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Measuring Off-Balance-Sheet Leverage

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Measuring Off-Balance-Sheet Leverage

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Abstract

The simultaneous unwinding of leveraged positions can trigger financial market turbulence. Although balance-sheet measures of leverage are available, it is useful to construct a measure of leverage that incorporates both on- and off-balance-sheet activities. This paper provides measures of leverage implicit in derivative contracts by decomposing the contracts into cash market equivalent components. A leverage ratio can then be calculated for this replicating portfolio, which consists of own funds (equity) and borrowed funds equivalents (debt). Methods for aggregating leverage by institution and by markets are presented. The interaction between leverage and risk is discussed, and a modified capital adequacy ratio is calculated, which captures off-balance-sheet exposure.

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I. Introduction

Leverage has been singled out as one of the most important factors in the buildup of financial conditions that enabled a single event—the unilateral Russian debt moratorium—to trigger the financial crisis in the fall of 1998, permeating even the deepest and most liquid financial markets in the world (e.g., International Monetary Fund, 1999). The crisis in mature markets has been partially attributed to the rapid and simultaneous unwinding of leveraged positions triggered by adverse price movements. It can further be argued that the ability of highly leveraged institutions to accumulate leverage off the balance sheet and thus their ability to elude the scrutiny of supervisors and the counterparty due diligence process contributed to the vanishing liquidity in normally highly liquid markets. Market participants were caught by surprise when their competitors desired to unwind their leveraged positions all at the same time because they did not know the extent of leveraged positions of everyone else in the market.[2] The President's Working Group (United States, 1999) concluded that the central public policy issue raised by the near collapse of the Long-Term Capital Management hedge fund is how to constrain leverage more effectively and called for an appropriate measurement of leverage and risk. While a controversy surrounds the issue of constraining leverage, observers agree that traditional on-balance-sheet measures do not accurately depict the degree of an institution's leverage because a significant degree of leverage is assumed through off-balance-sheet activities, which are not fully reflected on the balance sheet.

Efforts to measure leverage implicit in derivatives, repurchasing agreements and short sales have only been rudimentary. There appear to have been no attempts in the academic literature to examine off-balance-sheet leverage. The subject has recently been identified as a public policy issue by a number of reports. In addition to the President's Working Group, the Basel Committee on Banking Supervision (1999a) underscored the important role leverage played during the mature markets crisis in 1998 and claimed that leverage of unregulated hedge funds could be reduced if banks obtained more information about their off-balance-sheet exposures. However, the report makes no concrete suggestions how this would be achieved in practice. In an accompanying paper (1999b), the Committee noted that the industry believes estimates of potential future exposure overestimate underlying exposure and has therefore not devoted sufficient resources to develop measures to limit the unsecured exposure inherent in collateralized derivatives positions. The Reserve Bank of Australia (1999) stressed that the lack of disclosure of the use of leverage by hedge funds, particularly through off-balance-sheet exposures, was a major contributing factor to the crisis. It also criticized the concessional treatment of derivatives in capital requirements. The President's

[2] For example, LTCM's on-balance sheet leverage may have conveyed a misleading picture: News reports indicate that its on-balance-sheet leverage ratio moved from a factor of 25 to 167 at the height of the collapse while its (undefined) off-balance-sheet leverage ratio moved from a factor of 270 to 2100 (Section VI discusses the construction of off-balance-sheet ratios).

Working Group on Financial Markets (United States, 1999) proposed that leverage be measured by the ratio of Value-at-Risk to net worth. This is not a measure of leverage per se and is further analyzed in section III.[3] The Counterparty Risk Management Group (1999) presents the first attempt to define various leverage ratios in broad terms. The report recognized that a decomposition of instruments into "notional equivalents" would be necessary. However, it did not define these notional equivalents, and called for "a detailed set of guidelines for conversion of off-balance-sheet positions into notional amounts" (Counterparty Risk Management Group, 1999). A report prepared by a group of hedge funds (Caxton et al., 2000) called on fund managers to track accounting and risk-based measures of leverage as proposed by the President's Working Group, but did not elaborate on the measurement of leverage implied by off-balance-sheet instruments.

This paper develops a technique to measure the degree of leverage implicit in individual derivative contracts. The quantitative measure of leverage implicit in a derivative instrument is derived by decomposing the instrument into own funds (equity) and borrowed funds (debt) equivalent components which, in turn, are used to derive an on-balance-sheet asset equivalent measure of off-balance-sheet exposure. The proposed measures can be aggregated to measure the overall on- and off-balance-sheet leverage of a financial institution. Total leverage measures provide an insight into the potential for default of institutions and into the sensitivity of investors to adverse price movements which could trigger the simultaneous unwinding of leveraged positions. Moreover, the approach to measuring on-balance-sheet asset equivalent positions of off-balance-sheet exposures allows the derivation of a modified capitalization ratio which captures the degree of off-balance sheet leveraging.

To set the paper in context, the importance of leverage is discussed in section II. As the public debate on leverage seems to mix occasionally the use of the terms 'leverage' and 'risk', section III discusses the differences between the two concepts. Section IV presents an example of how multiple layers of leverage can be built up through off-balance-sheet transactions. Section V derives measures of leverage implicit in individual derivative instruments. Methods for aggregating leverage by institution and by markets are presented in sections VI and VII. Section VIII considers how the method proposed in the paper could be used to modify traditional capital adequacy ratios to incorporate off-balance-sheet exposure. The final section concludes.

II. The Importance of Leverage

Leverage is achieved by increasing the investment through either outright borrowing or off-balance-sheet transactions, particularly derivatives. In the former case, a loan (or a repurchase agreement) is used to supplement the equity investment, which is expected to have a rate of return higher than the interest rate on the loan. Instead of cash, the loan could

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[3] Value-at-Risk is a measure of the maximum potential change in value of a portfolio of financial instruments with a given probability over a preset horizon.

consist of a security (as in short-selling operations). In the latter case, derivative positions (such as futures and options) allow the investor to earn the return on the notional amount underlying the contract by committing a small portion of equity in the form of initial margin or option premium payments.

Leverage is the magnification of the rate of return (positive or negative) on a position or investment beyond the rate obtained by a direct investment of own funds in the cash market. As debt is a fixed obligation equity is the residual claim, so that all gains or losses on assets accrue to equity. Leverage can be thought of as an elasticity, indicating the responsiveness of the value of an equity stake to changes in the value of overall assets. As changes in the value of equity are equal to changes in the asset portfolio, leverage is conventionally defined as the ratio of assets to equity.

Leverage is of concern because of two effects; (1) by definition it creates and enhances the risk of default by market participants; and (2) it increases the potential for rapid deleveraging—the unwinding of partially debt financed positions by market participants—which can cause major disruptions in financial markets by exaggerating market movements. If the rate of return on an investment to which borrowed funds have been committed turns out to be less than expected, the investor's equity may very quickly diminish and become insufficient to cover the loans. In response to an adverse price movement, a leveraged position will be closed faster by an investor (with a given loss tolerance) than if it were not leveraged. The larger the leverage, the smaller is the price change that may be needed to trigger an unwinding of the position. The rapid unwinding of large positions in response to margin calls following exogenous price movements can magnify these movements in a destabilizing manner. That is, a "long" leveraged position will be sold as a result of an exogenous price decline, thus contributing to the price movement even further. Conversely, a "short" position needs to be covered in a rising market by buying the security, therefore contributing to upward price pressure. While any (unleveraged) position would require similar actions, leveraged positions may amplify this destabilizing mechanism and increase volatility more rapidly.[4]

If there are many similar leveraged positions, if there is a single large position, or if the underlying market is not very liquid, rapid deleveraging can create price disconnects (large price moves resulting from temporarily one-sided markets). These price movements in a mark-to-market environment will trigger margin calls or cause other investors to reevaluate their positions. This, in turn, will force the liquidation of more leveraged positions, resulting in a knock-on effect, which can send ripples through diverse financial markets spawned by

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[4] Leverage also has benefits. It enables borrowers to invest in projects requiring a certain minimum investment but subject to increasing returns. Leverage can also be usefully employed to hedge an existing commitment in a cost-saving manner. Furthermore, leverage facilitates speculation, which is necessary for the efficient functioning of markets and tends to enhance liquidity. Some firms, such as banks, need to be leveraged by the nature of their business.

leveraged positions. [5] Likewise, overreliance on Value-at-Risk models and mark-to-market accounting, and other rules that encourage frequent portfolio rebalancing, can induce large scale selling of positions (Schinasi and Smith, 1999).

To determine the potential for financial market turbulence stemming from deleveraging and to judge the extent of potential defaults, it is useful to have a measure which not only captures on-balance-sheet leverage but also the leverage implicit in off-balance-sheet transactions, particularly as financial derivatives have gained significantly in importance over the past decade. As noted above, leverage is traditionally measured by the ratio of a firm's total assets relative to its equity. Calculating this ratio is straightforward if the firm only relies on on-balance-sheet transactions, such as bank loans, to increase its assets. However, if the firm uses off-balance-sheet transactions, such as derivative instruments, the notion of leverage is more complicated.

III. Leverage and Risk: How Do They Differ?

Some of the reports contributing to the recent public policy debate do not draw a sufficient distinction between the concepts of *leverage* and *risk* and may contribute to confusion by defining leverage directly in terms of risk. Leverage is the link between the risk of an asset position and the corresponding risk of an equity stake. The risk on equity has two components: (1) the market risk on the investment portfolio (assets) and (2) the leverage ratio with which this risk is translated to the equity position. Leverage, L, is conventionally defined as the elasticity of the value of equity stake, E, with respect to the value of assets, A:

$$L = \frac{dE}{E} \cdot \frac{A}{dA} = \frac{A}{E}, \quad \text{for} \quad E > 0 \tag{1}$$

where the last equality, which yields the standard leverage ratio, holds since equity is the residual value and captures the gains or losses on assets, i.e. $dE = dA$.[6] The leverage ratio implies that a one percentage point rate of return on assets translates into a L percentage point return on equity:

$$r(E) = L \cdot r(A), \tag{2}$$

where $r(\cdot)$ denotes the rate of return. Similarly, leverage translates the riskiness of the asset portfolio into the riskiness of the equity position. For example, if risk is measured by the

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[5] While the simultaneous build up of leveraged positions could have a similar impact, this tends to occur over a longer period than the abrupt reversal of these positions, and hence the impact is more gradual.

