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Risk Management and Banking: The Principles

1. Introduction

Corporate risk management is important for firms in the banking industry for at least two reasons. First, the asset risk in a bank's loan portfolio depends on its customers' risk-management policies. Second, a bank's value depends directly on its risk-management policy. In this paper, I analyze these implications of corporate risk-management for banks. In section 2, I array corporate risks along a spectrum. Firm-specific risks are at one extreme while market-wide risks are at the other. I note that derivatives such as forwards, futures, options, and swaps are specialized off-balance-sheet risk-management tools that allow the firm to hedge many sources of market-wide financial risk. In addition, financially engineered instruments, such as dual-currency bonds, provide on-balance-sheet hedging alternatives. In section 3, I examine motives for value-maximizing firms to use risk-management instruments. This section thus identifies the implications of customer hedging for a bank's asset-portfolio risk. Section 4 applies these principles to derive the implications for bank risk-management policies. In section 5, I present my conclusions.

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2. Risk Exposures and Hedging Instruments

Of the numerous risks to which firms are exposed, some are firm-specific while others are market-wide. In figure 1, I array these risks along a risk spectrum. At one end are firm-specific risks; examples include fires, lawsuits, outcomes of research and development projects, and outcomes of exploration and development activities. At the other are market-wide risks; examples include the impact of unexpected changes in interest rates, foreign exchange rates, oil prices and GNP.

2.1 Corporate Risk Exposures

To analyze firms' hedging incentives, it is important to understand how their exposures are related to value. For some risks, this relation is straightforward. For example, an uninsured casualty loss directly reduces firm value. However other exposures are more complex. In figure 2, I illustrate the risk profile for an oil producer. This firm is long oil, thus higher oil prices raise revenues and increase firm value (see SMITH/SMITHSON/WILFORD (1990)). Therefore, the risk profile has a positive slope. For simplicity, I illustrate this relation with a straight line. But, for an oil user, the firm is short oil; thus higher oil prices raise costs and reduce firm value. In figure 2, this firm's risk profile has a negative slope. With the firm's risk exposure iden-

Figure 1: Risk Management Spectrum.

	Risk Exposures	Risk Management Tools		
		Off-Balance-Sheet	On-Balance-Sheet	
			Financial	Production
Firm Specific	Fire	Insurance		Loss Prevention and Control
	Lawsuit	Warrants		
	Payoffs to R&D Projects		Convertible Bonds	Joint Ventures
Market Wide	Commodity Prices	Forwards	Hybrids (Dual Currency Oil Indexed Notes, etc.)	Technology Choice
	Interest Rates	Futures		Plant Siting
	Foreign Exchange Rates	Swaps		Vertical Integration
		Options		

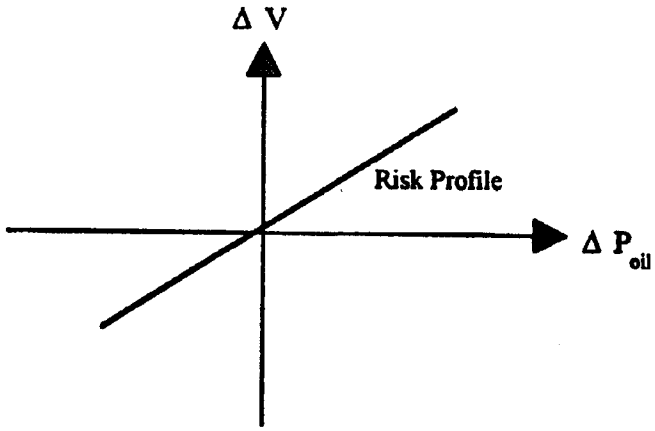
tified, we now can examine the impact of hedging on firm value. To hedge its exposure to oil prices, the oil user in figure 2 must employ a hedging instrument that with higher oil prices will appreciate in value. Because gains on the hedge offset losses in the firm's core business, hedging reduces this firm's exposure to oil-price changes. Therefore the variance of firm-value is reduced through risk management.

2.2 Off-Balance-Sheet Hedging Instruments

A major advantage of arraying the sources of risks as in figure 1 is that it clearly illustrates that different risks are managed with different hedging instruments. In the second column, I note that insurance policies are employed to hedge firm-specific risks like fires or lawsuits. Market-wide risks such as exposures to interest rates, foreign-exchange rates, and commodity prices can be managed with the use of off-balance-sheet derivative instruments, such as forward, futures, swap, and option contracts.

