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Asset-Liability Management in Commercial Banks:
Basis Risk, Size Effects, and the Optimal Gap

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ABSTRACT

ASSET-LIABILITY MANAGEMENT IN COMMERCIAL BANKS: BASIS RISK, SIZE EFFECTS, AND THE OPTIMAL GAP

by

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Monitoring and controlling interest rate risk is a primary concern of depository institutions. A part of interest rate risk is basis risk which is caused by the imperfect correlation between the changes in interest rates on the institution's assets and liabilities.

A risk-adjusted valuation model of a bank is derived. The optimal ratio of rate-sensitive assets to rate-sensitive liabilities derived from the model is $\sigma_{RSA\ RSL} / \sigma_{RSA}^{2}$ where $\sigma_{RSA\ RSL}$ is the covariance of returns of rate-sensitive assets to rate-sensitive liabilities and σ_{RSA}^2 is the variance of returns on rate-sensitive assets.

The optimal gap estimated by regressing returns of a portfolio of rate-sensitive assets on a portfolio of rate-sensitive liabilities is zero or slightly positive. Comparing this result to the average gap of a sample of banks, it is concluded that the average gap is "too positive".

Other factors studied in addition to basis risk are bank size and the presence of LDC loans in the loan portfolio. Net interest income/total assets is negatively related to rate-sensitive

assets/total assets, a dummy variable signifying LDC loans, and bank size. However, market risk is positively related to bank size, LDC loans, and rate-sensitive assets/total assets. This implies that banks with the highest market risk have the lowest net interest income/total assets.

Gap/total assets is positively related to net interest income/total assets and market risk implying that the bank with the highest measure of gap/total assets has the greatest measure of net interest income/total assets and market risk. This result is interesting because the original purpose behind narrowing the gap was to reduce risk. The results indicate that banks have positioned themselves beyond this point.

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ASSET-LIBILITY MANAGEMENT IN COMMERCIAL BANKS:

BASIS RISK, SIZE EFFECTS, AND THE OPTIMAL GAP

CHAPTER I

INTRODUCTION

The late 1970s and early 1980s were characterized by volatile and unprecedented high interest rates. Until this time, the practice at many depository institutions was to invest a significant percentage of their assets in fixed-rate, long-term loans and investments and rely on short-term deposits to fund these loans and investments. In the late 1970s, high interest rates and competition for deposits increased the cost of funds while the revenues remained fixed. This resulted in reduced profit margins and declining stock prices of depository institutions. Moreover, long-term, fixed-rate loans and investments declined in value as interest rates rose and this further depressed the stock prices of depository institutions.

The correlation between depository institution market values and interest rates makes it necessary for depository institutions to closely monitor and control risk exposure due to changing interest rates. Interest rate risk is divided into several categories: income risk, investment risk, and basis risk. Interest rate swaps, futures hedging, and gap management are among the methods used to control this risk. Basis risk, a subset of income risk, has been largely ignored by management as well as academic and practitioners' literature. A focus of the dissertation is basis risk as it affects the overall interest rate risk management process.

The next section of this chapter defines terms used in the dissertation. This is followed by a discussion of gap management strategies and a review of the existing literature on gap management. The chapter concludes with a discussion of the purpose of this dissertation and its overall plan.

DEFINITIONS

Rate-Sensitivity

When the income generated by an asset or liability changes with a change in interest rates, that asset or liability is said to be rate-sensitive. When studying rate-sensitivity in this setting, the only assets and liabilities which are to be repriced by bank managers are those which have matured, are variable-rate, represent cash flows from loan runoff, or are prepaid loans or early deposit withdrawals. Rate-sensitivity can be expected or unexpected. It is expected in the case of repricing of assets and liabilities through maturity, loan run-off (amortization), and through periodic repricing of variable-rate loans.
Rate-sensitivity is unexpected in the case of non-contractual repricing which takes the form of loan prepayments or early deposit withdrawals. A rate-sensitive asset is an asset that is

repriced within some defined short-term period. A rate-sensitive liability is a liability that is expected to be repriced during some short-term period.

Interest Rate Risk

Income Risk Income risk is the risk of a change in the net interest margin resulting from a mismatch in the repricing of assets and liabilities as interest rates change. This can occur because rate-sensitive assets are not equal to rate-sensitive liabilities in quantity or it can occur through basis risk. Rate-sensitive assets and liabilities are affected by income risk. Fixed-rate assets and liabilities are by definition unaffected by income risk.

Basis Risk Basis risk is the risk of a change in income resulting from a lack of co-movement between the rates of return on rate-sensitive assets and rate-sensitive liabilities. This risk reduces the effectiveness of depository institution efforts to control interest rate risk.

Investment Risk Investment risk, also called price risk, is defined as a change in the market value of assets and liabilities resulting from a change in interest rates. It occurs in non-rate-sensitive assets and liabilities and is an important component of interest rate risk (see Phelps [1987]).

Gap Management

The Gap = rate-sensitive assets - rate-sensitive liabilities. When a positive gap exists, a decline in interest rates results in a reduction in revenue larger than the corresponding reduction in expenses and this reduces income. With a negative gap, an increase in interest rates results in a larger increase in expenses than the corresponding increase in revenues, thus reducing income. Sizable gaps in either direction cause earnings to be more volatile.

The practice in the 1970s was to have a negative gap. Borrowers preferred long-term, fixed-rate loans. Depositors, on the other hand, preferred short-term deposits. When interest rates rose, depository institutions' profits suffered because revenues generally remained fixed while interest costs increased. Recently, the trend has been to narrow the gap from one that is negative to one that is closer to zero. However, an implicit assumption of gap management is that the rates on assets and liabilities move together, that is, a zero gap should result in little or no interest income volatility. This is not necessarily the case and is a focus of the dissertation.

Hedge

To hedge is to protect income or market value from changes caused by changes in rates. To hedge with futures is to take opposite positions in spot and futures securities for instance buying a Treasury Bill taking a short position in a Treasury Bill futures contract. The purpose is to lock in a price, to profit from basis movements, or to reduce the volatility of earnings or market value of the firm.

Gap management is analogous to hedging with futures. In gap management, assets and liabilities represent opposite positions which may be taken for purposes similar to futures hedging. The difference is that a futures hedge can be separated from the rest of the balance sheet and studied in isolation. A gap cannot be separated from the balance sheet. If the gap is changed, the entire balance sheet is affected. Therefore, the traditional hedging models, which assume that the hedge can be separated from the balance sheet and studied in isolation, are inappropriate for the study of basis risk in gap management. The model used to study this problem must consider effects on the entire balance sheet and must tie this action to changes in the value of the firm.

Cross-Hedge

A cross-hedge protects against changes in income or value due to fluctuations in rates by using different securities on the opposite positions of the hedge (see Anderson and Danthine [1981]). For example, a bank may make a loan and take a short position in Treasury Bill futures. This is done because no opposite position is available in the hedged security. The security chosen for the hedge should react similarly to changes in loan interest rates.

As stated before, an analogy exists between gap management and cross-hedging using futures contracts. Typically, loans are assets and certificates of deposit are liabilities. The assets and liabilities, in this case, represent opposite positions but consist of different securities.

GAP MANAGEMENT STRATEGIES

Gap management is a form of asset-liability management that provides the financial institution with a defense against the effects of interest rate swings on the spread between the revenues earned on assets and the costs of liabilities. Gap management is analogous to hedging. With effective gap management, liability rate changes are countered with similar asset rate changes. The expected effect is a reduction of interest income volatility. This dissertation is concerned with basis risk in gap management. Since gap management is similar to hedging with futures, a particular gap management strategy can be analyzed according to its success as a hedge against basis risk. The purpose of this section is to define various strategies of gap management and note the strengths and shortcomings of each strategy. The strategies defined are similar to those in the hedging literature but are modified for use in gap management. Borrowing from Gray and Rutledge [1971], the strategies are insurance (zero gap), risk reduction, speculation, and risk-return tradeoff strategies.

Insurance

If the depository institution manager uses an insurance or naive strategy, a one-to-one hedge or zero gap is maintained. The manager is aware that narrowing the gap is an appropriate action but is not aware of risks generated by this action. The manager is aware of the advantages of the action but not of the disadvantages. Basis risk is exchanged for the risk of being fully exposed to interest rate swings. Basis risk is assumed to be zero or at least considerably less than the risk of being unhedged.

While this approach usually reduces the bank's risk exposure, it does not necessarily reduce risk. An implicit assumption of this approach is that the variance of rate-sensitive asset rates equals the co-variance between rate-sensitive liability and asset rates. That is, the ratio of rate-sensitive assets to rate-sensitive liabilities is $\sigma_{RSA\ RSL} / \sigma^2_{RSA}$ (where $\sigma_{RSA\ RSL}$ is the covariance of returns of rate-sensitive assets with rate-sensitive liabilities and σ^2_{RSA} is the variance of the returns of rate-sensitive assets) equals unity. This is not necessarily true. For example, the prime rate, which is an asset rate, tends to move up quickly and down slowly whereas certificate of deposit rates, (usually liability rates), move up slowly and down quickly. Certificate of deposit rates follow Treasury Bill rates rather closely but prime rates lag behind Treasury Bill rates by a month (see Figure 1). Therefore, it is doubtful if the implied assumptions are valid. The result is that the depository institution may be accepting more risk than necessary and as a result, reducing the value of the firm.

<u>Risk Reduction</u>

The purpose of gap management is to reduce the variance of the spread between rate-sensitive asset and liabilities to acceptable levels. A depository institution manager who uses the strategy of variance risk reduction realizes that basis risk is

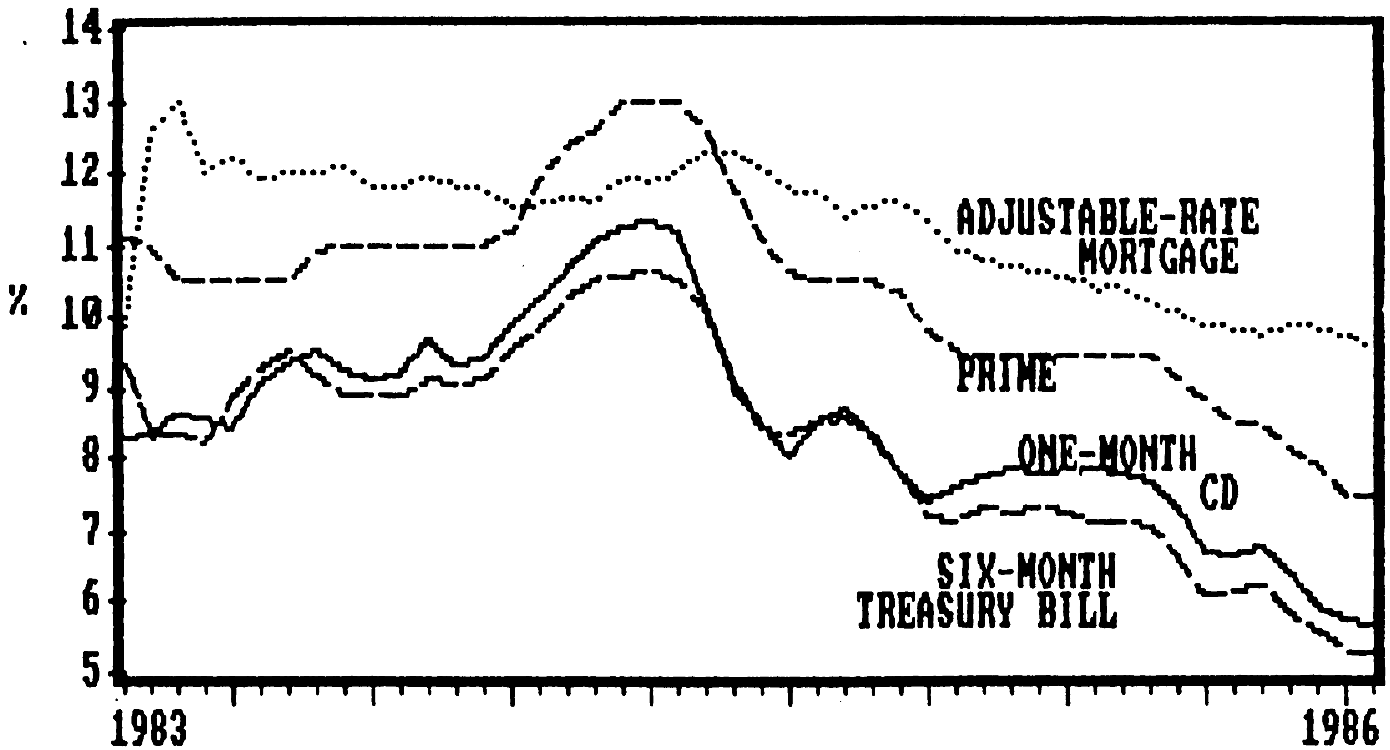

FIGURE 1 COMPARATIVE INTEREST RATES

not zero and that a gap of zero may not provide the minimum variance.

The risk reduction strategy is an improvement over the insurance strategy because it acknowledges that basis risk exists and may be of a size to be considered a disadvantage. Moreover, the optimal gap may not be zero. The shortcoming of this strategy is that risk reduction may become the sole objective at the expense of the interest margin. When the costs as well as the benefits are considered, a risk reduction strategy may in fact reduce the value of the firm.

Speculation

The depository institution manager who trusts economic forecasts may prefer the speculative approach. Using a forecast of future rates, the depository institution manager positions the gap to take advantage of expected rate changes. If rates are expected to go up, the balance sheet is positioned to have a positive gap. If rates are expected to decline, the balance sheet is positioned to have a negative gap.

The problem with this is that interest rate forecasts are notoriously unreliable. In recent banking history, a number of managers "bet the bank" and lost. This strategy is unacceptable for responsibly managed banks.

Risk-Return Tradeoff

The objective of this strategy follows the Markowitz [1959] theory of having the lowest variance given a level of return or conversely, the highest return given a level of variance. The balance sheet of the depository institution is thought of as a portfolio. The manager seeks that balance sheet which represents a portfolio on the efficient frontier of attainable portfolios in risk-return space. This strategy is the most sophisticated of those discussed and requires depository institution managers to consider interest income as well as risk.

Conclusions

Four strategies (insurance, risk reduction, speculation, and risk-return tradeoff) have been described in an attempt to explain the objectives inherent in gap management. The speculative strategy is dangerous because it requires depository institution managers to accurately predict the future. "Betting the bank" may be the unfortunate result. The other three strategies reduce risk with varying degrees of success. The insurance strategy is adequate if several strong assumptions regarding the movement of asset and liability rates hold. The risk reduction strategy is an improvement over the insurance strategy because of the awareness that rates may not move together and a zero gap may not be optimal because additional risk may be added unnecessarily. The risk reduction strategy is suboptimal to the extent that risk reduction becomes the bank's sole objective at the expense of a minimum acceptable return. The risk-return tradeoff strategy reduces risk and simultaneously maintains a desired level of return. The resulting balance sheet represents a portfolio on the efficient frontier of attainable portfolios in a risk-return framework. The next section of this dissertation reviews several studies of gap management.

METHODS OF CONTROLLING FOR INTEREST RATE RISK: A LITERATURE REVIEW

The theoretical and empirical portions of this dissertation focus on gap management of basis risk. Basis risk arises from a lack of co-movement of the market rates of return on rate-sensitive assets and liabilities and is one component of income risk. Gap management is but one of several alternatives that have been suggested for managing a bank's exposure to the income risk portion of interest rate risk. Much of the literature on interest rate risk either ignores the basis risk component of income risk or assumes it to be insignificant. Other methods suggested in the literature for managing rate-sensitive assets and liabilities include interest rate swaps, option hedges and futures contract hedges. Although options, futures, and swaps are the recent and glamorous innovations, few depository institutions use them. Considering some of the risks peculiar to a depository institution, evidence presented in this section indicates that hedging with futures may be less effective at controlling interest rate risk than simply remaining unhedged. This section reviews the literature regarding methods of controlling for the income portion of interest rate risk.

Controlling Interest Rate Risk

Gap Management Gap management is a viable and for many depository institutions, the only practical method available to control interest rate risk. Studies of the optimal gap and its effectiveness have been largely absent from the literature in favor of studies of other methods of controlling interest rate risk such as hedging with futures contracts and interest rate swaps. The only gap management studies available discuss the comparative advantages of a duration gap over the gap and measure average gaps. Measures of basis risk and optimal gap measures remain absent from the literature.

For example, Mitchell [1985] suggests a duration gap to correct for the deficiency of gap management. He argues that the deficiency of gap management is that market value changes in the value of bank assets and liabilities are not monitored. This reflects the investment risk of non-rate-sensitive assets and liabilities as well as those of rate-sensitive assets and liabilities which do not move in perfect unison with the market. In his study of tenth district banks, he found that large banks had a narrower gap than small banks (and presumably less interest rate risk) and that, the gap in all banks has narrowed over time. Toevs [1983] also argues that gap management is flawed as a management tool and is of little practical interest because it is difficult to narrow the gap. Toves suggests the use of a general duration gap hedged with futures contracts to correct for the deficiencies.

It is difficult in practice to narrow the gap. Customers prefer long-term loans and short-term deposits. The loan market is thin, and it is difficult to sell long-term loans in order to replace them with rate-sensitive assets. To increase the quantity of rate-sensitive assets to match the quantity of rate-sensitive liabilities, adjustable-rate mortgages (more commonly found in savings and loans) and adjustable-rate loans (more commonly found in banks) are often used. One adjustable-rate mortgage of interest is the Texas mortgage (see Brock [1983]) which is actually a series of short term (5 year) loans. The borrower must return in five years to obtain a new loan.

Two main problems arise with adjustable-rate mortgages and adjustable-rate loans. First, interest rate risk is traded for credit risk to the depository institution as interest rate risk is passed to the borrower. Second, to attract customers for the adjustable-rate mortgages and adjustable-rate loans, lower rates are offered to the borrower. The spread between assets and liabilities is reduced, which in turn reduces interest income.

The tradeoff between the benefits of reduced exposure and the costs of foregone income is seldom explicitly evaluated. Whether the risk reduction is commensurate with the reduction in interest income is uncertain (see Binder [1980]). McNulty [1987], for example, argues that the optimal gap is not zero. Brewer [1985] argues that repricing of assets and liabilities continues during the gap period and that it is unlikely that the bank is perfectly hedged against interest rate risk by using gap management. As a result of these arguments, some researchers (see McCabe and Blackwell [1981]) claim that depository institutions should hedge the gap with futures contracts or some other instrument rather than manage it .

Hedging with Futures Contracts National banks were permitted to participate in the futures market as early as 1976 for the purpose of controlling interest rate risk. Research regarding the use of futures contracts at depository institutions has yielded some interesting insights. Booth, Smith, and Stolz [1984] surveyed depository institutions using interest rate futures and found that savings and loans were most likely to use them. Futures were also used predominantly for insurance against price changes of portfolios of assets which the depository institution planned to sell in the future. Pomeranz [1985] found that savings and loans used futures to hedge mortgages and preserve prices. Koch, Steinhauser, and Whigham [1982] note that the mark-to-market accounting convention for futures, which treats gains and losses as current income even though the position has not been closed out, may deter depository institutions from trading in futures because of the resulting volatility to income statements. Koch et al. found that banks have been more successful than savings and loans at using short-term assets rather than futures to hedge earnings fluctuations. That is, banks have been more successful than savings and loans at switching to variable-rate loans which may be a reason why futures are used more extensively by savings and loans. Drabenstott and

McDonley [1982] and Veit and Reiff [1983] argue that futures hedging may be less effective than gap management when risks peculiar to a depository institution are considered . Other studies found that futures contracts were not extensively used, large rather than small depository institutions used them, and many institutions have suffered losses from inexperienced dealings in the futures market. There is some evidence (see Ryan [1982]) that depository institutions have been speculating in futures contracts which is not within the regulatory guidelines for participation in futures trading by depository institutions.

Many articles (see Belongia and Santioni [1985] and Drabenstott and McDonley [1984]) have been written that instruct the depository institution on the use of futures contracts and extol the virtues of hedging using futures contracts. These authors argue that hedging the existing gap with futures is more effective than gap management. Crane [1985] found that hedging with futures contracts reduced the variance of earnings without reducing earnings when he examined savings and loan institutions. Bookstaber [1986] argues that narrowing the gap is not optimal because the use of adjustable-rate mortgages forces the borrower to accept risk. Moreover, the interest rate caps required to attract borrowers restrict the ability of the adjustable-rate mortgage to float with changes in interest rates. In his simulation, he found that the risk of an adjustable-rate mortgage was small if rate changes remained moderate but became acute when the simulation included large rate swings. He found the conventional mortgage hedged with a market instrument to be superior to an unhedged adjustable-rate mortgage at reducing interest rate risk.

Several articles discuss the best method of hedging using futures contracts. Speakes [1983] studied the 'phased in' money market hedge. He does not guarantee that the hedge would occur at the low point in rates but that a rate would be 'locked in'. No test of this rule was performed. Maness and Senchack [1986] argued that 'continuous' hedging with futures was the best way to manage interest rate risk. Dew and Martell [1981] suggest a synthetic fixed-rate loan which reduces interest rate risk to the bank but does not require the bank to participate in the futures market, the borrower held the futures position.

A number of articles describe the effectiveness of futures in hedging interest rate risk. Koppenhaver [Summer, 1984] designed a model based on Sealey's 1980 model to test the hedging effectiveness of Treasury Bill futures. Unlike Sealey's model, Koppenhaver's model allows banks no control over deposit rates as they are set by Regulation Q. Liabilities are assumed to be more rate sensitive than assets. Using simulation to examine a Treasury Bill futures hedge, Koppenhaver found that a partial hedge was optimal. Larger banks' hedge ratios and the effectiveness of the hedge was independent of the particular interest rate forecast used while smaller banks were more rate-sensitive. Hedging effectiveness was similar to that modelled and estimated by Ederington [1979] and Franckle [1980] but the optimal hedge ratios were higher.

In a later study, Koppenhaver [March, 1985] compared the performance of various futures as hedges in a depository institution setting . He tested certificate of deposit futures against Treasury Bill futures. Certificate of deposit futures minimize the variability of certificate of deposit costs better than Treasury Bill futures. However, if the goal is to maximize the utility of profits under constant risk aversion, there is little difference in performance between certificate of deposit and Treasury Bill futures as hedges.

Morgan, Shone, and Smith [1988] found that the effect of deregulation was to reduce interest rate risk. The objective was to find the optimal hedge ratio of futures contracts to hedge loans and deposits. They extended Koppenhaver's model and Morgan and Smith's model to incorporate uncertainty about deposit supply and loan demand was extended. Using a sample of 82 banks, they found that the optimal hedge was better estimated using seemingly unrelated regressions rather than ordinary least squares. The optimal hedge ratio was lower than previously thought and has generally declined in the time period after deregulation.

Unexpected loan and deposit repricing has been incorporated into futures hedging studies. Ho and Saunders [1983] studied futures hedging and incorporated loan takedown risk. After deriving and testing the model, they found that when price and quantity risks were present, it was impossible to form a perfect hedge using interest rate futures. The optimal hedge would vary considerably over time. Therefore, a reservation fee was suggested to compensate for the loan takedown risk.

Koppenhaver [Journal of Futures Markets, 1985] obtained disappointing results when he incorporated prepayment risk into Sealey's model. Using a simulation and hedging with Treasury Bill futures, he found a small (10%) reduction in interest rate risk.

Batlin [1983] found that a synthetic fixed-rate loan (the borrower shelters the lender from interest rate risk) was the best hedge against interest rate risk when the risk of loan prepayment was considered. Hedging with futures provided less protection than being unhedged in this case .

Hedging the gap with futures is a popular topic in academic and practitioner's literature. However, considerable controversy exists regarding the effectiveness of using futures as a hedge. Research results have shown the variable effectiveness of hedging with futures depending on the conditions studied. Some question exists regarding the use of futures are used within the legal constraints required. Finally, by hedging with futures, the bank may be taking an additional risk of which it is unaware and lacks expertise to manage. Therefore, managing the gap may be as effective as and generate less risk than hedging the gap with futures.

Interest Rate Swaps and Options Other writers have suggested using interest rate swaps or options. Loeys [1985] compared swaps to hedging with futures contracts. He argues that interest rate swaps can be tailored to the needs of the firm provided that another firm can be found to provide the other half of the contract. This provides more flexibility than the three month delivery dates of futures contracts. He notes that swaps are more costly than futures contracts but swaps are less costly than realigning the firm's assets and liabilities. Problems include the fact that the contract must be negotiated, and that default risk is higher in swaps than in futures.

Lacey [1986] describes the mechanics of a swap and includes suggestions for selecting the index as well as measuring the performance of the swap. No simulation or other empirical studies are included in either Lacey's or Loeys' article.

Bookstaber [1982] compared hedges of futures contracts with hedges of forward delivery loans which are essentially option contracts on loan rates. To evaluate the futures position, he uses Ederington's model [1979] and various option strategies including writing calls, buying calls, and a combination of the two to measure the effectiveness of options in hedging interest rate risk. He uses a numeric utility maximization example to illustrate the performance of each hedge. This paper offers a useful methodology for the evaluation of options and futures. Koppenhaver [January/February, 1986] discussed the use of futures options to hedge interest rate risk. He found that the instrument was used by only 90 large banks.