[6] Since assets are the sum of debt and equity, the leverage ratio can be expressed as the debt-equity ratio plus unity.

variance of asset returns, the leverage ratio increases the risk of equity returns disproportionately:

$$\mathrm{var}(E) = L^2 \cdot \mathrm{var}(A). \tag{3}$$

The President's Working Group on Financial Markets proposed as a measure of leverage the Value-at-Risk of an institution's asset portfolio, *VaR(A)*, relative to its equity, *E*:[7]

$$l = \frac{VaR(A)}{E} \tag{4}$$

This ratio is not a measure of leverage per se, but rather a measure of risk. Value-at-Risk is a measure of the maximum potential change in value of a portfolio of financial instruments with a given probability over a preset horizon. Thus, the proposed ratio measures whether sufficient equity is available to cover potential losses on the asset portfolio. Therefore, the ratio would be more appropriately termed the *risk coverage ratio*. It differs from leverage because it lumps together two separate concepts: market risk on the asset portfolio, as expressed by the Value-at-Risk, *VaR(A)*, and leverage, *L*, which transfers and magnifies asset market risk onto the equity position:

$$l = \frac{VaR(A)}{E} = \frac{VaR(A)}{A} \cdot \frac{A}{E} = \frac{VaR(A)}{A} \cdot L \tag{5}$$

Leverage has the capacity to increase risk in the equity position. Equation (5) shows that an institution's relative equity risk consists of the relative (market) risk of its asset portfolio, as well as the leverage ratio with which this risk is magnified and translated to the equity position. For a given equity base, leverage allows the borrower to build up a larger investment position and thus higher exposure to market risk. Increasing *either* the risk of the assets *or* the leverage ratio increases the riskiness of the equity base.[8] The risk coverage ratio does not allow to distinguish between these two effects. In particular, it does not indicate whether an institution's additional riskiness stems from increased market risk on the asset portfolio or from increased leveraging.

The decomposition of equity risk into market risk and leverage is important to determine the potential for market instability stemming from the simultaneous unwinding of leveraged positions. For the same level of the risk coverage ratio, a more leveraged investor facing a given adverse price movement may be forced by collateral requirements (i.e. margin calls) to unwind the position sooner than if the position were not leveraged. The unwinding decision of an unleveraged investor depends merely on the investor's risk preferences and

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[7] The VaR measure is kept generic here, but can be defined for different pre-set probabilities.

[8] It is interesting to note that a highly leveraged portfolio of low risk assets can imply less risk to equity than an unleveraged portfolio of very risky assets.

not on potentially more restrictive margin requirements. Furthermore, if the decision to issue margin calls is concentrated among a few lending institutions simultaneously issued margin calls to many leveraged investors will trigger a simultaneous unwinding that magnifies the initial adverse price movement, resulting in potential market turbulence. In addition, the risk coverage ratio does not capture the extent to which the institution has pooled economic resources from outside debt investors and therefore its systemic importance. A measure is necessary that addresses these two concerns and captures the full extent of an institution's activities, on and off the balance sheet.

This paper presents a method to calculate a leverage ratio that incorporates on-balance-sheet, as well as off-balance sheet activity. While on-balance-sheet leverage is straightforward to calculate, it does not include an institution's leveraging activity involving off-balance-sheet instruments. The method employed in this paper uses replicating portfolios in order to translate the exposure implicit in off-balance-sheet instruments into an on-balance-sheet asset equivalent form. Together with on-balance-sheet equity, this facilitates the computation of a new leverage ratio taking into account the full extent of an institution's activities. The leverage ratio suggested in this paper therefore captures more accurately the sensitivity of investors to adverse price movements that could trigger the simultaneous unwinding of positions.[9]

IV. Assuming Leverage through Off-Balance-Sheet Transactions: An Example

Acquiring leverage through derivatives or repos is cheaper than through on-balance-sheet transactions because it allows firms to assume a given position by committing less capital than would be the case with an equivalent cash market position. For example, derivative contracts are recorded at market value in the trading account of the balance sheet, but allow the holder to earn the return on the (higher) notional amount (Figure 1). Forward contracts tend to be the least costly way of acquiring exposure as they typically have a zero value at inception and frequently have no margin requirements. Similarly, repurchase agreements with small or no haircuts (another form of margin payment) are inexpensive ways to assume leverage.[10] Exchange-traded futures tend to have higher initial margin and maintenance margin requirements than forward contracts and thus are more expensive.[11]

[9] Two important shortcomings of the risk coverage ratio and the off-balance-sheet leverage ratio are that these ratios need to be reported by the financial institutions themselves in order to assure the privacy of their individual position taking. In addition, the Value-at-Risk data are based on very specific assumptions. Nevertheless, an independent outside auditor can certify periodically the consistency of the data with a computation method that has been agreed with the supervisor.

[10] However, they increase the cost of capital to the extent that they are reflected on the balance sheet.

[11] Margin payments in the form of cash are just one way of posting collateral. In the following example, securities are frequently used to post collateral.

Options, on the other hand, are more costly instruments to acquire leverage with because of their declining time value. Typically, on-balance-sheet loans will be the most expensive way to establish a leveraged position.

Many institutional investors, such as hedge funds, employ leverage in various ways, aimed at designing strategies to bet on developments in many different markets by committing as little of their own equity as possible. The following hypothetical scenario illustrates how an institution can lever up its equity several times, using on-balance-sheet and off-balance-sheet transactions. It also shows how seemingly exogenous events can cause this strategy to unravel, magnifying the turbulence in financial markets. The example is inspired by, but does not necessarily accurately reflect, positions alleged to have been taken by Long-Term Capital Management (LTCM). It is by no means unique; similar leveraged positions might also have been taken by many hedge funds and investment banks alike.

The first layer in this particular example takes advantage of the interest rate differential between Japan and the United States at the time by using a small amount of equity as collateral to secure a conventional yen-denominated loan (the "carry trade") (see Figure 2). The proceeds from the loan are exchanged into U.S. dollars and used as collateral to short-sell on-the-run government bonds.[12] The second layer of leverage is designed to profit from an expected reversal of an abnormally high liquidity premium of on-the-run government bonds over off-the-run government bonds at the time. The proceeds from shortselling on-the-run bonds finance the purchase of off-the-run government bonds in the expectation that the yield spread between the two bond types would narrow. In the third layer of leverage, the fund would use its long position in off-the-run government bonds as collateral to borrow funds under a repurchase agreement.[13] The proceeds of the repo could be invested in floating rate notes (FRNs), issued by U.S. investment banks, that earn a higher return than has to be paid under the repo. The investor could lend these FRN securities back to the investment bank from which it had bought them through another repo agreement. As is common under repo agreements, the investor would continue to earn the floating-rate coupon

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[12] On-the-run securities are the latest issue of a particular maturity. Usually they are the most actively traded issues for a particular maturity. Off-the-run securities are the previous issues of the same maturity. For example, in October 1998 the on-the-run 30-year treasury bond matured in August 2028; the most recent off-the-run 30-year treasury bond matured in November 2027.

[13] The lender of cash in a repo may also demand a "haircut" (margin payment) to limit his credit exposure resulting from a decline in price of the collateral. This margin payment would reduce leverage. While stock margins are 50 percent and exchange-traded futures margins are between 2 and 8 percent, haircuts on repos are between 1 and 2 percent. Hedge funds have in some cases been able to negotiate a zero margin. Without any cushion to accommodate fluctuations, a 4 percent price movement (as occurred in the fall of 1998) on a few trillion dollars of assets serving as collateral in a repo would cause massive margin calls and result in a major market movement.

on the FRN, which by assumption is higher than the rate it has to pay for the repo. Furthermore, the last repo frees up cash that can in turn be used for another investment, facilitating the increase in leverage a fifth time through a derivative instrument. For example, the fund could buy a call option on equity of firms targeted for a takeover.[14]

At each stage of this strategy, the assets of the institution are increased without committing further equity, leveraging up its equity base through a series of investments on margins, short sales, repurchase agreements, and derivative securities. It allows the firm to bet on yen depreciation, narrowing U.S. treasury yield spreads, rising U.S. investment bank FRN prices, and rising equity prices of takeover targets. Furthermore, some of these activities are not recorded on the firm's balance sheet. The initial loans and U.S. treasury positions will be booked on the balance sheet. However, the repos and the derivative transactions are off-balance-sheet activities.

The investment strategy outlined in this example can easily unravel during times of market turbulence, such as occurred in the fall of 1998 after the Russian debt restructuring. The subsequent flight to quality and liquidity widened the yield spread between on-the-run and off-the-run U.S. treasury bonds. At the same time the turbulence and losses dampened prospects for the U.S. investment banking industry. The widening of the liquidity spread not only implied a loss on the second leg of the transaction, owing to relative price movements, but also triggered a margin call on the first repo as the value of off-the-run bonds serving as collateral was reduced. This meant the hedge fund would not only have to buy on-the-run bonds when their price was rising to cover its short position, but also to sell off-the-run bonds in a falling market to meet the margin call. Similarly, the FRN securities in the second repurchase agreement had dropped in price and would therefore also trigger a margin call. To raise the cash needed to meet the margin calls, the investor would likely sell the FRNs in the rapidly declining market. As rumors spread that a financial institution is in a liquidity crisis, counterparties would raise the "maintenance" margin to the level of the initial margin to ensure that the loss in value of collateral would not expose counterparties to credit risk. This in turn accelerated the unwinding of leveraged positions, causing even sharper price movements. The FRN market seized up completely at the beginning of October. Similarly, the bond market experienced significant turbulence in the period of October 7–9, 1998, around the time that much of this deleveraging may have been going on. Furthermore, the continuous appreciation of the yen prior to October 1998 would have squeezed the fund on the first leg of the transaction, triggering a rush into yen to repay the initial loan, which is consistent with the observed sharp yen appreciation in the first week of October. This illustrative scenario shows how leveraged positions may have amplified the exogenous price movement triggered by the Russian crisis and spread to other seemingly unrelated markets.

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[14] Balance sheet leverage is limited by two factors: underlying equity and requirements to hold capital against the assets created from the equity, which limits the number of times equity can be leveraged up. Leverage accumulated through off-balance-sheet derivative contracts is limited by the amount of margin payments counterparties require. If there is no margin payment, leverage can be unlimited.

It can be argued that the build-up of similar leveraged positions by many market participants simultaneously could have been prevented if each participant would have had the ability to evaluate the overall degree of leveraged positions in each market segment and the market as a whole. For private and systemic risk management, and for market surveillance, it would be useful to have broad measures of the extent of leveraged positions in capital markets. This knowledge would allow market participants to assess the potential for rapid price movements resulting from exogenous adverse market shocks that may cause investors to deleverage in an attempt to mitigate their losses. Anticipation of possible turbulent deleveraging might limit the build up of unsustainable leverage. Investors might themselves limit their positions so as to avoid being caught in an illiquid market in which it is impossible to unwind their position. Hence, a publicly available measure for overall leverage by institutions and in markets could enhance self-stabilizing forces without necessitating disclosure of proprietary position data to the public. Since leverage in modern financial markets can easily be assumed by using derivative contracts, it is useful to have a measure that not only captures on-balance-sheet leverage but also the leverage implicit in off-balance-sheet transactions. Despite its importance, empirical measures of off-balance-sheet leverage are difficult to implement.