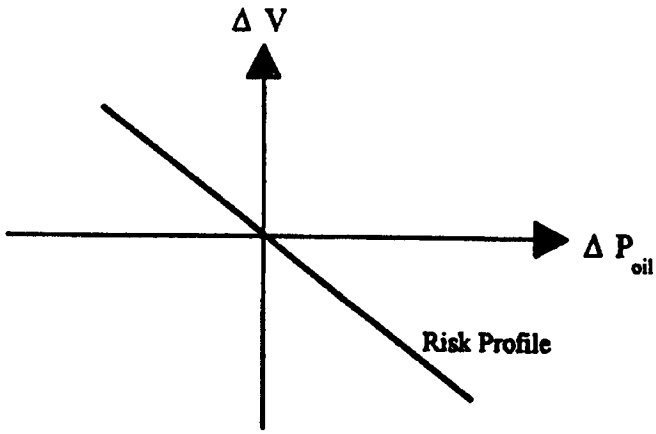
The forward contract is the simplest of these four basic instruments. A forward contract obligates it's owner to buy a stipulated asset on a stipulated date at a stipulated price. These provisions are all specified at contract origination. At the maturity date, the buyer has a contract whose value is equal to the difference between the market value of the asset and the exercise price. If the spot price of the asset is higher than the exercise price, the buyer has a gain; however if, the market price is lower than the exercise price, the buyer has suffered a loss. In figure 3, the payoff profiles from buying and writing a forward contract are illustrated. Buying a forward contract hedges the firm's exposure if its core business cash flows are a negative function of the asset value; writing a forward hedges the exposure if core business cash flows are a positive function of the asset value.

Figure 2: Relation between the change in firm value and change in oil prices for an oil producer and an oil user.



For an oil Producer, rising oil prices ($\Delta P_{oil} > 0$) and rising revenues lead to an increase in the value of the firm ($\Delta V>0$).

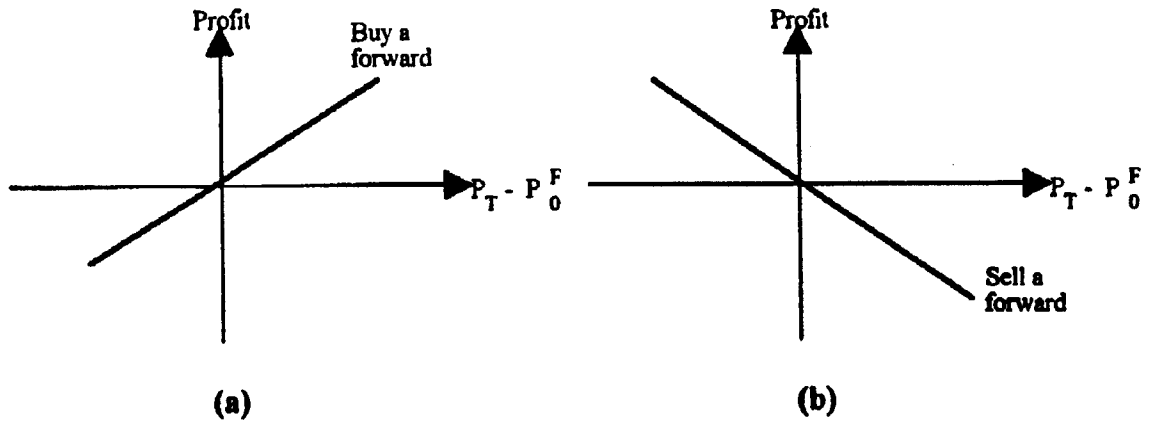
(a)



For an oil user, rising oil prices ($\Delta P_{oil} > 0$) mean increasing costs: so the value of the firm declines ($\Delta V<0$).

(b)

Figure 3: Payoff profile from (a) buying a forward and (b) selling a forward contract.



Comment:
At contract maturity (time = T), the profit to the buyer of a forward contract is equal to the difference between the spot price at T and the exercise price agreed to at contract origination ($P_T - P_0^F$) times the size of the forward contract. The profile to the seller of the contract is the reverse.

In form, a futures contact is quite similar to a forward contract. Buying futures also obligates the purchaser to buy a stipulated asset at a stipulated price on a stipulated date. Aspects of the contract administration such as marking to market with daily settlement, margin accounts, exchange trading, and contract standardization are the primary differences between forwards and futures. However, their impact on hedging firm value is similar; figure 3 can thus be employed to illustrate the payoff profiles for futures.

A swap obligates two parties to exchange cash flows at specified intervals. For example, in a simple interest rate swap, parties exchange specified cash flows determined by two different interest rates. At each settlement date, this interest rate swap provides an imbedded forward contract on interest rates. Therefore a swap is in essence a strip of forward contracts, each with a different maturity date (see SMITH/SMITHSON/WAKEMAN (1986, 1988)); and thus figure 3 also can be employed to illustrate the basic payoff profile for a swap.