The optimal gap position and its effectiveness in hedging interest rate risk remains an unresolved issue even though narrowing the gap is frequently cited as desirable. In nearly all of the existing academic studies, researchers assume that the volatility of interest income is eliminated as the gap is narrowed to zero. This represents an important source of risk for depository institutions which is often overlooked. This over-simplification of reality is examined in the next section.

Basis Risk

Causes While hedging may reduce a bank's total exposure to interest rate risk, it does not necessarily reduce the basis risk component of interest rate risk. In a depository institution which narrows the gap to control interest rate risk, basis risk may remain because of the imperfect correlation between the rates at which assets and liabilities are repriced.

Sources of basis risk include a number of situations peculiar to depository institutions. First, assets and liabilities are mismatched by type of security. It can not be assumed that the rates of the two move together unless they are tied to the same index. An example of this is an adjustable-rate mortgage asset matched with a certificate of deposit liability. Second, a distortion could occur in the market rate of a security used as an asset or liability. The announcement of a significant event such as a bank closing would, for example affect the certificate of deposit market, but not the adjustable-rate mortgage market. Third, some rates, such as the rate on prime commercial loans, are administered rates. These rates are set by management in response to changing market conditions. Administered rate changes appear to be "sticky" compared to market rate changes. This may be caused by inertia or by competitive, political, or policy conditions which preclude immediate response to changes in market required rates of return.

Significance When discussing gap management, the literature generally assumes basis risk to be zero and ignores it. Basis risk, when mentioned, is assumed to be less than and more easily controlled than market risk (see Drabenstott and McDonley [1984]).

Basis risk is important to management because it reduces the effectiveness of gap management. As stated before, gap management can be analogous to futures hedging because a gap management strategy consists of opposite positions in the securities of the depository institution. Basis risk has been found to be significant in futures hedging because the hedge is often less effective than desired because of the lack of perfect co-movement of the opposing positions (Dale [1981]).

Consequently basis risk is important when evaluating the effectiveness of gap management. Beighley [1985] argues that basis risk could be large and should be monitored or the 'hedging' objective will not be achieved. Barnhill and Handorf [1985] state that the average yield on repriced assets changes by a smaller amount than the average yield on liabilities. Some of the rates on the loans they examined were approaching the usury limits of the state which further constrains the level of repricing and increases basis risk. Brewer [1985] argues that assets and liabilities are repriced during the gap period, and gap management may not provide the level of interest rate risk reduction required.

As indicated previously, basis risk in gap management can be large. First, the match of assets and liabilities in gap management is analogous to a futures cross-hedge because different securities comprise assets and liabilities. It has been found that futures cross-hedges are less effective at risk reduction than hedges of like securities (Parker and Daigler [1981]). Simply narrowing a depository institution's gap without consideration of the basis risk inherent in cross-hedging a depository institution's assets and liabilities holds similar perils. Second, competition, politics, policy, and management inertia create lags in the response time to changing the rates of administered funds which means that asset and liability rates do not move in perfect unison. Finally, market price distortions described above may affect some assets or liabilities that are found in the balance sheets of depository institutions but not other firms. These are three important sources of basis risk which are typically ignored or assumed away in the existing literature on hedging interest rate risk.

Conclusion

The literature has been concentrated on hedging the gap with futures contracts, options, and interest rate swaps and has largely ignored gap management as a hedge to reduce the income portion of interest rate risk. In practice, futures are not used extensively by depository institutions, and some of the literature indicates that futures hedges are not as effective as originally thought when risks peculiar to these institutions are considered. Gap management emerges as a viable method of insulating a bank against its exposure to interest rate risk. The measurement of basis risk, the optimal gap position, and the effectiveness of gap management strategies in hedging interest rate risk remain unsolved issues.

PURPOSE AND CONTRIBUTION

This dissertation addresses the question: do depository institution managers maintain the optimal gap considering basis risk? The results of this dissertation will provide economic benefit. A cost of narrowing the gap has been a reduction in net interest income. Fees have been used to smooth income. Moreover, it is possible that volatility of interest income has not been reduced sufficiently to justify the interest income reduction. That is, the narrower gap may not be mean-variance efficient. Mean-variance efficiency implies that the gap provides the lowest level of risk given a level of return. The depository institution may be better off maintaining a slightly negative or positive gap than by reducing it to zero.

This dissertation will model the optimal gap by viewing the balance sheet of a depository institution as a portfolio with the goal of maximizing the risk-adjusted value of the firm. The model implies the optimal gap and the effects adjusting the gap has on the value of the firm.

The important part of basis risk is its effect on the value of the firm as proxied by stock returns of the firm. A modified two-index model is used to measure the change in the value of the firm generated by a change in gap. A modification of the standard single-index model is the use of an ordinary least squares estimate of the market and interest rate risk coefficients based on aggregate coefficient estimates of the coefficients rather than the typical single period ordinary least squares estimate of these coefficients. Finally, the optimal relationship of rate-sensitive assets and rate-sensitive liabilities is explored using a linear regression model.

DISSERTATION PLAN

This dissertation investigates basis risk in gap management. Chapter II reviews the literature which empirically measures the value of a bank using single- and multiple-index pricing models. To measure the basis risk effect on the value of the firm, an aggregate two-index model is used. Therefore, the literature pertaining to the empirical measurement of the value of a bank using single- and multiple-index models is reviewed to learn the boundaries of research in this area.

Chapter III derives the model of a bank using a risk-adjusted valuation model. Chapter IV states the hypotheses to be tested and describes empirical methodology to test the hypotheses. Chapter V describes the empirical test results and Chapter VI follows with conclusions and suggestions for future research.

CHAPTER II

A LITERATURE SURVEY

This chapter reviews literature pertaining to empirical tests of extra-market interest rate-sensitivity that tie interest rate risk to the return of the stock. The review provides background for the remaining chapters. Research deficiencies are noted and support for empirical processes is provided.

EMPIRICAL TESTS OF INTEREST RATE SENSITIVITY

Considerable research has been done on the rate-sensitivity of common stocks. It has frequently been found that banks show some degree of extra-market rate-sensitivity, but the evidence is mixed. Moreover, evidence exists that the estimates of the coefficients in the two-index model are biased in some studies, and at least one study has been discredited for possible measurement or calculation errors. Therefore, to date, the probability of error in existing research is great and the evidence of extra-market rate-sensitivity of bank stock returns is unreliable. While theoretically one would expect bank stock returns to show extra-market rate-sensitivity, the results of existing research are inconsistent.

The purpose of this section is to review papers which study the rate-sensitivity of stocks of banking firms. First Stone's two-index model is described. Next, empirical tests of Stone's model are examined. Finally, empirical tests of other models are described and a summary follows.

Stone's Two-Index Model

Stone argues that the stocks of some firm groups (utilities, for example) are acceptable substitutes for fixed-income securities. The stock return should be sensitive to interest rate movements as well as the market. To measure the extra-market rate-sensitivity, a two-index model is devised.

The model is as follows:

$$R_j = \alpha + \beta_d R_d + \beta_e R_e + \epsilon ,$$

where

R_j = return on stock

R_d = return on debt

R_e = return on equity

ϵ = error term

β_d = debt beta

β_e = equity beta

Since some co-movement between the market and interest rate index exists, a popular technique to eliminate the problem is to orthogonalize the two indices. However, using this procedure, all of the coefficients except the one for which error terms are substituted may then be biased as will be discussed later.

Stone's model is tested by a number of researchers. The results are mixed. Moreover, at least one study has been discredited.

Martin and Keown Martin and Keown used Stone's model to test for the existence of extra-market rate-sensitivity of the stocks of utilities and financial institutions. Evidence is found of extra-market rate-sensitivity in various groups of stocks. They concluded that this extra-market rate-sensitivity is shared by the group as a whole. Therefore, a portfolio which contains a large concentration of these stocks contains more risk than the single-index Capital Asset Pricing Model would reveal.

Lloyd and Schick Lloyd and Schick used Stone's model to test for the existence of extra-market rate-sensitivity of a group of sixty large commercial banks. The rate-sensitivity of bank stock is compared to a group of stocks comprised of the Dow Jones Industrial Average. They found that the equity beta of the bank stock is insignificant (some betas are negative) and the significance of the bond index beta is also low. The stocks in the Dow Jones Industrial Average had higher betas in both cases.

They conclude that adding a bond index only partially improves the model's explanatory power. They argue that this is not surprising because banks should be more rate-sensitive to short-term rates than the long-term rates used in the index.

Chance Chance questions the results obtained by Lloyd and Schick. By replicating Lloyd and Schick's study as closely as possible, he found the average market beta to be significant (.71) and found nonegative betas. (Some of Lloyd and Schick's betas are negative.) He concludes that a measurement error existed in the Lloyd-Schick study.

He criticizes the Lloyd-Schick use of two one-sided t tests because the wrong significance level is tested. Upon replicating tests of bond betas, he noted that seven of the fifteen bond betas in the bank sample are not significant at the .05 level and in the Dow Jones Industrial Average sample, six of the twenty-one bond betas are no longer significant. Therefore the significance of the bond index is overstated by Lloyd and Schick.

Gultekin and Rogalski Gultekin and Rogalski argue that conceptual flaws in Stone's model are over looked by Lloyd and Schick. They argue that Lloyd and Schick attempted to test for the existence of covariance rather than returns as a function of covariance.

They replicated Lloyd and Schick's study and are unable to duplicate the results. Measurement error is cited as the probable cause. The bank market betas that Gultekin and Rogalski estimate are higher than those of Lloyd and Schick. Moreover, they argue that Lloyd and Schick should have used an adjusted R^2 rather than R^2 . Gultekin and Rogalski found that Stone's model is not supported.

Lynge and Zumwalt Lynge and Zumwalt empirically test the rate-sensitivity of returns on bank stock. Two bond yield indices are used, one is a long-term bond index, the other a short-term bond index. A market proxy is used as a third index. A three index model is used to show sensitivity of bank stock returns. Bank stock returns showed significant extra-market rate-sensitivity to the interest rate indices and are more rate-sensitive than industrial common stocks.

Chance and Lane Chance and Lane re-examine the relationship between interest rates and returns on common stocks of financial institutions. Using a sample of six groups of firms from the Compustat tapes, they test the stock of each group for extra-market rate-sensitivity. The Standard and Poor's 500 proxies the market and three interest rate proxies of short-, medium-, and long-term maturities are used. They find no extra-market rate-sensitivity to any of the bond indices on the returns of financial institutions.

Flannery and James, (1984 JF) Flannery and James wanted to determine whether the interest rate-sensitivity of common stock returns of a bank is related to the maturity of its assets. Using Stone's model, three indices are used to proxy the interest rate index: GNMA 8%, seven-year Treasury Bonds, and one-year Treasury Bills.

Bank stock show extra-market rate-sensitivity to all three indices, although the effect is stronger with Treasury Bills. Further testing of savings and loans reveal a larger coefficient of extra-market rate-sensitivity than in the case of banks.

The bank results are used to determine if a maturity mis-match exists in the balance sheet. A net short (assets) position is calculated (this is an estimated one-year gap). By regressing the net short position against the extra-market rate-sensitivity coefficient, they find that "short" has a significant negative relationship to all the extra-market rate-sensitivity based on all indices. This means that an increase in the maturity of net nominal assets corresponds to greater rate-sensitivity of the common stock price.

Flannery and James (1984 JMCB) Flannery and James uses the same methodology as in the previous paper to obtain the measure of extra-market rate-sensitivity of a sample of bank stock returns. The paper determines which asset or liability most closely explains the extra-market rate-sensitivity. They find that except for "short", no balance sheet item had significant explanatory power.

Phelps uses Stone's model and Flannery and James' methodology to measure market risk and extra-market rate-sensitivity of large banks. He finds evidence of significant extra-market rate-sensitivity in the earlier period of his test (1980-1982) but not in the later period (1983-1985).

To find the balance sheet link, he regresses the coefficient of extra-market sensitivity against interest income and a measure of non-rate-sensitive investment. Non-rate-sensitive investment is insignificant in the later period whereas interest income is significant. He regresses the gap ("short") against the coefficient of the firm's market beta and finds a significant positive relationship.

Booth and Officer Booth and Officer examined the effect of current and expected interest rate changes on bank equity values.

They proxy actual, anticipated, and unanticipated rate changes. Using Stone's model, bank stock shows extra-market rate-sensitivity to all three proxies.

Giliberto Giliberto argues that the common orthogonalization procedure used to minimize multicollinearity generates a biased estimate for all coefficients except the variable for which error terms are substituted because an explanatory variable is mis-specified. The result is that the hypothesis tests are flawed and the findings are questionable. He suggests not orthogonalizing the two series or using a different t test to establish significance.

Scott and Peterson Scott and Peterson use Stone's model to test for the extra-market rate-sensitivity of commercial banks, savings and loans, and life insurance companies. Using changes in rates of thirty year Treasury Bonds to proxy the unexpected change in rates, they find that all three firm groups have extra-market rate sensitivity to unexpected changes in rates. Moreover, banks and life insurance firms have similar extra-market rate-sensitivity while the extra-market rate-sensitivity of savings and loans is much larger. Scott and Peterson find no difference in the results if the market and interest rate index are first orthogonalized or not.

Unal and Kane Unal and Kane use two approaches to test for interest rate-sensitivity of the stock returns of banks and savings and loans. One approach is Stone's model and the other is a new approach called the balance sheet approach.

They argue that bank and savings and loan stock returns become more rate-sensitive as a result of regulatory changes which affect interest rates. Two time periods are tested: 1975-1980 and 1981-1985. The sample of banks is divided into three groups by size. The results show a size effect. The interest rate-sensitivity of the stock returns of banks and savings and loans show a significant increase in the latter period. The results are virtually identical regardless if the market and interest rate indices are orthogonalized or not. Using an autoregressive model to find an unanticipated measure of interest rates generates identical results to using the interest indices without adjustment. The stock returns are not sensitive to short-term rates but are sensitive to long-term rates. The results of Stone's model and the balance sheet approach are similar and can easily be reconciled.

<u>Other Models</u>

<u>Joehnk and Petty</u> Joehnk and Petty use a single-index model to determine stock return sensitivity against a return in some interest rate index. Five stock groups are studied: growth, equity, moderate, income, and utilities. Interest rate-sensitivity vary by group and in all groups over time. Evidence indicates that the stocks become increasingly sensitive over time.

<u>Folger, John, and Tipton</u> Folger, John, and Tipton used a multi-period model to regress excess returns on stock against the market index, an index of three-month Treasury Bills, and an index

of long-term AAA utility bonds. The stocks are divided into the following groups: growth, stable, cyclical, industry, and other.

All stocks show statistically significant market betas. Three-month Treasury Bill rates are statistically significant although the coefficient is small and long-term utility bonds generate an insignificant coefficient of extra-market rate-sensitivity.

Beedles and Bushmann Beedles and Bushmann test the adequacy of the single-index pricing model at measuring the risk of bank stock. Since the risk is perceived to be nonstationary, the Scholes-Williams model is used to determine risk. They find that only 6% of the variability of equity returns of banks is explained by the market. By comparing the results of other firms to banks, they fail to show that bank risk is different. It is argued that bank returns are described by the market model at least as well as other returns.

Santoni Santoni argues that the owners of financial firms accept more rate-sensitivity than owners of non-financial firms. Using AAA bond rates to proxy interest rates, the Standard and Poor 400 index to proxy the market, and the growth of real Gross National Product for cyclical factors, he finds that interest elasticities are not equal between groups. A 1% increase in rates is associated with a reduction of .4% of the value of an industrial firm, a .9% reduction in the value of a bank, and a 2.41% reduction in the value of a savings and loan.

He argues that these results are explained because financial institutions are highly leveraged relative to other firms, and the portfolios of savings and loans are mismatched with long-term assets and short-term liabilities. He further argues that matching maturities would not reduce interest rate risk, and reversing maturities (borrow long, lend short) is not consistent with the mission of a bank and would create serious problems.

Booth, Officer, and Henderson Booth, Officer, and Henderson measure the impact of interest rate changes on the systematic risk of bank stock. A single-index Capital Asset Pricing Model with a moving average beta measure is used. The sample is divided into two periods depending on whether interest rates are high or low.

Money-center banks are found to show more risk than non-money-center banks. The average beta of banks has increased over time. Moreover, the pattern of the moving average beta is related to the interest rate cycle.

Brewer and Lee Brewer and Lee use a multi-index market model to measure extra-market sensitivity of bank stocks. The indices used are a market return, a risk adjusted return on a portfolio of bank industry stocks, and an index of unexpected interest rate changes.

The stock returns of large money center banks show no significant extra-market rate-sensitivity. However, the stock returns of a sample of banks taken from other areas do show extra-market rate-sensitivity.

They test the explanatory value of a number of accounting ratios on the market, industry, and interest rate measures of risk. The ratios tested are book capital/assets, after tax income/assets, standard deviation of net income/taxes, purchased funds/assets, loans/assets, and charge-offs/assets. The ratios involving book capital, loans, and purchased funds are significant when explaining market risk and industry risk. After tax income, purchased funds, and loans are significant when explaining interest rate risk.

Sweeny and Warga Sweeny and Warga use a two-index model to measure rate-sensitivity in a number of industries perceived to have stock which possess the trait of extra-market rate-sensitivity. Using a market proxy and the change in long-term bonds as the interest rate proxy, they find that the following industries showed extra-market rate-sensitivity: utilities; banking and finance; and stone, clay, and glass. The extra-market rate-sensitivity betas are unstable for banking and finance and stone, clay, and glass but are stable for utilities. The remainder of the article further examines the rate-sensitivity of utilities.

Brickley and James Brickley and James use a single index Capital Asset Pricing Model with a dummy variable to study the effects of modification of insolvency rules issued by insuring agencies of the savings and loan industry during periods of distress. They find that this rule modification reduced the co-movement of savings and loan stock returns with savings and loan portfolio holdings. This is referred to as the subsidy hypothesis.

It is found that the market beta coefficient declined significantly during the post 1979 period. This decline is related to a decline in the elasticity of savings and loan stock price with respect to the value of underlying assets.

Johnson, Brick, and Price Johnson, Brick, and Price find that interest rate-sensitivity is independent of the amount of financial leverage of a firm but not independent of the level of systematic risk. A multi-index model is used to test the rate sensitivity of a portfolio of stocks. A sample of firms is divided into two portfolios depending on market beta (high or low) and then each of these portfolios is divided into five portfolios depending on level of debt.

They find that high beta portfolios are sensitive only to short-term rates but low beta portfolios are sensitive to both long- and short-term rates. The level of debt is irrelevant. Studies of the lead/lag effects indicate that interest rates lead stock prices.

SUMMARY

This chapter reviews studies of the use of various market models to examine extra-market rate-sensitivity of banks. The evidence of extra-market rate-sensitivity is mixed. Further confusion results because the results of several studies contain possible measurement errors or biased coefficients of rate-sensitivity.

It is likely that extra-market rate-sensitivity of bank stock returns has changed over time. Large-sized bank stock returns may show different levels of extra-market rate-sensitivity from small-sized bank stock returns. This point has not been fully studied because many of the stock return tapes used in previous studies only contain stock returns of large-sized bank holding companies rather than stocks of small-sized bank holding companies.

Some researchers indicate that the single period, ordinary least squares estimate of the firm's market beta is biased because of thin trading and various frictions in the market.[1] An aggregate beta is recommended when estimating the single-index Capital Asset Pricing Model. Shanken studies the use of this method to estimate aggregate firm betas and finds that the measure of the beta in some cases is double the single-period estimate indicating a serious bias. He further recommends that in the arbitrage pricing model, all factors be estimated using an aggregate measure.[2]

The next chapter analyzes the depository institution using a value maximizing model. The proposed methodology in Chapter IV suggests the use of an aggregate two-index model to tie the measure of basis risk to the value of the firm as proxied by the firm's stock returns. A measure of the optimal gap is also provided.

FOOTNOTES

[1] See Dimson [1979], Cohen, K. et. al., [January, 1983] and [1983].

[2] See Shanken [1987].

CHAPTER III

MODELLING A DEPOSITORY INSTITUTION USING A RISK-ADJUSTED VALUATION MODEL

As shown in Chapter I, the gap can be viewed as a hedge. Most articles on gap management either accept the gap as given and suggest hedging with futures or discuss the relative merits of different kinds of gaps such as duration gaps. Some insight into the optimal gap is found in several of the articles discussed in Chapter I. It is argued that the zero gap may not be optimal, considerable basis risk occurs in short time periods, and basis risk could be large (see McNulty [1987], Brewer, [1985], Barnhill and Handorf, [1985], and Beighly, [1985]). However, none of these studies measures basis risk or the empirically determined optimal gap.

The purpose of this chapter is to derive the optimal gap and relate the balance sheet structure and gap to the value of the firm. The chapter is organized as follows. First, the nature of the bank balance sheet problem is explored. Second, a formal model of bank assets and liabilities is developed in a Markowitz [1959] mean-variance efficient portfolio framework. Finally, the model is solved and the implications of the model solution, including its shadow prices, are developed.

NATURE OF THE BALANCE SHEET PROBLEM

This section addresses the nature of the balance sheet problem. The following topics are discussed. First, the bank balance sheet is described. Second, income and variance of income are studied using a simple bank example showing the effects of four different gaps. Finally, management decisions and preferences about the bank balance sheet are stated.

The Bank Balance Sheet

The bank balance sheet consists of assets of cash, investments, loans, and fixed assets. The liabilities consist of deposits, borrowings, and capital.

Cash includes currency and coin, Federal Reserve deposits, cash items in process of collection and deposits with other banks. Cash earns some interest although vault cash does not. It is required for liquidity purposes and to meet Federal Reserve requirements.

Investments are used to pledge government deposits,for profit, and for public relations purposes. Treasury Bills and Bonds, corporate bonds, commercial paper, and municipal bonds are frequently used as investments. Government agencies demand that a particular investment is pledged as collateral for their deposits in excess of $100,000. For some government deposits, only Treasury Bills are acceptable. Some local agencies, however, will permit use of a municipal bond to pledge the deposit. This can be quite profitable for the bank.

The loan portfolio consists of commercial, personal (installment), and real estate loans. The actual composition of the loan portfolio depends on the bank's marketing strategies and opportunities. Fixed assets consist of the building, related equipment, and additional real estate owned by the bank.

Deposits consist of several types: demand deposits (checking accounts), NOW or Super NOW passbook accounts, certificates of deposit, and IRA's. Demand deposits pay no interest or a very low rate of interest. These deposits frequently take the form of small saver checking accounts or compensating balances required as part of a business loan covenant. The passbook account is generally a small, fixed rate account which can be withdrawn at any time, but usually some base amount remains at any given time. As of 1986, the rates paid on these accounts are permitted to float, but to date, interest rates have not increased so this still represents a low interest rate account. Money market accounts are floating rate accounts which can be withdrawn at any time. Time deposits include various certificates of deposit, IRA accounts, and other long-term deposits. The depositor is required to leave these funds with the bank for a minimal time or forfeit the interest. The rate paid on these deposits is higher than on the passbook accounts and floats with some index. Large certificates of deposit (over $100,000) have higher rates. Purchased funds and short-term borrowings, which are Fed funds and repurchase agreements, are obtained on a short-term basis from other banks.

Borrowings include long-term debt (maturing over one year) and represent a small portion of total liabilities. (Deposits are usually about 80% of liabilities: long-term debt is a smaller portion.) Capital consists of stock and retained earnings. The capital account is about 6% of liabilities for reasons of capital adequacy. This figure should be increased if default risk of the loan portfolio is high.

A Simple Bank Example

The first step toward the development of the model of the optimal balance sheet, and implied gap and a measure of basis risk will be a description of the mechanics of gap management at the hypothetical Simple Bank . The purpose of this chapter is to illustrate the repricing of rate-sensitive assets and liabilities and the accompanying effects on interest income.

Four scenarios are examined representing widely diverse gap policies. Scenario 1 illustrates a depository institution with a balance sheet which has an almost wholly negative gap. Scenario 1 is similar to the situation of many depository institutions in the 1970s and may still be found in some depository institutions today. The reason why a large negative gap is still found today is customer preference and competitive pressure. Customers who are the most credit-worthy are in a position to dictate the terms of a loan and are not required to accept an adjustable-rate loan. Scenario 2 illustrates a depository institution with a balance sheet with a gap of zero. The asset side of the balance sheet is adjusted so that a gap of zero occurs each quarter. The liability side of the balance sheet is identical to that of Scenario 1. The other two scenarios are variations of Scenario 2. Scenario 3 illustrates a depository institution with a balance sheet showing a slightly positive gap and Scenario 4 illustrates a slightly negative gap.

Scenarios 3 and 4 are trial and error attempts to find a balance sheet which represents a Markowitz [1959] mean-variance efficient portfolio. A Markowitz efficient portfolio is defined as follows: given a required return, the variance of the return is a minimum. Conversely, given a particular variance, the return is at a maximum. The zero gap balance sheet may represent an efficient portfolio but this is not known for certain. As the balance sheet changes, as few changes as possible are made in an attempt to represent market and regulatory constraints on asset and liability accounts and to avoid introducing uncontrolled variables.

The balance sheet of Simple Bank is shown in Table 1 and Figure 2. Its assets and liabilities each total $200 million. The gap of this particular balance sheet is negative. It is assumed that all income is paid to the stockholders. Only the base amount of the asset or liability is repriced. Second, it is assumed that there is no risk of loan prepayment or early deposit withdrawal so that repricing will follow the schedule indicated. Third, as the rate-sensitive assets and rate-sensitive liabilities are repriced, the composition of the bank's balance sheet is maintained.