V. Measuring Leverage Implied in Off-Balance-Sheet Transactions

Particular difficulties in measuring leverage arise for off-balance-sheet positions. While intuitively it is clear that off-balance-sheet positions entail leverage, it is not immediately obvious how to measure the leverage embedded in a forward contract or an option. The challenge arises in extracting and separating the debt component and the equity component embedded in a derivative contract.

The approach to measuring leverage in a derivative contract that is employed here is to decompose the contract into its cash market equivalent components. The basic derivative instruments—forwards and options—can be replicated by holding (and, in the case of options, constantly adjusting) appropriate positions in the underlying asset, and by borrowing or lending. This replication can be used to map the individual components into own funds equivalents (equity) and borrowed funds equivalents (debt), which can be used to measure the leverage contained in long and short forward positions and option contracts. More complicated derivatives, such as swaps, structured notes, etc. can be decomposed into spot market, forward and option positions and will therefore not be considered separately. However, it should be noted that through the combination of various derivative securities, structured notes in particular allow very high levels of leverage.

A. Forward Contracts

Consider a **long forward** contract on a security that, for simplicity, is assumed to provide no (interest or dividend) income. Purchasing a security forward can be replicated —based on the no-arbitrage assumption—by borrowing cash at the risk free interest rate and investing it into the underlying asset in the spot market. Using this relationship, the value of a long forward contract at time t, f_t^l, is the difference between the current price of the underlying asset, S_t, and the present discounted value of the price, X, at which the security has to be delivered at maturity, T, given the risk-free rate, r:

$$f_t^l = S_t - Xe^{-r(T-t)}.^{15} \tag{6}$$

In other words, instead of buying a forward contract at a cost of f_t^l, the investor could pursue the following investment strategy and obtain an identical payoff at maturity: borrow an amount of cash equal to $Xe^{-r(T-t)}$,[16] supplement it with his own equity in the amount of f_t^l, and invest the total in the underlying asset at a total cost, $S_t = Xe^{-r(T-t)} + f_t^l$. At maturity T, the profit (or loss) on this position is the difference between the value of the stock position, S_T, and the loan obligation, X.

The degree of leverage, which the investor assumes by engaging in the forward contract, is the ratio of total assets, $Xe^{-r(T-t)} + f_t^l$ (borrowed and own funds), to the equity in the position, f_t^l.[17] Using the forward pricing formula (6), the leverage ratio of a long forward position, L_f^l, can be expressed as a function of the underlying asset price, S_t:

$$L_f^l(S) = \begin{cases} \dfrac{S_t}{f_t^l} & \text{for } S_t > Xe^{-r(T-t)} \\ \infty & \text{otherwise} \end{cases}. \tag{7}$$

Hence, the leverage embedded in a forward contract is the *current* notional value of the forward contract divided by its market value.[18] The *current notional value* of a derivatives contract reflects current market prices and is defined as the product of the number of underlying shares and their current market price. It is a measure of the on-balance-sheet asset equivalent position of off-balance-sheet exposure and reflects the economic exposure implicit

[15] Many forward contracts are written so that they have no value at their inception.

[16] The short position in the money market is indicated by the minus sign in the forward pricing equation.

[17] To the extent that the long forward contract has a positive value at inception, it can be purchased in part with (on-balance sheet) debt, thereby increasing the overall degree of leverage of the investor. Methods for calculating total leverage are considered in the following section.

[18] Note that the definition of leverage used in this paper makes the leverage ratio remain at infinity when losses exceed equity, even though the mathematical ratio would change signs.

in a derivative instrument. By contrast, the *notional amount* is based on the delivery (exercise) price; it refers to the product of the number of underlying shares and the delivery (exercise) price specified in the contract. The degree of leverage varies with the price of the underlying asset, not unlike on-balance-sheet leverage.[19] As the price of the underlying asset changes, the value of the forward contract—and thus the value of equity in the position—will change, which implies a constantly changing leverage ratio.

As the value of the underlying security increases, the investor's equity rises at a faster rate than the value of the assets, thereby reducing the leverage ratio until it reaches 1 in the limit (Figure 3). As the value of the underlying security falls and approaches the discounted delivery price, the leverage ratio increases and tends to infinity as losses equal or exceed the equity in the position:

$$\lim_{S_t \to Xe^{-r(T-t)}} L_f^l = \infty \qquad \lim_{S_t \to \infty} L_f^l = 1$$

The leverage ratio for a long forward position, L_f^l, changes with the underlying assets price, S, at the following rate:

$$\frac{dL_f^l}{dS} = \frac{-Xe^{-r(T-t)}}{\left(S - Xe^{-r(T-t)}\right)^2} \leq 0, \tag{8}$$

reflecting the decreasing slope of the leverage ratio function.

While the leverage ratio for an individual security can theoretically reach infinity, in practice the ratio for an institution is bounded from above by margin requirements or credit limits. Margin requirements on exchange traded futures range between 2 percent and 8 percent, implying maximum leverage ratios between 50 and 12.5. In over-the-counter forward markets, leverage may be bounded by overall credit and trading limits that counterparties have with each other, but is not typically bounded by margin requirements.[20]

Leverage implied in **short forward** positions can similarly be measured. In that case, the value of the forward contract is determined by the equation:

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[19] Even though changes in the price of the underlying asset result in changes in the value of equity in the position of the same size, the leverage ratio varies between infinity and 1 as the price of the asset increases.

[20] An alternative approach to measuring leverage, which takes the posted margin as the investor's equity position, does not take into account the constantly changing degree of leverage and subsequent margin adjustments.

$$f_t^s = Xe^{-r(T-t)} - S_t.^{21} \tag{9}$$

Holding a short forward contract is equivalent to using own funds of f_t^s as collateral to borrow security S_t, (short) selling the security, and lending the proceeds at the risk-free rate, r (i.e. by investing in a Treasury bill). The underlying assets in this position can be expressed as $f_t^s - Xe^{-r(T-t)}$, where f_t^s is the amount of equity in the position and $-Xe^{-r(T-t)}$ is the amount of debt in the money market (which has a negative sign because the investor is actually lending). The arbitrage condition (9) implies that the leverage ratio of a short forward position, L_f^s, can be expressed as a function of the underlying price, S_t:

$$L_f^s(S) = \begin{cases} -\dfrac{S_t}{f_t^s} & for\ S_t < Xe^{-r(T-t)} \\ -\infty & otherwise \end{cases}. \tag{10}$$

The negative sign indicates the short leveraged position and implies that the rate of return on the contract increases if the price of the underlying security declines. If the value of the short position, f_t^s, in this ratio were replaced with the value of the forward contract, f_t^l, this ratio would be positive. The artificial construct of a negative ratio is introduced to underscore the existence of short leveraged positions. To compare the degree of leverage on short positions with the degree of leverage on long positions, it is necessary to take the absolute value of the respective leverage ratios.

The leverage ratio on a short forward position behaves differently from the ratio of long forward positions (Figure 4). As the price of the underlying security falls, the absolute value of the leverage ratio decreases and in the limit approaches 0. By contrast, as the price of the security rises, the leverage ratio increases until the equity in the position is eliminated. At that point the leverage ratio turns infinite, unless the investor must maintain a positive margin.

$$\lim_{S_t \to 0} L_f^s = 0 \quad and \quad \lim_{S_t \to Xe^{-r(T-t)}} L_f^s = -\infty$$

The leverage ratio function (as a function of the underlying asset price) , L_f^s, slopes downward:

[21] Note that $f_t^s = -f_t^l$.

$$\frac{dL_f^s}{dS} = \frac{-Xe^{-r(T-t)}}{(S - Xe^{-r(T-t)})^2} \leq 0 . \tag{11}$$

B. Option Contracts

Similar to forward markets, option positions can be mapped into an equivalent spot market position in the underlying asset and in the money market. For example, a call option, like a long forward position, is equivalent to supplementing own equity by borrowing funds to establish a long spot position in the underlying security. In contrast to a synthetic forward position, a synthetic option position needs to be constantly adjusted to ensure accurate replication.

According to the Black-Scholes formula, the value of a European non-dividend paying **call option** at time *t*, c_t^l, is a function of the value of the underlying security, S_t, the strike price, *X*, and the "delta" of the option, $\Delta_t^c = N(d_1)$.[22] The volatility, σ, of the rate of return of the underlying security, the risk-free interest rate, *r*, and the remaining time to maturity, *T-t* are additional factors determining the option value:

$$c_t^l = N(d_1)S_t - N(d_2)Xe^{-r(T-t)} ,$$

$$\text{where } d_1 = \frac{\ln(S_t / X) + (r + \sigma^2 / 2)(T - t)}{\sigma\sqrt{T-t}} ,\ d_2 = d_1 - \sigma\sqrt{T-t} , \tag{12}$$

and *N(x)* is the cumulative probability distribution function for a standardized normal variable. The pricing equation indicates that the option can be replicated by borrowing the amount $N(d_2)Xe^{-r(T-t)}$ at the risk-free rate and using the proceeds together with own equity in the amount of c_t^l to purchase $\Delta_t^c S_t$ of the underlying security. As the delta changes with the current spot price of the security, the volatility, and the time to maturity, the amounts borrowed and invested need to be continuously adjusted to ensure that the option is replicated accurately.

The assets associated with this replicating portfolio are equal to the current value of the investor's debt plus the investor's own equity, $N(d_2)Xe^{-r(T-t)} + c_t^l$. Thus, the leverage ratio function of a long call option position, L_{co}^l, can be expressed as:

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[22] The "delta" of the option is defined as the rate of change of the option price with respect to the price of the underlying asset. It is also called the "hedge ratio".

$$L_{co}^{l}(S)=\frac{N(d_2)Xe^{-r(T-t)}+c_t^{l}}{c_t^{l}}=\frac{\Delta_t^{c}S_t}{c_t^{l}}, \qquad (13)$$

$$\lim_{S\to\infty} L_{co}^{l}=1 \quad \text{and} \quad \lim_{S\to 0} L_{co}^{l}=\infty.$$

Using the option pricing formula (12), the leverage ratio can be expressed as delta times the current notional value divided by the market value of the option, as indicated by the second equality.[23]

While the leverage ratio function of a long call option is downward sloping like that of a long forward position and approaching the same limits, the leverage ratio is smaller than that of a long forward contract with the same characteristics at the same asset price:

$$L_{co}^{l}\le L_{f}^{l}.$$

This can be easily verified by comparing equation (13) with equation (7). The delta of an option is less or equal to the delta of a forward contract ($\Delta_t^{c}\le 1=\Delta_t^{f}$), which implies that the leverage ratio of an option is less or equal to that of a similar forward contract. Another interpretation of the same explanation is that the lower bound of a European call option price is its intrinsic value, $S-Ke^{-r(T-t)}$, which is the forward price.[24] The boundary condition implies that the value of the call option exceeds or is equal to the value of a forward contract with the same specifications ($c_t^{l}\ge f_t^{l}$).

