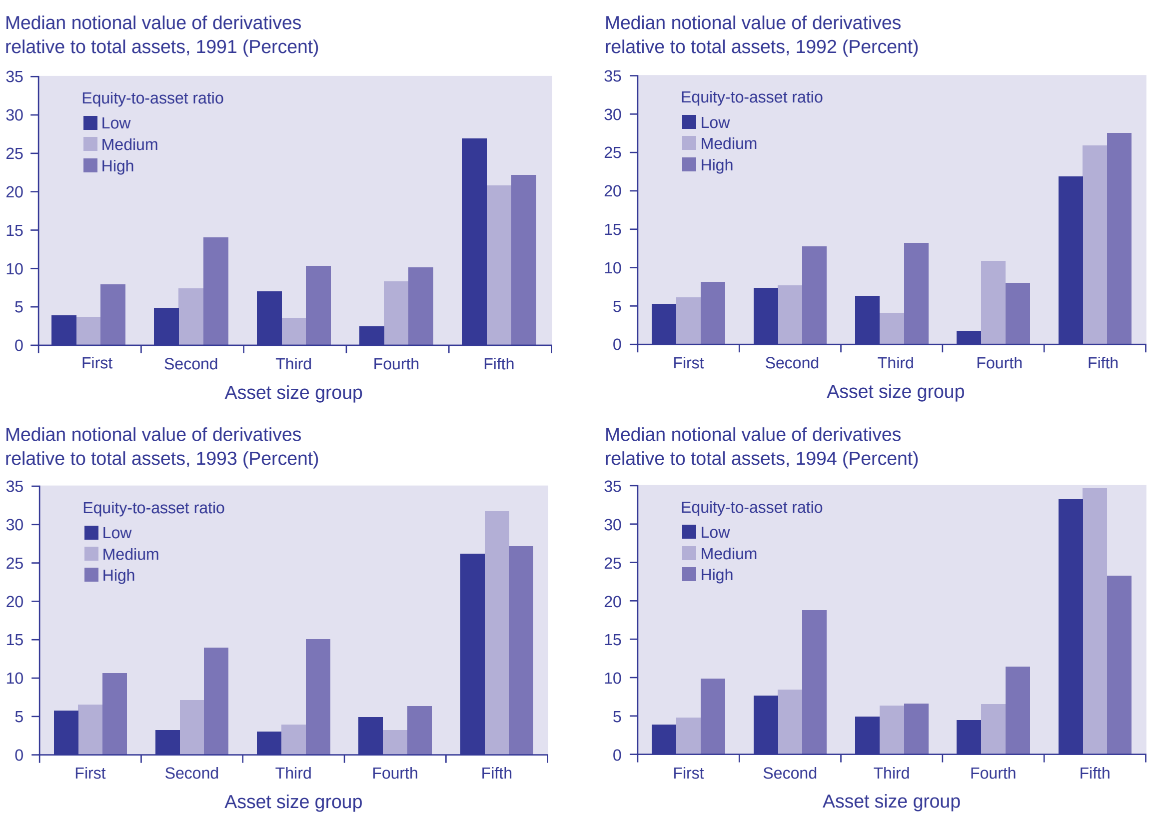
combinations of time period and size. The only exceptions occur for the largest group of banks, which exhibits a negative relationship between capitalization and derivatives activities in 1991 and 1994. These departures from the general positive capital–derivatives relationship represent a source of concern, since they occur at the largest banks, which tend to dominate smaller banks in terms of derivatives participation.

However, the mixed results for the group of largest banks may simply reflect the greater participation of large banks in dealing activities. Because dealers oversee large portfolios of derivatives and manage the net risk, or residual risk, of their overall derivatives positions, the relationship between capital and total derivatives activities may be muted. For dealers, derivatives activities may be much more a function of a bank's size, its trading expertise, and its reputation than of its capital level. Moreover, capital levels increased over the time period examined here, so that the median capital-to-asset ratio for the large banks categorized as having low capitalization was 6.07 percent in 1994, versus 5.34 percent in 1991. Viewed in the context of dealing activities, for which reputational capital is particularly important, the lack of a consistently positive relationship between capitalization and derivatives activities at the large banks may have few implications for the motivations and potential losses of derivatives participants.[10]

Overall, the positive association between bank capital and derivatives activities is comforting from a regulatory perspective. To the extent that derivatives are used primarily to hedge, then the related policy concerns are minimal in any case. And the positive capital–derivatives relationship shown here provides evidence against the view that banks are pursuing moral hazard incentives through derivatives speculation, since, under moral hazard, it is thinly capitalized banks that have the greatest incentive to take on risk. If derivatives are being used for speculative purposes, at least regulatory discipline, and possibly market forces, have required additional capital as a prerequisite for increased derivatives participation.

Gunther and Siems (1995) report similar findings on the capital–derivatives relationship. Gunther and Siems employ a general statistical framework to analyze the separate relationships between capitalization, a bank's participation in derivatives (or lack of it), and the extent of participation. After controlling for the potential

Chart 3
Equity-to-Asset Ratio and Derivatives Activity



[10] In addition, analyzing the five asset size groups separately only partly controls for the influence of size on derivatives activities. In particular, the fifth, or largest, asset size group includes a wide range of asset sizes, and the two cases of a seemingly negative relationship between capitalization and derivatives activities partly reflect relatively high derivatives participation by the very largest banks in the group, which often tend to manage their capital levels relatively close to regulatory minimums.

influence of a number of additional variables, capital levels are found not to influence banks' decision to participate in derivatives activities. However, in agreement with the results reported here, Gunther and Siems find capitalization to be positively associated with the magnitude of derivatives activities for those banks participating in the derivatives markets.