To more clearly illustrate what is repriced at a given time, Table 1 shows a repricing schedule of rate-sensitive assets and rate-sensitive liabilities. Columns entitled "1-month" through "3-month" list the rate-sensitive assets and rate-sensitive liabilities that are repriced each month. The column entitled "Total" indicates the total amount that is repriced each quarter.

The average spread and its standard deviation are calculated in each of the four scenarios. Only interest income is studied. Fee income and other incidentals are not considered. The focus of this section is to discover the effects of repricing various combinations of rate-sensitive assets and rate-sensitive liabilities on interest income and its volatility.

Where possible, monthly data was collected from The Federal Reserve Bulletin for the years 1983-1986. The only rates unavailable on a monthly basis were auto loan rates which were available only on a quarterly basis. To solve the problem, it was assumed that the rate was applicable for each of the three months of the quarter.

Setting the initial rate for assets and liabilities of maturities greater than one month was a problem because it was unrealistic to assume that the entire account was priced at the January, 1983 rate, for example. The problem was solved by using the average of the preceding three or six months for three or six month instruments as the initial rate and longer average rates for accounts with longer average maturities such as home mortgages. The initial auto loan rate was the average for the years

1980-1982. This was accurate because before 1983, the average auto loan was a three year loan. After 1983, the average was four years. The initial mortgage rate was the average for the preceding 12 years i.e. 1970-1982. Due to the mobility of the population, the typical home mortgage matures in about 12 years regardless of the loan arrangement. Therefore a 12 year maturity is appropriate.

Scenario 1 describes the effects on interest income and its volatility of a balance sheet with a gap that is almost completely negative, meaning that there is a small quantity of rate-sensitive assets compared to rate-sensitive liabilities each quarter. Scenario 2 describes the effects on interest income and volatility of interest income of a balance sheet where the values in the asset accounts have been manipulated to form a zero gap each quarter. The liability side of the balance sheet is identical to Scenario 1.

Scenario 3 and 4 represent banks with slightly positive and negative gaps respectively. Scenario 3 describes the effects on interest income and its volatility of a balance sheet with the same asset structure as in Scenario 2, but the values in the liability accounts have been changed so that the quarterly gap is slightly positive. Scenario 4 is also a deviation of Scenario 2. Changes are made in the asset side of the balance sheet to form a negative gap, although the changes are not as extreme as the gap in Scenario 1.

This procedure is weakened in that the balance sheet must be changed each time which may introduce additional changes which are unexpected. The problem is this: essentially two different balance sheets are compared. If the gap is changed, then the entire balance sheet is changed. A minimal number of changes are made from one scenario to another in order to minimize any problems that may arise.

At this point, all basic information has been revealed. The four scenarios are discussed next.

Scenario 1. A Large Negative Gap In Scenario 1, Simple Bank has an almost entirely negative gap. Rate-sensitive assets total $6.47 million while rate-sensitive liabilities total $110.98 million each quarter (see Table 1 and Figure 2). The average spread is $9.57 million and the standard deviation of interest income is $1.28 million. The return on assets is 4.79%.

Table 1 illustrates the movements of interest income over the time period. Notice that the average interest income is large but so is its volatility.

While interest income is positive over the entire time period studied, it should be noted that interest rates have followed a general downward trend since 1983. If interest rates increase, interest income could become negative.

This scenario illustrates the income portion of interest rate risk described in Chapter I. Notice that while the average rate of the assets changes slowly, the average rate of the liabilities is quite sensitive and changes rapidly. The result is a large volatility of interest income.

TABLE 1

THE SIMPLE BANK: LARGE, NEGATIVE GAP

BALANCE SHEET

ASSETS	(000,000)	%
Cash and Due from Banks	28.00	14.00
(Non Interest Earning)		
Investments:		
Fed Funds Sold (overnight)	0.00	0
Repos	0.00	0
Securities		
3 Mo. T-Bill (Reprice 1 Mo.)	0.00	0
3 Mo. T-Bill (Reprice 2 Mo.)	0.00	0
3 Mo. T-Bill (Reprice 3 Mo.)	0.00	0
6 Mo. T-Bill (Reprice 1 Mo.)	0.00	0
6 Mo. T-Bill (Reprice 2 Mo.)	0.00	0
6 Mo. T-Bill (Reprice 3 Mo.)	0.00	0
6 Mo. T-Bill (Reprice 4 Mo.)	0.00	0
6 Mo. T-Bill (Reprice 5 Mo.)	0.00	0
6 Mo. T-Bill (Reprice 6 Mo.)	0.00	0
Total Investments	0.00	0
Loans:		
Commercial (Prime)	0.00	0
Consumer		
Auto (48 Mo.)	88.00	44.00
Mortgage (20 yr.)	78.00	39.00
Total Loans	194.00	97.00
Other Assets	6.00	3.00
Total Assets	200.00	100.00

LIABILITIES	(000,000)	%
Deposits		
Demand Deposits	41.00	20.50
Now Accounts	13.00	6.50
Passbook Accounts	12.00	6.00
Money Market Funds	48.00	24.00
Time Deposits		
1 Mo. CD	40.00	20.00
3 Mo. CD (Repriced 1 Mo.)	5.33	2.67
3 Mo. CD (Repriced 2 Mo.)	5.33	2.67
3 Mo. CD (Repriced 3 Mo.)	5.33	2.67
6 Mo. CD (Repriced 1 Mo.)	1.00	0.50
6 Mo. CD (Repriced 2 Mo.)	1.00	0.50
6 Mo. CD (Repriced 3 Mo.)	1.00	0.50
6 Mo. CD (Repriced 4 Mo.)	1.00	0.50
6 Mo. CD (Repriced 5 Mo.)	1.00	0.50
6 Mo. CD (Repriced 6 Mo.)	1.00	0.50
Total Deposits	176.00	88.00
Borrowed Funds		
Fed Funds Purch (overnight)	4.00	2.00
Long Term Debt and Other	8.00	4.00
Capital	12.00	6.00
Total Liabilities	200.00	100.00

TABLE 1 (Continued)

ASSETS AND LIABILITIES TO BE REPRICED
(000,000)

ASSETS	ONE	TWO	THREE	TOTAL
Cash and Due from Banks				0.00
(Non Interest Earning)				0.00
Investments:				
Fed Funds Sold (overnight)				0.00
Repos				0.00
Securities				
3 Mo. T-Bill (Reprice 1 Mo.)				0.00
3 Mo. T-Bill (Reprice 2 Mo.)				0.00
3 Mo. T-Bill (Reprice 3 Mo.)				0.00
6 Mo. T-Bill (Reprice 1 Mo.)				0.00
6 Mo. T-Bill (Reprice 2 Mo.)				0.00
6 Mo. T-Bill (Reprice 3 Mo.)				0.00
6 Mo. T-Bill (Reprice 4 Mo.)				0.00
6 Mo. T-Bill (Reprice 5 Mo.)				0.00
6 Mo. T-Bill (Reprice 6 Mo.)				0.00
Total Investments				0.00
Loans:				
Commercial (Prime)				0.00
Consumer				
Auto (48 Mo.)	1.83	1.83	1.83	5.49
Mortgage (20 Yr.) (240 mo.)	0.33	0.33	0.33	0.99
Total Loans				
Other Assets				0.00
Total Assets				6.47

LIABILITIES	ONE	TWO	THREE	TOTAL
Deposits				
Demand Deposits				0.00
Now Accounts				0.00
Passbook Accounts				0.00
Money Market Funds	48.00	48.00	48.00	48.00
Time Deposits				
1 Mo. CD	40.00	40.00	40.00	40.00
3 Mo. CD (Repriced 1 Mo.)	5.33			5.33
3 Mo. CD (Repriced 2 Mo.)		5.33		5.33
3 Mo. CD (Repriced 3 Mo.)			5.33	5.33
6 Mo. CD (Repriced 1 Mo.)	1.00			1.00
6 Mo. CD (Repriced 2 Mo.)		1.00		1.00
6 Mo. CD (Repriced 3 Mo.)			1.00	1.00
6 Mo. CD (Repriced 4 Mo.)				0.00
6 Mo. CD (Repriced 5 Mo.)				0.00
6 Mo. CD (Repriced 6 Mo.)				0.00
Total Deposits				106.99
Borrowed Funds				
Fed Funds Purch (Overnight)	4.00	4.00	4.00	4.00
Long Term Debt and Other				0.00
Capital				0.00
Total Liabilities				110.99

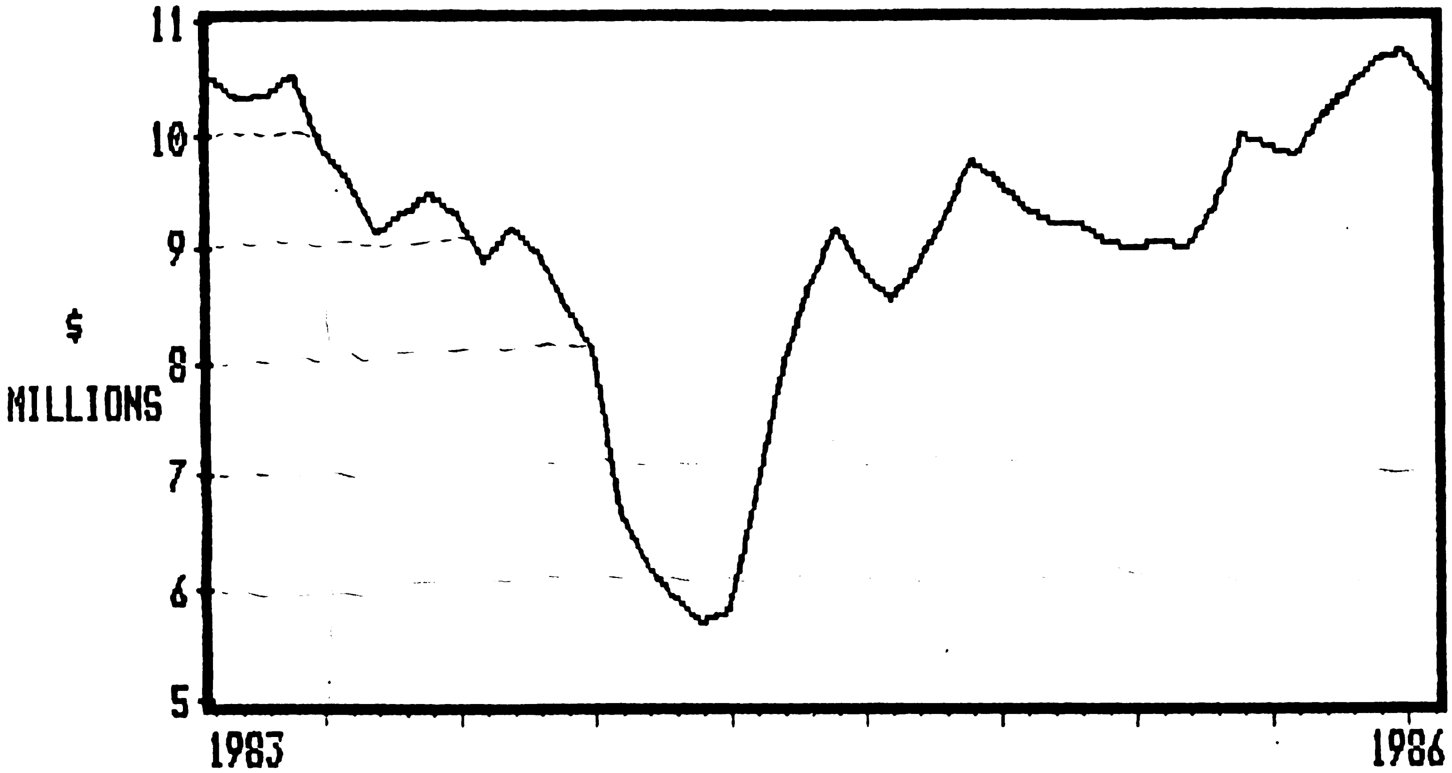

FIGURE 2: NET INTEREST INCOME: THE LARGE NEGATIVE GAP

During the late 1970s and early 1980s, many depository institutions had a balance sheet similar to that of Scenario 1. As interest rates rose, the assets were not repriced quickly enough to keep abreast of changes in the liability rates. Some depository institutions found themselves in the dilemma of being locked into a negative spread. The purpose of the zero gap strategy was to mitigate this problem and hedge movements in liability rates with corresponding movements in asset rates. Scenario 2 illustrate the effects of a zero gap.

Scenario 2. A Zero Gap Table 2 and Figure 3 illustrate the balance sheet, repricing schedule, and interest income of Simple Bank redesigned to have a zero gap. The liability side of the balance sheet is identical to that of Scenario 1 but the asset side has been changed to include more assets with shorter maturities and fewer assets with long maturities. $110.98 million in assets and liabilities are repriced each quarter.

According to Table 2, both the level and the volatility of interest income are reduced considerably compared to Scenario 1. Interest income is $5.945 million and its volatility is $.48 million. This represents a 2.97% return on assets which is a significant reduction over the return on assets of 4.79% in Scenario 1.

The average interest income of Scenario 2 is lower than Scenario 1. The volatility of interest income is lower in Scenario 2 than in Scenario 1 but volatility still exists. Basis risk has not been eliminated as assumed by the literature. The chance of

TABLE 2

THE SIMPLE BANK: ZERO GAP

BALANCE SHEET

ASSETS	(000,000)	%
Cash and Due from Banks	28.00	14.00
(Non Interest Earning)		
Investments:		
Fed Funds Sold (Overnight)	4.00	2.00
Repos	0.00	0
Securities		
3 Mo. T-Bill (Reprice 1 Mo.)	10.00	5.00
3 Mo. T-Bill (Reprice 2 Mo.)	10.00	5.00
3 Mo. T-Bill (Reprice 3 Mo.)	10.00	5.00
6 Mo. T-Bill (Reprice 1 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 2 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 3 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 4 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 5 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 6 Mo.)	3.00	1.50
Total Investments	80.00	40.00
Loans:		
Commercial (Prime)	36.00	18.00
Commercial (Three Month Reprice)		
3-Month T-Bill - 2.5%		
1-Month Reprice	10.00	5.00
2-Month Reprice	10.00	5.00
3-Month Reprice	10.00	5.00
Consumer		
Auto (48 Mo.)	28.00	14.00
Mortgage (20 Yr.)	20.00	10.00
Total Loans	114.00	57.00
Other Assets	6.00	3.00
Total Assets	200.00	100.00

LIABILITIES	(000,000)	%
Deposits		
Demand Deposits	41.00	20.50
Now Accounts	13.00	6.50
Passbook Accounts	12.00	6.00
Money Market Funds	48.00	24.00
Time Deposits		
1 Mo. CD	40.00	20.00
3 Mo. CD (Repriced 1 Mo.)	5.33	2.67
3 Mo. CD (Repriced 2 Mo.)	5.33	2.67
3 Mo. CD (Repriced 3 Mo.)	5.33	2.67
6 Mo. CD (Repriced 1 Mo.)	1.00	0.50
6 Mo. CD (Repriced 2 Mo.)	1.00	0.50
6 Mo. CD (Repriced 3 Mo.)	1.00	0.50
6 Mo. CD (Repriced 4 Mo.)	1.00	0.50
6 Mo. CD (Repriced 5 Mo.)	1.00	0.50
6 Mo. CD (Repriced 6 Mo.)	1.00	0.50
Total Deposits	176.00	88.00
Borrowed Funds		
Fed Funds Purch (overnight)	4.00	2.00
Long Term Debt and Other	8.00	4.00
Capital	12.00	6.00
Total Liabilities	200.00	100.00

TABLE 2 (Continued)

ASSETS AND LIABILITIES TO BE REPRICED
(000,000)

ASSETS	ONE	TWO	THREE	TOTAL
Cash and Due from Banks				0.00
(Non Interest Earning)				
Investments:				
Fed Funds Sold (Overnight)	4.00	4.00	4.00	4.00
Repos				0.00
Securities				
3 Mo. T-Bill (Reprice 1 Mo.)	10.00			10.00
3 Mo. T-Bill (Reprice 3 Mo.)		10.00		10.00
3 Mo. T-Bill (Reprice 3 Mo.)			10.00	10.00
6 Mo. T-Bill (Reprice 1 Mo.)	3.00			3.00
6 Mo. T-Bill (Reprice 2 Mo.)		3.00		3.00
6 Mo. T-Bill (Reprice 3 Mo.)			3.00	3.00
6 Mo. T-Bill (Reprice 4 Mo.)				
6 Mo. T-Bill (Reprice 5 Mo.)				
6 Mo. T-Bill (Reprice 6 Mo.)				
Total Investments				
Loans:				
Commercial (Prime)	36.00	36.00	36.00	36.00
Commercial: Repriced Three Mo.				
T-Bill 3 + 2.5				
One Month	10.00			10.00
Two Month		10.00		10.00
Three Month			10.00	10.00
Consumer				
Auto (43 Mo.)	0.58	0.58	0.58	1.74
Mortgage (20 Yr.)	0.08	0.08	0.08	0.24
Total Loans				
Other Assets				
Total Assets				110.98

LIABILITIES	ONE	TWO	THREE	TOTAL
Deposits				
Demand Deposits				0.00
Now Accounts				0.00
Passbook Accounts				0.00
Money Market Funds	48.00	48.00	48.00	48.00
Time Deposits				
1 Mo. CD	40.00	40.00	40.00	40.00
3 Mo. CD (Repriced 1 Mo.)	5.33			5.33
3 Mo. CD (Repriced 2 Mo.)		5.33		5.33
3 Mo. CD (Repriced 3 Mo.)			5.33	5.33
6 Mo. CD (Repriced 1 Mo.)	1.00			1.00
6 Mo. CD (Repriced 2 Mo.)		1.00		1.00
6 Mo. CD (Repriced 3 Mo.)			1.00	1.00
6 Mo. CD (Repriced 4 Mo.)				0.00
6 Mo. CD (Repriced 5 Mo.)				0.00
6 Mo. CD (Repriced 6 Mo.)				0.00
Total Deposits				106.99
Borrowed Funds				
Fed Funds Purch (Overnight)	4.00	4.00	4.00	4.00
Long Term Debt and Other				0.00
Capital				0.00
Total Liabilities				100.99

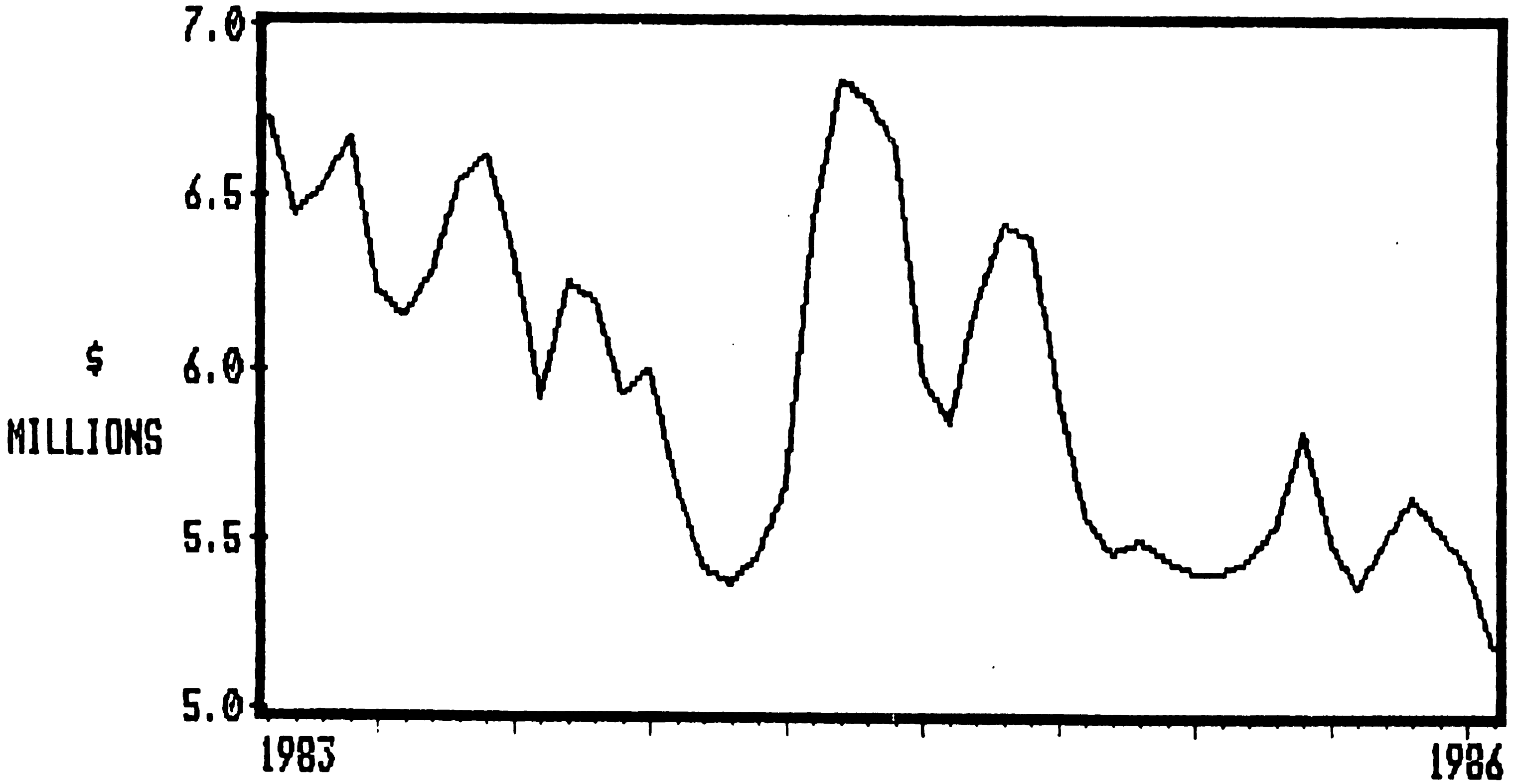

FIGURE 3 NET INTEREST INCOME: THE ZERO GAP

being locked into a negative spread is reduced considerably.

Scenario 3. A Slightly Positive Gap Table 3 and Figure 4 illustrate the balance sheet, repricing schedule, and interest income of Simple Bank with a balance sheet that has been manipulated to have a slightly positive gap. The ratio of rate-sensitive assets to rate-sensitive liabilities is 1.047. This balance sheet is created by making a few adjustments to the liability side of the balance sheet of Scenario 2. The asset side of the balance sheet is identical to that of Scenario 2.

Interest income is $5.89 million and its standard deviation is $.442 million. Return on assets is 2.95%. Volatility is down but so is interest income. It is likely that a small increase in volatility will be tolerated to obtain an increase in income. This can be provided by adjusting the balance sheet to have a slightly negative gap.

Scenario 4. A Slightly Negative Gap In Scenario 4, the balance sheet of Scenario 2 is changed to one with a slightly negative gap. The amount invested in prime rate loans is reduced and the funds are invested into auto loans and home mortgages (see Table 4 and Figure 5).