An option gives the owner of the contract the right, but not the obligation, to transact (see BLACK/SCHOLES (1973) or SMITH (1976)). Options come in two basic forms: puts and calls. A call is an option to buy a stipulated asset at a stipulated price on or before a stipulated date; a put is an option to sell. Buying a call plus writing a put on the same asset with the same exercise price and the same expiration date creates payoffs that are equivalent to those of buying a forward. This equivalence among puts, calls, and forwards is referred to as put-call parity.

2.3 On-Balance-Sheet-Hedging

The previous decade has produced a substantial increase in financially engineered securities to provide customized solutions to corporate financing problems. Financial engineers operate much like General Motors. GM produces automobiles to meet specific customer demands by offering different models with different wheel bases, different engines, different exteriors, different interior appoint-

ments, different sound systems, etc. By exploiting the myriad opportunities to mix different off-the-shelf options, GM produces many different cars. Similarly, financially engineered instruments are customized securities, but the components that make up the securities are themselves fairly basic off-the-shelf loans, forwards, swaps, and options. (see SMITH/SMITHSON (1990)).

For example, Phillip Morris Credit Corporation issued over $50 million of dual-currency bonds. While the principal amount of the bonds is stated in US dollars, the interest payments are denominated in swiss-francs. Therefore, the cashflows of this dual-currency bond are equivalent to those of a financial package containing a level-coupon swiss-franc bond plus a long-term forward-exchange forward contract to exchange the swiss-franc principal repayment into dollars.

SallieMae, the Student Loan Marketing Association issued yield-curve notes. The coupon payments on the yield-curve notes are equal to twice the fixed rate minus the floating rate times the principal; hence, if the floating rate rises, the net coupon payment falls. Thus, the cashflows of this reverse floating-rate note are equivalent to those of a package containing a traditional fixed rate bond plus a swap where the party pays fixed and receives floating.

As a last illustration, the Standard Oil Company issued oil indexed notes. At maturity, the holder of each note receives $1000 plus the excess of the crude oil price over $25 multiplied by 170 barrels ($1000 + 170 x ($P_{\text{crude oil}}$ - $25)). The cashflows of these notes are equivalent to those of a 48 month maturity zero-coupon bond with a face value of $1000 plus a 4 year call option on 170 barrels of crude oil with an exercise price of $25.

As illustrated in figure 1, these risks can also be managed by the firm's choice of real production activities. For example, foreign-exchange risk can be reduced by moving production overseas. Yet it is difficult to believe that plant-siting decisions would be made primarily to manage foreign-exchange exposures. Producing in a new market with new suppliers, new workers, different labor laws, etc. is not a decision to be taken lightly. Moreover, if market conditions change, exposures change; financial contracts are more flexible and thus can be modified at lower cost than real production decisions.

3. Risk Management Benefits

Financial markets have experienced a dramatic increase in volatility over the past two decades. Given the firm's risk exposure, increased volatility of foreign-exchange rates, interest rates or commodity prices translates into increased volatility of firm value. Since risk management reduces firm-value volatility, one might presume that all firms would want to engage in hedging. Yet there is wide variation in the use of risk-management instruments across firms. Thus, I now focus on identifying firm characteristics that provide strong economic incentives to hedge.

3.1 Company Ownership Structure

To examine economic risk-management incentives, I assume that the firm's objective is to maximize the expected present value of its net cash flows. Hence, a company should manage its financial price risk if that risk management strategy increases the expected present value of its cash flows. In their individual affairs, risk-averse people have incentives to hedge because reducing risk lowers the rate of return they require to engage in a risky activity. However, for a widely-held corporation, this logic fails. Portfolio theory tells us that a corporation's required rate of return doesn't depend on total risk but only on systematic risk. A hedging instrument that works primarily on diversifiable risk does not provide a lower discount rate for firms with well-diversified owners. Yet, for organizations in which the owners do not hold well-diversified portfolios, such as partnerships, proprietorships, and closely-held firms, risk aversion can be an important risk-management incentive (see MAYERS/SMITH (1982)).

If hedging does not reduce the required rate of return for widely-held firms, then to increase value, hedging must increase the firm's expected net cash flows. To analyze how this might occur, recall the Modigliani-Miller proposition. It states that the firm's financial decisions, including its risk management decisions, will not affect firm value if there are no taxes, no transactions costs, and if the firm's real investment activities are fixed. Although this is the emphasis Modigliani/Miller gave the proposition in their original paper, it is useful to restate it. If financial decisions affect firm value, the decisions must do so through their impact on taxes, transactions costs, or investment decisions. The Modigliani/Miller proposition thus can be employed to identify firms that have strong economic incentives to hedge.