The treatment of off-balance-sheet activities under risk-based capital guidelines may be one regulatory force contributing to the positive association between derivatives usage and capitalization. Wall, Pringle, and McNulty (1990) describe the treatment of derivatives activities under the international risk-based capital standards established by the 1988 Basle Accord. These standards set forth a framework for measuring capital adequacy under which risk-weighted assets are calculated by assigning assets to broad categories of activities based primarily on their perceived credit risk. Off-balance-sheet transactions are included in risk-weighted assets by converting each transaction item into a credit-equivalent amount, which is then assigned to a particular credit-risk category.

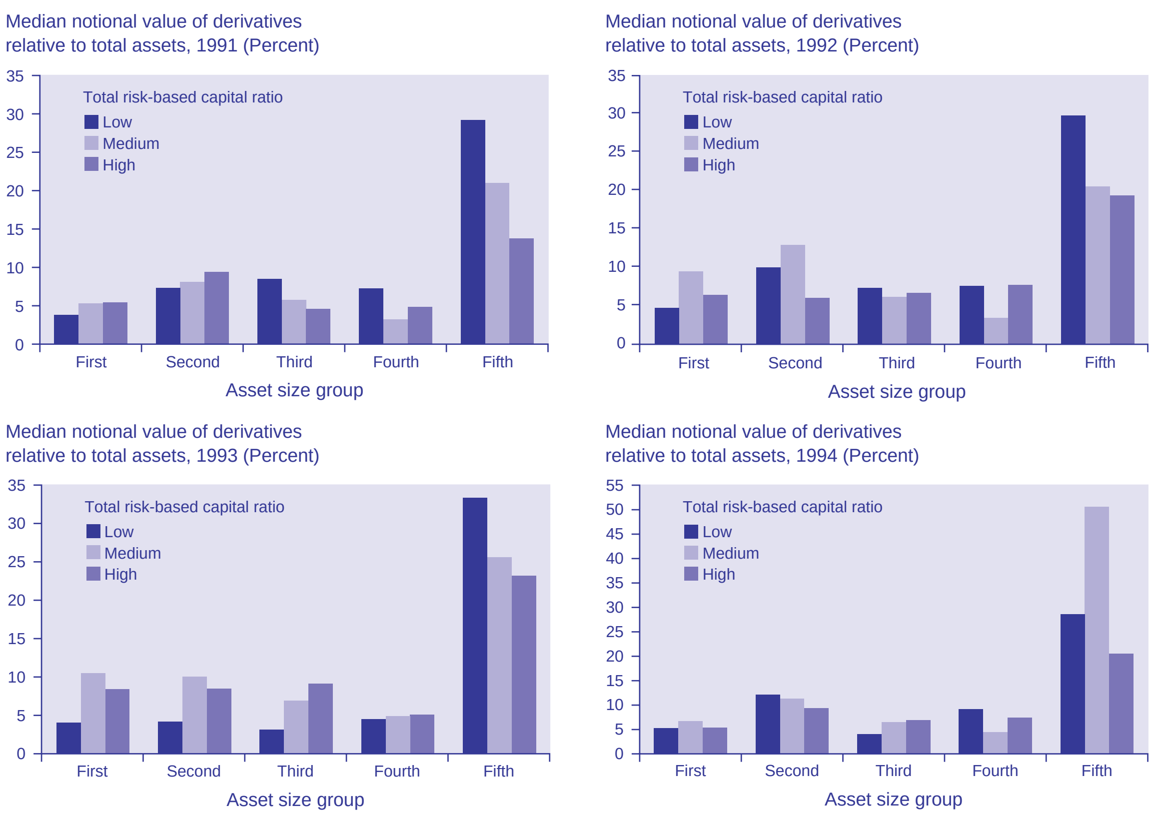
While the results presented so far indicate that derivatives activities tend to be relatively high at highly capitalized banks, it is difficult to assess whether the observed higher capital levels fully compensate for the potential risks of derivatives activities. However, some evidence is available to address this issue in the form of the risk-based capital requirements. To the extent that the risk-based capital requirements effectively categorize banking activities according to risk, the amount of regulatory capital per dollar of risk-weighted assets should indicate whether banks with extensive derivatives activities are more or less adequately capitalized than banks with relatively low levels of derivatives participation.

Based on data from 1991 through 1994, Chart 4 shows the median notional value of derivatives relative to total assets for each asset size category and total risk-based capital level. The statistics are obtained in exactly the same manner as those presented in Chart 3, with the exception that the three capitalization categories now are based on the total risk-based capital ratio, rather than the equity-to-asset ratio.

In Chart 4, no clear relationship emerges between risk-based capital and derivatives participation, with one half of the twenty combinations of time period and asset size suggest-

Chart 4

Total Risk-Based Capital Ratio and Derivatives Activity



ing a positive relationship and the other half showing a negative one. These results suggest that, to the extent that the risk-based capital requirements accurately reflect risk, the relatively high equity-to-asset ratios of banks with extensive derivatives activities do compensate, in general, for the associated risks.