The average spread is $9.24 million and the standard deviation of interest income is $1.169 million. Return on assets is 4.62%. Assuming that it would be possible to adjust the balance sheet of Scenario 2 to this one (no market, regulatory, legal, or accounting constraints), the balance sheet of Scenario 4 represents an improvement over the balance sheet of Scenario 2 if

TABLE 3

THE SIMPLE BANK: SLIGHTLY POSITIVE GAP

BALANCE SHEET

ASSETS	(000,000)	%
Cash and Due from Banks (Non Interest Earning)	28.00	14.00
Investments:		
Fed Funds Sold (Overnight)	4.00	2.00
Repos	0.00	0
Securities		
3 Mo. T-Bill (Reprice 1 Mo.)	10.00	5.00
3 Mo. T-Bill (Reprice 2 Mo.)	10.00	5.00
3 Mo. T-Bill (Reprice 3 Mo.)	10.00	5.00
6 Mo. T-Bill (Reprice 1 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 2 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 3 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 4 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 5 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 6 Mo.)	3.00	1.50
Total Investments	80.00	40.00
Loans:		
Commercial (Prime)	36.00	18.00
Commercial (Three Month Reprice) 3-Month T-Bill + 2.5%		
1-Month Reprice	10.00	5.00
2-Month Reprice	10.00	5.00
3-Month Reprice	10.00	5.00
Consumer		
Auto (48 Mo.)	28.00	14.00
Mortgage (20 Yr.)	20.00	10.00
Total Loans	114.00	57.00
Other Assets	6.00	3.00
Total Assets	200.00	100.00

LIABILITIES	(000,000)	%
Deposits		
Demand Deposits	41.00	20.50
Now Accounts	13.00	6.50
Passbook Accounts	12.00	6.00
Money Market Funds	38.00	19.00
Time Deposits		
1 Mo. CD	40.00	20.00
3 Mo. CD (Repriced 1 Mo.)	5.33	2.67
3 Mo. CD (Repriced 2 Mo.)	5.33	2.67
3 Mo. CD (Repriced 3 Mo.)	5.33	2.67
6 Mo. CD (Repriced 1 Mo.)	2.66	1.33
6 Mo. CD (Repriced 2 Mo.)	2.66	1.33
6 Mo. CD (Repriced 3 Mo.)	2.66	1.33
6 Mo. CD (Repriced 4 Mo.)	2.66	1.33
6 Mo. CD (Repriced 5 Mo.)	2.66	1.33
6 Mo. CD (Repriced 6 Mo.)	2.66	1.33
Total Deposits	176.00	88.00
Borrowed Funds		
Fed Funds Purch (overnight)	4.00	2.00
Long Term Debt and Other	8.00	4.00
Capital	12.00	6.00
Total Liabilities	200.00	100.00

TABLE 3 (Continued)

ASSETS AND LIABILITIES TO BE REPRICED
(000,000)

ASSETS	ONE	TWO	THREE	TOTAL
Cash and Due from Banks				0.00
(Non Interest Earning)				
Investments:				
Fed Funds Sold (Overnight)	4.00	4.00	4.00	4.00
Repos				0.00
Securities				
3 Mo. T-Bill (Reprice 1 Mo.)	10.00			10.00
3 Mo. T-Bill (Reprice 3 Mo.)		10.00		10.00
3 Mo. T-Bill (Reprice 3 Mo.)			10.00	10.00
6 Mo. T-Bill (Reprice 1 Mo.)	3.00			3.00
6 Mo. T-Bill (Reprice 2 Mo.)		3.00		3.00
6 Mo. T-Bill (Reprice 3 Mo.)			3.00	3.00
6 Mo. T-Bill (Reprice 4 Mo.)				0.00
6 Mo. T-Bill (Reprice 5 Mo.)				0.00
6 Mo. T-Bill (Reprice 6 Mo.)				0.00
Total Investments				43.00
Loans:				
Commercial (Prime)	36.00	36.00	36.00	36.00
Commercial: Repriced Three Mo. T-Bill 3 + 2.5				
One Month	10.00			10.00
Two Month		10.00		10.00
Three Month			10.00	10.00
Consumer				
Auto (43 Mo.)	0.58	0.58	0.58	1.74
Mortgage (20 Yr.)	0.08	0.08	0.08	0.24
Total Loans				67.98
Other Assets				0.00
Total Assets				110.98

LIABILITIES	ONE	TWO	THREE	TOTAL
Deposits				
Demand Deposits				0.00
Now Accounts				0.00
Passbook Accounts				0.00
Money Market Funds	38.00	38.00	38.00	38.00
Time Deposits				
1 Mo. CD	40.00	40.00	40.00	40.00
3 Mo. CD (Repriced 1 Mo.)	5.33			5.33
3 Mo. CD (Repriced 2 Mo.)		5.33		5.33
3 Mo. CD (Repriced 3 Mo.)			5.33	5.33
6 Mo. CD (Repriced 1 Mo.)	2.66			2.66
6 Mo. CD (Repriced 2 Mo.)		2.66		2.66
6 Mo. CD (Repriced 3 Mo.)			2.66	2.66
6 Mo. CD (Repriced 4 Mo.)				0.00
6 Mo. CD (Repriced 5 Mo.)				0.00
6 Mo. CD (Repriced 6 Mo.)				0.00
Total Deposits				102.00
Borrowed Funds				0.00
Fed Funds Purch (Overnight)	4.00	4.00	4.00	4.00
Long Term Debt and Other				0.00
Capital				0.00
Total Liabilities				106.00

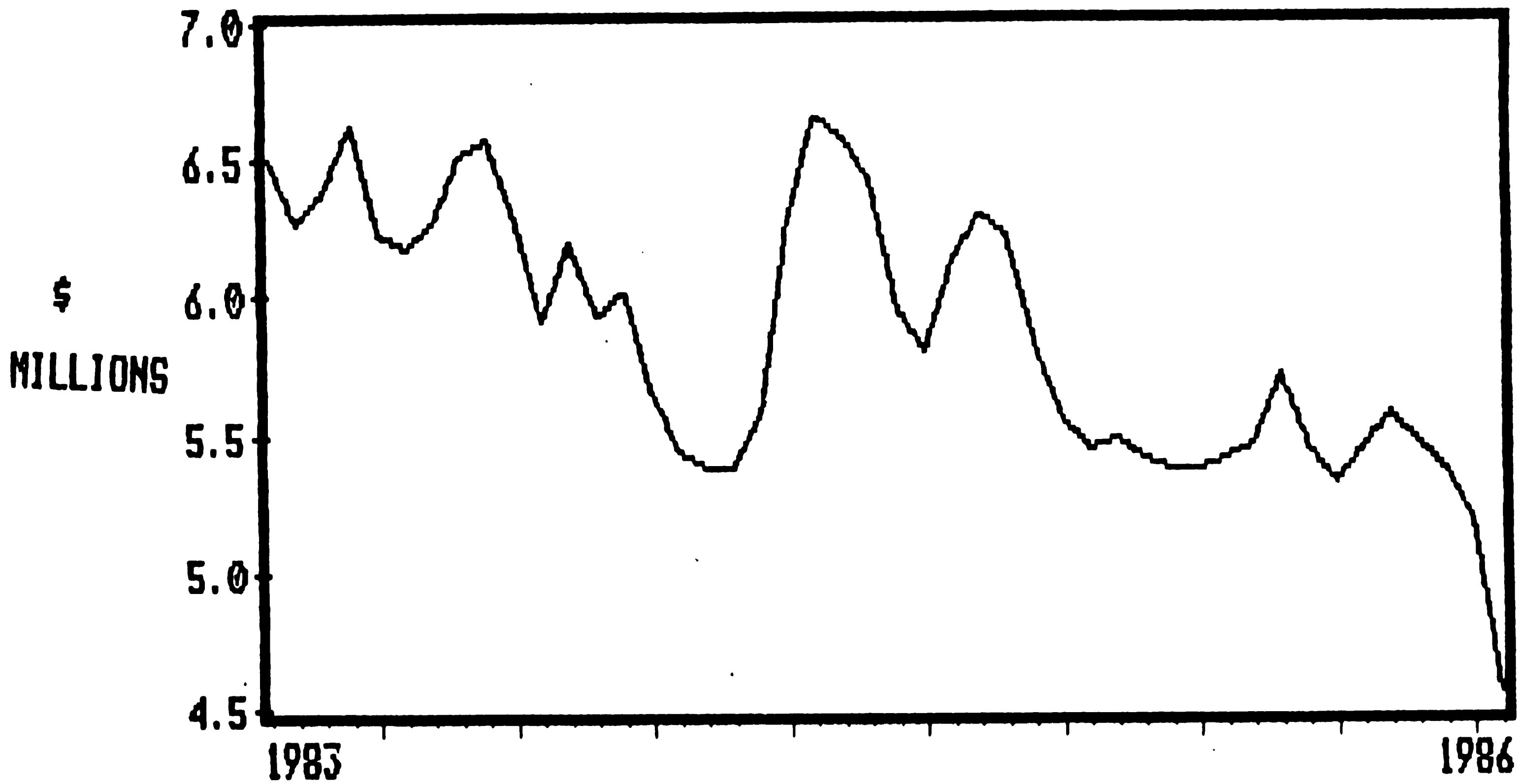

FIGURE 4 NET INTEREST INCOME: THE SLIGHTLY POSITIVE GAP

TABLE 4

THE SIMPLE BANK: SLIGHTLY NEGATIVE GAP

BALANCE SHEET

ASSETS	(000,000)	%
Cash and Due from Banks (Non Interest Earning)	28.00	14.00
Investments:		
Fed Funds Sold (Overnight)	4.00	2.00
Repos	0.00	0
Securities		
3 Mo. T-Bill (Reprice 1 Mo.)	10.00	5.00
3 Mo. T-Bill (Reprice 2 Mo.)	10.00	5.00
3 Mo. T-Bill (Reprice 3 Mo.)	10.00	5.00
6 Mo. T-Bill (Reprice 1 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 2 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 3 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 4 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 5 Mo.)	3.00	1.50
6 Mo. T-Bill (Reprice 6 Mo.)	3.00	1.50
Total Investments	80.00	40.00
Loans:		
Commercial (Prime)	36.00	18.00
Commercial (Three Month Reprice) 3-Month T-Bill + 2.5%		
1-Month Reprice	10.00	5.00
2-Month Reprice	10.00	5.00
3-Month Reprice	10.00	5.00
Consumer		
Auto (48 Mo.)	28.00	14.00
Mortgage (20 Yr.)	20.00	10.00
Total Loans	114.00	57.00
Other Assets	6.00	3.00
Total Assets	200.00	100.00

LIABILITIES	(000,000)	%
Deposits		
Demand Deposits	41.00	20.50
Now Accounts	13.00	6.50
Passbook Accounts	12.00	6.00
Money Market Funds	48.00	24.00
Time Deposits		
1 Mo. CD	40.00	20.00
3 Mo. CD (Repriced 1 Mo.)	5.33	2.67
3 Mo. CD (Repriced 2 Mo.)	5.33	2.67
3 Mo. CD (Repriced 3 Mo.)	5.33	2.67
6 Mo. CD (Repriced 1 Mo.)	1.00	0.50
6 Mo. CD (Repriced 2 Mo.)	1.00	0.50
6 Mo. CD (Repriced 3 Mo.)	1.00	0.50
6 Mo. CD (Repriced 4 Mo.)	1.00	0.50
6 Mo. CD (Repriced 5 Mo.)	1.00	0.50
6 Mo. CD (Repriced 6 Mo.)	1.00	0.50
Total Deposits	176.00	88.00
Borrowed Funds	0.00	0
Fed Funds Purch (Overnight)	4.00	2.00
Long Term Debt and Other	3.00	4.00
Capital	12.00	6.00
Total Liabilities	200.00	100.00

TABLE 4 (Continued)

ASSETS AND LIABILITIES TO BE REPRICED
(000,000)

ASSETS	ONE	TWO	THREE	TOTAL
Cash and Due from Banks				0.00
(Non Interest Earning)				
Investments:				
Fed Funds Sold (Overnight)	4.00	4.00	4.00	4.00
Repos				0.00
Securities				
3 Mo. T-Bill (Reprice 1 Mo.)	10.00		10.00	
3 Mo. T-Bill (Reprice 2 Mo.)		10.00		10.00
3 Mo. T-Bill (Reprice 3 Mo.)			10.00	10.00
6 Mo. T-Bill (Reprice 1 Mo.)	3.00			3.00
6 Mo. T-Bill (Reprice 2 Mo.)		3.00		3.00
6 Mo. T-Bill (Reprice 3 Mo.)			3.00	3.00
6 Mo. T-Bill (Reprice 4 Mo.)				0.00
6 Mo. T-Bill (Reprice 5 Mo.)				0.00
6 Mo. T-Bill (Reprice 6 Mo.)				0.00
Total Investments				33.00
Loans:				
Commercial (Prime)	12.00	12.00	12.00	12.00
Commercial: Repriced Three Mo.				
T-Bill 3 + 2.5				
One Month	10.00			10.00
Two Month		10.00		10.00
Three Month			10.00	10.00
Consumer				
Auto (48 Mo.)	1.00	1.00	1.00	3.00
Mortgage (20 Yr.)	0.10	0.10	0.10	0.30
Total Loans				45.30
Other Assets				
Total Assets				88.30

LIABILITIES	ONE	TWO	THREE	TOTAL
Deposits				
Demand Deposits				0.00
Now Accounts				0.00
Passbook Accounts				0.00
Money Market Funds	48.00	48.00	48.00	48.00
Time Deposits				
1 Mo. CD	40.00	40.00	40.00	40.00
3 Mo. CD (Repriced 1 Mo.)	5.33			5.33
3 Mo. CD (Repriced 2 Mo.)		5.33		5.33
3 Mo. CD (Repriced 3 Mo.)			5.33	5.33
6 Mo. CD (Repriced 1 Mo.)	1.00			1.00
6 Mo. CD (Repriced 2 Mo.)		1.00		1.00
6 Mo. CD (Repriced 3 Mo.)			1.00	1.00
6 Mo. CD (Repriced 4 Mo.)				0.00
6 Mo. CD (Repriced 5 Mo.)				0.00
6 Mo. CD (Repriced 6 Mo.)				0.00
Total Deposits				106.99
Borrowed Funds				0.00
Fed Funds Purch (Overnight)	4.00	4.00	4.00	4.00
Long Term Debt and Other				0.00
Capital				0.00
Total Liabilities				110.99

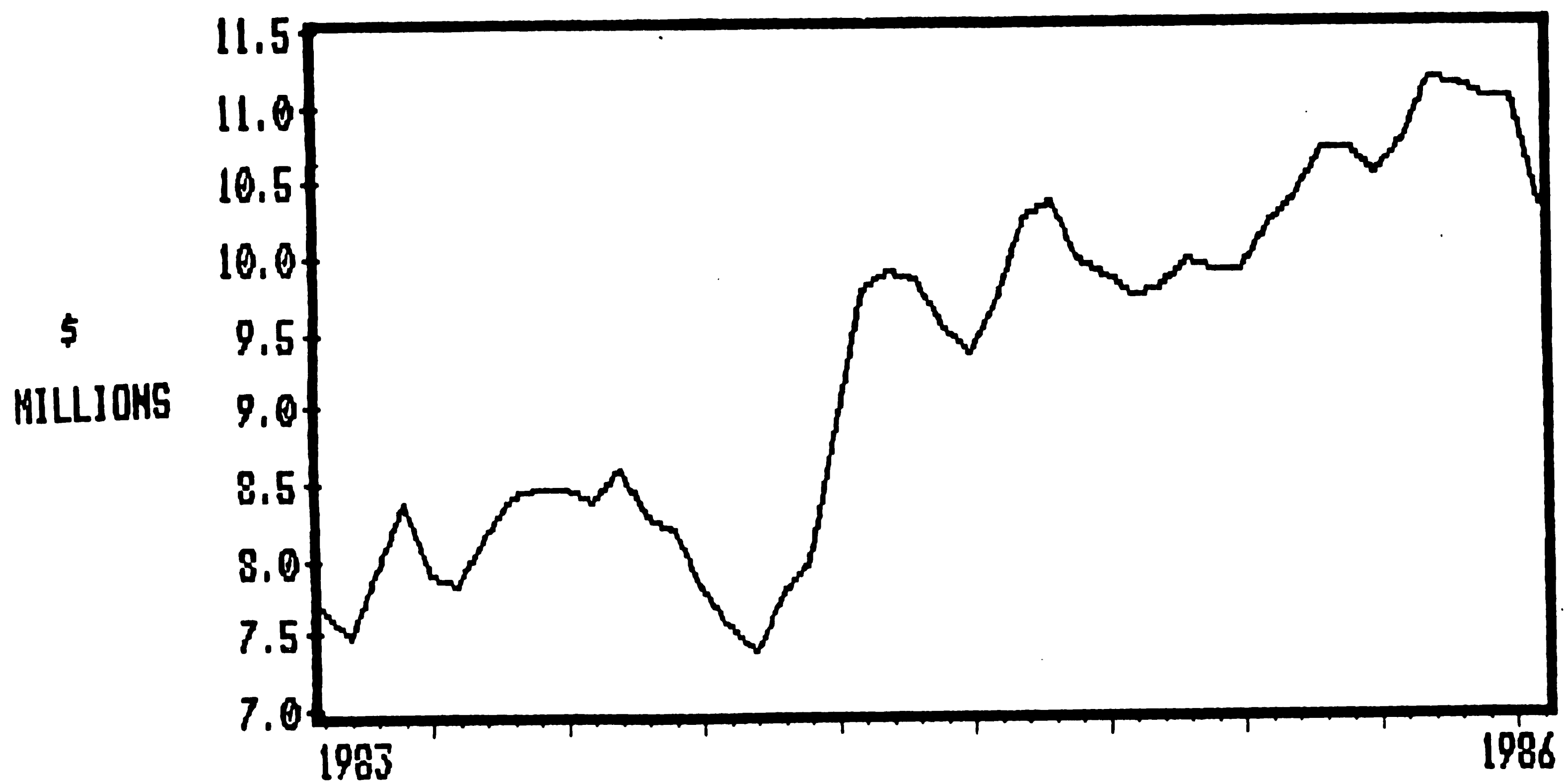

FIGURE 5 NET INTEREST INCOME: THE SLIGHTLY NEGATIVE GAP

one's objective is maximization of interest income. However, the standard deviation of interest income is higher meaning that the objective of minimum variance is not satisfied if the balance sheet of Scenario 2 is used as the benchmark. From a managerial view point, however, this balance sheet may be easily manipulated so that it would be easy to move to a zero gap balance sheet if the direction of interest rates changed.

The next step in development of a formal model is to address managerial preferences.

Managerial Decisions and Preferences

Investment Decisions Chen [1972] outlines a number of decisions to be made by a bank manager at the beginning of each period: the amount of cash to cover expected needs, the amount and composition of security investments, the amount and composition of loans, investments in fixed assets, the amount and composition of deposits, the amount of capital be obtained, and dividends paid. The bank manager would like to maximize profit and simultaneously minimize risk. Risk is defined as the variance of income.

Time Horizon and Forecast Certainty It is assumed that the bank manager possesses perfect information. Uncertainty could be introduced into the model, but this is beyond the scope of this dissertation.

The bank manager must consider long-term returns. However, in this situation, a single-period model is used. It can be argued that a single-period model is myopic. However, Francis and Archer [1979] argue that the 'myopic model' is optimal if the following three requirements are satisfied. First, the investor must have a positive but diminishing utility of terminal wealth. Second, the investor's utility is some form of one of the classes of isoelastic utility functions. Third, the single period return should approximate a normal distribution.

The first two requirements are irrelevant. The investor is the stockholder of the depository institution. Regardless of the investor's utility function, the investor can diversify away firm specific risk and maintain only that proportion of depository institution stock that satisfies the investor's utility function. Regarding the requirement that single-period rates of return should approximate a normal distribution, the Central Limit Theorem holds that as the sample size increases, the distribution approaches a normal distribution. The rates used represent averages from a large number of banks and other investors. The distribution should therefore approximate a normal distribution (see Francis and Archer [1979]).

THE MODEL

One concern of gap management is that when a depository institution adjusts its balance sheet to narrow the gap to zero or to a positive level, the average rate of return declines. An example of this rate decline is observed when a depository institution shifts from fixed-rate to adjustable-rate mortgages. Rates on adjustable-rate mortgages are lower than fixed-rate mortgages. Since the cost of deposits does not decline, then interest income declines.

The objective of gap management is to reduce risk. Since a reduction in interest income occurs with the narrowing of the gap, it is expected that the reduction in risk is commensurate with the reduction in return. The risk that remains from narrowing the gap is basis risk caused by a lack of co-movement of rates of rate-sensitive assets and rate-sensitive liabilities.

Ideally, the objective of any managerial action is to maximize the value of the firm. A bank can be modelled as a portfolio of assets and liabilities. The assets are rate-sensitive loans, cash, and investments and non-rate-sensitive assets, denoted in proportions as X_l, X_c, X_i, and X_{NRA}, and rate-sensitive deposits and non-rate-sensitive liabilities of deposits, borrowings, and capital, denoted in proportions as X_d and X_{NRL}. Rate-sensitive means that the asset or liability is repriced during the time period studied.

Non-rate-sensitive means that the asset or liability is not repriced during the time period studied. The variance of non-rate-sensitive assets and liabilities is assumed to be zero. The variance of rate-sensitive assets and liabilities is assumed to depend on the change in rate. The covariance between rate-sensitive assets is expected to be positive.

Each asset and liability has a return or cost of R_j, a variance of σ_i^2, and covariance with other assets and liabilities of σ_{ji}. The variance of non-rate-sensitive assets and liabilities is assumed to be zero. The variance of rate-sensitive assets and liabilities is assumed to depend on the change in rate. The covariance between rate-sensitive assets is expected to be positive. The covariance between returns on assets and liabilities is expected to be negative because assets have a positive weight and liabilities a negative weight.

The return on net interest income at the end of the time period is { $E(\Pi) = R_l X_l + R_c X_c + R_i X_i + R_{NRA} X_{NRA} - R_d X_d - R_{NRL} X_{NRL}$ }. If one seeks to maximize the value of the firm, the Capital Asset Pricing Model is used, which is similar to the model of Lam and Chen [1985].

The model is formulated as follows:

$$\text{Maximize } V = (1/R)(E(\Pi) - \lambda \, CV(\Pi, M)) \qquad [1]$$

Subject to: Assets = Liabilities + Capital

where

Π = net interest income/total value

R = 1 + the risk free rate

λ = market price of risk

$CV(\Pi, M)$ = covariance of the return on net interest income with the return on the market

The value of the firm's stock is the present value of the expected net interest income adjusted for a risk premium, $\lambda \, CV(\Pi, M)$. The market return includes the bank and other firms or $M = \Pi + W$, where W is the return of all other firms excluding the bank. 1/R is dropped because it has no effect on future calculations. The model can be rewritten by dividing the covariance into two parts, internal and external. External risk is the covariance of the return on net interest income of the firm with all other firms excluding the firm studied. Internal risk is the variance of the firm's return on net interest income. The model can be expressed as follows:

$$\text{Maximize } V = (E(\Pi) - \lambda\, CV(\Pi, M)) - \lambda_1\, CV(\Pi,\Pi) \qquad [2]$$

Subject to: Assets = Liabilities + Capital

where

Π = net interest income/total value

λ = market price of risk

CV (Π , M) = covariance of the firm's return on net interest income with the return on the market

CV (Π, Π) = variance of the firm's return on net interest income

CV(Π, Π) is income and internal risk, the weighted average of the covariance of the net interest income of the bank. It is largely basis risk because the gaps of many depository institutions are narrowed to zero, and the risk remaining is largely risk of rate-sensitive asset rates and rate-sensitive liability rates not moving together or basis risk. CV (Π, W) is external risk, the weighted average covariance of the bank's return on net interest income with the return of other firms in the market. There may still be some collinearity between the market risk and internal risk, but this model represents the best available attempt to eliminate it.

If balance sheet variables are substituted into the model, it becomes:

$$\text{Maximize } V = R_l X_l + R_c X_c + R_i X_i + R_{NRA} X_{NRA} - R_d X_d - R_{NRL} X_{NRL} - \lambda(X_l \sigma_{lw} + X_i \sigma_{iw} + X_c \sigma_{cw} + X_{NRA} \sigma_{NRAw} - X_d \sigma_{dw} - X_{NRL} \sigma_{NRLw}) - \lambda_1 (X_i^2 \sigma_i^2 + X_l^2 \sigma_l^2 + X_d^2 \sigma_d^2 + X_c^2 \sigma_c^2 + 2X_i X_l \sigma_{il} + 2X_l X_c \sigma_{lc} + 2X_i X_c \sigma_{ic} - 2 X_d X_c \sigma_{cd} - 2X_d X_l \sigma_{dl} - 2X_d X_i \sigma_{di}) \quad [3]$$

$$\text{Subject to } X_l + X_c + X_i + X_{NRA} + X_f = X_d + X_{NRL} + C + D$$

The model is explained in some detail in Appendix A. The model is solved in the next section.

SOLVING THE MODEL

First Order Conditions

The main decision variables chosen for study are X_c, X_i, X_l, and X_d which are the proportions of rate-sensitive assets and liabilities. Non-rate-sensitive assets and liabilities are largely eliminated from the equation by substitution. It is assumed that debt, capital, and fixed assets remain constant in proportion. Managerial decisions will center on shifting funds between rate-sensitive assets and liabilities and non-rate-sensitive assets and liabilities. The descriptions are brief. For a detailed study, see Appendix A. The first order conditions are listed below:

$$\delta V/\delta X_c = R_c - R_{NRA} - \lambda(\sigma_{cw} - \sigma_{NRAw})$$
$$- 2\lambda_1(X_c\sigma_c^2 + X_l\sigma_{lc} + X_i\sigma_{ic} - X_d\,\sigma_{cd}) = 0 \quad [4]$$

$$\delta V/\delta X_l = R_l - R_{NRA} - \lambda(\sigma_{lw} - \sigma_{NRAw})$$
$$- 2\lambda_1(X_l\,\sigma_l^2 + X_i\,\sigma_{il} - X_d\,\sigma_{ld}) = 0 \quad [5]$$

$$\delta V/\delta X_i = R_i - R_{NRA} - \lambda(\sigma_{iw} - \sigma_{NRAw})$$
$$- 2\lambda_1(X_i\,\sigma_i^2 + X_l\,\sigma_{li} + X_c\,\sigma_{ic} - X_d\,\sigma_{id}) = 0 \quad [6]$$

$$\delta V/\delta X_d = - R_d + R_{NRL} - \lambda(\sigma_{dw} + \sigma_{NRLw})$$
$$- 2\lambda_1(X_d\,\sigma_d^2 + X_l\,\sigma_{ld} + X_i\sigma_{id} - X_c\sigma_{cd}) = 0 \quad [7]$$

$$\delta V/\delta\theta = X_l + X_c + X_i + X_{NRA} + X_f - X_d - X_{NRL}$$
$$- C - D = 0 \quad [8]$$

In all cases except Equation 8, the first term is net interest income spread, which is defined as the change in net interest income/total value given a unit change in the given variable. An increase in rate-sensitive assets/total value is expected to generate a decline in net interest income because a shift will result from long-term to short-term securities. Short-term rates are lower than long-term rates, thus net interest income is expected to decline. Using the same reasoning, an increase in rate-sensitive deposits/total value is expected to cause an increase in net interest income.