To see why the leverage embedded in an option is less than the leverage implied in a forward contract or an outright loan, we rewrite equation (13) as:

$$L_{co}^{l}=\frac{dc}{dS}\cdot\frac{S}{c}. \qquad (14)$$

Comparing this notation to equation (1), we note that in a portfolio leveraged through a forward contract or a loan changes in the asset prices accrue to equity one-to-one (i.e. in eq. (1) $dE=dA$). In the case of an option where the delta is not necessarily equal to one, the underlying asset position is adjusted in a way that changes in the asset price are only partially reflected in the investor's equity in the position (i.e. in equation (14) $dc=\Delta_t^{c}dS$).

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[23] This ratio is sometimes referred to in the literature as the 'lambda' of an option.

[24] This statement simply indicates that the value of an option cannot be less than its intrinsic value, even if its time value is zero.

The deeper the option is in the money, the larger is the value of the investor's equity in the position and the lower is the leverage ratio, which ultimately approaches one. Due to the time value of the option, the option price, c_t^l (the current value of the investor's equity in the position), remains positive until expiration, even if it has no intrinsic value. Hence, the leverage ratio of the long call option is bounded away from infinity but approaches infinity as the price of the option tends to zero. As the time to maturity decreases and the interest rate decreases, the leverage ratio for out-of-the money options will approach infinity faster. More formally, the slope of the leverage ratio function with respect to the price of the underlying asset is:

$$\frac{dL_{co}^l}{dS} = \frac{\left(\frac{dN(d_s)}{dS}c - N(d_1)N(d_2)\right)Xe^{-r(T-t)}}{\left(N(d_1)S_t - N(d_2)Xe^{-r(T-t)}\right)^2}. \tag{15}$$

For the same reasons as noted above, this implies that

$$\frac{dL_{co}^l}{dS} \leq \frac{dL_f^l}{dS},$$

indicating that leverage implied by a long call option position is not only smaller than that of a comparable forward contract, but the leverage also rises at a slower rate as the price of the underlying asset falls.

A **short call option** can be replicated by selling short the underlying security, supplementing the proceeds with own equity, c_t^s, which is the amount one would otherwise be willing to spend to assume the short option position, and invest the funds at the risk-free interest rate.[25] The value of a short call option position is $c_t^s = N(d_2)Xe^{-r(T-t)} - \Delta_t^c S_t$. Hence, leverage of a short call option position, L_{co}^s, can be measured again as equity plus debt, which in this case is negative as the investor is effectively lending:

$$L_{co}^s(S) = \frac{c_t^s - N(d_2)Xe^{-r(T-t)}}{c_t^s} = \frac{-\Delta_t^c S_t}{c_t^s}. \tag{16}$$

Taking the absolute value of this ratio allows quantitative comparisons to leverage implicit in long positions.

[25] Note that $c_t^s = -c_t^l$.

Calculating the leverage ratio for long and short **put option** positions follows the same method, taking into account the different pricing formula for a put option. The ratios are reported in Table 1, where p_t indicates the value of a put option.[26]

Table 1. Leverage ratios in basic derivative instruments

Derivative	Long position	Short position
Forward contract	$\frac{S_t}{f_t^l}$	$\left\lvert -\frac{S_t}{f_t^s} \right\rvert$
Call option	$\frac{\Delta_t^c S_t}{c_t^l}$	$\left\lvert -\frac{\Delta_t^c S_t}{c_t^s} \right\rvert$
Put option	$\left\lvert \frac{\Delta_t^p S_t}{p_t^l} \right\rvert$	$-\frac{\Delta_t^p S_t}{p_t^s}$

C. Repurchase Agreements

Leveraged positions can also be built up using **repurchase agreements** combined with further asset purchases. Leverage through a repo is achieved by lending a security, in return for cash, using the cash to acquire another security, which then, in turn, can be "repoed" again to raise more cash. As security lenders continue to be exposed to the market risk of securities they have repoed they increase their leverage.[27] In each repo transaction, the provider of cash will charge the securities lender an initial margin or haircut, *h*, diminishing the full value of the collateral. The assets under the control of the leveraged investor are the sum of his equity, consisting of the value of the original security, *S*, and his debt consisting of the sum of cash obligations under each repo. The leverage ratio in a series of repurchase agreements, L_r, can be expressed as a function of the value of the securities and the number of times, *n*, they have been repoed:

$$L_r = \frac{S + \sum_{i=1}^{n} (1-h)^i S}{S}. \tag{17}$$

Hence, the upper bound on leverage is determined by the size of the haircut required by the lender of cash. Since haircuts on repos are typically between 1 and 2 percent, leverage using multiple repos can potentially be huge. With zero haircuts (several hedge funds are reported

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[26] The delta of a put option, Δ_t^p, is related to the delta of a call option: $\Delta_t^p = \Delta_t^c - 1$.

[27] Even though not all repurchase agreements take place off-balance sheet, they are such an important tool to acquiring leverage that they have been included here.

to have received such favorable terms in 1998) leverage can potentially be infinite. More formally, the limits can be expressed as:

$$\lim_{h\to 0} L_r = 1+n \qquad \lim_{h\to 1} L_r = 1$$
$$\lim_{n\to\infty} L_r = \infty \qquad \lim_{n\to 1} L_r = 2-h.$$

Leverage in a series of repos can be constrained by either increasing haircuts, or the number of times a security can be repoed out.

VI. Measuring Aggregate Leverage of a Financial Institution

To obtain an overall measure of off- and on-balance-sheet leverage of a financial institution, the mapped asset components developed in the previous section and on-balance-sheet assets can be aggregated for an institution and expressed relative to its total equity. To obtain the leverage ratio, the on-balance-sheet asset equivalent of the exposure that is implied by an off-balance-sheet instrument is calculated. The on-balance-sheet asset equivalent (also called the *current* notional amount) is the sum of the own funds and borrowed funds equivalent positions in the replicating portfolio. The off-balance-sheet exposure is then added to on-balance-sheet assets, and this asset total is divided by on-balance-sheet equity. Hence, the ratio of current notional values outstanding to the equity of the institution indicates the extent of off-balance-sheet leverage. The sum of this ratio and the conventional balance sheet leverage ratio serves as the total leverage ratio.

The leverage ratios applicable to an institution are based on on-balance-sheet equity because some of the equity equivalent position in a derivatives position may partially be financed by on-balance-sheet debt. While some individual instruments in the institution's portfolio may have infinite leverage due to the lack of a positive equity equivalent component, the overall leverage ratio will be less than infinity, to the extent that the institution's on-balance-sheet equity is positive.

There are at least two ways of aggregating underlying asset positions to arrive at an overall measure of leverage for a financial institution: the "gross leverage ratio" and the "net leverage ratio".[28] [29] The "*gross leverage ratio*" adds the absolute amount of short (negative)

[28] Alternatively, the "off-balance-sheet gross" and "off-balance-sheet net leverage ratios" could be calculated by dividing the sum of asset equivalent components implicit in off-balance-sheet items by the sum of their equity equivalent components. Positions that have an infinite leverage ratio will only contribute to the numerator, but not to the denominator. Both ratios do not take into account that portions of the equity equivalent components of derivatives, in turn, may be financed by on-balance-sheet leverage.

[29] Various other ways of combining (on-balance-sheet) asset positions are considered in Counterparty Risk Management Group (1999).

asset equivalents to that of long (positive) positions and divides by on-balance-sheet equity. This ratio, in general, overstates the total market exposure since it neglects the possibility that short positions may offset long positions to some extent. Subtracting short matched book asset positions from long asset positions before dividing by equity yields the "*net leverage ratio*", which is smaller than the gross leverage ratio. Not perfectly correlated assets would involve modeling assumptions about their correlations and covariances akin to VaR models, which may break down during precisely those moments of market turbulence that the leverage indicator is supposed to provide insights for. This would blur the separation between leverage and risk. Both ratios measure the relationship between an investor's exposure and his equity. While the net leverage ratio may more accurately reflect the market risk of a leveraged investor by focusing on the net asset position, it does not take into account credit and liquidity risk inherent in individual contracts. By contrast, the gross leverage ratio incorporates all those risks.

It is impossible to precisely measure leverage for institutions active in derivative markets without full knowledge of their positions, including hedges. However, data filed by commercial banks and trust companies in the United States with the Office of the Comptroller of the Currency (OCC) allow a rough approximation. The quarterly OCC Bank Derivatives Report is based on call report information provided by U.S. commercial banks. Notional amounts of all derivatives outstanding (not subject to netting) and credit equivalent exposures are reported by 416 insured commercial banks. The report lists separately the 25 banks with the most derivative contracts, which in June 2000 held 99 percent of the notional amount of derivatives in the domestic banking system and 41 percent of derivatives outstanding worldwide. While OCC data do not report equity of financial institutions, total regulatory capital, the sum of tier 1 and tier 2 capital, can be extracted from the data and can be substituted for equity. The report also discloses total on-balance-sheet assets.

In the absence of better data, the best approximation to the total gross leverage ratio is to divide total notional amounts by regulatory capital. This has been done on an aggregate basis for the top 25 and the remaining 391 banks in Figure 5 (data are available for 1995 to 2000). The indicator is an approximation to gross leverage, rather than net leverage, because it does not take into account netting across positions. An important shortcoming is that the ratio uses notional amounts and not *current* notional amounts as suggested by the analysis in section V to accurately reflect the exposure of an institution. This may cause particular distortions for option contracts, which represent about one fifth of total notional amounts, as their delta is implicitly set equal to 1. Hence, the total gross leverage ratios in Figure 5 have to be interpreted as the upper limit to the ratio that would be calculated under the methodology proposed in section V if the data were available. Furthermore, the measure lumps together exposures at all maturity horizons. In addition, the indicator does not differentiate between leveraged positions taken on for speculative purposes and leveraged positions taken on to hedge existing exposure, which may not be unwound in case of an adverse price shock. With more precise data, more sophisticated leverage indicators could be developed which differentiate exposure by maturity and other factors. Nevertheless, to the extent that the deviations of the indicator from a better measure are constant, the relative movements of the indicator are indicative of the degree of leveraging in U.S. commercial banks.

The most striking feature (in Figure 5) is that total gross off-balance-sheet leverage of the top 25 U.S. commercial banks exceeds total on-balance-sheet leverage by a wide margin. While this is somewhat expected given the limitations of the indicator, it is still noteworthy that the two measures would differ by a factor as large as 16, with total gross leverage reaching a level as high as 97. In contrast, total gross leverage among all other commercial banks did not exceed on-balance-sheet leverage by a factor larger than 1½. Moreover, total gross leverage, as well as on-balance-sheet leverage, is vastly higher for the top 25 banks than all other commercial banks. These two outcomes are partially explained by the degree of concentration in the derivative business. The figure illustrates the fact that the top U.S. commercial banks assume leverage mostly through off-balance-sheet transactions rather than through traditional means. It also emphasizes the need to develop proper data collection methods to accurately monitor the leverage assumed in derivatives transactions, so as to assure proper capitalization of banks and anticipate potential episodes of unwinding.