Conclusion

Derivatives usage among U.S. banking organizations is surprisingly low, given the flexibility and adaptability derivatives offer in managing risk exposures. A primary reason for the low participation rate seems to be the large amount of intellectual and reputational capital required to develop and maintain a comprehensive and knowledgeable derivatives trading function. Typically, only the largest institutions can gather the necessary resources to produce extensive derivatives trading operations, and the available data confirm that the largest banks are the dominant players in the derivatives industry.

But for banks involved with derivatives, our results indicate that derivatives participants with the greatest derivatives usage as a percentage of assets in general have the highest capital levels. And this finding of a positive relationship between derivatives and capital has important policy implications. From a regulatory perspective, the speculative use of derivatives by relatively weak banks would represent the worst-case scenario. However, our finding of a positive capital–derivatives relationship argues against the view that banks are pursuing moral hazard incentives through derivatives speculation. If derivatives are being used for speculative purposes, at least regulatory discipline, and possibly market forces, have tended to require additional capital as a prerequisite for increased derivatives participation. These results reflect a general tendency in the banking industry, and we cannot rule out the possibility that some institutions may have speculated heavily with derivatives. Nevertheless, our finding of a positive capital–derivatives relationship is consistent with the view that banks generally have used derivatives in a prudent fashion.

The results reported here favor the view that regulatory efforts to monitor the derivatives activities of U.S. commercial banks should emphasize supervisory guidelines and market-oriented incentives as opposed to an overly restrictive legislative response that might impair the ability of banks to manage risk effectively.

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Interesting Times For Banks Since Basle

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Unanticipated increases in interest rates are often viewed as harmful to banks. Here, two approaches are used to estimate whether interest-rate risk at banks has increased significantly since the implementation of risk-based capital standards.

The potential impact of changes in market interest rates on commercial banks' revenues, costs, and profitability has long been a concern of policymakers and bankers. A fairly traditional view of banks is that they borrow short and lend long. That is, banks engage in financial intermediation activities such that the maturity structure of their assets may exceed the maturity structure of their liabilities. If so, then bank earnings and net worth could be negatively affected by unanticipated increases in interest rates. The exposure of bank profitability and net worth to unanticipated changes in interest rates is what is meant by the term *interest-rate risk.*

A number of studies have examined the extent of banks' exposure to interest-rate risk. Most of these studies use data on how bank stock prices react to interest-rate movements. Bank stock returns that respond to unexpected changes in interest rates indicate that banks are exposed to interest-rate risk. Other studies use bank accounting data to infer the average maturity structure of assets and liabilities and to judge the long-run effect on banks' profitability from changes in interest rates. The empirical evidence is mixed, with several studies finding that bank stock prices react negatively to interest-rate increases. But results using accounting data provide little evidence of a maturity mismatch or a negative effect on bank profitability arising from interest-rate movements.

Recently, concerns about banks' exposure to interest-rate risk have increased with the introduction of risk-based capital standards. These standards, known as the Basle Accord, were approved in mid-1988 with the purpose of requiring banks that undertake more risky activities to hold more capital. The focus of these requirements, however, is on the credit risk, or risk of default, of banks' assets and off-balance-sheet positions. The Basle Accord does not currently impose capital requirements on banks' exposure to interest-rate risk. As a result, banks may have an incentive to alter their portfolios to substitute interest-rate risk for credit risk.[1]

Here, the two alternative approaches are used to judge whether interest-rate risk at U.S. banks has increased since the adoption of the risk-based capital standards. The first approach uses bank stock price data to estimate whether interest-rate risk has increased significantly since the Basle Accord. As a check on the robustness of these results, bank accounting data are used to analyze the long-run effects of interest-rate movements on banks' revenues, costs, and profitability. Overall, the results provide some support for the notion that interest-rate risk has increased

[1] Modifications to the risk-based capital requirements have been proposed to address the problem of interest-rate risk (*Federal Register* 1993).

since the implementation of the Basle Accord and its emphasis on credit risk.

Before presenting these two approaches, a more formal discussion of interest-rate risk and its relationship with the Basle risk-based capital requirements will be offered. Next will come a brief look at some aggregate bank data that might give some indication of banks' exposure to interest-rate risk. Then, the results using both bank stock prices and bank accounting data to estimate interest-rate-risk exposure are presented, followed by some conclusions.

Interest-rate risk in more detail

In principle, the most straightforward method of evaluating the effects of changes in market interest rates on banks' economic well-being is to calculate the changes' effects on bank net worth. The change in bank net worth resulting from a change in interest rates is equal to the change in the present value of current and expected revenues minus the change in the present value of current and expected costs.