The second term is market risk. A change in rate-sensitive assets should cause a change in the covariance of net interest income return with the return of the market, and therefore, a change in market risk. A change in gap/total value should cause a change in market risk because rate-sensitive assets will increase, non-rate-sensitive assets will decrease, and rate-sensitive deposits will remain constant or decline. This hypothesis is tested in the next chapter. The third term is income risk which is largely basis risk when it is assumed that the gap will probably be in the zero range.

The next step is to determine whether the optimal solution represents a global or local optimum. In order to determine whether this is so, second derivatives with respect to each variable studied are calculated and studied next.

Is the Optimal Solution a Global Optimum?

To determine whether the optimal equation is a global or local optimum, the second partial derivatives with respect to all variables are calculated (see Appendix A). The solution is a global optimum if the border preserving Hessian (Appendix A) is negative semidefinite. This means that the determinants of the four minors must alternate in sign (-, +, -, +).

To determine the signs, weekly returns, of a number of proxies were calculated, over the time period 1984-1986 . The time period was chosen for consistency with the remainder of the dissertation. The proxies used were Fed funds for cash, six-month Treasury bills for investments, prime rate loans for loans, and one-month certificates of deposit for deposits. The variances and covariances of the weekly returns were calculated and the determinants calculated. The resulting signs were -, +, -, + indicating that the solution represents a global optimum. The next step is to solve for each optimal variable.

Solving for X_n

Solving for each decision variable gives the following results:

$$X_c = \{ R_c - R_{NRA} - \lambda(\sigma_{cw} - \sigma_{NRAw}) - 2\lambda_1(X_1\sigma_{1c} + X_i\sigma_{ic} - X_d\sigma_{cd})\}/\sigma_c^2 \quad [9]$$

$$X_i = \{ R_i - R_{NRA} - \lambda(\sigma_{iw} - \sigma_{NRAw}) - 2\lambda_1(X_1\sigma_{1c} + X_c\sigma_{ic} - X_d\sigma_{id})\}/\sigma_i^2 \quad [10]$$

$$X_1 = \{R_1 - R_{NRA} - \lambda(\sigma_{cw} - \sigma_{NRAw}) - 2\lambda_1(X_c\sigma_{1c} + X_i\sigma_{i1} - X_d\sigma_{1d})\}/\sigma_1^2 \quad [11]$$

$$X_d = \{- R_d + R_{NRL} - \lambda(- \sigma_{dw} + \sigma_{NRLw}) - 2\lambda_1(- X_1\sigma_{1d} - X_i\sigma_{id} - X_c\sigma_{cd})\}/\sigma_d^2 \quad [12]$$

The first term is net interest income spread, the second is external market risk, the third is internal market risk, and the denominator is the variance of the rate of the asset or liability. Since a common adjustment is to change the proportion of rate-sensitive loans rather than other rate-sensitive assets, the next step is to determine the change in optimal rate-sensitive loans given a change in rate-sensitive deposits. This is shown as

$$\delta X_1/\delta X_d = \sigma_{d1}/\sigma_1^2 . \qquad [13]$$

The result is analogous to the result obtained by Ederington [1979] in his study of the optimal hedge of futures. Equation 15 represents the optimal ratio of rate-sensitive loans to rate-sensitive deposits. A zero gap or rate-sensitive loan to rate-sensitive deposit ratio of one is optimal only if $\sigma_{d1} = \sigma_1^2$. Otherwise variance of income is not at a minimum and the value of the firm declines. If $\sigma_{d1} > \sigma_1^2$, then a positive gap is optimal. If $\sigma_{d1} < \sigma_1^2$, then a negative gap is optimal.

The problem at this point is that only rate-sensitive loans are compared to rate-sensitive deposits, and other rate-sensitive assets are ignored. If all rate-sensitive assets are grouped together in Equation 3, then the optimal proportion of rate-sensitive assets would be

$$X_{RSA} = \{R_{RSA} - R_{NRA} - \lambda(\sigma_{RSAw} - \sigma_{NRAw}) - 2\lambda_1(X_d\sigma_{RSAd})\}/\sigma_{RSA}^2 \qquad [14]$$

Taking the change in rate-sensitive assets given a change in rate-sensitive deposits gives:

$$\delta X_{RSA}/\delta X_{d} = \sigma_{dRSA} / \sigma_{RSA}^{2} \qquad [15]$$

Since rate-sensitive liabilities are deposits, Equation 15 is the optimal gap ratio. An optimal rate-sensitive asset to rate-sensitive liability ratio of one implies that a zero gap is optimal. An optimal rate-sensitive asset to rate-sensitive liability ratio of less than one implies that a negative gap is optimal. An optimal rate-sensitive asset to rate-sensitive liability ratio of more than one implies that a positive gap is optimal.

The variance of assets is assumed to be greater than the variance of liabilities. All rates are assumed to be positively correlated. Therefore, the optimal rate-sensitive asset to rate-sensitive liability ratio is expected to be slightly less than one, implying that a slightly negative gap is optimal. This result is hypothesized in the next chapter and empirically tested in Chapter V.

CONCLUSIONS

Managing the gap has important implications for the value of the firm. As gap/total value is increased, interest income declines. The covariance of the firm's returns with the market changes, which implies a change in external market risk.

The optimal rate-sensitive asset to rate-sensitive liability ratio is $\sigma_{RSA\ RSL} / \sigma_{RSA}^2$. A rate-sensitive asset to rate-sensitive liability ratio of a different size is not optimal because the risk level is too high for the level of return, thus the value of the firm declines. The next chapter states hypotheses which were formulated in this chapter and describes tests of the hypotheses.

FOOTNOTES

[1] See McNulty [1987], Brewer [1985], Barnhill and Handorf [1985], and Beighley [1985].

[2] See Markowitz [1959].

[3] See Chen [1972].

[4] See Francis and Archer [1979].

[5] *Ibid*. p. 312.

[6] See Lam and Chen [1985].

[7] See Ederington [1979].

CHAPTER IV

METHODOLOGY AND HYPOTHESIS TESTING

The rationale for this dissertation is as follows. In order to reduce interest rate risk, depository institution managers (here after to be called bank managers because commercial banks are studied) have matched maturities of assets and liabilities of the balance sheet and have narrowed the gap toward zero. [1] A consequence of narrowing the gap is that interest income is reduced. To compensate for the reduction in interest income, fee revenue is increased.

Hedging replaces full exposure to price risk with exposure to basis risk. [2] Gap management is a type of hedge because rate-sensitive liabilities are hedged by rate-sensitive assets. When the gap is narrowed to zero, exposure to basis risk is substituted for exposure to interest rate risk. Basis risk is expected to be smaller than the risk of being fully exposed to changes in interest rates and is therefore preferred.

Several concerns should be stated. First, when the gap is narrowed to zero, long-term assets are replaced by short-term assets. Short-term asset rates are generally lower than long-term rates (assuming a normal yield curve). Therefore, interest income is reduced. Second, although basis risk is thought to be smaller than the risk of being fully exposed to changes in interest rates, basis risk can become quite large (see Beighly [1985] and Drabenstott and McDonley [1984]). Since interest income is reduced when the gap is narrowed, if risk remains high, then the risk-return tradeoff is not optimal.

The variables to be examined include the following: income/total assets, fee revenue/total assets, and market risk are the dependent variables. Rate-sensitive assets/total assets, rate-sensitive liabilities/total assets, (rate-sensitive assets + rate-sensitive liabilities)/total assets, gap/total assets, bank size, and the presence of LDC loans in the loan portfolio are independent variables. Research on the optimal gap will use the returns on a portfolio of rate-sensitive assets and rate-sensitive liabilities.

Gap/total assets is expected to affect the market value of the firm by affecting both income and risk. Rate-sensitive assets/total assets represents an important consideration when the gap is narrowed. If more assets are repriced at a given time, then the effect on risk is greater than if a smaller portion of assets are repriced. The size of the bank is expected to affect income and risk as well as the presence of LDC loans (loans to under developed nations) in the loan portfolio.

Several questions are studied in this chapter. They are 1) Is net interest income/total assets affected by the previously mentioned independent variables? 2) Is fee revenue a defensive measure for the effects of narrowing the gap? 3) How do gap/total assets, rate-sensitive assets/total assets, the size of the bank, and the presence of LDC loans in the portfolio affect market risk of the bank? 4) What is the optimal gap considering the risk-return tradeoff inherent in narrowing the gap? 5) Do banks maintain an optimal gap?

The chapter is organized as follows. First, it is determined whether net interest income/total assets is affected by the previously mentioned variables. Second, it is determined whether evidence exists that fee revenue is a defensive measure to counter the effects of narrowing the gap. Third, using an aggregate two-index model to estimate the coefficients of market risk and extra-market rate-sensitivity, the effect of the previously mentioned variables on market risk of the firm is studied. Finally, using a number of portfolios of various rate-sensitive loan and investment combinations financed by deposits, the optimal gap is estimated. The average gap of a sample of banks is calculated and statistical tests are performed to determine if banks maintain an optimal gap.

GAP MANAGEMENT AND INTEREST INCOME EFFECTS

The purpose of this section is to show that narrowing the gap has had significant implications for bank management and interest income. This section illustrates why the topic of basis risk as it pertains to gap management is important and worthy of study. An effect of narrowing the gap is that interest income has declined because the rates of short-term assets (which replace long-term assets) are usually lower than rates of long-term assets (assuming a normal upward sloping term structure of interest rates). Reducing interest income reduces a "cushion" available for bad loans.[3]

To compensate for the decline in interest income, fee revenue has increased. Fee revenue generates public relations problems because it is difficult to justify attaching a fee to a service that was previously provided 'free'. Fees are in general competitively priced because many bank services are offered by other institutions as well as banks. The most credit-worthy customers can obtain funds elsewhere if the fee structure is unacceptable. Moreover, large firms, which are the best bank loan customers, have other sources of funds such as commercial paper, and banks may be forced to issue loans below the prime rate to obtain the loan business of large firms. The result is that the bank must lose its most credit-worthy customers or reduce the price of its loans and fees in order to retain these customers. The bank could attract less credit-worthy customers despite high fees, but this practice would increase default risk. In either case, expected income is reduced. The reduction in interest income and the resulting necessity of additional fee revenue is tied to narrowing the gap.

Rate-sensitive assets/total assets is an important variable in this study. Assuming a gap of zero, if more liabilities are rate-sensitive, then more assets must be rate-sensitive. This is important because to change the gap in one bank may imply repricing a small percent of total assets and liabilities, whereas in another bank, it would mean repricing a large percent of total assets and liabilities. Basis risk is greater if a large percent of the assets are repriced at any given time period than if a small percent of the assets are repriced.

Rate-sensitive assets/total assets is related to the amount of a bank's fixed-rate core deposits. The smaller this amount, the more likely the bank must rely on negotiated certificates of deposit and other purchased funds for its liabilities. This increases the amount of rate-sensitive liabilities and, as a result, increases the required amount of rate-sensitive assets needed to narrow the gap to zero, thus increasing rate-sensitive assets/total assets. To counter possibilities of a lack of correlation of rate-sensitive assets/total assets and rate-sensitive liabilities/total assets, both variables are studied.

Two additional variables of interest are the size of the bank and whether its loan portfolio contains a sizeable investment in LDC loans. LDC loans are unsecured loans made to the governments of under developed countries. Large money-center banks particularly have been encouraged to make these loans by the United States government (see Sinkey [1986] or Koch [1988]). An implied promise of the Federal government is that these banks will not be permitted to become insolvent.

LDC loans present a number of problems. First, the loans have had a poor performance record due to economic problems of the countries. Second, the loans are not collateralized because the funds are loaned to the country's government which is not expected to fail. Many loans are umbrella loans. The government of the country receives the funds and distributes them in the form of loans or grants to whomever it chooses. The bank is not involved in this process. The result is that many firms and projects which the bank would judge to be poor credit risks may obtain loans, but the bank has no control over selection of the final loan recipient and as a result, no control over the risk of the loan. Third, while some banks have increased reserves for bad loans to reflect this problem, the increase in reserves for bad loans on the part of some banks is insufficient to fully reflect the decline in value of the loans. To date, the action taken to reflect this loss in value does not reflect a serious attempt to address the difficult problem.[4] Fourth, to disguise the non-performing nature of these loans and to keep the loan status current, banks have engaged in the questionable practice of rolling the loan or lending the country additional funds to meet interest and principal payments. The result is that the bad loan grows in size. Finally, there is some question as to whether the loan was expected to be profitable at its inception. Loans were typically priced at about 1% over the average cost of funds. In hindsight, the expected return on such loans was well below market considering their risk.

Some large regional banks which are not heavily invested in LDC loans have started to write off these loans.[5] The signals to the market are 1) these banks are not heavily invested in LDC loans, 2) management realizes that these loans are worthless, 3) these banks have sufficient capital to write down the loan, and

4) the banks plan to minimize future investment in these loans. Given this signalling effect, it is expected that stock returns to these banks will increase while stock returns to money-center banks which are too thinly capitalized to write down LDC loans will decline as they fail to mark these loans to market. This topic is addressed only briefly in this dissertation.

It can be argued that small banks have a larger spread (interest income) than medium-sized or large banks. This can be explained in part because small banks have a customer clientele consisting predominantly of small firms and individuals, meaning that the firm or individual is unlikely to be able to negotiate special concessions on loans, such as a rate below prime. The deposits of small banks are provided largely by small savers (who are paid rates below the rates on negotiated certificates of deposit) rather than by the large negotiated certificates of deposit used to finance large banks' portfolios. The loan portfolios of small banks are typically more heavily invested in consumer installment loans than those of large or medium-sized banks. These loans pay higher rates than commercial loans which tends to improve the interest income of small banks. Moreover, small banks are not usually invested in LDC loans. A conclusion is that bank size may be a significant factor in interest income and the tendency to use fee revenue to smooth earnings. Small banks have a larger spread and would be less likely to have to use fee revenue to smooth earnings than medium-sized or large banks.

Equation 14 is stated as follows:

$$X_{RSA} = \{ R_{RSA} - R_{NRA} - \lambda(\sigma_{RSAw} - \sigma_{NRAw})$$

$$- 2\lambda_1(X_d \sigma_{RSAd})\}/2\lambda_1 \sigma_{RSA}^2 .$$

Solving for $R_{RSA} - R_{NRA}$ yields

$$X_{RSA} 2\lambda_1 \sigma_{RSA}^2 + \lambda(\sigma_{RSAw} - \sigma_{NRAw}) + 2\lambda_1(X_d\sigma_{RSAd})$$

$$= R_{RSA} - R_{NRA} .$$

Since $R_{RSA} - R_{NRA}$ is negative, then a negative relationship exists between net interest income and rate-sensitive assets/total assets. Subtracting X_{RSd} from both sides of Equation 14 and solving for $R_{RSA} - R_{NRA}$ yields

$$(X_{RSA} - X_{RSd}) 2\lambda_1 \sigma_{RSA}^2 + \lambda(\sigma_{RSAw} - \sigma_{NRAw})$$

$$+ 2\lambda_1(X_d \sigma_{RSAd} + X_{RSd} \sigma_{RSA}^2) = R_{RSA} - R_{NRA} .$$

Using similar reasoning, a negative relationship exists between net interest income and the gap ratio.

Fee revenue is used as a defensive measure to smooth earnings, therefore an opposite relationship should hold. The first two hypotheses are stated below.

> Hypothesis 1: The return on net interest income is negatively related to gap/total assets, rate-sensitive assets/total assets, the size of the bank, and the presence of LDC loans in the loan portfolio.
>
> Hypothesis 2: Fee revenue/total assets is positively related to gap/total assets, rate-sensitive assets/total assets, bank size, and the presence of LDC loans in the loan portfolio.

Test of Hypothesis 1

The Equation To estimate the relationship of gap/total assets, rate-sensitive assets/total assets, size, and the presence of LDC loans in the bank's loan portfolio, the following cross-sectional equation is estimated using ordinary least squares. The RCON numbers from the Report of Condition data are listed in Appendix B.

$$\text{Net Interest Income/Total Assets} = \alpha + \beta_1 \text{ Gap/Total Assets} + \beta_2 \text{ Rate-Sensitive Assets/Total Assets} + \beta_3 \text{ Dummy Size} + \beta_4 \text{ Dummy LDC Loans} + \epsilon \qquad [1]$$

A discussion of statistical problems with such a multiple regression model is deferred to Chapter V.

Data The regression is run using quarterly data from the Federal Reserve Report of Condition Data available at University of Missouri, St. Louis. Appendix C provides the list of sample banks. The banks are divided into three groups by size. Small banks are defined to be under $2 billion in assets, medium-sized banks are between $2 and $7 billion in assets, and large banks are over $7 billion in assets. To determine if LDC loans are a part of the bank's loan portfolio, annual reports are consulted as well as Value Line, and Keefe Nationwide Bank Scan (see McDermott).

The time period chosen for study is April 1, 1984 to September 30, 1987. This time period is chosen for several reasons. First, the disclosure of the quarterly gap/total assets measure listed on Schedule J, used as the measure of gap/total assets, was required beginning in 1983. Prior to that time, gap/total assets had to be estimated by the maturity category of the assets. There is some question concerning the consistency of a measure of gap/total assets prior to 1984 compared to a measure of gap/total assets after 1984. By using post-1984 data, consistency is maintained. Second, gap management was an established procedure by 1984. This was not true of earlier time periods. Finally, interest rates are less volatile in this time period than in previous time periods, which introduces less noise into the regression.

Quarterly data are used. Other studies have used annual data (see Flannery and James [1984]), but it can be argued that fluctuations are smoothed by the use of annual data. The effects studied may tend to smooth out by the end of the year, but considerable fluctuation of gap/total assets and net interest income/total assets may remain hidden by use of annual data.

Test of Hypothesis 2

The Equation To determine if fee revenue is used as a defensive measure against the decline in net interest income, the following cross-sectional equation is estimated using ordinary least squares.

$$\text{Fee Revenue/Total Assets} = \alpha + \beta_1 \text{ Gap/Total Assets} + \beta_2 \text{ Rate-Sensitive Assets/Total Assets} + \beta_3 \text{ Dummy Size} + \beta_4 \text{ Dummy LDC Loans} + \epsilon \quad [2]$$

The RCON numbers used from the Report of Condition are shown in Appendix B.

Data The data used is identical to the previous test. The only difference is that the dependent variable is non-interest income which is used as a proxy for fee revenue.

GAP MANAGEMENT AND THE RESULTING EFFECTS ON RISK

The model in Chapter III describes two types of risk. The first is external risk or the covariance of the firm's net interest income return with returns of other firms. The second is internal risk or the variance of the firm's net interest income return.

Narrowing the gap to zero reduces much of the risk except basis risk. Basis risk is defined as the mismatch of returns of rate-sensitive assets and rate-sensitive liabilities. Basis risk tends to reduce the hedging effectiveness of a narrowed gap. The importance of basis risk is its effect on the value of the firm.

A measure of market risk should signal changes in the value of the firm caused by a change in the covariance of the firm's returns with the returns of other firms in the market. A change in the gap/value ratio should change both the market risk and the basis risk of the firm.

Since net interest income appears to show a size effect, it is likely that basis risk may also be size dependent. Flannery and James [1982] found evidence of a size effect in interest rate risk. In general, large banks, for example, have loan customers that are able to negotiate significant concessions in loan rates and terms (below prime rate loans), purchase a large percentage of deposits in the form of negotiated certificates of deposit, and have lower levels of interest income. Rate-sensitive assets/total assets and the presence of LDC loans in the bank's loan portfolio should also affect the market risk of the bank if rate-sensitive assets/total assets is a proxy for basis risk.

Equation 14 is stated as follows:

$$X_{RSA} = \{ R_{RSA} - R_{NRA} - \lambda(\sigma_{RSAw} - \sigma_{NRAw})$$
$$- 2\lambda_1(X_d\sigma_{RSAd})\}/2\lambda_1 \sigma_{RSA}^2 .$$

Solving for market risk yields

$$[- X_{RSA} 2\lambda_1 \sigma_{RSA}^2 - \{R_{RSA} - R_{NRA}$$
$$- 2\lambda_1(X_d\sigma_{RSAd})\}] \lambda = (\sigma_{RSAw} - \sigma_{NRAw}).$$

A negative relationship of market risk to the ratio of repriced assets is shown. Subtracting X_{RSL} from both sides of Equation 14 and solving for market risk yields

$$[- (X_{RSA} - X_{RSL}) 2\lambda_1 \sigma_{RSA}^2 - \{R_{RSA} - R_{NRA}$$
$$- 2\lambda_1(X_d\sigma_{RSAd} + X_{RSL} \sigma_{RSA}^2)\}] \lambda = (\sigma_{RSAw} - \sigma_{NRAw})$$

indicating a negative relationship between gap/total assets and market risk. Hypothesis 3 follows:

> Hypothesis 3: Market risk of a bank is negatively related to gap/total assets and rate-sensitive assets/total assets. Market risk is positively related to the size of the bank and the presence of LDC loans in the portfolio.

Test of Hypothesis 3

The Model The first step in the investigation of this hypothesis is the development of a measure of risk. Then, the relationship of a change in risk to a change in gap is examined. Much of the methodology of this section parallels that of Flannery and James [1984], but some deviations are introduced. The model of market risk used is similar to Stone's [1974] two-index model except that a time structure change is introduced. Instead of a single-period least-squares estimate of the market beta coefficient and the extra-market interest sensitivity coefficient, aggregate coefficients are employed (see Dimson [1979]). The leads and lags are designed to capture effects of thin trading of bank holding company stock, the use of weekly rather than monthly data, and frictions in trading.

Dimson [1979] argues that the ordinary least squares single-period beta estimate of a thinly traded stock is biased downward. He suggests using an aggregate beta to solve the problem. Additional work on the single-index model was done by Cohen et. al. ([1983] and [January, 1983]). They argue that current research uses weekly or daily stock return data whereas previous research used monthly data. To generate comparable results, an aggregate beta should be estimated. Moreover, they argued that certain frictions in the market suggest that an aggregate beta is a better measure of market risk. Shanken [1987] shows that the firm's beta estimated by the aggregate method is as much as double the single period estimate. Further, he argues that all factors in the arbitrage pricing model should be aggregated.

Stone's two-index model is a particular form of a more general n-index arbitrage model. The market risk and extra-market interest rate sensitivity factors, however, are of vital importance to this study. The aggregate coefficient estimation procedure of Dimson is applied to both factors to improve the statistical properties of the slope estimates given the use of weekly observations. The importance of factors other than market and extra-market interest rate risk is left to future research. Therefore, an aggregate coefficient two-index model should be studied.[6] To measure the market and extra-market interest rate risk of the stock returns of a bank holding company, the following time series equation is estimated using ordinary least squares.

$$R_{jt} = \alpha + \Sigma\beta_{mt} R_{mt} + \Sigma\beta_{it} R_{it} + \epsilon \qquad [3]$$

Where

R_{jt} is the return on the jth stock at time t

$\Sigma\beta_{mt}$ is the aggregate firm beta , $t = -4,-3,\ldots,1$,

R_{mt} is the return on the market

$\Sigma\beta_{it}$ is the aggregate measure of extra-market interest rate risk

where, $t = -4, -3, -2, -1, 0, 1$

R_{it} is the return on some interest rate index

<u>The Model Tying Market Risk to Gap</u> Once market risk is estimated, then the relationship of market risk to gap is found by estimating the following cross-sectional equation using ordinary least squares.

$$\Sigma\,\beta_{mt} = \alpha + \beta_1 \text{ Gap/Total Assets}$$

$+ \beta_2$ Rate-Sensitive Assets/Total Assets $+ \beta_3$ Dummy Size

$+ \beta_4$ Dummy LDC Loans $+ \epsilon$ [4]

Cross-sectional regressions are run using quarterly data for the years January 1, 1984, through September 30, 1987, to determine the relationship of a change in gap to market risk. The RCON data numbers taken from the Report of Condition are listed in Appendix B.

Data The bank sample (See Appendix C) consists of 67 banks. Flannery and James [1984] suggest appropriate criteria to determine which bank holding companies should be studied. A bank is included if it satisfies the following requirements. First, the stock of the bank holding company to which the bank belongs must have traded on at least a weekly basis over the time period of April 1, 1984 to September 30, 1987. Second, the bank must be the lead bank of the bank holding company, and its assets must comprise at least 50% of the assets of the bank holding company. The purpose of this filter is to ensure that the stock returns of the bank holding company reflect activities of the bank under study. Some bank holding companies are actually investment firms or credit card companies, for example, rather than banks. In these cases, the bank is used for some specific service that a bank provides, but the activities of the bank are not central to the mission of the firm and do not seriously affect the value of the firm. Other bank holding companies consist of a large number of banks. If no dominant lead bank exists, then it is impossible to determine the effects on the value of the firm of a particular bank unless all of the banks are managed identically . Third, all banks must be sufficiently large to provide the reporting detail required. The smallest bank in the sample has 1986 assets of $158 million. Therefore, all information needed in this study is required by the Federal Reserve and is available.

Weekly rates of return are computed for each bank using daily returns from the CRSP tape where available. If the returns are not available, successive Wednesday ask or closing prices are used to calculate weekly returns after being adjusted for dividends and stock splits. [7] The proxy for the market is the weekly return on Standard and Poor's 500 index.