The total gross leverage indicator for the top 25 commercial banks in Figure 5 is consistent with anecdotal evidence about leveraging activities of market participants (International Monetary Fund, 1996 and 1999).[30] For example, in the aftermath of the 1996 bond market turbulence and during the subsequent period of deleveraging total gross leverage fell from 87 during the second quarter to 76 during the fourth quarter. Leverage rose again in 1997 and experienced a sharp boost of 17 percent in the third quarter of 1998 when hedge funds and proprietary desks were said to be particularly active with convergence plays and similar highly leveraged activities.[31] The build up in leverage was largely due to an upsurge in exposure rather than a decrease in capital (Figure 6). Following the LTCM crisis at the end of 1998, the leverage indicator started to decline. With the exception of the second quarter in 1999, this decline continued until the second quarter of 2000, when the indicator registered a modest increase. The expanded period of decreasing leverage is consistent with anecdotal evidence that points to the absence of LTCM's participation in the market after the crisis as a major factor contributing to substantially lower liquidity. Market participants, including the liquidators of LTCM, needed to wait for market conditions to return to normal to unwind their positions, thus prolonging the period of unwinding. The introduction of the euro at the beginning of 1999 may also have contributed to deleveraging as institutions reduced their positions to avoid computer problems related to the merger of 12 currencies into one. The subsequent elimination of foreign exchange business among the European currencies is likely to be another cause for the lower observed leverage during that period. The deleveraging process may also been aided by the desire of institutions to reduce their positions in anticipation of possible year 2000 (Y2K) computer problems. The unusual surge in leverage during the second quarter in 1999 could be related to expectations of rising interest rates in the United States and the associated hedging activity at that time. These

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[30] Due to the quarterly nature of the data and reporting lags, there may not be precise relationship between events and the observed leverage indicator.

[31] One globally active bank reached a ratio as high as 579.

observations support the hypothesis that the approximate total leverage indicator reveals information about leveraging activities of banks.

VII. Measuring Leverage in Markets

To determine the potential for financial market turbulence stemming from deleveraging it is useful to estimate the extent of leveraged positions in a particular market. In practice, it is not possible to gather such data without individual position data, particularly for off-balance-sheet transactions.

Two reports by the Bank for International Settlements (BIS), the triennial Central Bank Survey of Foreign Exchange and Derivatives Market Activity (BIS, 1999) and the Global OTC Derivative Markets Report (BIS, 2000), allow approximations of the extent of leverage in certain derivatives markets on a global basis. The surveys report total gross notional amounts and total gross market values outstanding at specific dates in various segments of the foreign exchange derivative and interest rate derivative markets. The data are subject to the same limitations as the OCC data. Nevertheless, similar approximations as above are possible. The approximation used here refers to the off-balance-sheet gross leverage ratio because market values refer to the equity equivalent position in a derivative contract, rather than the total on-balance-sheet equity of an institution.[32]

The data confirm stylized facts about the leverage implicit in various derivative contracts (Table 2). Interest rate derivative contracts had higher inherent leverage ratios than foreign exchange derivative contracts, reflecting the fact that the former—unlike the latter—typically do not involve an exchange of principal. In addition, interest rates tend to be less volatile than exchange rates, so that interest rate contracts tend to have smaller market values (for a given notional amount) than those of foreign exchange contracts, but larger implied leverage. Foreign exchange contracts represent exposure to both currency and interest rate risks, which also contributes to a higher market value relative to the notional amount and therefore lower leverage. The reported high degree of leverage in option contracts overstates actual leverage because of the implicit assumption of delta being unity.

The data indicate that the approximate gross leverage ratio for all classes of derivatives covered by the survey increased from 22 in March 1995 to 28 in June 1998 as banks increased leveraged positions (Table 2).[33] Following the mature market crisis in the autumn of 1998, this indicator dropped to 25 at year-end, but rose throughout 1999 and peaked at 36 at end-June 2000, suggesting a strong rebound in leverage implicit in derivatives. Both, the drop during the crisis and the subsequent rebound, were driven mainly by interest rate products, particularly those dominated in euros (Table 3). In order to use this

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[32] See footnote 23.

[33] This compares to a ratio of 36 for the top 7 US commercial banks at the end of the second quarter in 1998.

method for market surveillance, it would be necessary to collect data on current notional amounts, to compile these data at a higher frequency, and to provide it with greater timeliness.

VIII. Capital Adequacy in Derivative Transactions

The approach suggested in this paper—decomposing derivative instruments into own funds and borrowed funds equivalents of the replicating portfolio—may also be useful in the context of ensuring the availability of adequate capital to cover losses arising from off-balance-sheet activities. Capital adequacy guidelines by the Basel Committee on Banking Supervision that are designed to cover credit risk in derivative instruments require banks to calculate credit equivalent amounts, which are to be weigthed according to the category of counterparty, with a maximum weighting of 50 percent (Basel Committee on Banking Supervision, 1988 and 1995).[34] The credit equivalent amounts consist of two components:[35] (1) the total current replacement cost obtained by "marking to market" of all contracts with positive value, and (2) an amount for potential future credit exposure calculated as a percentage (ranging from 0 to 15 percent) of the total notional amount, split by risk category and residual maturity (the "add-on"). Thus, capital adequacy requirements for derivatives containing credit risk depend on a combination of their market value and their notional value.[36] They range from 0 to 4 percent of the full market value plus 0 to 7½ percent of the notional amount (due to the cap on risk weighting).[37]

The approach to capital requirements covering credit risk is based on the recognition that banks are not exposed to credit risk for the full face value of their contracts, but only to the potential cost of replacing the cash flow of the contract if the counterparty defaults.

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[34] The consultation paper for a new Basel Accord (Basel Committee on Banking Supervision, 1999c) abolishes the limit on risk weightings for exposures to counterparties in OTC derivatives transactions.

[35] Note: The term 'credit equivalent' refers to the amount of a derivative contract that exposes the holder to credit risk and is typically the contract's positive market value. The term 'debt equivalent' refers to the portion of the exposure of a derivative contract (the *current* notional amount) that would have to be borrowed to replicate the derivative in the spot market.

[36] Derivatives containing credit risk are mostly traded over-the-counter. Exchange traded derivatives with relatively little credit risk may be considered under the 1996 Amendment to the Capital Accord to Incorporate Market Risk.

[37] While derivatives are often referred to as off-balance-sheet financial transactions because the notional amounts of their contracts are not recorded on the balance sheet, the market values on trading derivatives, which—as pointed out above—generally represent a small fraction of the notional amount, are recorded on the balance sheet and are therefore captured by capital adequacy requirements.

However, the amount of potential future credit exposure to be added on to the current total replacement cost is determined in a somewhat ad hoc fashion through the "add-on matrix".

Derivative instruments can be used for regulatory capital arbitrage similar to other techniques, such as securitisation with partial recourse or indirect credit enhancements (see Jackson, 1999). Derivatives allow banks to lever up their capital to gain an exposure which is disproportionate to capital requirements. The capital adequacy ratio covering credit risk is calculated based on the market value of the derivative contract and the add-on factor, but does not necessarily reflect economic exposure accurately (see Figure 1).[38] When the marginal risk created by a derivative instrument exceeds the average risk implied by the Basel capital charge, the capital standard may unwittingly encourage (insured) institutions to accumulate additional risk. If exposures equivalent to those implicit in a derivative contract would be achieved through on-balance-sheet positions, capital requirements could be much higher and overall position taking by banks could be lower. This discrepancy in the treatment of derivative positions and on-balance-sheet positions may allow increasing the riskiness of the bank's portfolio through the use of derivatives without adequately increasing the regulatory capital to be held against this exposure. Arguably, this relatively low-cost form of capital arbitrage may have contributed to the significant growth of derivatives markets, and it could have fueled the buildup of leverage in the financial system.

The leverage indicators and the decomposition of derivatives into their replicating portfolios developed in this paper could perhaps be used to more accurately translate economic exposure in a derivative contract into credit equivalent amounts. Neither the market value nor the notional value adequately reflect the current credit exposure. The full current exposure of a derivative contract could be thought of as the product of its market value and its implicit leverage ratio. Following the exposition in section V, this product equals the *current* notional value, *S*, as defined above:

$$\textit{credit exposure} = f \times \frac{S}{f} = S = \textit{current notional amount}$$

Hence, the decomposition of off-balance-sheet contracts into equity and debt equivalent positions could be used to convert the exposure in a derivative contract to an equivalent portfolio of on-balance-sheet assets to which the regular capital adequacy requirement calculations would be applied. This may result in capital charges that differ significantly from those under the Basel Accord, as the following example demonstrates:

Consider a short 6-month call option contract with a private corporation in the over-the-counter market, which gives the bearer the right to obtain 100 shares of the

[38] The 1996 Market Risk Amendment does base capital requirements on an improved representation of exposure for some instruments. However, it ignores exposure beyond the market value for others, and requires capital charges against the full notional amount of another set of instruments.

underlying stock at $40 each. We assume that the current share price is $42, the risk-free interest rate (continuously compunded) is 10 percent per annum and the volatility of the stock is 20 percent per annum. The option contract is worth $476 and has a delta of 0.78. In this case, the Basel Accord would require a capital charge of 4 percent on the credit equivalent amount, i.e. the market value of the contract plus the add-on which multiplies the notional amount, $4,000, by the appropriate factor, 6 percent in this case. Thus, the overall capital requirement would be $28.60. Using the economic exposure approach developed in this paper (and keeping the 50 percent cap on risk weightings for comparison purposes) the capital charge would be 4 percent of the current notional amount, $4,200 x 0.78 = $3,276, or $131. Thus, accounting for the leverage provided by a derivative contract could increase the capital charge significantly.

It is interesting to note that the economic exposure approach takes into account that a contract which is further out-of-the money has a lower probability of potential future exposure, and thus should require a lower capital charge, than a contract that is closer to at-the-money. By contrast, the Basel approach sets the capital charge for out-of-the money contracts equal to zero regardless of how far out-of-the money they are, and regardless of their potential future exposure.