3.2 Taxes

If the firm faces some form of effective tax progressivity (the firm's effective tax function is convex) then hedging taxable income by reducing the volatility of pretax income, reduces the firm's expected tax liability. As long as the tax function is linear - the firm faces a constant effective tax rate - hedging doesn't affect the expected tax liability of the firm. This implication is quite general, it follows from Jensen's Inequality (see SMITH/STULZ (1985)). Convexity in the tax schedule can arise from three general considerations: First, although its range is limited, the tax code specifies statutory progressivity. Second, tax-preference items such as tax-loss carry forwards, foreign tax credits, and investment tax credits generally have limitation on use. If taxable income falls below some level, the tax-preference item's value is reduced either by the loss of the tax shield or by the postponement of its use (see DE ANGELO/MASULIS (1980)).

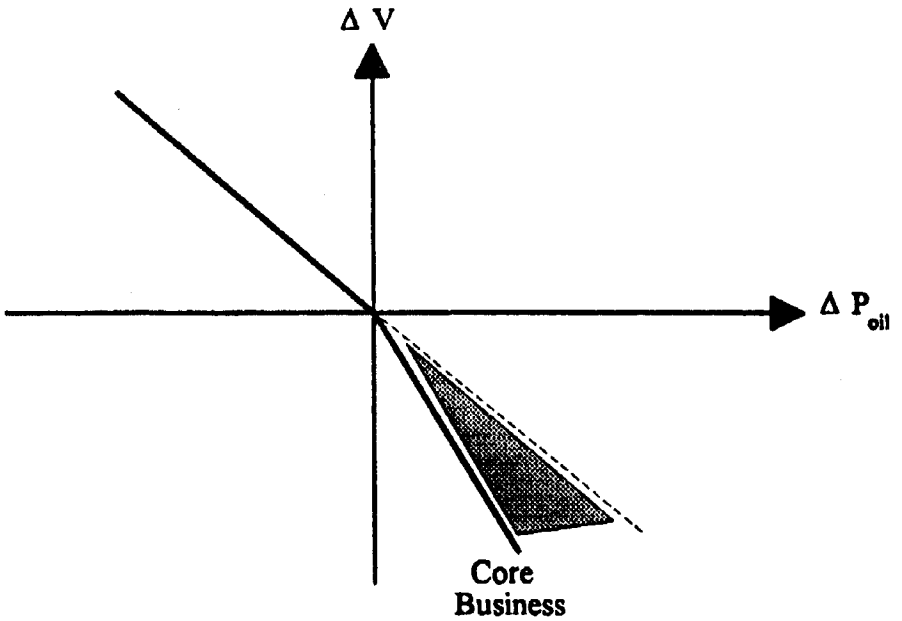
These tax provisions imply that firms with stronger tax-related incentives to hedge are: firms with a higher probability of income in the progressive region of the tax schedule (e.g. smaller firms, start-up firms), and firms with more tax-preference items. Finally, the US has adopted the alternate minimum tax which specifies tax liabilities linked to the difference between reported income and taxable income. Thus, the alternate minimum tax produces an incentive to hedge for firms with greater volatility of the difference between taxable and financial income.

3.3 Financial Distress Costs

Risk management reduces the expected costs of financial distress the firm faces by reducing the variance of firm value, thereby reducing the probability of encountering financial distress. The size of this expected cost reduction depends both on the change in probability of distress from hedging and the level of costs associated with financial distress. There are two major components of the cost of financial distress. The first is the direct expense of dealing with a default, bankruptcy, reorganization, or liquidation. The second is the indirect costs arising from the changes in incentives of the firm's various claimholders. For example, if the firm files for bankruptcy and attempts to reorganize its business, the bankruptcy court judge overseeing the case is unlikely to approve non-routine expenditures. The judge receives little credit if the activities turn out well, but is criticized by creditors with impaired claims if they turn out badly. Thus firms undergoing reorganization are likely to systematically pass up positive net present value projects due to the nature of the oversight by the bankruptcy court.

Incentives to turn down positive net present value projects also can arise in firms that avoid bankruptcy. For a firm with fixed claims in its capital structure, enough of the benefits of taking a positive net present value project can accrue to the debtholders that the stockholders are not provided a normal expected return. MYERS (1977) calls this the underinvestment problem. The greater firm's leverage, the greater is this underinvestment incentive. I illustrate this incentive to engage in risk management in figure 4. The risk profile of this oil user

Figure 4: Illustration of the underinvestment costs for an oil user.