Weekly returns of three interest rate indices are used to determine whether extra-market interest rate-sensitivity exists.[8] The indices used here are analogous to those of other research: weekly returns on three-month Treasury Bills, weekly returns on one-year Treasury Bills, and the return on a portfolio of long-term bonds. The data are collected from weekly market and long-term bond series rates in The Federal Reserve Bulletin.

ESTIMATION OF THE OPTIMAL GAP

As noted in Chapter III, the optimal change in rate-sensitive assets given a change in rate-sensitive liabilities is equal to $\sigma_{RSA\ RSL} / \sigma_{RSA}^2$. Therefore, rate-sensitive assets/rate-sensitive liabilities of one or a gap of zero is optimal only if

$\sigma_{RSA\ RSL} = \sigma_{RSA}^2$. Since loan rates have a larger variance than deposit rates and it is assumed that loan and deposit rates are positively correlated, it is likely that the optimal gap is not zero.

Equation 15 is stated as follows:

$$\delta X_{RSA} / \delta X_d = \sigma_{d\ RSA} / \sigma_{RSA}^2.$$

Multiplying both sides by δX_d yields

$$\delta X_{RSA} = \delta X_d [\sigma_{d\ RSA} / \sigma_{RSA}^2].$$

Hypothesis 4 is stated below.

> Hypothesis 4: The optimal rate-sensitive asset to rate-sensitive liability ratio is less than one, implying that the optimal gap (from the model of Chapter III) is slightly less than zero.

Test of Hypothesis 4

The Equation The optimal gap ratio is estimated using the following time series equation.

$$RSA = \alpha + \beta\ RSL + \epsilon \qquad [5]$$

where

RSA = the return on a portfolio of rate-sensitive assets

RSL = the return on a portfolio of rate-sensitive liabilities

β = Rate-sensitive Assets/Rate-sensitive Liabilities

ϵ = the error term.

Data Weekly interest rate data are collected from The

Federal Reserve Bulletin, The Bank Quotation Record, and The Wall Street Journal for the period April 1, 1984 to September 30, 1987. Consumer loan data (such as auto, personal, motor home, and credit card loan rates) are only available on a quarterly basis. Fortunately, this is not a problem because these rates do not change very often. Therefore, quarterly data is acceptable.

Most certificate of deposit rates, Treasury Bill rates, prime, and Fed funds rates are found in The Federal Reserve Bulletin as were the consumer installment loan rates. One-year certificate of deposit rates are taken from The Bank Quotation Record. Adjustable-rate mortgage rates are taken from The Wall Street Journal.

The following portfolios are studied.

I) Prime rate loan assets and one-month certificate of deposit liabilities.

II) Prime rate loans and adjustable-rate mortgages in the asset portfolio and one-month and one-year certificates of deposits as liabilities

III) Prime rate loans, auto loans, and adjustable-rate mortgages as assets with one-month and one-year certificates of deposit as liabilities

IV) Prime rate loans, auto loans, adjustable-rate mortgages, three-month Treasury Bills, and Fed funds as assets and one-month, three-month, and one-year certificates of deposit as liabilities.

The first three portfolios are assumed to be equally weighted as far as the proportion of the assets or liabilities is concerned, but are further weighted according to the repricing schedule suggested by the maturity of the assets or liabilities. For example, since adjustable-rate mortgages are repriced once a year, the weight is 1/12 of the weight of a comparable prime rate loan. Auto loans are assumed to be of four-year maturity and certificates of deposit and Treasury Bills follow the maturity stated. The assets of the fourth portfolio are weighted originally according to the weights found in the 1986 Functional Cost Analysis. The proportions for a large bank are chosen because most banks in the sample fit into the large bank category. According to the 1986 Functional Cost Analysis, the asset structure of large banks (over $250 million in assets which covers most of the banks in the sample) consists of 15.28% real estate loans, 26.58% commercial loans, 13.65% consumer loans, 4.5% cash and due from banks, and about 12.85% government securities. Again, repricing schedule weights are used to further weight these portfolios.

SUMMARY

Net interest income/total assets is expected to be negatively related to gap/total assets, rate-sensitive assets/total assets, the size of the bank, and the presence of LDC loans in the bank's loan portfolio. Second, fee revenue is expected to be a defensive measure against the decline in net interest income/total assets.

Third, market risk is expected to be directly related to the size of the bank and the presence of LDC loans in the loan portfolio and negatively related to gap/total assets and rate-sensitive assets/total assets. Finally, the optimal ratio of rate-sensitive assets to rate-sensitive liabilities depends on $\sigma_{RSA\ RSL} / \sigma_{RSA}^2$. It is expected to be less than one, implying that the optimal gap is negative. The next chapter provides evidence concerning the hypotheses presented in this chapter.

FOOTNOTES

1 Gap = rate-sensitive assets less rate-sensitive liabilities.

2 Basis risk is defined as the risk that the two parts of a hedge do not move together. Generally basis risk is an accepted fact of hedging and is considered preferable to being exposed to other risk. There is a large body of futures hedging literature which evaluates basis risk and notes that the hedge need not be one to one in order to minimize risk.

3 To increase loan-loss reserves, the contra-asset entitled Loan-Loss Reserves is increased. A comparable amount is immediately expensed from income. The result is that income is reduced. Therefore, a smaller amount is added to retained earnings. Thus, capital is reduced.

4 See The Value Line Investment Survey.

5 See Chipello [1987] and Truell [1987].

6 Dimson, [1979] suggested an aggregate beta where all lead and lag coefficients were estimated simultaneously. Fowler and Rorke, [1983], stated that Dimson was in error. Cohen, et. al., [January, 1983] derived a new method for estimating the beta that was consistent with the objections of Fowler and Rorke. However, Dimson and Marsh [1983], indicated that the differences between the two methods were negligible.

7 The data origination and calculation is the same as that of Ahrony, Saunders, and Swary, [1986].

8 Evidence of rate-sensitivity of stock returns of bank holding companies is contradictory . Sweeny and Warga [1986] find the rate-sensitivity of bank stock returns to be unstable . Phelps' [1987] results show that in the later time period regression [1983-1985], banks showed no statistically significant rate-sensitivity to interest indices regardless of whether the index was long- or short-term although the results of the earlier time period regression [1980-1982] showed significant rate-sensitivity . Unal and Kane's [1987] results provide evidence that bank stock returns showed no rate-sensitivity to short-term rates but are sensitive to long-term rates. At this time, it is not certain if bank holding company stocks are rate-sensitive and if so, to what indices. Therefore, the indices chosen are as acceptable as any other index.

CHAPTER V

TEST RESULTS

The purpose of this chapter is to report test results of the hypotheses presented in Chapter IV and to determine whether evidence supports or is not consistent with the hypotheses presented in Chapter IV. Explanations are offered for unexpected results.

The chapter is organized as follows. First, descriptive statistics related to the studies are reviewed. Second, the relationship of net interest income/total assets to gap/total assets, rate-sensitive assets/total assets, bank size, and the presence of LDC loans is reported. Third, the use of fee revenue as a defensive measure against a decline in net interest income/total assets resulting from narrowing the gap is examined. Fourth, the relation of market risk to gap/total assets, rate-sensitive assets/total assets, bank size, and the presence of LDC loans in the bank's loan portfolio is shown. Fifth, the optimal gap is estimated under a variety of asset-liability combinations and is compared to the average gap of a sample of banks. This section is followed by a summary.

DESCRIPTIVE STATISTICS

Table 5 shows descriptive statistics for the banks included in the tests for the period April 1, 1984 through September 30, 1987. Statistics include the following ratios: average net interest income/total assets, non-interest revenue or fee revenue/total assets, gap/total assets, rate-sensitive assets/total assets, rate-sensitive liabilities/total assets, (rate-sensitive assets + rate-sensitive liabilities)/total assets, and a break-down of rate-sensitive assets and liabilities by component. The balance sheet measures are shown for three, six, and twelve-month time frames.

The average gap/total assets ratio for all banks is positive (18 to 19 percent). The smallest measure of gap/total assets is -13 percent. It appears that banks now prefer a positive gap over a zero or negative gap, assuming that the competitive structure permits some choice in the matter.

Since the average gap is positive, banks are generally positioned for an increase in interest rates rather than a decline. Interest rates have been declining over the last few years, so this has not been a profit maximizing position during this period because the average rate on assets in the balance sheet has declined faster than the rate on liabilities. It might be profitable now, however, barring strong expectations to the contrary.

A zero or slight negative gap may better position the bank

TABLE 5

DESCRIPTIVE STATISTICS OF RATE-SENSITIVE ASSETS AND LIABILITIES FOR BANKS IN APPENDIX C FOR THE PERIOD APRIL, 1984 THROUGH SEPTEMBER, 1987

938 OBSERVATIONS

Item *	Mean	Standard Deviation	Range
Net Interest Income	.036	.002	.077 - .01
Fee Revenue	.013	.0016	.067 - .0002
Three-Month			
Gap	.18	.09	.49 - -.11
Rate-Sensitive:			
Assets	.42	.08	.67 - .17
Liabilities	.24	.07	.51 - .02
Assets + Liabilities	.66	.13	.97 - .23
Six-Month			
Gap	.18	.1	.56 - -.13
Rate-Sensitive:			
Assets	.47	.08	.69 - .22
Liabilities	.29	.08	.54 - .07
Assets + Liabilities	.76	.12	1.09 - .37
Twelve-Month			
Gap	.19	.1	.54 - -.12
Rate-Sensitive:			
Assets	.52	.08	.77 - .26
Liabilities	.33	.08	.58 - .13
Assets + Liabilities	.85	.11	1.17 - .49

* All measures are divided by total assets.

TABLE 5 (Continued)

DESCRIPTIVE STATISTICS OF INDIVIDUAL RATE-SENSITIVE ASSETS AND LIABILITIES

938 OBSERVATIONS

Item*	Mean	Standard Deviation	Range
Loans			
Overnight	.25	.1	.64 - 0
Three-month	.11	.07	.49 -.0005
Six-Month	.027	.017	.13 -.0008
Twelve-Month	.03	.024	.34 -.002
Investments			
Overnight	.0012	.004	.04 - 0
Three-month	.013	.014	.07 - 0
Six-Month	.010	.010	.07 - 0
Twelve-Month	.018	.018	.12 - 0
Other			
Overnight	.039	.042	.35 - 0
Three-month	.008	.022	.18 - 0
Six-Month	.010	.018	.13 - 0
Twelve-Month	.002	.005	.05 - 0
Certificates of Deposit (Over $100,000)			
Overnight	.002	.009	.08 - 0
Three-month	.07	.04	.24 -.0003
Six-Month	.014	.013	.13 -.0004
Twelve-Month	.007	.008	.09 - 0
Other Time Deposits			
Overnight	.003	.01	.14 - 0
Three-month	.05	.035	.23-.00003
Six-Month	.038	.027	.17-.00007
Twelve-Month	.029	.029	.21 - 0
Other Borrowings and Fed Funds			
Overnight	.088	.064	.36 - 0
Three-month	.028	.029	.20 - 0
Six-Month	.002	.004	.07 - 0
Twelve-Month	.0003	.002	.02 - 0

for an optimal risk-return tradeoff. Banks could maximize income during the interest rate decline, but, at the same time, they would be in a position to restructure quickly if rates start to increase. The average gap measured in the sample of banks may be "too positive" in the sense that not only is net interest income low, but also risk is high.

A proxy of basis risk is the proportion of the balance sheet that is repriced in a given time period, as measured by the ratio of rate-sensitive assets/total assets. A bank that reprices a large portion of its balance sheet should experience lower net interest income than one that reprices a small portion of its balance sheet. Rate-sensitive liabilities/total assets and (rate-sensitive assets + rate-sensitive liabilities)/total assets ratios are offered as alternatives to rate-sensitive assets/total assets ratio to determine whether additional information is revealed by these measures or if these measures are substitutes for each other. Hereafter, the ratios rate-sensitive assets/total assets, rate-sensitive liabilities/total assets, and (rate-sensitive assets + rate-sensitive liabilities)/total assets will be called the rate-sensitive assets/total assets ratio or a substitute. Rate-sensitive assets/total assets averages 42, 47, and 52 percent for three, six, or twelve-month time periods respectively. Rate-sensitive liabilities/total assets averages 24, 29, and 33 percent. (Rate-sensitive assets + rate-sensitive liabilities)/total assets averages 66, 76, and 85 percent. The range of rate-sensitive assets/total assets is 67 to 17, 69 to 22, and 77 to 26 percent. The range of rate-sensitive liabilities is 51 to 2, 54 to 7, and 58 to 13 percent. The range of (rate-sensitive assets + rate-sensitive liabilities)/total assets varies widely from 97 to 23, 109 to 37, and 117 to 49 percent depending on the time frame studied. As can be seen, a large portion of the balance sheet is frequently repriced. However, note that the range of observed values of these measures is large.

Rate-sensitive assets/total assets and rate-sensitive liabilities/total assets ratios are shown in Table 5 by component part. The ranges are wide indicating dramatically differing banking practices. It appears that the majority of the rate-sensitive assets are loans which are continually repriced. By contrast, the liabilities are deposits which are repriced most often at the one to three-month range. On average, banks have positioned themselves to have deposit maturities of a longer time period than the asset maturities, thus creating the positive gap.

The factors affecting the wide ranges of rate-sensitive assets and rate-sensitive liabilities among banks include amounts of capital, long-term debt, the amount of core fixed-rate deposits, geographical location, size, and market position of the bank. The ties of these variables and others to the proportion of rate-sensitive assets and liabilities is a topic for future research.

The net interest income/total assets ratio is found by taking interest revenue less interest expense and dividing by total assets.[1] Non-interest revenue/total assets is the proxy for fee revenue/total assets. Both ratios are calculated from quarterly data which has been annualized. Net interest income/total assets and non-interest revenue/total assets (hereafter to be called fee revenue/total assets) averages 3.6 and 1.3 percent respectively.

Net interest income/total assets and fee revenue/total assets are important parts of the return of a bank.[2] The backbone of bank income is net interest income. Fees are rapidly becoming an important source of income. The other sources of income are considered to represent accounting adjustments and are not regarded as continuing or important sources of income for the purposes of this study. These include non-trading gains or losses on assets and extraordinary items. Extraordinary items are one-time only events and only serve to add volatility to the return measures rather than reflect typical income. Non-trading gains or losses include gains or losses on assets the bank holds, such as loans. Bank managers prefer not to write down assets in value because this practice reveals losses. A net gain is possible but highly unlikely because recent gains would be used to balance losses in value of assets from the 1970s. Since taxes reflect the effects of extraordinary items as well as other income, they are excluded.

HYPOTHESIS 1 RESULTS

> Hypothesis 1: The return on net interest income is negatively related to gap/total assets, rate-sensitive assets/total assets, the size of the bank, and the presence of LDC loans in the loan portfolio.

<u>Preliminary Information</u>

In terms of the equation in Chapter IV, Hypothesis 1 is expressed as follows:

$$\text{Net Interest Income/Total Assets} = \alpha + \beta_1 \text{ Gap/Total Assets} + \beta_2 \text{ Rate-Sensitive Assets/Total Assets} + \beta_3 \text{ Dummy Size} + \beta_4 \text{ Dummy LDC Loans} + \epsilon \ . \qquad [1]$$

The regression results of Hypothesis 1 are shown in Table 6. The results are separated by time periods three, six, and twelve-months. A second division employs the rate-sensitive assets/total assets ratio or a substitute.

A high degree of multicollinearity may exist. The estimator is unbiased and is the best linear unbiased estimator. The R^2 remains unaffected [see Kennedy, p.128]. The problem with multicollinearity is that a lack of significant coefficients exists although the R^2 or F (joint significance of the variables) value of the regression may be large. Large variance estimates may not signal a multicollinearity problem because the variance of the estimated coefficients may be large without the presence of multicollinearity. Second, the degree of multicollinearity may be low and not create a problem. Finally, the cure for multicollinearity may be worse than the problem. A discussion of several possible remedies follows.

If multicollinearity is not too large, it can probably be

TABLE 6

TEST RESULTS: HYPOTHESIS 1

Equation

Net Interest Income/Total Assets = α + β_1 Gap/Total Assets + β_2 Rate-Sensitive Assets/Total Assets + β_3 Dummy LDC Loans + β_4 Size + ϵ

Three-Month **938 Observations**

α	β_1	β_2	β_3	β_4	R^2
.01153*	.00967*	-.008098*	-.00092*	-.03909*	.355
.01153*	.00157*	-.008098[b]*	-.00092*	-.03909*	.355
.01153*	.005616*	-.00405[c]*	-.00092*	-.03909*	.355

Six-Month

α	β_1	β_2	β_3	β_4	R^2
.01182*	.00675*	-.00654*	-.00106*	-.03944*	.318
.01182*	.000218	-.00654[b]*	-.00106*	-.03944*	.318
.01182*	.00348*	-.00327[c]*	-.00106*	-.03944*	.318

Twelve-Month

α	β_1	β_2	β_3	β_4	R^2
.0103*	.00225*	-.00145**	-.001298*	-.03327*	.278
.0115*	.00024	.004507[b]*	-.001218*	-.03808*	.288
.0168*	.001397*	-.00227[c]*	-.001201*	-.03516*	.29

**Statistically significant at the 10% level
* Statistically significant at the 5% level
b Rate-Sensitive Liabilities/Total Assets
c (Rate-Sensitive Assets + Rate-Sensitive Liabilities)/Total Assets

ignored. It is probably not a problem if the t statistics of the estimated coefficients are greater than 2 or if the R^2 of the regression is greater than the R^2 found by regressing the two independent variables on each other (see Kennedy, p.132). A procedure often used to reduce multicollinearity is to orthogonalize the series, but this procedure is flawed because reduction of the multicollinearity is exchanged for a biased estimate of all coefficients except the orthogonalized variable. [3]

A third solution is to drop one of the variables if it appears that the variable does not provide significant explanatory information to the regression. Fourth, if multicollinearity is large, then a ridge regression may be run (see Judge, et.al. [1985]). The tradeoff is an increase in the bias of the estimate for a reduction in the variance. This tradeoff depends on the value of k. [4] The value of k should be small because a large value of k generates a large bias and little variance reduction. If k is not small, then this method is probably of little use.

Finally, the presence of multicollinearity may suggest that additional data should be found or that the data should be expressed in a different manner. That is, the data set is not rich enough.

Some multicollinearity is suspected in these regressions. One solution to reduce multicollinearity is to redefine the data. This is achieved by redefining the dummy variables 'small', 'medium', and 'large' into a variable called 'size' which is total assets weighted by a constant. The results are calculated using both the dummy variables for size and 'size'. The results using 'size' show a greater number of statistically significant coefficients so the results are expressed using 'size' rather than a dummy variable for size. A second solution that will be used is to consider dropping one or more of the variables.

Results

At the three-month level, the net interest income/total assets ratio is negatively related to the rate-sensitive assets/total assets ratio, the size of the bank, and the presence of LDC loans in the loan portfolio. The ratio of net interest income/total assets is positively related to the gap/total assets ratio. All coefficient estimates are significant at the 5% level indicating that any remaining multicollinearity is not a problem. The ratios rate-sensitive assets/total assets and rate-sensitive liabilities/total assets are close substitutes for each other in the regression equation. The coefficients of (rate-sensitive assets + rate-sensitive liabilities)/total assets are often one-half the size of the individual rate-sensitive assets/total assets and rate-sensitive liabilities/total assets coefficients. The gap/total assets coefficient is lower when paired with rate-sensitive liabilities/total assets indicating a possible high correlation between the two variables but the coefficients are still significant. R^2 is .36 indicating that 36% of the variation of net interest income/total assets is explained by these variables.

At the six-month level, the results are similar to the three-month results except in the equation estimating the coefficients gap/total assets and rate-sensitive liabilities/total assets together. In this equation, gap/total assets does not add significant information to the equation and can be dropped. To test for the addition of significant additional information, an F test is performed comparing the restricted model (without the variable) to the unrestricted model (with the variable) [Kmenta, page 418]. F = 0 (critical F = 3.84) indicating that the gap/total assets ratio provides no significant additional information to that regression equation. R^2 is slightly smaller than at the three-month level.

At the twelve-month level, the results are somewhat different from the three and six-month results. The regression at the twelve-month level has an insignificant coefficient of gap/total assets and the coefficient rate-sensitive liabilities/total assets is positive. The value of F in this case is .30 (critical F = 3.84) indicating that no significant additional information is provided by the addition of the explanatory variable gap/total assets in that regression equation. Rate-sensitive liabilities/total assets appears to move differently from rate-sensitive assets/total assets at the twelve-month levels. The size and LDC loan coefficients are slightly different in the twelve-month regressions. R^2 is smaller than at the six-month level. It is now .28 or .29 depending on the regression.

A stepwise regression is run to determine which variables best explain the movements of net interest income/total assets.

The variable explaining the largest portion of net interest income/total assets is 'size' followed by the presence of LDC loans in the loan portfolio. Rate-sensitive liabilities/total assets enters third and gap/total assets enters last. If rate-sensitive assets/total assets and (rate-sensitive assets + rate-sensitive liabilities)/total assets are used instead, these variables enter fourth and gap/total assets enters third.

As can be seen, a balance sheet tie exists between net interest income/total assets and gap/total assets and rate-sensitive assets/total assets or a substitute. However, it is smaller than size and the presence of LDC loans in the loan portfolio.

The ratio net interest income/total assets is positively related to gap/total assets in all cases which is an unexpected result. To determine why the sign is opposite from the expected sign, gap/total assets is regressed on the variables 'small', 'medium', and 'large'. Gap/total assets is positively related to 'small' and 'large' although the relationship to 'large' is not significant. Gap/total assets is negatively related to 'medium'. Since small-sized banks have larger ratios of net interest income/total assets and the relationship of gap/total assets to 'large' is insignificant then the unexpected sign can be explained by the size factor and the positive gap found in small banks.

In all three time periods, virtually all variables are statistically significant when 'size' is used indicating that any remaining multicollinearity is not severe. The model is probably not completely specified because the constant term is significantly different from zero. The search for additional explanatory variables is a topic for future research.

HYPOTHESIS 2 RESULTS

> Hypothesis 2: Fee revenue/total assets is positively related to gap/total assets, rate-sensitive assets/total assets, bank size, and the presence of LDC loans in the loan portfolio.

Preliminary Information

In terms of the equation in Chapter IV, Hypothesis 2 can be expressed as follows:

$$\text{Fee Revenue/Total Assets} = \alpha + \beta_1 \text{ Gap/Total Assets} + \beta_2 \text{ Rate-Sensitive Assets/Total Assets} + \beta_3 \text{ Dummy Size} + \beta_4 \text{ Dummy LDC Loans} + \epsilon \ . \qquad [2]$$

The results are shown in Table 7. The first group of results excludes the dummy variable 'medium' and the second group excludes 'large'. The results are separated by three, six, and twelve-month time frames and measures of rate-sensitive assets/total assets or a substitute. The regressions are rerun using 'size' as a variable instead of the dummy variables 'small', 'medium', and 'large'. The results using the dummy variables for size better explained fee revenue/total assets. Therefore, the results using the dummy variable for size are the focus of discussion.

TABLE 7

TEST RESULTS: HYPOTHESIS 2

Equation

Fee Revenue/Total Assets = $\alpha + \beta_1$ Gap/Total Assets + β_2 Rate-Sensitive Assets/Total Assets + β_3 Dummy LDC Loans + β_4 Dummy Small + β_5 Dummy Large + ϵ

Three-Month 938 Observations

α	β_1	β_2	β_3	β_4	β_5	R^2
.00242*	-.00049	.00336*	-.000305*	-.00089*	-.00013	.0728
.00242*	.00287*	.00336*[b]	-.000305*	-.00089*	-.00013	.0728
.00242*	.001092*	.00168*[c]	-.000305*	-.00089*	-.00013	.0728

Six-Month

α	β_1	β_2	β_3	β_4	β_5	R^2
.00275*	.00151*	.00166**	-.00028*	-.00103*	-.000215**	.077
.00275*	.00317*	.00165[b]**	-.00028*	-.00103*	-.000215**	.077
.00275*	.00234*	.00083[c]**	-.00028*	-.00103*	-.000215**	.077

Twelve-Month

α	β_1	β_2	β_3	β_4	β_5	R^2
.00317*	.00276*	.00023	-.00025*	-.00107*	-.00027*	.082
.00319*	.00278*	-.000018[b]	-.00024*	-.00108*	-.00027*	.0815
.00315*	.00284*	.000014[c]	-.000249*	-.00107*	-.00027*	.0816

** Statistically significant at the 10% level
* Statistically significant at the 5% level
b Rate-Sensitive Liabilities/Total Assets
c (Rate-Sensitive Assets + Rate-Sensitive Liabilities)/Total Assets

TABLE 7 (Continued)

Equation

Fee Revenue/Total Assets = α + β_1 Gap/Total Assets + β_2 Rate-Sensitive Assets/Total Assets + β_3 Dummy LDC Loans + β_4 Dummy Small + β_5 Dummy Medium + ϵ

Three-Month **938 Observations**

α	β_1	β_2	β_3	β_4	β_5	R^2
.00229*	-.00049	.00336*	-.000305*	-.000758*	.00013	.0728
.00229*	.00287*	.00336*[b]	-.000305*	-.000758*	.00013	.0728
.00229*	.00119*	.00168*[c]	-.000305*	-.000758*	.00013	.0728

Six-Month

α	β_1	β_2	β_3	β_4	β_5	R^2
.00254*	.001515*	.00165**	-.00028*	-.000818*	.000215*	.077
.00254*	.00317*	.00166[b]**	-.00028*	-.00082	.000215**	.077
.00254*	.002343*	.00083[c]**	-.00028*	-.000818*	.000215**	.077

Twelve-Month

α	β_1	β_2	β_3	β_4	β_5	R^2
.00289*	.00276*	-.000233	-.00025*	-.0007998*	.000274*	.0817
.00301*	.00278*	-.000018[b]	-.00024*	-.000802*	.000275*	.0817
.00288*	.00284*	.000139[c]	-.00025*	-.000799*	.000269*	.082

**Statistically significant at the 10% level
* Statistically significant at the 5% level
b Rate-Sensitive Liabilities/Total Assets
c (Rate-Sensitive Assets + Rate-Sensitive Liabilities)/Total Assets

<u>**Results**</u>

At the three-month level, the ratio fee revenue/total assets is positively related to the ratios gap/total assets (in two cases), rate-sensitive assets/total assets or a substitute, and 'medium'. The ratio fee revenue/total assets is negatively related to the presence of LDC loans in the loan portfolio, 'small', and 'large'.