A related concept to estimating interest-rate risk is the calculation of the duration of bank assets and liabilities. Duration is defined as the weighted average maturity of the cash flows in present value terms. Duration measures the sensitivity of net worth to changes in interest rates by assessing the effects of interest-rate changes on the discounted value of future earnings. Calculating the duration of assets and liabilities, though, requires major assumptions about maturity structures and interest rates.[2]

The borrow short and lend long view of banks and the view's role in interest-rate risk are easy to understand in terms of revenue and cost. Under this type of portfolio mismatch, an unanticipated increase in interest rates would raise costs relative to revenues for some time. As a result, the bank's market value would decline in response to the increase in interest rates. A gap, or mismatch, in the asset/liability maturity structure is not the only factor that can expose banks to interest-rate movements, however. If unanticipated changes in interest rates affect the rate at which market participants discount the present value of banks' future profit streams, then banks' vulnerability to unexpected interest-rate movements would also increase. Also, bank revenues and costs may be affected by the level of interest rates and the variability or predictability of interest rates within each period.

Where do capital requirements fit in?

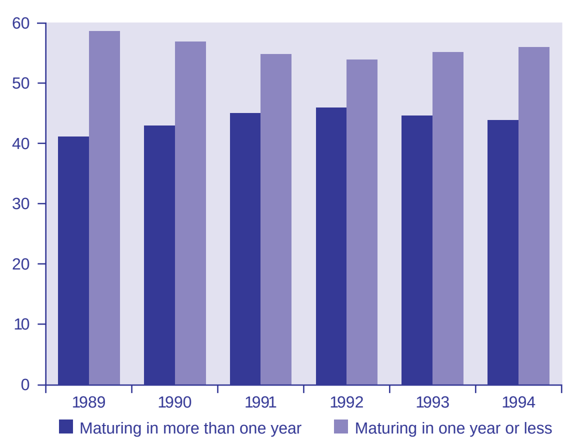
Capital requirements have been imposed on banks for some time. Bank capital represents a cushion to absorb losses during economic downturns. This cushion also helps shield the deposit insurance fund from losses that might be incurred from bank failures. Until recently, bank capital regulations were not explicitly linked to banks' risk profile. On July 11, 1988, the Basle Committee on Banking Regulations and Supervisory Practices—meeting under the auspices of the Bank for International Settlements in Basle, Switzerland—reached what has come to be known as the Basle Accord. Under this agreement, which covers banks in the United States, Canada, Europe, and Japan, banks' minimum capital requirement now depends on the perceived credit-risk exposure of their assets and off-balance-sheet positions. This assessment is made by assigning different risk weights to various categories of assets and off-balance-sheet items to reflect their risk of default. The Basle Accord is structured to reflect that riskier banks are more likely to fail and, therefore, should be required to hold more capital. Interim requirements became effective at the end of 1990, with final implementation occurring at the end of 1992.

However, the Basle Accord only covers banks' credit-risk exposure. Calculation of the risk-based capital standards does not include interest-rate-risk exposure. A regulatory system that favors some types of assets over others could create incentives for banks to alter the composition of their portfolios. Under the current Basle risk-based capital requirements, then, banks may be tempted to reallocate their portfolios to substitute interest-rate risk, which has no explicit capital charge, for credit risk.[3] A look at banks' exposure to increases in interest rates

Chart 1

U.S. Insured Commercial Bank Loans And Debt Securities

Percent of total loans and debt securities



DATA SOURCE: Report of Condition and Income.

2 For more on the concept of duration, see Houpt and Embersit (1991) and Santoni (1984).

3 See Houpt and Embersit (1991). Also, see Neuberger (1992) for a description of some other problems associated with the current Basle Accord.

since the Basle Accord was adopted would shed light on whether banks have altered their portfolios toward greater interest-rate-risk exposure.

A look at some aggregate bank data

Before turning to the two alternative approaches to estimating banks' exposure to interest-rate risk, a cursory review of aggregate bank data might reveal whether banks have altered the composition of their portfolios. Chart 1 shows how the maturity structure of banks' loans and securities holdings has changed since 1989—the first year after the Basle Accord was approved—through the end of 1994. Asset structure lengthened somewhat over this period. Loans and debt securities with a maturity of more than one year represented 41 percent of the total in 1989, increased to 46 percent in 1992, and fell slightly to 44 percent in 1994. Alternatively, loans and debt securities at commercial banks with a maturity of one year or less declined from 59 percent in 1989 to 56 percent in 1994.

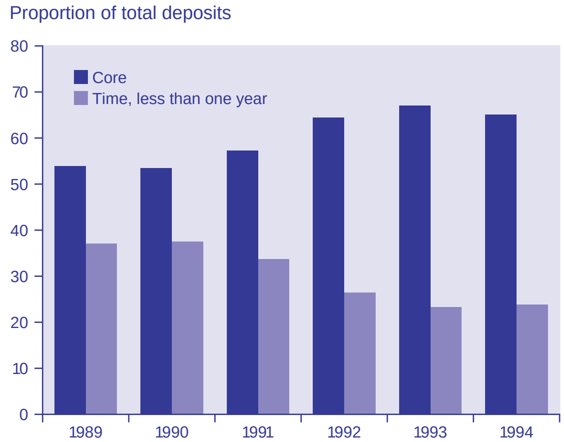
Because interest-rate risk can arise from a mismatch between the maturity structure of assets and liabilities, the liability side of banks' balance sheets must also be examined. Chart 2 reveals how the maturity structure of deposits at banks has changed from 1989 to 1994. What stands out in this chart is how the proportion of core deposits has increased by 11 percentage points, from 54 percent of total deposits in 1989 to 65 percent in 1994.[4] Meanwhile, time deposits of less than one year decreased from 37 percent of total deposits to 24 percent. To the extent that core deposits represent a relatively stable funding source, the liability side of banks' balance sheets shows some lengthening in the maturity structure.[5] Thus, while loans and securities may have shown an increase in their maturity composition, deposits at U.S. banks have also probably lengthened in their maturity as well.