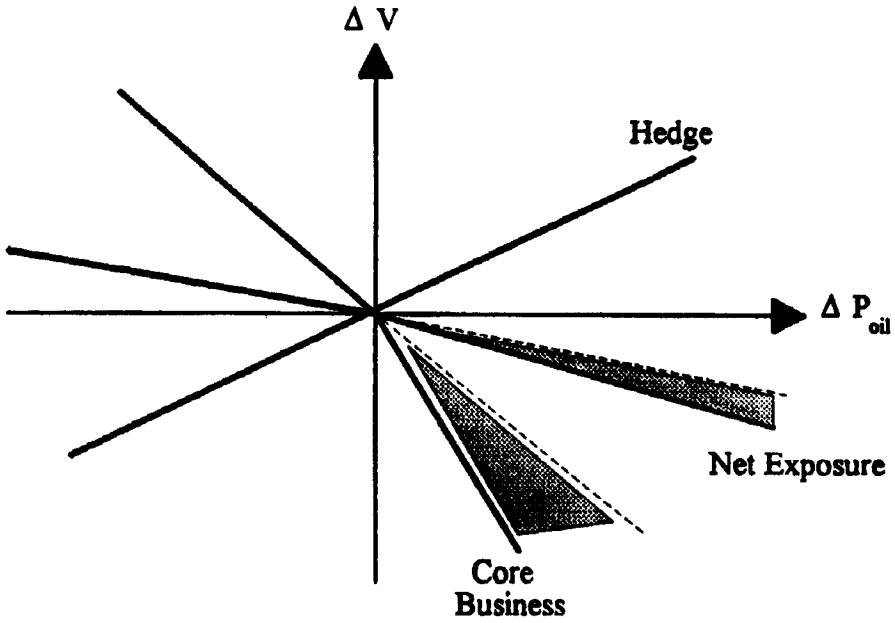


indicates that if oil prices increase, firm value falls. Unless the firm reduces the fixed claims in its capital structure, effective leverage increases. Higher leverage exacerbates the underinvestment problem causing the firm to turn down additional positive net present value projects. Thus, the underinvestment costs are graphically depicted by the shaded area in figure 4. For this firm to hedge its oil price exposure, it must add hedging instruments with payoffs that increase with higher oil prices (see figure 5). By acquiring forwards, futures, or swaps, the firms reduces its net exposure to oil price changes. With such a hedge, a given increase in oil prices results in a smaller fall in firm value, a smaller induced change in leverage, a smaller exacerbation of the underinvestment problem, and a reduction in the frequency of rejected positive net present value projects (see MAYERS/SMITH (1987)). Thus, the impact of hedging on the control of the underinvestment problem is graphically illustrated by the reduction in the shaded area between the firms core business exposure and its net exposure in figure 5.

Firms that produce goods or services where quality is difficult to ascertain prior to purchase (e.g., airlines) can bear large financial-distress costs. If such firms operating results deteriorate, their customers' expectation of product quality can suffer and thus the price they are willing to pay for their product can fall. This problem is ultimately another facet of the underinvestment problem discussed above. For example, if an airline experiences financial distress, the benefits of an investment in maintaining its equipment disproportionately accrue to the bondholders. Because of the underinvestment problem, customers rationally expect that the firm will reduce its maintenance activities. To credibly promise to potential customers that maintenance will be performed and product quality will be maintained, such firms should employ less leverage and engage in more hedging.

The more important are product warranties or guarantees offered to the customers, the larger are the costs of financial distress. Product warranties are product-specific insurance policies. If the firm experiences financial distress, the price customers

Figure 5: Impact of hedging for oil user in Figure 4.



are willing to pay for the firm's product falls, in part because the value of this insurance policy falls. Moreover, if there is an important continuing stream of firm-provided customer services, similar revenue deterioration occurs. For example, expectations about continuing software development by a computer manufacturer or replacement parts for automobiles are important considerations in the purchase decision. If financial distress reduces the probability of the continuation of these activities then customers lower their valuation of the firm's product.

A complementary set of problems arises between the firm and its suppliers. When the supplier provides specialized inputs to the firm, these problems are most severe. The problem is exacerbated if there is a relatively long time between incurring production costs and the ultimate receipt of the revenue. In such circumstances financial distress disrupts normal supply relationships. The supplier typically responds by demanding either cash in advance or cash on delivery. This exacerbates the firm's liquidity problems. Such changes in effective supply prices are additional costs of financial distress.

3.4 Riskshifting within the Corporation

Although thus far, I have focused on corporate bondholders and stockholders, the firm is really a vast network of contracts among parties with common as well as conflicting interests. Managers, employees, and certain customers and suppliers are frequently less able to diversify their claims on the firm than stockholders and bondholders; in this respect, they are materially different. Thus, like the owners of a closely-held firm, the risk aversion of these corporate claimholders can provide an important incentive for the firm to engage in risk-management activities.