A high degree of multicollinearity is not a problem except possibly in the combination gap/total assets and rate-sensitive assets/total assets regression because virtually all the coefficients are statistically significant except 'medium' and 'large'. The variable 'medium' or 'large' could be dropped because it adds no significant additional information to the regression equation (F = 1.26 in all cases, critical F = 3.84). In the ratios gap/total assets, rate-sensitive assets/total assets combination equations, both the coefficients for gap/total assets and either 'medium' or 'large' are insignificant. In this case, both variables can be dropped because they provide no significant additional information (F = .42 in each case, critical F = 3.00).

The six-month results show all coefficients to be statistically significant except for 'large', 'medium', and rate-sensitive assets/total assets or a substitute (but these coefficients are significant at the 10% level) when the dummy variables for size are used. The signs of the coefficients are similar to those of the three-month results. Notice that 'medium' is positive and 'large' is negative indicating that medium-sized banks tend to use fee revenue.

At the twelve-month level, the rate-sensitive assets/total assets coefficient or a substitute is insignificant. These variables can be dropped with no loss of information (F = 0 in all cases, critical F = 3.84). The other coefficients are significant and the signs are consistent with the three and six-month results.

A stepwise regression is run to determine which variables best explain the variance of fee revenue/total assets. The first variable is 'small' which is followed by rate-sensitive assets/total assets or a substitute, gap/total assets, the presence of LDC loans in the loan portfolio, and finally, 'medium' or 'large' at the three and six-month levels. At the twelve-month level, gap/total assets enters after 'small' and is followed by the presence of LDC loans in the loan portfolio, 'medium' or 'large', and rate-sensitive assets/total assets or a substitute.

Two unexpected results occur. First, the ratio fee revenue/total assets is negatively related to the presence of LDC loans in the loan portfolio. Second, the ratio fee revenue/total assets is positively related to medium-sized banks (the relationship is not statistically significant at the three-month level although the relationship is significant at the six and twelve-month levels) and is negatively related to small and large-sized banks.

An explanation of these results stems from several banking practices. First, small-sized banks usually generate larger values of the ratio net interest income/total assets and may not be seeking additional revenue sources. The managers may be less sophisticated, or the competitive structure may not permit use of fees. Second, banks with LDC loans and large-sized banks use large negotiated certificates of deposit rather than individual deposit accounts to fund deposits. Fees are generally charged to individual depositors rather than large certificate of deposit holders. Moreover, many of the large money-center banks show a preference for wealthy individual customers or corporate customers to whom fees are usually not charged. Third, medium-sized bank managers are sophisticated enough to use fees. These banks rely more on individual consumers to fund deposits and therefore can obtain fees. Finally, a problem may have occurred in the measurement of fee revenue/total assets. Net interest income/total assets includes some fees connected with loans. Separating these fees from net interest income/total assets is impossible because the RCON data reports interest and fees as a total amount with no breakdown of component parts. The bank's records would be required to determine the proportion of fee revenue. These records are confidential and not publicly available. The measure of fee revenue/total assets used reflects fees collected on checking accounts, safe deposit boxes, and similar items as well as non-interest related management fees. Therefore, the regression results reflect the limits of the data.

These factors probably explain the relationships that were found. Some of the factors could be tested and this is a project for further research.

The constant term is significantly different from zero indicating that additional explanatory variables exist to explain the dependent variable. Further research is needed to reveal additional variables.

HYPOTHESIS 3 RESULTS

Hypothesis 3: Market risk is negatively related to gap/total assets and rate-sensitive assets/total assets. Market risk is positively related to the size of the bank and the presence of LDC loans in the portfolio.

Preliminary Information

In terms of the equation in Chapter IV, market risk is measured as follows:

$$R_{jt} = \alpha + \Sigma\beta_{mt} R_{mt} + \Sigma\beta_{it} R_{it} + \epsilon \qquad [3]$$

Where

R_{jt} is the return on the jth stock at time t

$\Sigma\beta_{mt}$ is the aggregate firm beta , t = -4,-3,...,1,

R_{mt} is the return on the market

$\Sigma\beta_{it}$ is the aggregate measure of extra-market interest rate risk where, t = -4, -3, -2, -1, 0, 1

R_{it} is the return on some interest rate index.

Once market risk is estimated, then the relationship of market risk to gap is found by estimating the following cross-sectional equation using ordinary least squares.

$$\Sigma \beta_{mt} = \alpha + \beta_1 \text{ Gap/Total Assets}$$
$$+ \beta_2 \text{ Rate-Sensitive Assets/Total Assets} + \beta_3 \text{ Dummy Size}$$
$$+ \beta_4 \text{ Dummy LDC Loans} + \epsilon \qquad [4]$$

To estimate market betas, regressions are run using weekly data for six month periods (26 observations). To match the betas with the balance sheet data, the ratios gap/total assets, and rate-sensitive assets/total assets or a substitute are averaged over six-month periods. Single-period and aggregate market betas are estimated for each bank stock using the two-index single-period model described by Stone [1979] and a two-index aggregate model. The following additional indices are used: none, weekly three-month Treasury bill returns, weekly one-year Treasury bill returns, and weekly long-term bond returns.

In theory, the market only reacts to unexpected changes in interest rate indices. Therefore, when estimating the coefficients of the two-index model, it is necessary to create an index which reflects only unexpected changes in returns [Flannery and James, Journal of Finance]. Autocorrelation coefficients of each index are found for a period of up to fifteen weeks to determine if the series are random or contain a lag. If a statistically significant lag appears, the index is regressed on itself at the length of the lag and the residuals from the regression are used instead of the index. The results in Table 8 reveal the first six lags. All indices show a statistically

TABLE 8

AUTOREGRESSIVE LAGS OF RETURNS ON TREASURY BILLS AND BONDS ON PAST RETURNS OF THE SAME

Index	1	2	3	4	5	6
Long	.33*	.02	-.007	-.033	.04	.096
TB 1 Year	1.26*	-.23	.012	.096	-.14	.11
TB 3 Month	.92*	.098	.094	.083	-.133	.04

EQUATION AR(1)

$$R_t = \alpha + \beta R_{t-1} + \epsilon$$

Index	α	β	SE
Long	.007	.993*	.00003
TB 1 Year	.004	.9955*	.00003
TB 3 Month	-.0005	.345*	.016

* Statistically significant at the 5% level.

significant lag of only one period.[5] Therefore, a single-period autocorrelation model is estimated for each index (Table 8). The residuals are used instead of the indices.

When estimating the two-index model, market and interest rate indices tend to move together. Multicollinearity results if the independent variables of a regression have a high degree of co-movement. The presence of multicollinearity means that estimates of the coefficients are not precise because the variances are large. Therefore, the t statistics are reduced and the significance of the estimates of the coefficients are biased.

As previously indicated, a common procedure to solve the problem in this case is to orthogonalize the two series. However, removal of the multicollinearity is exchanged for biased estimates of all coefficients except the orthogonalized variable.[6] The only time the coefficients that are not orthogonalized are not biased is when the error term series substituted for the orthogonalized variable is the same as the vector of values that is orthogonalized.[7] That is, the series are independent.[8]

Multicollinearity is not expected to be a problem if the R^2 of the regression is greater than the R^2 found by regressing the two independent variables on each other [Kennedy]. The R^2 found by regressing weekly market returns on weekly one-year Treasury bill returns, three-month Treasury bill returns, and long-term bond returns are .04, .00006, and .14 respectively. The smallest R^2 of a portfolio of bank stock returns on the market return and an interest rate index is .20 (using a portfolio of small-sized banks). The R^2 of a regression of a portfolio of medium or large-sized banks on the market returns and an interest rate index is larger than .2 indicating that multicollinearity is not a problem. Moreover, Unal and Kane [1987] find no difference in the results whether the indices are orthogonalized or not. Therefore, any multicollinearity between the market and interest rate indices, does not appear to be a problem and is ignored.

When the regressions are run, only the market coefficient is used as the dependent variable. Regression results are referred to by the co-index of the market beta dependent variable and are hereafter called no index, three-month Treasury bill, one-year Treasury bill, and long-term. The second index has been argued to be not stable for bank stock returns, and test results searching for the existence of rate-sensitivity of bank stock returns are mixed. [See Sweeny and Warga 1986. See also the discussion in Chapter II.] Moreover, when the interest index coefficients are used as dependent variables, the regression results have small R^2 and low values of F which are statistically insignificant.

Table 9 gives the test results. The results are separated by beta measure (no index, three-month Treasury bill, one-year Treasury bill, and long-term), by use of three, six, or twelve-month time frames, and by use of the ratios rate-sensitive assets/total assets or a substitute. As before, the regressions are run using 'size' as an independent variable as well as the dummy variables 'small', 'medium', and 'large'. Since the lowest degree of multicollinearity appears in the regressions using the

TABLE 9

TEST RESULTS: HYPOTHESIS 3

Equation

Market Risk = α + β_1 Gap/Total Assets + β_2 Rate-Sensitive Assets/Total Assets + β_3 Dummy LDC Loans + β_4 Size + ϵ

Three-Month **467 Observations**

Single-Period

No Index

α	β_1	β_2	β_3	β_4	R^2	F
.16	-.37	.83*	.18*	7.87*	.17	24.34
.16	.47	.83*[b]	.18*	7.87*	.17	24.34
.16	.05	.42*[c]	.18*	7.87*	.17	24.34

Three-Month Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.16	-.27	.79*	.18*	7.23*	.17	22.9
.16	.13	.396*[b]	.18*	7.23*	.17	22.9
.16	.53**	.79*[c]	.18*	7.23*	.17	22.9

One-Year Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.06	-.29	.91*	.19*	6.99*	.16	22.66
.06	.62*	.91*[b]	.19*	6.99*	.16	22.66
.06	.17	.46*[c]	.19*	6.99*	.16	22.66

Long-Term

α	β_1	β_2	β_3	β_4	R^2	F
.23**	-.25	.48	.18*	6.7*	.136	18.2
.23**	.23	.48[b]	.18*	6.7*	.136	18.2
.23**	-.01	.24[c]	.18*	6.7*	.136	18.2

TABLE 9 (Continued)

Six-Month

Single-Period

No Index

α	β_1	β_2	β_3	β_4	R^2	F
.095	-.03	.75**	.19*	7.32*	.176	24.6
.095	.72*	.75**[b]	.19*	7.32*	.176	24.6
.095	.34	.37**[c]	.19*	7.32*	.176	24.6

Three-Month Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.068	.006	.80*	.19*	6.69*	.17	23.66
.068	.81*	.80*[b]	.19*	6.69*	.17	23.66
.068	.407	.40*[c]	.19*	6.69*	.17	23.66

One-Year Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
-.086	-.098	1.06*	.20*	6.51*	.17	23.88
-.086	.96*	1.06*[b]	.20*	6.51*	.17	23.88
-.086	.43**	.53*[c]	.20*	6.51*	.17	23.88

Long-Term

α	β_1	β_2	β_3	β_4	R^2	F
.16	.03	.48	.19*	6.22*	.14	18.58
.16	.51	.48[b]	.19*	6.22*	.14	18.58
.16	.27	.24[c]	.19*	6.22*	.14	18.58

TABLE 9 (Continued)

Twelve-Month

Single-Period

No Index

α	β_1	β_2	β_3	β_4	R^2	F
.34**	.38	.07	.21*	7.01*	.17	23.47
.71*	.43	-.72*[b]	.25*	7.09*	.18	24.79
.62*	.26	-.28[c]	.23*	7.09*	.17	23.8

Three-Month Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.59*	.49**	-.5	.24*	6.34*	.166	23.01
.41**	.41	-.06[b]	.22*	6.19*	.16	22.37
.24	.55**	.28[c]	.21*	6.49*	.16	22.48

One-Year Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.06	.74*	.56	.22*	6.3*	.16	22.04
.49*	.57*	-.43[b]	.25*	5.9*	.16	22.4
.22	.54**	.08[c]	.23*	5.87*	.16	21.98

Long-Term

α	β_1	β_2	β_3	β_4	R^2	F
.56*	.38	-.49	.22*	5.98*	.14	18.8
.34**	.31	-.017[b]	.2*	5.87*	.14	18.22
.53*	.25	-.23[c]	.22*	5.98*	.14	18.43

** Statistically significant at the 10% level
* Statistically significant at the 5% level
b Rate-Sensitive Liabilities/Total Assets
c (Rate-Sensitive Assets + Rate-Sensitive Liabilities)/Total Assets

variable 'size', these results are the focus of discussion.

The results are calculated using single-period market betas and aggregate market betas. Generally, use of the aggregate beta as a dependent variable yields results with low values of R^2 and insignificant F values. These results are not included in the discussion.[9] The long-term or one-year Treasury bill cases are important examples of this result. This means that the independent variables are not even jointly significant and contain little explanatory power. Generally, the short-term index aggregate market betas generate jointly significant results while the long-term index aggregate market betas generate insignificant results although in both cases, the values of R^2 and F are small [see Appendix D].

Explanations for the poor aggregate results include a number of possibilities. First, there may be a timing mismatch of dependent to independent variables created by the leads and lags included in the dependent variable. Second, the aggregate beta may not be measured accurately.[10] Third, the aggregate beta may be an inappropriate measure of the market beta. Finally, more risk may be captured by the interest index when a longer-term index is used. The answer to this question is a topic for future research.

Results

The single-period results are the focus of discussion. The results are similar for all the cases except for the long-term case which generates fewer significant coefficients than the others. A possible cause of this result is the different interest sensitivity of long-term bonds to bank stock returns as compared to that of three-month Treasury bills and one-year Treasury bills. The relationship may affect the market beta in a different fashion than the short-term indices. Moreover, the shorter-term returns are calculated somewhat differently from the long-term returns.[11]

In all cases where the gap/total assets coefficient is significant, it is positive. The gap/total assets coefficient is occasionally negative but at these times, it is not significantly different form zero. The rate-sensitive assets/total assets coefficient or a substitute is generally positive when significant except for the twelve-month single-period no index case. When insignificant, rate-sensitive liabilities/total assets is often negative at the twelve-month time frame. Bank size and LDC loan coefficients are positive.

At the three-month level, market risk is positively related to bank size, the presence of LDC loans in the loan portfolio, and the ratio rate-sensitive assets/total assets or a substitute. Gap/total assets is positive when significant. The results are significant at the 5% level except in the long-term case where the ratio rate-sensitive assets/total assets or a substitute is not significant.

In the cases where gap/total assets is the sole insignificant variable, F tests are performed to determine if gap/total assets could be dropped from the equation. The F values range from .02 to 2.18 (critical F is 3.84) indicating that in these cases, gap/total assets could be dropped.

In the long-term index case, both gap/total assets and rate-sensitive assets/total assets or a substitute are insignificant. Testing for the explanatory power of these variables yields F = .72 (critical F = 3.00). The variables have little explanatory power and can be dropped. This regression is thin compared to the others and is of limited value because no significant balance sheet tie is revealed. A reason for these results is that perhaps a large portion of market risk is captured in the estimate of the long-term rate-sensitivity coefficient.

At the six-month level, the results are similar to the three-month results. Gap/total assets is insignificant for some tests. To determine if gap/total assets adds significant information to the regression, F is calculated comparing the restricted and unrestricted model. F ranges from .002 to 2.5 (critical F = 3.84). Therefore, gap/total assets can be dropped.

Again, the long-term case generates the same two insignificant coefficients as before. Gap/total assets and rate-sensitive assets/total assets or a substitute can be dropped because the variables have no significant explanatory power (F = 1.33 in all cases, critical F = 3.00).

At the twelve-month level, the results are somewhat different. In the no index case, gap/total assets is insignificant when paired with rate-sensitive assets/total assets or a substitute. Testing for the explanatory power of gap/total assets yields F = 2.55 (critical F = 3.84). Therefore, gap/total assets can be dropped in this case. When a substitute for rate-sensitive assets is used, both gap/total assets and either rate-sensitive liabilities/total assets or (rate-sensitive assets + rate-sensitive liabilities)/total assets are jointly insignificant and both variables can be dropped (F = 1.42 and .84, critical F = 3.00).

In the three-month Treasury bill case, both gap/total assets and rate-sensitive assets/total assets or a substitute can be dropped. Testing for explanatory power of the variables yields F = 1.53, 2.42, and 1.35 (critical F = 3.00).

The one-year Treasury bill case yields results which indicate that gap/total assets coefficient is significant but rate-sensitive assets/total assets coefficient or a substitute is insignificant. Rate-sensitive assets/total assets or a substitute can be dropped. (F = .096, 1.5, and 1.53 respectively, critical F = 3.84).

The long-term case is a repeat of the three and six-month long-term case. Both gap/total assets and rate-sensitive assets/total assets or a substitute provide little explanatory power and can be dropped (F = 1.71, .69, and 1.065, critical F = 3.00).

A stepwise regression is run using each beta separately as a dependent variable to determine which variables best explain the variance in the beta. The variable that is first is size which is followed by the presence of LDC loans in the loan portfolio. At the three and six-month levels, rate-sensitive assets/total assets or a substitute enters third followed by gap/total assets. At the twelve-month level, gap/total assets enters third followed by rate-sensitive assets/total assets or a substitute.

The signs of the coefficients of gap/total assets and rate-sensitive assets/total assets or a substitute are unexpected. The fact that rate-sensitive assets/total assets or a substitute has a positive coefficient is important for two reasons. First, rate-sensitive assets/total assets or a substitute is a proxy for basis risk. This means that basis risk is an important part of market risk. Second, the hypothesized signs assume an optimal risk-return tradeoff. The sign reversal signals that in actual practice, the risk-return tradeoff is suboptimal.

The positive coefficients of bank size, LDC loans and rate-sensitive assets/total assets or a substitute combined with the negative coefficients in the net interest income/total assets regression signal that banks with low net interest income/total assets ratios have high market risk. Large-sized banks, banks with LDC loans in their loan portfolios, and banks with large rate-sensitive assets/total assets ratios or a substitute show more risk and less net interest income return than other banks. The gap/total assets ratio shows positive coefficients in the income and risk regressions signalling a possibly optimal risk-return tradeoff. The relationship of risk to gap/total assets, however, is reversed which is an interesting result. The idea behind narrowing the gap to zero and beyond is expected to reduce risk. The result signals that as the ratio gap/total assets increases, so does risk.

HYPOTHESIS 4 TEST RESULTS

Hypothesis 4: The optimal rate-sensitive asset to rate-sensitive liability ratio is less than one, implying that the optimal gap is slightly less than zero.

In terms of the equation in Chapter IV, Hypothesis 4 can be expressed as follows:

$$RSA = \alpha + \beta \; RSL + \epsilon \qquad [5]$$

where

RSA = the return on a portfolio of rate-sensitive assets

RSL = the return on a portfolio of rate-sensitive liabilities

β = Rate-sensitive Assets/Rate-sensitive Liabilities

ϵ = the error term.

The test results are shown in Table 10. When regressing the returns from rate-sensitive assets on the returns from rate-sensitive liabilities, the Durbin Watson Statistic is approximately .29 for each regression of the pairs of portfolios studied. Since this is a time-series regression, this statistic indicates positive autocorrelation of the error terms.

Autocorrelation occurs when the least squares assumption of no correlation of the error terms is violated [see Kmenta, pp. 299-309]. The resulting estimates of β are unbiased but

TABLE 10

TEST RESULTS: HYPOTHESIS 4

MODEL

$$R_{RSA} = \alpha + \beta R_{RSL} + \epsilon$$

PORTFOLIO **	α	β	R^2	D.W.
I	.000019 (.000015)	1.0001 (.000096)	.999	1.96
II	.000015 (.000014)	1.0002* (.00009)	.999	1.97
III	.0000116 (.000008)	1.0002* (.00005)	.999	2.12
IV	.000014 (.000015)	1.00015 (.00008)	.999	2.03

* The estimated ratio rate-sensitive assets/rate-sensitive liabilities is significantly different from one at the 5% level.

inefficient. This means that the test statistics are invalid. To determine if the coefficients are significantly different from 1 (hence a positive or negative gap is optimal), valid test statistics are necessary.

The error terms are of the form

$$\epsilon_t = \rho\epsilon_{t-1} + v_t \quad [6]$$

ρ is estimated as

$$\Sigma\, \epsilon_t\epsilon_{t-1} / \Sigma\, \epsilon_t^2 \quad [7]$$

where t = 2, ..., n. Once ρ is estimated, then the generalized difference equation

$$Y_t - \rho\, Y_{t-1} = \alpha(1 - \rho) + \beta(X_t - \rho X_{t-1}) + v_t \quad [8]$$

is run. The coefficients are unbiased and efficient [see Kmenta, pp. 315-316 and Intriligator, p. 165]. The only remaining problem is that one data point is removed in the process. The problem is remedied by setting $Y_1 = Y_1(1 - \rho^2)^{.5}$ and $X_1 = X_1(1 - \rho^2)^{.5}$ [see Prais-Winsten, 1954 and Gujarati, p. 380]. Now, all data points are included in the regression.

Some studies attempt to circumvent the problem of autocorrelation by regressing the change in the dependent variable on the change in the independent variable. This method is not advisable unless the researcher is certain that $\rho = 1$. If ρ is not 1 then the estimate of the variance of β is biased so the use of this estimate is inappropriate [Kmenta, p. 322].

In this study, ρ is approximately .85 for the first three portfolios and .82 for the fourth portfolio. Equation 8 is estimated using the values of ρ. In all equations, β is approximately one indicating that a zero gap is optimal. To determine whether β is significantly different from 1, the t statistic $t = (1 - \beta)/\sigma$ where σ is the standard error of β is estimated. The t statistics of each portfolio are 1.86, 2.25, 4.12, and 1.78 respectively. This means that the optimal gap in portfolios one and four is not significantly different from zero. However, the optimal gap in portfolios two and three is significantly different from zero and, in fact, is slightly positive.

An extra hypothesis can be included at this time.

H_0: The average bank gap/total assets ratio is not significantly different from zero.

To test the hypothesis, the average measure of gap/total assets and the standard deviation are calculated. The results are shown in Table 11 by bank size and time frame. In all cases, medium-sized banks have the smallest measure of gap/total assets. Small and large-sized banks have larger measures of gap/total assets.

Table 12 shows the results of a series of pair-wise t tests that determine if the average measures of the gap/total assets ratios are significantly different from each other within each time frame. Generally, the measures of average gap/total assets of large and small-sized banks are not significantly different from each other except at the twelve-month time frame. The measures of average gap/total assets of medium-sized banks are significantly different from those of small and large-sized banks at the three and six-month time frames. At the twelve-month time

TABLE 11

THE AVERAGE GAP/TOTAL ASSETS: SEPARATED BY BANK SIZE AND TIME FRAME

Three-Month

	Mean	Standard Deviation	Range
Large[a]	.19	.096	.434 to -.108
Medium[b]	.168	.083	.384 to -.044
Small[c]	.198	.103	.485 to -.017

Six-Month

	Mean	Standard Deviation	Range
Large[a]	.184	.114	.561 to -.087
Medium[b]	.155	.085	.416 to -.11
Small[c]	.1997	.114	.463 to -.131

Twelve-Month

	Mean	Standard Deviation	Range
Large[a]	.218	.114	.482 to -.113
Medium[b]	.173	.087	.539 to -.1005
Small[c]	.178	.104	.44 to -.116

a 322 Observations
b 420 Observations
c 196 Observations

TABLE 12

RESULTS OF PAIRWISE T TESTS TO DETERMINE IF THE AVERAGE GAP/TOTAL ASSETS OF BANKS OF DIFFERENT SIZES ARE SIGNIFICANTLY DIFFERENT FROM EACH OTHER

Three-Month	t
Large-Medium	3.34*
Large-Small	.862
Medium-Small	3.82*
Six-Month	t
Large-Medium	6.12*
Large-Small	1.52
Medium-Small	3.52*
Twelve-Month	t
Large-Medium	6.07*
Large-Small	3.99*
Medium-Small	.62

* Statistically Significant at the 5% Level.

frame, the measure of average gap/total assets of large-sized banks is significantly different from that of small and medium-sized banks.