Examining aggregate bank data, though, may not reveal the extent of banks' exposure to interest-rate risk. Changes in interest rates alter the present value of bank assets and liabilities. This correlation implies that the market value of the firm changes, depending on assets and liabilities' sensitivity to changes in interest rates. This change in market value is reflected in the stock prices of publicly traded firms.

Measuring interest-rate risk—two approaches

If some banks have undertaken portfolio reallocations that increased their sensitivity to interest-rate movements, then this might be reflected in an increased sensitivity of share prices

Chart 2
Deposits at U.S. Insured Commercial Banks



DATA SOURCE: Report of Condition and Income.

to changes in interest rates. Alternatively, bank revenues, costs, and income are all affected by changes in interest rates. Estimates of the long-run effect of interest-rate movements on these variables would provide another view of banks' interest-rate-risk exposure since the adoption of risk-based capital requirements.

Can the stock market tell us anything?

When using stock price data to estimate banks' exposure to interest-rate changes, a model of the determination of stock prices is needed. The so-called *market model* is a widely used and relatively simple model of stock prices. To some degree, all stocks are affected by general economic conditions or overall economic activity. This relationship implies a fairly close connection between an individual security's return and the return on a broad-based, marketwide index of stocks. Therefore, the market model describes an individual security's return over a certain period as a function of the returns generated over that period on a market index of stocks. In this model, how an individual stock's return is affected by marketwide returns is widely referred to as the stock's *beta*. For example, if beta equals one, the security's return moves one-for-one with the overall market. If beta is less than one, the security's return would change by a smaller amount than overall market returns, and if beta exceeds one, the change in the security's return would exceed the change in overall market returns. A stock with a beta greater than one implies that the security's return exhibits more cyclical movements than the overall market does.

When examining banks' interest-rate risk, an augmented-market model is used. The model

[4] Core deposits are defined as the sum of demand deposits, NOW and ATS accounts, MMDA savings, and other savings deposits.

[5] Uncertainty over the effective maturity of core deposits represents a significant obstacle to measuring the gap between asset and liability maturity structures and also to measuring the duration of assets and liabilities.

Table 1

Estimates of Interest-Rate Sensitivity of Bank Stock Returns Using ARIMA Residuals

Pre- and Post-Basle 1989 Periods

Variable	1973:1–94:3	1973:1–88:4	1989:1–94:3
	Interest-Rate Variable: *TBILL*		
CONSTANT	.1401** (.0118)	.1184** (.0114)	.1446** (.0327)
BETA	1.0509** (.0310)	1.0016** (.0273)	1.4766** (.1200)
INTEREST-RATE SENSITIVITY	–.0759** (.0087)	–.0685** (.0075)	–.1354** (.0432)
	R^2 = .25	R^2 = .36	R^2 = .14
	Interest-Rate Variable: *TBOND*		
CONSTANT	.1467** (.0118)	.1303** (.0112)	.1364** (.0328)
BETA	1.0166** (.0320)	.9420** (.0276)	1.8166** (.1322)
INTEREST-RATE SENSITIVITY	–.1212** (.0133)	–.1547** (.0115)	.2201** (.0538)
	R^2 = .26	R^2 = .37	R^2 = .14

** = Statistically significant at the 1-percent level.

NOTES: Standard errors are in parentheses.

The model estimated is $RETURN_{it} = \alpha_{it} + \beta_{it} \bullet MARKET_t + \zeta_{it} \bullet RATE_t + \varepsilon_{it}$, where $RETURN_{it}$ is defined as the (annualized) rate of return on bank *i*'s stock in time period *t*; *MARKET* is the rate of return on a broad market index of stocks at time *t*; *RATE* is a measure of the change in interest rates from *t*–1 to *t* (measured as percentage points), and ε_{it} is an error term to capture all other factors. *CONSTANT* is the estimate derived for α, *BETA* is the estimate derived for β, and *INTEREST-RATE SENSITIVITY* is the estimate of ζ. R^2 is the proportion of the variation in *RETURN* that is explained by *MARKET* and *RATE*.

is augmented by a variable that proxies for unanticipated interest-rate movements. If this interest-rate factor is negative and statistically significant, it suggests that banks' market value is adversely affected by increases in interest rates. A number of previous studies have used an augmented-market model to judge the sensitivity of bank security returns to unexpected interest-rate movements. Flannery and James (1984), Aharony, Saunders, and Swary (1986), Sweeney and Warga (1986), Saunders and Yourougou (1990), and Yourougou (1990) all find evidence that bank stock returns are negatively related to interest-rate changes. Chance and Lane (1980), however, do not find much evidence that the stock prices of financial firms exhibit sensitivity to interest-rate fluctuations.