Using data from the Office of the Comptroller of the Currency described in section VI, a modified capital adequacy ratio which incorporates asset equivalents of off-balance-sheet instruments can be approximated. This approximate ratio can be compared to the traditional capital adequacy ratio (Figure 7). Since data on risk-weighted assets were not available, the traditional capital adequacy ratio had to be approximated by dividing regulatory capital by total on-balance-sheet assets. Using total assets instead of risk-weighted assets will bias the ratio downward. The modified capitalization ratio is defined as regulatory capital divided by the sum of total risk-weighted on-balance-sheet assets and off-balance-sheet asset equivalents. Given the lack of data on off-balance-sheet asset equivalents, notional amounts (along with on-balance-sheet assets) had to be used to approximate the ratio. The lack of data on risk-weighted assets and off-balance-sheet asset equivalents implies a stronger downward bias than that contained in the approximate traditional capital adequacy ratio. Given these biases, it is hardly surprising that the traditional capitalization ratio exceeds the modified ratio by a wide margin. Still, this analysis emphasizes the need to collect relevant data to accurately monitor the capitalization of banks even if they assume a large amount of exposure off their balance sheet. While the actual difference between the traditional and modified capitalization ratios may not be as stark as in Figure 7, it is likely to reveal substantially lower capitalization of banks.

IX. Conclusion

Counterparty due diligence, market level surveillance and prudential supervision at the level of individual institutions are currently constrained by the lack of a measure for off-balance-sheet leverage. The regulatory costs associated with assuming leverage on-the-balance sheet have prompted institutions to take on leverage through off-balance-sheet operations. To judge potential defaults and to determine the potential for financial market turbulence it is necessary to gain an understanding of overall leverage, incorporating both, on- and off-balance-sheet activities. This paper presents a method of measuring the degree of leverage implicit in selected derivative contracts by decomposing the contract and mapping the replicating portfolio into equity and debt components. The resulting measure differs from commonly used measures of leverage implicit in derivative contracts, such as the ratio of notional value over market value. Specifically, the analysis shows that data on current notional amounts need to be collected to measure the economic exposure of an institution more accurately. Evidence that approximates the degree of total leverage indicates a substantial degree of off-balance-sheet leveraging, particularly among a few internationally active financial institutions. Changes in the total leverage indicator correspond to anecdotal evidence of leveraging and deleveraging activities of U.S. banks, underscoring the informational content of the indicator. The substantial off-balance-sheet leveraging activities and the limitations of current capital adequacy requirements for derivatives call for an appropriate capitalization measure that accurately captures total exposure, on- and off-balance-sheet. Approximating such a modified capitalization measure suggests that there could be large discrepancies with traditional capitalization ratios.

Table 2. Global Over-the-Counter (OTC) Derivatives Markets: Notional Amounts, Gross Market Values of Outstanding Contracts, and Approximate Gross Leverage Ratios, 1995-2000[1]

(In billions of U.S. dollars)

	Notional Amounts						Gross Market Values						Approximate Gross Leverage Ratio					
	End-Mar. 1995	End-Jun. 1998	End-Dec. 1998	End-Jun. 1999	End-Dec. 1999	End-Jun. 2000	End-Mar. 1995	End-Jun. 1998	End-Dec. 1998	End-Jun. 1999	End-Dec. 1999	End-Jun. 2000	End-Mar. 1995	End-Jun. 1998	End-Dec. 1998	End-Jun. 1999	End-Dec. 1999	End-Jun. 2000
Total	**47,530**	**72,143**	**80,317**	**81,458**	**88,201**	**94,037**	**2,205**	**2,580**	**3,231**	**2,628**	**2,813**	**2,581**	**22**	**28**	**25**	**31**	**31**	**36**
Foreign exchange	**13,095**	**18,719**	**18,011**	**14,899**	**14,344**	**15,494**	**1,048**	**799**	**786**	**582**	**662**	**578**	**12**	**23**	**23**	**26**	**22**	**27**
Outright forwards and forex swaps	8,699	12,149	12,063	9,541	9,593	10,504	622	476	491	329	352	283	14	26	25	29	27	37
Currency swaps	1,957	1,947	2,253	2,350	2,444	2,605	346	208	200	192	250	239	6	9	11	12	10	11
Options	2,379	4,623	3,695	3,009	2,307	2,385	71	115	96	61	60	55	34	40	38	49	38	43
Interest rate[2]	**26,645**	**42,368**	**50,015**	**54,072**	**60,091**	**64,125**	**647**	**1,160**	**1,675**	**1,357**	**1,304**	**1,230**	**41**	**37**	**30**	**40**	**46**	**52**
Swaps	18,283	29,363	36,262	38,372	43,936	47,993	562	1,018	1,509	1,222	1,150	1,072	33	29	24	31	38	45
Forward rate agreements	4,597	5,147	5,756	7,137	6,775	6,771	18	33	15	12	12	13	255	156	384	595	565	521
Options	3,548	7,858	7,997	8,562	9,380	9,361	60	108	152	123	141	145	59	73	53	70	67	65
Equity-linked	**579**	**1,274**	**1,488**	**1,511**	**1,809**	**1,671**	**50**	**190**	**236**	**244**	**359**	**293**	**12**	**7**	**6**	**6**	**5**	**6**
Options	527	1,120	1,342	1,313	1,527	1,323	43	170	192	193	288	231	12	7	7	7	5	6
Forwards and swaps	52	154	146	198	283	348	7	20	44	52	71	62	7	8	3	4	4	6
Commodity[3]	**318**	**451**	**415**	**441**	**548**	**584**	**28**	**38**	**43**	**44**	**59**	**80**	**11**	**12**	**10**	**10**	**9**	**7**
Gold	147	193	182	189	243	262	10	10	13	23	23	19	15	19	14	8	11	14
Other	171	258	233	252	305	323	18	28	30	22	37	61	10	9	8	11	8	5
Forwards and swaps	120	153	137	127	163	169	13	...	...	...	...	...	9	...	...	...	...	...
Options	51	106	97	125	143	154	5	...	...	...	...	...	10	...	...	...	...	...
Other[4]	**6,893**	**9,331**	**10,388**	**10,536**	**11,408**	12,163	**432**	393	**492**	**400**	**429**	**400**	**16**	**24**	**21**	**26**	**27**	**30**
Memorandum items:																		
Gross credit exposure[5]	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	...	1,203	1,329	1,119	1,023	937	...	...	...	...	...	...
Exchange-traded derivatives	9,841	14,792	13,932	14,440	13,522	13,904	...	...	...	...	...	...	...	...	...	...	...	...

Source: Bank for International Settlements (2000).

[1]All figures are adjusted for double-counting. Notional amounts outstanding have been adjusted by halving positions vis-à-vis other reporting dealers. Gross market values have been calculated as the sum of the total gross positive market value of contracts and the absolute value of the gross negative market value of contracts with non-reporting counterparties.

[2]Single-currency contracts only.

[3]Adjustments for double-counting are estimated.

[4]For end-June 1998: positions reported by institutions that only participated in the 1998 Triennial Survey of Foreign Exchange and Derivatives Market Activity; for subsequent periods: estimated positions of those institutions.

[5]Gross market values after taking into account legally enforceable bilateral netting agreements.

Table 3. Global Over-the-Counter (OTC) Derivatives Markets: Notional Amounts, Gross Market Values, and Approximate Gross Leverage Ratios of Outstanding Contracts by Counterparty, Remaining Maturity and Currency Composition, 1998-2000[1]

(In billions of U.S. dollars)

	Notional Amounts					Gross Market Values					Approximate Gross Leverage Ratio				
	End-Jun. 1998	End-Dec. 1998	End-Jun. 1999	End-Dec. 1999	End-Jun. 2000	End-Jun. 1998	End-Dec. 1998	End-Jun. 1999	End-Dec. 1999	End-Jun. 2000	End-Jun. 1998	End-Dec. 1998	End-Jun. 1999	End-Dec. 1999	End-Jun. 2000
Total	**72,143**	**80,317**	**81,458**	**88,201**	**94,037**	**2,580**	**3,231**	**2,628**	**2,813**	**2,581**	**28**	**25**	**31**	**31**	**36**
Foreign exchange	**18,719**	**18,011**	**14,899**	**14,344**	**15,494**	**799**	**786**	**582**	**662**	**578**	**23**	**23**	**26**	**22**	**27**
By counterparty															
With other reporting dealers	7,406	7,284	5,464	5,392	5,827	314	336	200	214	168	24	22	27	25	35
With other financial institutions	7,048	7,440	6,429	6,102	6,421	299	297	246	281	242	24	25	26	22	27
With non-financial customers	4,264	3,288	3,007	2,850	3,246	186	153	136	167	168	23	21	22	17	19
By major currency															
U.S. dollar[3]	16,167	15,810	13,181	12,834	13,178	747	698	519	581	518	22	23	25	22	25
Euro[3,4]	8,168	7,658	4,998	4,667	5,863	193	223	206	239	242	42	34	24	20	24
Japanese yen[3]	5,579	5,319	4,641	4,236	4,344	351	370	171	262	157	16	14	27	16	28
Pound sterling[3]	2,391	2,612	2,281	2,242	2,479	55	62	63	55	76	43	42	36	41	33
Other[3]	5,133	4,623	4,697	4,709	5,124	252	219	205	187	163	20	21	23	25	31
Interest rate[5]	**42,368**	**50,015**	**54,072**	**60,091**	**64,125**	**1,160**	**1,675**	**1,357**	**1,304**	**1,230**	**37**	**30**	**40**	**46**	**52**
By counterparty															
With other reporting dealers	18,244	24,442	27,059	30,518	32,208	463	748	634	602	560	39	33	43	51	58
With other financial institutions	18,694	19,790	21,149	24,012	25,771	515	683	559	548	518	36	29	38	44	50
With non-financial customers	5,430	5,783	5,863	5,562	6,146	182	244	164	154	152	30	24	36	36	40
By major currency															
U.S. dollar	13,214	13,763	16,073	16,510	17,606	311	370	337	376	367	42	37	48	44	48
Euro[4]	13,576	16,461	17,483	20,692	22,948	476	786	584	492	467	29	21	30	42	49
Japanese yen	7,164	9,763	10,207	12,391	12,763	194	212	192	232	207	37	46	53	53	62
Pound sterling	3,288	3,911	4,398	4,588	4,741	59	130	103	94	84	56	30	43	49	56
Other	5,126	6,117	5,911	5,910	6,067	120	177	141	110	105	43	35	42	54	58
Equity-linked	**1,274**	**1,488**	**1,511**	**1,809**	**1,671**	**190**	**236**	**244**	**359**	**293**	**7**	**6**	**6**	**5**	**6**
Commodity[6]	**451**	**415**	**441**	**548**	**584**	**38**	**43**	**44**	**59**	**80**	**12**	**10**	**10**	**9**	**7**
Other[7]	**9,331**	**10,388**	**10,536**	**11,408**	**12,163**	**393**	**492**	**400**	**429**	**400**	**24**	**21**	**26**	**27**	**30**

Sources: Bank for International Settlements (2000).

[1]All figures are adjusted for double-counting. Notional amounts outstanding have been adjusted by halving positions vis-à-vis other reporting dealers. Gross market values have been calculated as the sum of the total gross positive market value of contracts and the absolute value of the gross negative market value of contracts with non-reporting counterparties.

[2]Residual maturity.

[3]Counting both currency sides of each foreign exchange transaction means that the currency breakdown sums to twice the aggregate.