The magnitude of the incentive provided the managers to adopt risk-management policies is directly related to the terms of their compensation package and the specification of the payoff structure of their claims. A manager's risk aversion will motivate lobbying for extensive risk-management activities if compensation is primarily through fixed claims such as salary. But managers compensated through stock options or bonus plans have incentives to increase the volatility of stock prices or reported

earnings because of the option-like payoffs of the compensation provisions (see SMITH/WATTS (1982)). The magnitude of these incentives depend both on the relative importance of the components of the compensation package as well as on the specific terms of the particular plan. For example, incentives with respect to increasing volatility are greatest when the stock option is at the money.

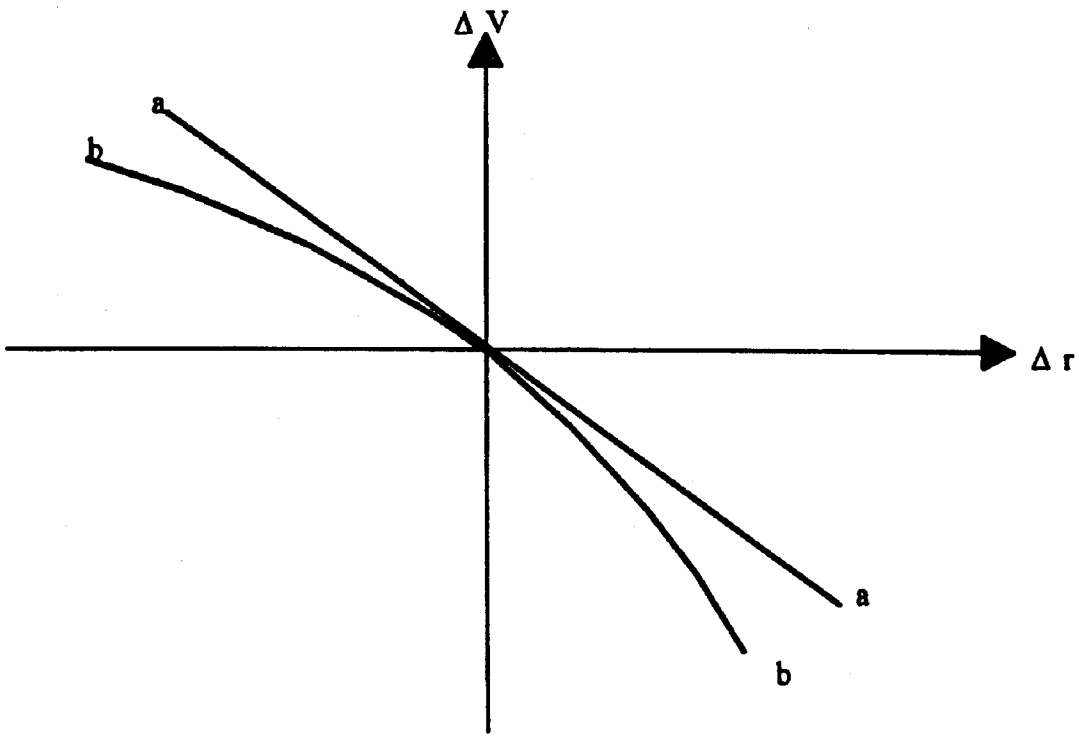
3.5 Customer Risk Management

The benefits of risk management are important for a bank to recognize. While risk management makes its customer firm more valuable, it also allows the bank to profit in at least three ways. First, a bank whose calling officers are well versed in risk management are likely to provide more effective advice to customers, more effectively differentiate their products, and thus are likely to book more profitable business. Second, fees associated with supplying derivatives and financially engineered transactions can be an important source of revenue for the bank. Third, these transactions make the bank's customers better, more profitable customers. Customer hedging changes incentives, changes activity choices, changes cash flow distributions and these transactions lower that bank's loss exposure. Therefore, hedging by the bank is not a substitute for hedging by the bank's customers.

4. Bank Exposure Management

Banking is an industry where product quality is an important concern of potential customers. This concern is primarily focused on whether the financial commitments of the bank under its contracts will be met. Thus, risk management by banks affects the probability of financial distress and therefore the willingness of potential customers to enter into contracts. For specific banks interest-rate

Figure 6: Line aa represents the interest rate exposure for a bank with a duration imbalance but no imbedded interest rate options. Line bb represents the interest rate exposure of a bank with imbedded interest rate options sold to its deposit and loan customers.



risk, foreign-exchange-rate risk and commodity-price risk can each be important, depending on the product mix of the bank. For example, a bank with oil producers as major loan customers will have an oil exposure. However, in this analysis I will focus primarily on interest-rate exposure management.