In estimating the augmented-market model to determine if interest-rate risk has increased since the Basle Accord, quarterly data from the 1973:1–94:3 period are used. Only banking organizations whose stocks traded continuously over the entire period are included in the analysis, for a total of forty-eight banks.[6] Data for bank stock prices and dividends are for the last trading day of the quarter, are obtained from *Compustat*, and are adjusted for dividend and stock splits. The market index used is Standard & Poor's stock price index and dividend index (S&P 500), based on the last trading day of the quarter. Two interest-rate variables are used: the three-month Treasury bill rate, last trading day of the quarter (*TBILL*); and the rate on ten-year Treasury bonds, last trading day of the quarter (*TBOND*). The interest-rate series were obtained from the H15 release of the Board of Governors of the Federal Reserve System.

Because the interest-rate sensitivity variables *TBILL* and *TBOND* are proxies for unanticipated changes in interest rates, the models are estimated using the residuals from an ARIMA model of these interest-rate series.[7] Table 1 shows

[6] An *F*-test was used to assess whether a single augmented-market model applied to all the banks, as opposed to forty-eight separate bank-specific models. For both interest-rate variables, the tests were insignificant at the 5-percent level, indicating that the data can be pooled and a single regression equation estimated.

[7] *ARIMA* stands for autoregressive integrated moving average. *ARIMA* models forecast a particular time series, say interest rates, by using prior movements in the series. In effect, *ARIMA* models are linear combinations of the series' own past values and, perhaps, past errors or innovations in the series. For *TBILL*, one lag of the series was used in the forecasting equation, while for *TBOND*, two lags of the series were used. Both of these models produced white noise residuals that are then used as proxies for unanticipated interest-rate movements.

Table 2

Estimates of Interest-Rate Sensitivity of Bank Stock Returns

Using Interest-Rate-Spread Variable

Pre- and Post-Basle 1989 Periods

Variable	1973:1–94:3	1973:1–88:4	1989:1–94:3
	Interest-Rate Variable: *TBOND-TBILL*		
CONSTANT	.1268**	.1016**	.1121**
	(.0119)	(.0114)	(.0342)
BETA	1.1250**	1.0698**	1.7043**
	(.0303)	(.0267)	(.1223)
INTEREST-RATE SENSITIVITY	.0329**	.0222**	.2834**
	(.0108)	(.0092)	(.0682)
	$R^2 = .25$	$R^2 = .34$	$R^2 = .14$

** = Statistically significant at the 1-percent level.

NOTES: See notes to Table 1.

the results of estimating the two versions of the augmented-market model over the entire period, 1973:1–94:3, and over the pre- and post-Basle time periods, here defined as 1973:1–88:4, and 1989:1–94:3, respectively.[8] Over the entire period, all of the variables are statistically significant in both versions of the model. The results indicate that bank stock returns tend to move fairly closely with the overall stock market, with beta close to 1. Both interest-rate sensitivity factors are negative and statistically significant, indicating that bank stock returns are negatively correlated with changes in interest rates. These results provide some evidence that banks were exposed to interest-rate risk over the entire period.

Examining the results over the pre- and post-Basle periods provides some insight into whether interest-rate risk has increased significantly since the Basle Accord was approved. In the pre-Basle period, both models indicate that bank stock returns were negatively correlated with unanticipated interest-rate changes. However, the results reveal a slightly different picture in the period after the risk-based capital requirements were approved. Bank stock returns are now more sensitive to unanticipated increases in short-term interest rates. In the pre-Basle period, a 100-basis-point increase in short-term interest rates reduces bank stock returns by 6.85 percent (holding the overall effect of the stock market constant), while in the post-Basle period, a 100-basis-point increase in short-term interest rates reduces bank stock returns by 13.54 percent. The evidence also indicates, though, that the stock market viewed increases in long-term rates as favorable developments for bank stock returns in the post-Basle period. A 100-basis-point increase in long-term rates is associated with a 22-percent increase in bank stock returns, compared with a negative effect in the pre-Basle period.[9]

The combination of a negative coefficient for short-term interest rates and a positive coefficient for long-term rates in the post-Basle period could indicate that market participants viewed increases in the yield spread as more important in determining bank profitability in the late 1980s and early 1990s. During this time, the yield spread between short- and long-term interest rates increased dramatically. At the same time, banks restructured their portfolios toward more holdings of government securities, perhaps in an attempt to increase current profits (Short, Gunther, and Moore 1993). Table 2 shows the results of estimating the augmented-market model using the difference between *TBOND* and *TBILL* as the interest-rate factor. This spread variable is statistically significant over the entire period, as well as in the pre- and post-Basle periods. But, comparing the results before and after the approval of risk-based capital requirements, the coefficient on the spread variable increases dramatically in the later period, from 0.022 to 0.28.[10] These results suggest that the yield spread was viewed as a much more important determinant of bank profitability in the post-Basle period.

If the introduction of risk-based capital requirements for banks provided incentives for banks to substitute interest-rate risk for credit

[8] Because the Basle capital standards were approved in July 1988, partially implemented at the end of 1990, and fully effective at the end of 1992, several break points were used in the estimation of the model. The first break point chosen was the end of 1988, and these results are reported in the text. Even though the Basle Accord was not in effect at the beginning of 1989, this break point was chosen because banks could have been forward looking, and anticipating the Basle requirements, could have chosen to take on more interest-rate risk at this time. Similarly, the Basle Accord began to be implemented at the end of 1990, making that a potential break point. The results are not affected if the models are estimated using a break point of the fourth quarter of 1990. While the Accord was fully implemented at the end of 1992, too few data points are available for each bank to place much faith in estimates of the models that began in 1993.