[4]Data before end-June 1999 refer to legacy currencies of the euro.

[5]Single-currency contracts only.

[6]Adjustments for double-counting are estimated.

[7]For end-June 1998: positions reported by institutions that only participated in the 1998 Triennial Survey of Foreign Exchange and Derivatives

Figure 1: Treatment of Derivatives on the Balance Sheet of a Financial Institution

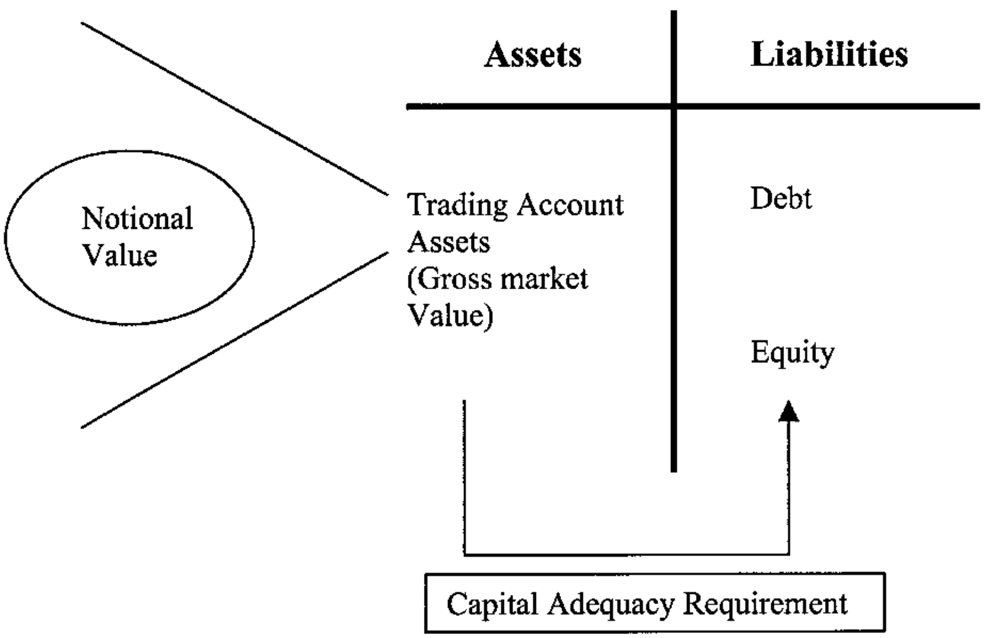


Figure 2: An Example of Off-Balance-Sheet Leverage

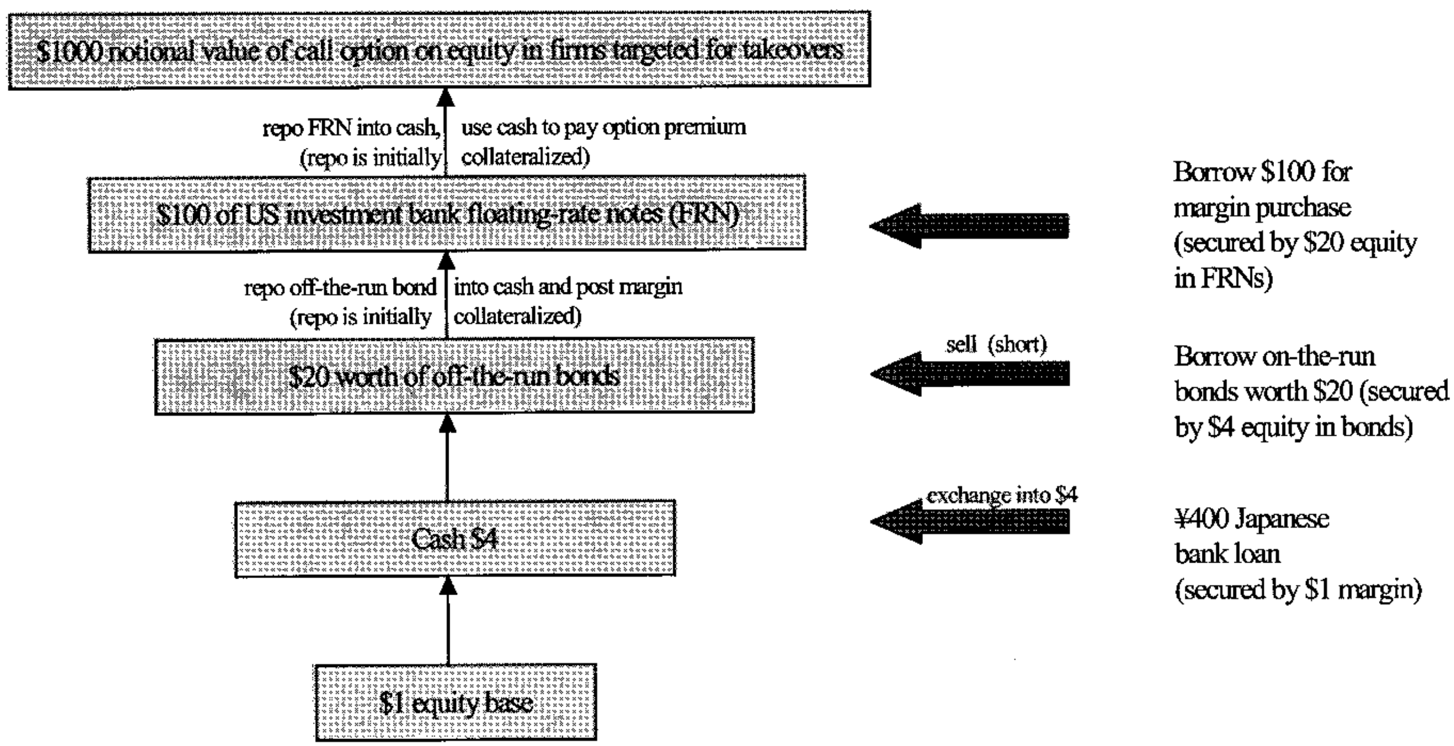


Figure 3a: Leverage of a Long Forward Position as a Function of the Underlying Asset Price

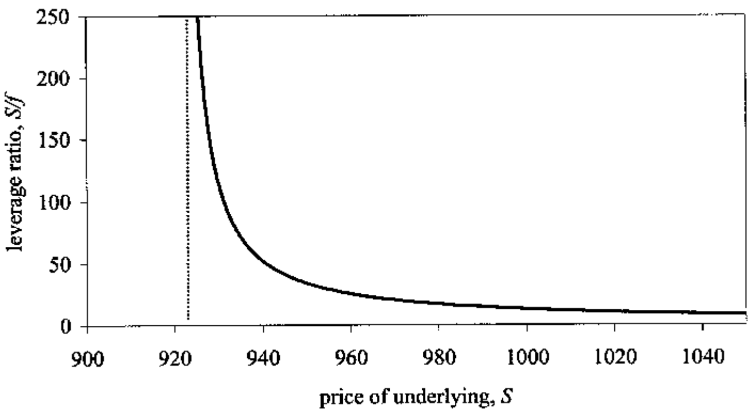


Figure 4a: Leverage of a Short Forward Position as a Function of the Underlying Asset Price

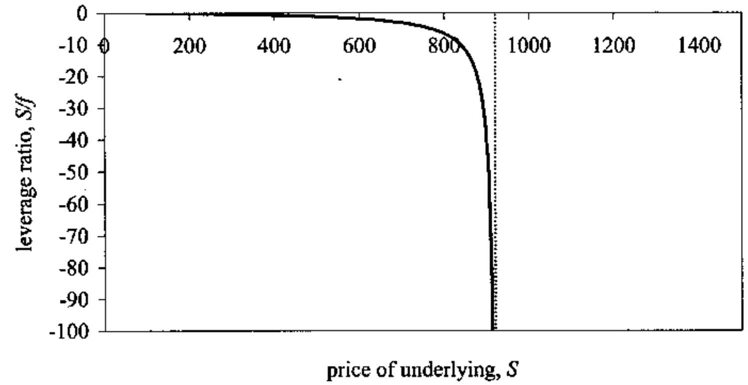


Figure 3b: Value of a Long Forward Position as Function of Underlying Asset Price