If the effective maturity of a bank's asset portfolio is greater than the effective maturity of its liabilities, then the bank has a duration imbalance and is exposed to interest-rate risk. Figure 6 illustrates the effect of interest rate changes on the value of a bank that books short-term deposits and long-term fixed-rate mortgage loans. If interest-rates rise unexpectedly, the market value of its asset portfolio will experience larger capital losses than that of its liabilities,thus bank value falls. Conversely if interest rates fall unexpectedly, firm value rises. Without imbedded options in its financial contracts, the response of the value of the bank to unexpected changes in interest rates is generally symmetric. Line aa in figure 6 illustrates the interest rate exposure for such an bank. If the duration imbalance is reduced, the response of bank value to a change in interest rates falls and the line becomes flatter. Conversely, if the duration imbalance increases, line aa becomes steeper.

4.1 Effect of Imbedded Options

Bank loan contracts historically have provided customers the option to prepay the loan prior to maturity. Early-withdrawal options also are included in certificates of deposit. Thus, if market interest rates change, these imbedded loan and deposit options change in value. These imbedded interest-rate options present an important complication to the analysis of the effects of interest-rate changes on bank value. Since the bank has written the imbedded options to the depositors and the borrowers, line aa in figure 6 is not appropriate. If interest rates fall, borrowers have incentives to prepay existing mortgages. They refinance the property at the new prevailing rate. Mortgage prepayments lower the value of a short-funded bank because the prepayment eliminates a capital gain equal to the difference between the market and face value of the mortgage. With prepayment options in its loan portfolio, the mortgage lender receives capital gains only on the mortgages which are not prepaid. Prepayments thus reduce the increase in bank value in response to lower interest rates. Line bb to the left of the origin in figure 6 reflects these reduced capital gains. Since early-withdrawal options in CDs are more valuable at higher rates, line aa also overstates the change in bank value if interest rates rise. The value of this option is reflected in line bb to the right of the origin. Bank value changes produced by interest-rate changes are not symmetric because of these imbedded options offered to both loan and deposit customers. Rate increases lead to reductions in loan prepayments and a lengthening of the effective maturity of the loan portfolio. This increases the fall in the value of a bank from a rate increase. Depositors simultaneously increase their demand for early withdrawal of funds from CDs, again increasing the fall in the value of the bank.

The gains from declines in interest rates are less than the losses associated with rate increases because of these imbedded financial options. As a result bank value is reduced by increases in interest-rate volatility. The bank is short interest- rate volatility because it has written a set of imbedded interest-rate options to its customers. Unexpected increases in volatility therefore reduce the firm value while unexpected reductions in volatility increase firm value.

4.2 Hedging Bank Interest-Rate Exposure

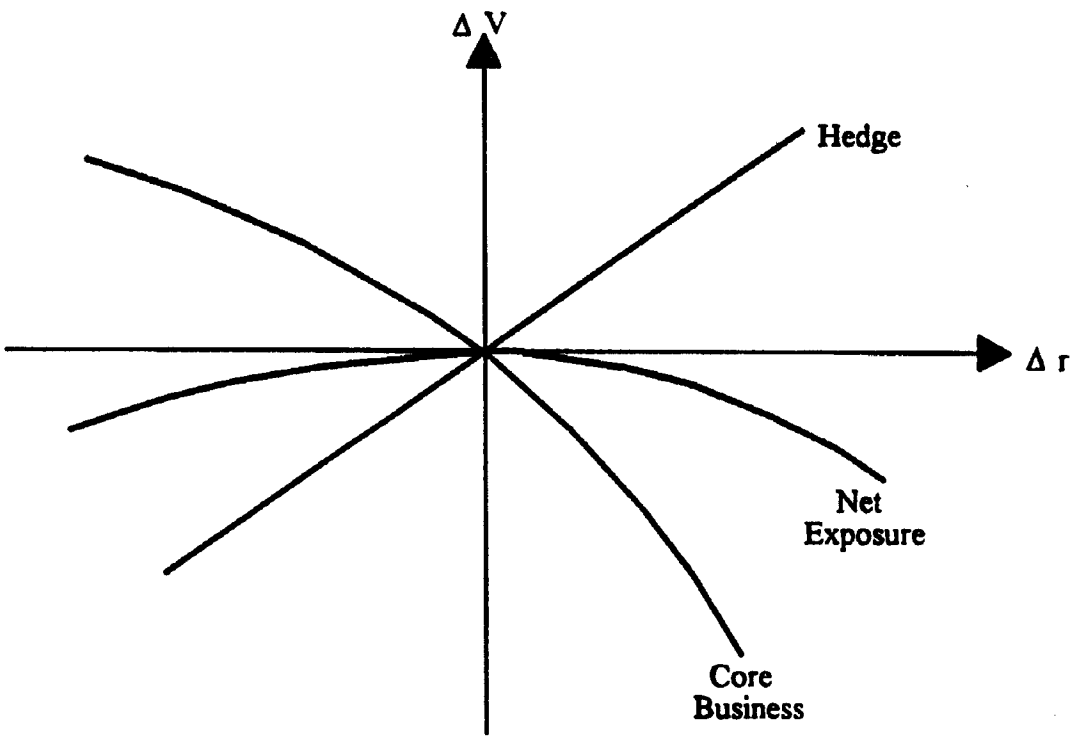
Through a simple static portfolio strategies involving forwards, futures or swaps, a bank can change the slope of its exposure. Figure 7 illustrates the firm's net exposure to interest-rate changes after hedging by entering an interest-rate swap where the bank pays fixed and receives floating. While its exposure to interest-rate changes is reduced, the firm is still exposed to changes in interest-rate volatility. To hedge this risk the bank must buy