[9] Tests for differences in the coefficients across these two periods are statistically significant at the 1-percent level. These procedures involved testing the hypothesis that the interest rate factors are significantly different across the two periods. The test statistic is distributed as standard normal and for *TBILL* is 52.18 and for *TBOND* is 234.10, both highly significant. Furthermore, Chow tests for a structural change in the regression equations across these two time periods are also statistically significant, with a value for the *F*-test statistic of 56.99 for the model containing *TBILL* and 42.0 for the model containing *TBOND*.

[10] This difference is statistically significant at the 1-percent level, with a value of the test statistic of 128.74.

Table 3

Estimates of the Long-Run Impact of a Change in Market Interest Rates on Banks' Operating ROA

Separate Specifications for Revenues and Costs

(Average for all banks)

	Period		
Interest rate	1973:1–94:3	1973:1–88:4	1989:1–94:3
TBILL	–.068**	–.046**	–.056*
TBOND	–.051**	–.034**	–.067**

** = Significant at the 1-percent level.

 * = Significant at the 5-percent level.

The partial adjustment framework for revenues and costs includes the following equations:

$$(1)\quad \frac{R_t}{TA_{t-1}} = \alpha_0 + \alpha_1\left(\frac{R}{TA}\right)_{t-1} + \alpha_2 r_t + \alpha_3\sigma_t^2 + \alpha_4\left[r_t\left(\frac{TA_t - TA_{t-1}}{TA_{t-1}}\right)\right] + \varepsilon_t\ ,$$

where: R_t = total operating revenues in period t,

TA_t = total assets in period t,

r_t = the current market interest rate,

σ_t^2 = intraperiod variability in r_t.

The first four terms incorporate a partial adjustment framework for revenue to its equilibrium level if all investable funds are placed in assets earning the current market rate. The term associated with α_4 represents the return on net new assets. The expected signs on the coefficients are α_0, α_2, $\alpha_4 > 0$; $0 < \alpha_1 < 1$; $\alpha_3 \leq \geq 0$. Current operating expenses are modeled as

$$(2)\quad \frac{C_t}{TA_{t-1}} = \beta_0 + \beta_1\left(\frac{C}{TA}\right)_{t-1} + \beta_2 r_t + \beta_3\sigma_t^2 + \beta_4\left[r_t\left(\frac{TA_t - TA_{t-1}}{TA_{t-1}}\right)\right] + \mu_t\ ,$$

where C_t = total current operating expense in time t. The coefficients' expected signs and interpretations in equation 2 are analogous to those in equation 1. The dependent variables are expressed in basis points. The volatility measure is the standard deviation of the weekly interest rate series over the quarter.

The long-run effect of a (permanent) change in market interest rates on operating ROA, or the difference between revenues and costs as a percent of assets, is defined as $\left[\frac{\alpha_2}{1-\alpha_1} - \frac{\beta_2}{1-\beta_1}\right]$.

risk, then the interest-rate factors should have been negative and greater in absolute value in the post-Basle period. Using different measures of unanticipated interest-rate changes, evidence from bank stock returns provides some proof that banks altered their portfolios such that their stock returns were more sensitive to interest-rate movements in the post-Basle period. Moreover, the stock market seemed to view movements in the interest-rate spread as a much more important factor in the post-Basle period.[11] An alternative approach that uses bank accounting data can offer additional insights into the extent of banks' exposure to interest-rate risk.

Bank accounting data: What do they reveal?

To judge the robustness of the results obtained with stock market data, estimates of the relationship between market conditions and bank revenues, costs, and net current operating earnings are obtained to assess the overall impact of interest-rate fluctuations on bank profitability.[12] This approach was developed by Flannery (1981, 1983) to judge how large and long-lasting interest-rate effects are on bank revenues, costs, and earnings.

Flannery begins by recognizing that banks can reallocate only a portion of their earning assets and their liabilities in the short run in response to changing market conditions. This constraint primarily arises from the limitations imposed by prior portfolio decisions that cannot be changed instantaneously. As a result, Flannery employs a partial-adjustment model to account for the lagged response of bank portfolio decisions to changing market conditions. For comparison's sake, the sample of banks consists of the same forty-eight banks that were used in estimating the market models. Two different interest rates are used, this time the quarterly average of the three-month T-bill rate and the ten-year T-bond rate.

The partial-adjustment framework allows estimates of the long-run impact of interest-rate changes to be obtained. Table 3 shows estimates of the effect of a permanent change in interest rates on the ratio of banks' net operating earnings to total assets, or *operating ROA*. These estimates are based on separate specifications for revenues and costs in the partial-adjustment framework. To conserve space, the results reported are the mean responses for the entire sample of banks. The long-run mean responses of operating ROA to an increase in interest rates are all negative and statistically significant. For example, a (permanent) 100-basis-point increase in *TBILL* is, on average, estimated to reduce banks' operating ROA by almost 7 (6.8) basis points over the entire period. Estimates comparing the pre- and post-Basle periods show an increase in the long-run impact associated with an increase in both *TBILL* and *TBOND*. Moreover, these differences in interest-rate sensitivities are statistically significant across the pre- and post-Basle periods at the 1-percent significance level.[13] These results provide some evidence that increases in interest rates do have a negative effect on profitability and that this interest-rate sensitivity increased after the introduction of the risk-based capital standards.