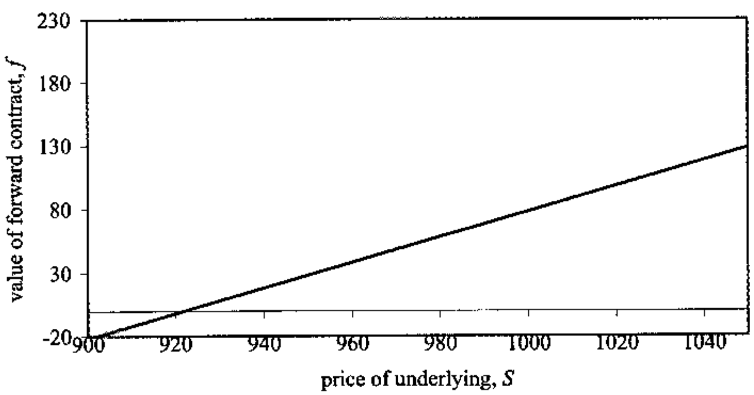
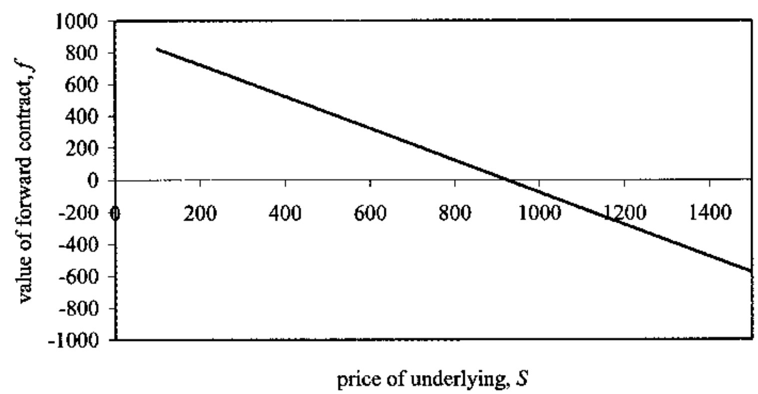
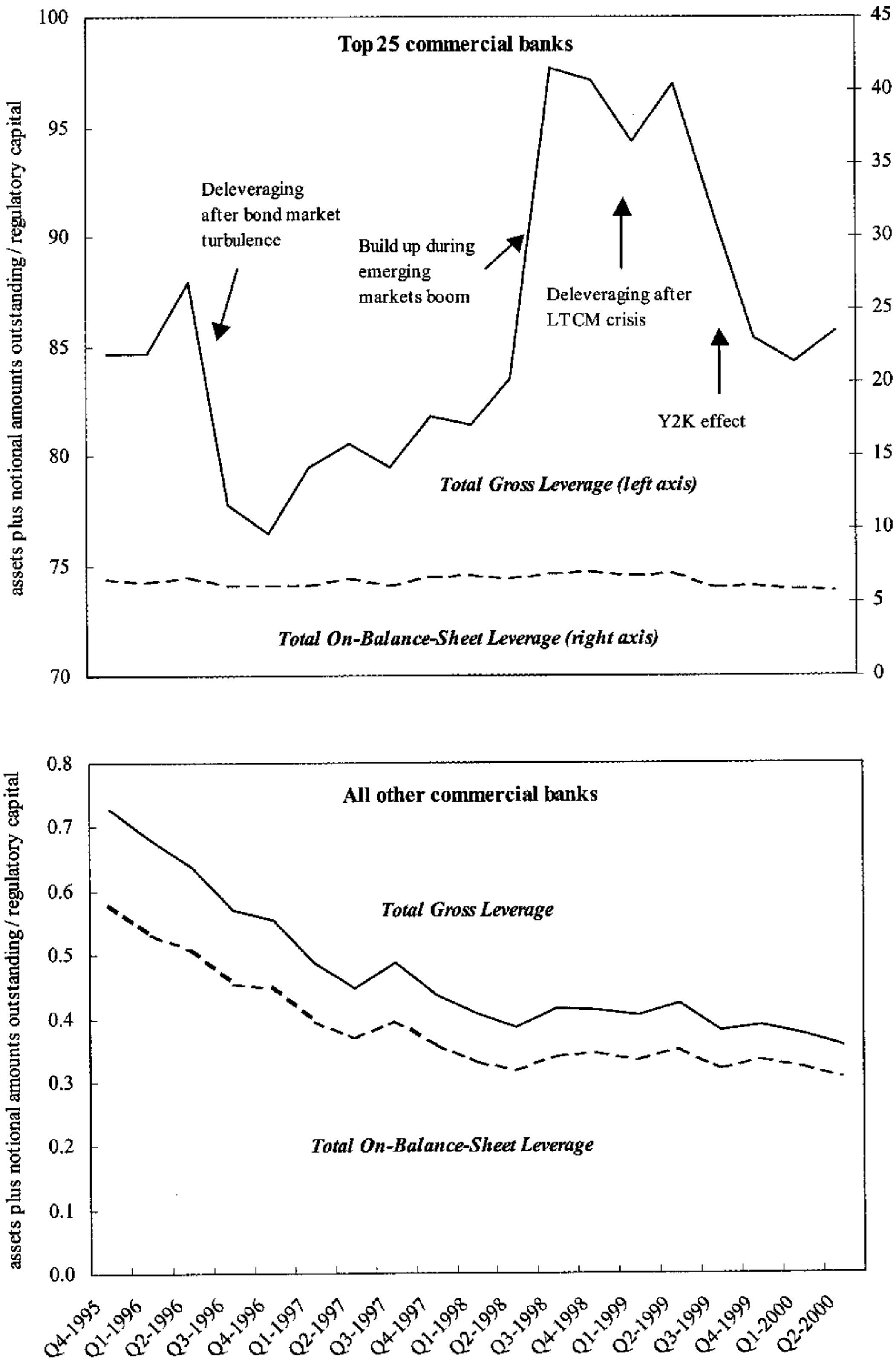


Figure 4b: Value of a Short Forward Position as Function of Underlying Asset Price



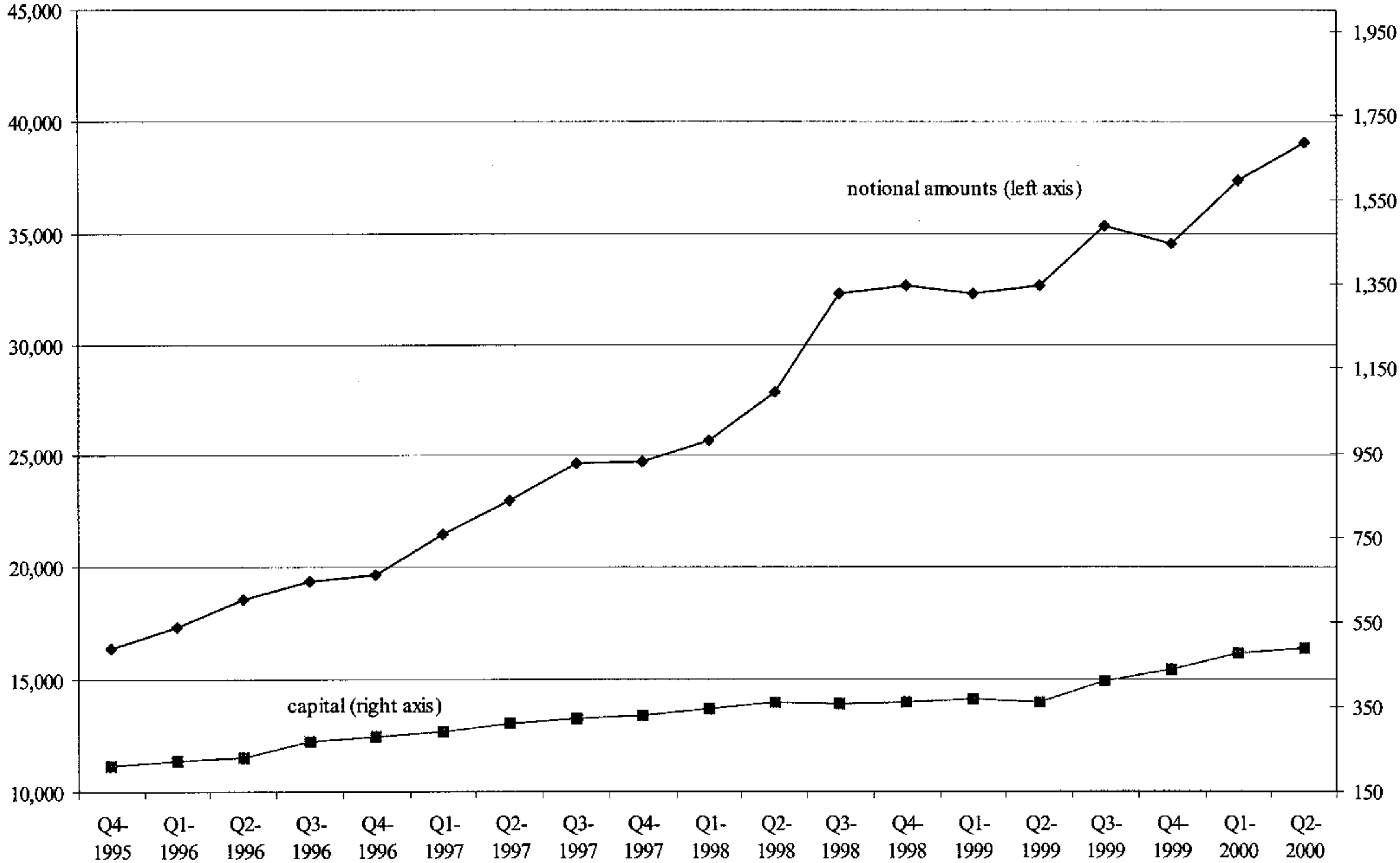
Specifications of forward contract: delivery price, X = 950; interest rate, r = 6 percent; time to maturity, T-t = 0.5 (6 months).

Figure 5: United States Banks:
Total Gross and On-Balance-Sheet Leverage Ratios 1995 - 2000



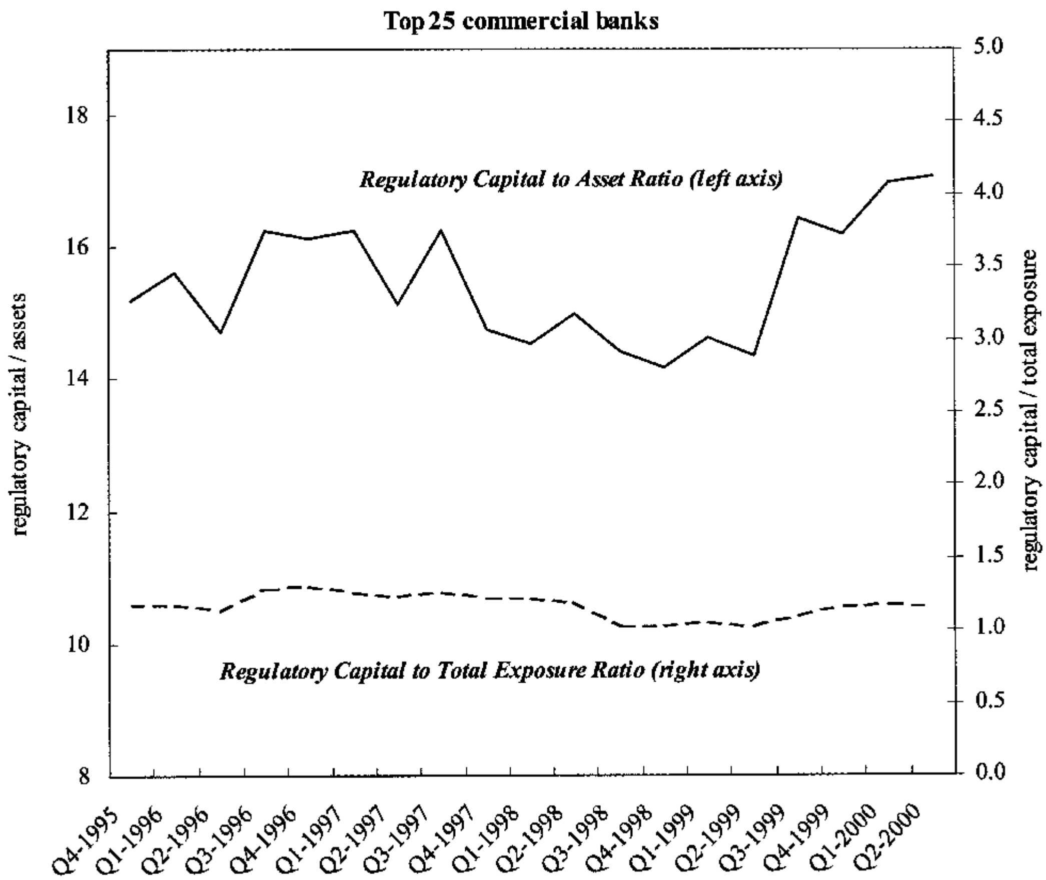
Source: Office of the Comptroller of the Currency
Note: Regulatory capital refers to tier 1 plus tier 2 capital.

Figure 6. Top 25 US banks: Total Notional Amounts of Derivatives and Capital, 1995-2000
(Billions of U.S. dollars)



Source: Office of the Comptroller of the Currency

Figure 7: United States Banks: Capitalization Ratios 1995 - 2000



Source: Office of the Comptroller of the Currency

Note: Regulatory capital refers to tier 1 plus tier 2 capital.

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