interest- rate options. The options either can be purchased by themselves or imbedded in other financial packages, for example, a securitized mortgage instrument like collateralized Mortgage Obligation residuals.

A strategy of buying a matching portfolio of options to hedge the portfolio of imbedded interest-rate options written is an unwieldy and expensive proposition. It is more efficient to manage this risk through a dynamic hedging strategy. In general, one cannot hedge both the interest-rate risk and the volatility risk through the simple dynamic trading strategy pioneered by Black/Scholes. Given the Black/Scholes assumptions of constant volatility of the underlying asset, no jumps in the value of the underlying asset, and continuous costless trading, the only risk that must be hedged is that of unexpected changes in the underlying asset value. (The delta of the option measures the sensitivity of the value of an option to changes in the value of its underlying asset.) Their delta-hedging strategy replicates the option payoffs by acquiring rate-sensitive assets as the option goes in the money. While this dynamic delta-hedging strategy can hedge the bank's interest-rate risk, given the volatility of rates, it can not simultaneously hedge volatility risk. This basic dynamic-hedging strategy must be extended to hedge additional option parameters.

A sophisticated dynamic-hedging strategy must consider the options gamma and vega in addition to the options delta. (Gamma is the second derivative of the option value with respect to a change in the underlying asset value; it is the change in delta associated with a change in the underlying asset value. Vega is the sensitivity of the option value to changes in the underlying asset's volatility.) To hedge the option's delta, gamma, and vega generally requires at least three assets; appropriate portfolio weights for the hedging portfolio can be derived with three linearly independent rate-sensitive assets (see BOOKSTABER (1993)). Use of such a generalized hedging strategy reduces the valuation errors from periodic rather than continuous rebalancing, jumps in the underlying asset value, and

Figure 7: Illustration of the impact of hedging interest rate risk with a swap for the bank in Figure 6.



volatility changes. Programming techniques can be employed to identify the minimum-cost hedging strategy with more than three assets. Yet, there are potential problems associated with such a technique. Estimation of relevant parameters inevitably involves measurement error. The impact of measurement-error-induced selection bias can be reduced by employing more assets than identified by the program as "optimal". If the program identifies out-of-the-money options, one must be especially careful since such options are typically illiquid.

5. Conclusions

In this paper, two major implications of risk-management theory for banks are explored: (1) The direct impact of interest-rate risk-management policy on the value of a bank, and (2) the risk-management policies of loan customers for the risk of the bank's asset portfolio. With respect to the first issue, I argue that in the traditional method of structuring this business, the bank sells imbedded interest-rate options and thus creates a significant exposure to interest-rate volatility. This exposure can be managed only by buying options. The second issue is important specifically because banks have not aggressively pressed their loan customers about their hedging policies. The hedging motives I identify in this paper change corporate activities, cash-flow distributions, and firm value. These benefits cannot be generated without borrower participation, therefore, hedging by lenders is not a substitute for hedging by borrowers. Banks have long exploited certain risk-management activities; the industry pioneered the use of duration as an interest-rate risk-management technique. However, the control of financial risks via derivative securities has been less extensively pursued. Surveys suggest that especially among smaller banks there is a problem with hiring and retaining management with the requisite skills to manage a financial risk-management program (see BOOTH/SMITH/ STOLZ (1984)). However, if financial prices remain volatile, the implications of not hedging can prove disastrous. With the increased awareness of the financial distress problems on the part of both regulatory bodies and customers as a result of the Savings and Loan crisis, the pressure for banks to adopt effective risk-management policies is likely to mount.

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