Finally, the partial-adjustment framework can supply another estimate of the effect of interest-rate changes on bank profitability. Table 4 contains additional estimates of the long-run impact of changes in interest rates on banks' operating ROA. These estimates are based on results from a single-equation estimation that uses the ratio of net current operating earnings to assets as the dependent variable. Again, the results are the average for all banks in the sample. Over the entire time period, (per-

[11] Because the sample of banks used in the analysis covers only those institutions whose stocks traded continuously over the entire period, the results obtained could suffer from survivorship bias. To test this possibility, the augmented-market model was estimated using data for all banks in the *Compustat* file that reported data for at least four years. This sample produces 134 banks. After expanding the sample of banks the results are substantially unaffected, which indicates the absence of any survivorship bias.

[12] Flannery (1981) argues that net current operating earnings are a more appropriate measure than net income because extraordinary income items and realized gains or losses on securities are often tax-related in their timing, which would obscure the true impact of interest-rate changes on bank profitability.

[13] These significance tests are based on the Wilcoxon rank tests for testing hypotheses about shifts in location parameters.

Table 4

Estimates of the Long-Run Impact of a Change in Market Interest Rates On Banks' Operating ROA

Single-Equation Estimation of Operating ROA

(Average for all banks)

	Period		
Interest rate	**1973:1–94:3**	**1973:1–88:4**	**1989:1–94:3**
TBILL	–.015**	.002	–.032**
TBOND	–.006*	.006**	–.075**

** = Significant at the 1-percent level.

* = Significant at the 5-percent level.

NOTE: See notes to Table 3.

Net earnings are given as

$$(3)\quad \frac{EA_t}{TA_{t-1}} = \gamma_0 + \gamma_1\left(\frac{EA}{TA}\right)_{t-1} + \gamma_2 r_t + \gamma_3 \sigma_t^2 + \gamma_4\left[r_t\left(\frac{TA_t - TA_{t-1}}{TA_{t-1}}\right)\right] + \varsigma_t ,$$

where EA_t = net current operating earnings. The coefficients' expected signs and interpretations in equation 3 are analogous to those in equation 1. The volatility measure is the standard deviation of the weekly interest-rate series over the quarter. Equations 1, 2, and 3 were estimated using techniques described in Flannery (1983, 1981). Similar to Flannery, the volatility measure is not statistically significant in most of the equations estimated.

The long-run impact of a change in market interest rates on banks' operating ROA is defined from equation 3 as $\frac{\gamma_2}{(1-\gamma_1)}$.

manent) increases in both *TBILL* and *TBOND* result in declines in banks' operating ROA. In the pre-Basle period, this effect is statistically insignificant for *TBILL* and positive and significant for *TBOND*. However, in the post-Basle period, increases in interest rates—for both interest-rate measures—exert a negative and statistically significant effect on net current operating earnings to assets. These coefficients are statistically different across the two periods at the 1-percent significance level. The results also suggest that the effect of interest-rate changes on earnings is greater in the post-Basle time period and in a direction that suggests greater exposure to interest-rate risk. However, the effect is not very large. A permanent 100-basis-point increase in *TBILL* reduces operating ROA by slightly more than 3 basis points in the post-Basle period, while a 100-basis-point increase in *TBOND* gives rise to a 7.5-basis-point decline in the ratio of net current operating earnings to assets.

Some caveats

Despite the robustness of the results, some caution should be used in interpreting their meaning. First, the interval associated with the post-Basle period exhibits some unusual interest-rate movements. In particular, the yield spread averaged 222 basis points in the post-Basle period, compared with an average spread of 158 basis points in the pre-Basle period. Another potential factor behind the results could be the brief period since the Basle agreement was implemented. Only four years' worth of data are available since the initial phase-in of the risk-based capital standards. A longer period for analysis would provide more evidence of any heightened interest-rate risk associated with the Basle agreements.

Conclusions

In mid-1988, major industrial countries agreed to a set of international capital guidelines for banks that are based on the perceived riskiness of the individual institutions. These capital charges recognize that banks with higher risk profiles are more likely to fail. To enhance financial safety and soundness and to protect the deposit insurance fund, riskier institutions are now required to hold a greater capital cushion to absorb losses. It is important to note that such risk-based capital requirements consider only the credit risk of banks' portfolios. This type of regulatory system could encourage banks to alter their portfolios in such a way that interest-rate risk, which is not explicitly accounted for, may increase.

Estimates presented here using data from the stock market as well as data from banks' balance sheets and income statements provide some support for this hypothesis. Since the Basle Accord was agreed upon, bank stock returns appear to be more negatively correlated with unanticipated short-term interest rates, while the stock market views increases in long-term rates positively. Moreover, banks' market values are more sensitive to changes in interest-rate spreads in the post-Basle period. Estimates of the long-run impact of interest-rate changes on interest margins are greater after the approval of the Basle Accord, with evidence that net earnings at banks have become more adversely affected by permanent increases in interest rates, although this effect is not very large.

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