Table 13 shows the results found when t tests are run to determine if the measure of average gap/total assets is significantly different from zero. The optimal gap estimated using Portfolio IV, which most closely represents the portfolio of a typical bank, is not significantly different from zero. The other three portfolios represent a portion of the bank balance sheet rather than the entire balance sheet. Therefore, the zero gap is chosen as a base. In all cases, the measures are significantly different from zero. The extra null hypothesis that was previously mentioned is rejected. This indicates that the average bank gap/total assets ratio is "too positive" and that medium-sized banks show a measure of average gap/total assets which is closer to the optimal measure than small or large-sized banks.

The optimal gap of a given bank is dependent on the comovement of the returns of portfolios of rate-sensitive assets and rate-sensitive liabilities of the bank. The returns used in this study represent averages of a collection of banks. While on average, the optimal gap may appear to be zero or slightly positive, the actual optimal gap of a given bank may vary considerably.

The optimal gap of the individual bank is a topic for future research if individual bank rate-sensitive asset and rate-

TABLE 13

T TEST RESULTS THAT DETERMINE IF THE AVERAGE MEASURE OF GAP/TOTAL ASSETS IS SIGNIFICANTLY DIFFERENT FROM ZERO

Three-Month	t
Large	35.37
Medium	41.19
Small	26.9
Six-Month	t
Large	31.50
Medium	37.33
Small	22.54
Twelve-Month	t
Large	34.26
Medium	35.03
Small	23.9

All are significant at the 5% level.

sensitive liability return information can be obtained. This information is generally confidential and is not easily obtained. A second study could examine additional portfolios of rate-sensitive assets and rate-sensitive liabilities other than the portfolios presented.

SUMMARY

Descriptive statistics show that for the period examined, banks, on average, tend to maintain a positive gap. The severe negative gap of the 1970s appears to be no longer in vogue. On average, a large portion of the bank's balance sheet is repriced within a one-year period.

Results of the tests find that the ratio of net interest income/total assets is usually positively related to the gap/total assets ratio and negatively related to all other variables tested. The rate-sensitive assets/total assets ratio is generally a close substitute for the ratios rate-sensitive liabilities/total assets except at the twelve-month level.

Tests find that fee revenue/total assets shows some elements of use as a defensive measure because the signs of gap/total assets and rate-sensitive assets/total assets coefficients or a substitute are positive as predicted. The coefficient of gap/total assets ratio is, however, inconsistent with the notion of defense because the signs of the coefficients are identical to those of the net interest income/total assets regressions and not opposite.

An unexpected result occurs. Large-sized banks and banks with LDC loans in their loan portfolios apparently do not use fee revenue. Medium-sized banks, however, use fee revenue. This result is explained by the lack of individual consumer accounts in the large-sized banks and banks with LDC loans in their portfolios. Medium-sized banks seek individual consumers as customers whereas the large-sized banks tend to seek out large corporations or wealthy individuals as customers. Large corporations and wealthy individuals can negotiate away fees whereas the individual consumer generally can not. Measurement error is also a possible problem.

Test results show that market risk is positively related to the rate-sensitive assets/total assets ratio or a substitute, the size of the bank, and the presence of LDC loans in the loan portfolio. The relationship to gap is not always significant but is generally positive when it is significant. Since a proxy of basis risk is the rate-sensitive assets/total assets ratio or a substitute, basis risk is an important component of market risk of a bank's stock returns. Moreover, these results, combined with the results of tests of Hypothesis 1, suggest that large-sized banks, banks with LDC loans in their loan portfolios, and banks with large measures of rate-sensitive assets/total assets or a substitute of that measure have low ratios of net interest income/total assets and high market risk. This is hardly an optimal risk-return tradeoff. The identical signs of gap/total assets coefficients in the Hypothesis 1 and 3 results imply an optimal risk-return tradeoff. However, the signs are reversed from those hypothesized. The positive relationship to market risk indicates that while net interest income increases with gap/total assets, so does market risk. This is a curious result since the idea behind narrowing the gap was to reduce risk.

The optimal gap is found to be zero or slightly positive depending on the portfolio of assets and liabilities used. When these results are compared with actual gap/total asset measures, assuming all other things are equal, the implication is that on average, the gap of the sample of banks is "too positive" to be optimal. Medium-sized banks have a gap which is closer to the optimal gap than other sized banks.

FOOTNOTES

1 Wall [1988] used net interest income/total assets as a measure of return but corrected it for tax free bonds and loans and loan-loss expenses. Loan-loss expenses are usually judgement estimates. The potential for accounting manipulation is great. For example, LDC loans were not generally adjusted by money-center banks in spite of the problem loan status. Therefore, regardless of actual performance of these loans, money-center banks would tend to understate loan losses. The large addition in the second quarter of 1987 made largely by money-center banks would cause a large break in the data and affect regression results. Therefore, the loan-losses are ignored for the purposes of this study. Also ignored are tax free investments and loans. Wall's study includes many very small banks (under $200 million in assets) which tend to have higher proportions of municipal bond investments. According to The Federal Reserve Bulletin , state and local bonds represent about 4% of the total assets of the average large bank. Many of the banks in this study are large banks by the definition of The Federal Reserve Bulletin. Moreover, the tax shelter is about 2% of interest revenue according to The Functional Cost Analysis, 1985. Therefore, the presence of state and local municipal bonds is not expected to have a large effect on net interest income/total assets.

2 The measure of fee revenue used does not include fees which may be charged as a part of the interest of a loan. These fees are included in net interest income and are not separated in the RCON data. Therefore, it would be difficult, if not impossible to obtain the information because the individual researcher would have to obtain it from the confidential records of the bank. The fee revenue here represents charges on deposit accounts, safe deposit boxes, or other similar items.

3 When orthogonalizing two variables, one variable is regressed on the other and the error terms are substituted for the orthogonalized variable (dependent) in the original equation. See Giliberto [1985].

4 In a ridge regression, $\beta(k) = (X'X + kI)^{-1} X'y$ instead of $\beta = (X'X)^{-1} X'y$.

5 Flannery and James [Journal of Finance] used a three period lag. Unal and Kane [1987] found that a different lag was appropriate. The different results are attributable to differences in interest indices used and measurement of the returns on the indices.

6 See Giliberto [1985].

7 When orthogonalizing, matrix Z replaces matrix X when

estimating $y = \alpha + \beta X + \epsilon$. Specifically, if Z and X are partitioned, $Z = [\ R{:}\epsilon_k\ ]$ and $X = [R{:}\ X_k]$. The variances are equal only if $X = Z$ or $\epsilon_k = X_k$ for all k which means that the series is not correlated with the other series and the process of orthogonalizing is unnecessary.

8 For a discussion of co-integration, see Engel and Granger [1987].

9 The aggregate beta results using the variable 'size' to signify bank size are reported in Appendix D for the interested reader. Generally, the values of R^2 and F are small. Few independent variables are significant indicating weak explanatory power of these regressions.

10 The aggregate beta suggested by Dimson [1979] is used. Fowler and Rourke [1983] argue that Dimson's aggregate beta is incorrect but Dimson and Marsh [1983] argue that the bias is small.

11 The three-month Treasury bill and one-year Treasury bill rates are discount rates. To determine the weekly return, the annualized yield is calculated. The weekly return is $(1 + r)^{1/52}$. In the long-term case, the return is $(Y_t - Y_{t-1})/Y_{t-1}$.

CHAPTER VI

CONCLUSIONS

The purpose of this chapter is to summarize the results of the hypotheses tested. This chapter is organized as follows. First, the conclusions of the tests of each hypothesis are summarized. Unexpected results are explained. Second, suggestions for future research are offered and this is followed by a conclusion.

HYPOTHESIS 1 RESULTS

> Hypothesis 1: The return on net interest income is negatively related to gap/total assets, rate-sensitive assets/total assets, the size of the bank, and the presence of LDC loans in the loan portfolio.

Tests find that the ratio net interest income/total assets is positively related to the gap/total assets ratio and negatively related to the rate-sensitive assets/total assets ratio or a substitute (except the twelve-month rate-sensitive liability/total assets case), the presence of LDC loans in the loan portfolio, and the size of the bank.

The sign of the gap/total assets coefficient is unexpected. However, the positive sign is found to be related to small and large-sized banks, although the positive relationship to large-sized banks is not significant, and for medium-sized banks, the sign is negative.

Since medium-sized banks have more individual consumers as customers than large-sized banks, a larger portion of the loan portfolio would be in longer term consumer loans and mortgages. The customers, moreover, are sophisticated enough to demand short-term deposits. Therefore, the gap of a medium-sized bank is more likely to be close to zero or negative. A small-sized bank faces the same customer clientele and loan portfolio but its customers are less sophisticated and frequently are willing to deposit funds into long-term deposit accounts. Large-sized banks have loan portfolios which consist largely of commercial (which are short-term) rather than consumer loans. Deposits consist of large negotiated certificates of deposit which can be tailored to a given maturity so the gap of a large-sized bank is expected to be zero or positive.

In virtually all cases, the coefficients are significant. However, when an insignificant coefficient occurs, it is shown that the variable adds little explanatory power to the regression equation and can be dropped.

The only result inconsistent from the discussion above is the twelve-month regression using the gap/total assets ratio paired with the rate-sensitive liabilities/total assets ratio. The sign of rate-sensitive liabilities/total assets is unexpected. An explanation for this is that the ratios rate-sensitive assets/total assets and rate-sensitive liabilities/total assets do not move together at the twelve-month level. This is reasonable because as the time period lengthens, it is difficult to match actual asset and liability maturities for the probability of loan prepayment or early deposit withdrawal increases. Moreover, the effects on asset or liability accounts are uncertain and not likely to occur simultaneously.

The most important explanatory variable of net interest income/total assets is 'size'. This is followed by the presence of LDC loans in the loan portfolio, rate-sensitive liabilities/total assets, and gap/total assets. When rate-sensitive assets/total assets or (rate-sensitive assets + rate-sensitive liabilities)/total assets is used instead, gap/total assets and rate-sensitive assets/total assets or (rate-sensitive assets + rate-sensitive liabilities)/total assets trade places.

HYPOTHESIS 2 RESULTS

> Hypothesis 2: Fee revenue/total assets is positively related to gap/total assets, rate-sensitive assets/total assets, bank size, and the presence of LDC loans in the loan portfolio.

Fee revenue is a defensive measure only as related to the balance sheet variables rate-sensitive assets/total assets or a substitute and 'small'. While tests find that it is positively related to gap/total assets as hypothesized (except in the three-month rate-sensitive asset/total assets case), the sign of the gap/total assets coefficient is consistent with the Hypothesis 1 results, indicating fee revenue is not used as a defense measure. In relation to bank size and the presence of LDC loans in the loan portfolio, fee revenue is found to be not a defensive measure for the reduction in interest income resulting from narrowing the gap except for 'small'.

An unexpected result is that fee revenue is negatively related to large-sized banks and banks with LDC loans in their loan portfolios while it is positively related to medium-sized banks. An explanation for this result is that large-sized banks and banks with LDC loans in their loan portfolios are more likely to have large corporate or wealthy individual customers and to fund deposits using large negotiated certificates of deposit rather than individual consumer deposit accounts. Wealthy individual and corporate customers can negotiate away checking account fees, for example, while individual consumers cannot. Medium-sized banks cater more to individual consumers and less to large corporate and wealthy individual customers and are able to charge fees. Small-sized banks appear not to need fee revenue or are unable to collect it because of competitive pressure.

The most important explanatory variable of fee revenue/total assets is 'small'. This is followed by rate-sensitive assets/total assets or a substitute, the presence of LDC loans in the loan portfolio, gap/total assets and 'medium' or 'large' in the three and six-month cases. In the twelve-month case, 'small' is first followed by gap/total assets, the presence of LDC loans in the loan portfolio, and 'medium' or 'large'. Rate-sensitive assets/total assets or a substitute is last.

HYPOTHESIS 3 RESULTS

> Hypothesis 3: Market risk is negatively related to gap/total assets and rate-sensitive assets/total assets. Market risk is positively related to the size of the bank and the presence of LDC loans in the portfolio.

The regressions are run using single-period market betas and aggregate market betas. Both are matched to a variety of interest indices. The single-period results have higher R^2 and all are jointly significant. The aggregate results have low values of R^2 and many are not jointly significant. The long-term and one-year treasury bill cases are important examples of this result. The no index and three-month treasury bill cases are jointly significant although the R^2 and F values are small. Therefore, the single-period results are the focus of discussion.

The three and six-month results are similar. Market risk is positively related to rate-sensitive assets or a substitute, the presence of LDC loans, and the size of the bank. The relationship of market risk to the gap/total assets ratio is positive when significant but frequently the relationship is insignificant.

The twelve-month results frequently show an insignificant relationship of market risk to rate-sensitive assets/total assets or a substitute (except in the no index case where the rate-sensitive liabilities coefficient is significant and negative). The relationship to gap/total assets is significant in the one-year Treasury bill case using rate-sensitive assets/total assets or rate-sensitive liabilities/total liabilities (at the 5% level). The relationship to bank size and LDC loan results are identical to the three and six-month results.

In the risk regressions, 'size' is the most important explanatory variable. The second is the presence of LDC loans in the loan portfolio. At the three and six-month levels, this is followed by rate-sensitive assets/total assets or a substitute and gap/total assets. These two final variables are reversed in order in the twelve-month regressions.

A surprising result is that the coefficients for gap/total assets and rate-sensitive assets/total assets ratios or a substitute have opposite signs to those hypothesized. The model assumes a risk-return tradeoff which the tests find does not appear in actual practice as far as rate-sensitive assets/total assets or a substitute is concerned. Gap/total assets is positively related to risk when significant. Although the signs of gap/total assets to net interest income/total assets and the firm's market beta are identical implying an optimal risk-return tradeoff, it is interesting that gap/total assets is positively related to the firm's market beta or risk. The purpose of narrowing the gap to zero or beyond is not to increase risk.

When Hypothesis 3 results are compared to the results of Hypothesis 1, market risk is highest for banks with low levels of net interest income/total assets. The important components of this result are size, LDC loans, and the rate-sensitive assets/total assets ratio or a substitute. The only exception is at the twelve-month level where the results show the risk coefficient of rate-sensitive assets/total assets or a substitute to be insignificant. The signs of gap/total assets coefficients are the same in the Hypothesis 1 and 3 results. However, the gap/total assets coefficient is positive (particularly at three and six-months), indicating that as gap/total assets increases, so does risk.

HYPOTHESIS 4 RESULTS

> Hypothesis 4: The optimal rate-sensitive asset to rate-sensitive liability ratio is less than one, implying that the optimal gap is less than zero.

The optimal gap is zero or slightly positive depending on the portfolio of rate-sensitive assets and rate-sensitive liabilities used. When the results are compared to the average gap reported in Tables 11 and 13, the average gap is "too positive". The results (Table 12) also indicate that medium-sized banks generally have a measure of gap/total assets that is significantly smaller than small or large-sized banks except at the twelve-month time frame. At twelve-months, the gap/total assets measure of large-sized banks is significantly larger than that of small or medium-sized banks. The gap/total assets measures of small or medium-sized banks are not significantly different from each other.

FUTURE RESEARCH SUGGESTIONS

An outcome of research is that it tends to raise as many questions as it answers. A number of research topics have been raised in this paper.

First, additional explanatory variables for net interest income/total assets and fee revenue/total assets should be found. Test results imply that additional explanatory variables exist and it would further bank research to find them.

Second, additional information regarding the extra-market rate-sensitivity of bank stock returns should be sought. The question of the rate-sensitivity of bank stock returns is still unanswered because published results show considerable confusion.

Third, it should be determined whether a better match of aggregate market betas and bank information can be found either by better measurement of the market beta or better matching of leads and lags. The regression results reported here are poor. More information would determine if the results could be improved.

Fourth, the tie of rate-sensitive assets/total assets ratios or a substitute to capital, fixed-rate deposits, and other long-term liabilities should be investigated. Since the rate-sensitive assets/total assets ratio or a substitute is a proxy of basis risk, it would be interesting to determine which banks have the most basis risk, and what other factors lead to it.

Fifth, actual bank data should be used to determine the optimal gap. This information is difficult to obtain but if it could be obtained, the results would be interesting and could determine if the optimal gap varies from bank to bank.

Sixth, the optimal proportions of various rate-sensitive asset and liability groups should be determined and compared to the amounts used in actual practice. This would show whether the bank is maintaining an optimal risk-return tradeoff by maintaining optimal proportions of each type of rate-sensitive asset and liability.

Finally, a quadratic programming model should be used to determine the optimal gap by first determining the optimal balance sheet. Quadratic programming is a neglected area of balance sheet management. Theoretically, it should be superior to the popular linear programming method used because the objective function described in Chapter III is quadratic and not linear. Linear programming demands a linear objective function to solve. Risk, defined as the variance of earnings must be redefined using a different measure or ignored. The result is that risk effects are not included or are included in a manner which may be theoretically incorrect.

SUMMARY

The results obtained may be related to the time period studied. The time period studied is characterized by a downward trend in interest rates and relatively low levels of interest rate volatility compared to the 1979-1982 period.

This study shows that the net interest income/total assets ratio is negatively related to the ratio rate-sensitive assets/total assets or a substitute (except for the twelve-month rate-sensitive liabilities/total assets case), size, and the presence of LDC loans in the loan portfolio. It is positively related to the gap/total assets ratio.

The ratio fee revenue/total assets shows some defensive aspects for a decline in net interest income caused by narrowing the gap but the relationship is defensive only to the extent that fee revenue is positively related to the ratio rate-sensitive assets/total assets or a substitute and negatively related to 'small'. The relationship to the gap/total assets ratio is positive as expected (except of the three-month rate-sensitive assets/total assets case), but it is not opposite that relationship found when regressing the ratio net interest income/total assets on the gap/total assets ratio as would be expected for a defensive measure. The relationship of the ratio fee revenue/total assets to the presence of LDC loans is negative, and medium-sized banks are more likely to use fee revenue than small or large-sized banks. The reason for this result is tied to the bank's choice of customer clientele and the composition of the deposit portfolio.

When regressing market risk on the independent variables, the single-period results have higher values for R^2 and F than the aggregate market beta results. The aggregate market beta results are plagued by low values of R^2 and insignificant values of F. In the single-period market beta results, the long-term case provides somewhat different results from the other cases. This is caused by different measures of rate-sensitivity of bank stock returns that is not captured in the market risk term or else by measurement error.

Market risk is positively related to the ratios gap/total assets and rate-sensitive assets/total assets or a substitute, bank size, and the presence of LDC loans in the loan portfolio. The relationship of market risk to the gap/total assets ratio is not significant at the three and six-month levels. However, at the twelve-month level, the ratio gap/total assets is occasionally significant, and the rate-sensitive assets/total assets ratio or a substitute becomes insignificant. In all of the regressions, at the twelve-month level, the ratios rate-sensitive assets/total assets or a substitute provide less in the way of perfect substitution qualities than at the three and six-month levels where the ratios rate-sensitive assets/total assets or a substitute are excellent substitutes for each other.

The results of the Hypothesis 3 tests are interesting when combined with the results of Hypothesis 1 regressions. All independent variables except for gap/total assets ratios generally have coefficients with opposite signs, indicating that banks with the lowest net interest income/total assets measures have the highest market risk measures. Gap/total assets is of interest because the original idea behind narrowing the gap is to reduce risk or beta rather than increase it.

At least theoretically, the ratio net interest income/total assets should measure much of a bank's return and should be the backbone of bank earnings. Other forms of income such as non-trade gains and losses and extraordinary items are seldom used or represent infrequent accounting adjustments rather than actual earnings. Fee revenue/total assets is becoming an important source of income. However, the only banks which appear to be using fee revenue as a defensive measure against lower interest income are medium-sized banks. The fee revenue/total assets ratio is negatively related to large-sized banks and banks with LDC loans in their portfolios. There is some evidence that banks with high measures of rate-sensitive assets/total assets or a substitute are using fee revenue. However, it would appear that in general, banks which need fee revenue are not collecting it.

Since net interest income is the backbone of bank earnings, a goal of banks should be to manage the gap so that it is in an optimal position to maximize net interest income while minimizing risk. The optimal gap is zero or slightly positive. However, the average gap measured is more than slightly positive. The result of this is that banks are unnecessarily reducing earnings and increasing risk (higher measures of rate-sensitive assets/total assets is a result) by maintaining a gap that is "too positive". A zero or slightly negative gap would assist banks to maximize net interest income in the recent scenario of declining interest rates, but at the same time, if interest rates increase, the bank would be able to reposition quickly.

APPENDIX

APPENDIX A

MATHEMATICAL DERIVATIONS

THE MODEL

$$\text{Maximize} \quad V = R_l X_l + R_c X_c + R_i X_i + R_{NA} X_{NA} - R_d X_d - R_{NL} X_{NL}$$
$$- \lambda (X_l \sigma_{lw} + X_i \sigma_{iw} + X_c \sigma_{cw} + X_{NA} \sigma_{NAw} - X_d \sigma_{dw} - X_{NL} \sigma_{NLw})$$
$$- \lambda_1 (X_i^2 \sigma_i^2 + X_l^2 \sigma_l^2 + X_d^2 \sigma_d^2 + X_c^2 \sigma_c^2 + 2X_i X_l \sigma_{il} + 2X_l X_c \sigma_{lc} +$$
$$2X_i X_c \sigma_{ic} - 2 X_d X_c \sigma_{cd} - 2X_d X_l \sigma_{dl} - 2X_d X_i \sigma_{di})$$

Subject to $X_l + X_c + X_i + X_{NA} + X_f = X_d + X_{NL} + C + D$

A = total assets/Market value of the firm

σ_{ij} is the covariance of rates of securities i and j

σ_{ij} is the covariance of rates of security i with the return of other firms on the market.

R_l return on rate-sensitive loans

R_c return on rate-sensitive cash

R_i return on rate-sensitive investments

R_{NA} return on non-rate-sensitive assets

R_d return on rate-sensitive deposits

R_{NL} return on non-rate-sensitive liabilities

X_l rate-sensitive loans/ market value of firm

X_c rate-sensitive cash/ market value of firm

X_i rate-sensitive investments / market value of firm

X_f fixed assets/market value of firm

X_{NA} non-rate-sensitive assets / market value of firm

$= (A - X_i - X_c - X_l - X_f)$

APPENDIX A (Continued)

X_d rate-sensitive deposits/ market value of firm

X_{NL} non-rate-sensitive liabilities/ market value of firm

$= (A - X_d - C - D)$

C = capital/market value of firm

D = debt/market value of firm

THE LAGRANGIAN FUNCTION

Maximize $V = R_l X_l + R_c X_c + R_i X_i + R_{NA} X_{NA} - R_d X_d - R_{NL} X_{NL}$

$- \lambda(X_l \sigma_{lw} + X_i \sigma_{iw} + X_c \sigma_{cw} + X_{NA} \sigma_{NAw} - X_d \sigma_{dw} - X_{NL} \sigma_{NLw})$

$-\lambda_1 (X_i^2 \sigma_i^2 + X_l^2 \sigma_l^2 + X_d^2 \sigma_d^2 + X_c^2 \sigma_c^2 + 2X_i X_l \sigma_{il} + 2X_l X_c \sigma_{lc} +$

$2X_i X_c \sigma_{ic} - 2 X_d X_c \sigma_{cd} - 2X_d X_l \sigma_{dl} - 2X_d X_i \sigma_{di}) - \theta (X_l + X_c + X_i +$

$X_{NA} + X_f - X_d - X_{NL} - C - D) = 0$

If $(A - X_i - X_c - X_l - X_f)$ is substituted in for X_{NA} and $(A - X_d - C - D)$ is substituted in for X_{NL} then the θ expression is zero. Taking the first derivative of V with respect to all rate-sensitive variables yields the results in the next section.

FIRST ORDER CONDITIONS

1) $\delta V/\delta X_c = R_c - R_{NA} - \lambda (\sigma_{cw} - \sigma_{NAw})$

$- 2\lambda_1(X_c \sigma_c^2 + X_l \sigma_{lc} + X_i \sigma_{ic} - X_d \sigma_{cd}) = 0$

2) $\delta V/ \delta X_l = R_l - R_{NA} - \lambda(\sigma_{lw} - \sigma_{NAw})$

$- 2\lambda_1(X_l \sigma_l^2 + X_i \sigma_{il} - X_d \sigma_{ld}) = 0$

3) $\delta V/ \delta X_i = R_i - R_{NA} - \lambda(\sigma_{iw} - \sigma_{NAw})$

$- 2\lambda_1(X_i \sigma_i^2 + X_l \sigma_{li} + X_c \sigma_{ic} - X_d \sigma_{id}) = 0$

APPENDIX A (Continued)

4) $\delta V/\delta X_d = -R_d + R_{NL} - \lambda(\sigma_{dw} + \sigma_{NLw})$

$- 2\lambda_1(X_d\ \sigma_d^2 + X_1\sigma_{1d} + X_i\sigma_i d - X_c\sigma_{cd}) = 0$

5) $\delta V/\delta\theta = X_1 + X_c + X_i + X_{NA} + X_f - X_d - X_{NL} - C - D$

$= 0$

Next, each expression is set equal to 0 and is solved for its respective X_j

THE OPTIMAL VALUE OF EACH RATE-SENSITIVE ASSET OR LIABILITY

1) $X_c = \{R_c - R_{NA} - \lambda(\sigma_{cw} - \sigma_{NAw}) - 2\lambda_1(X_1\sigma_{1c} + X_i\sigma_{ic}$

$- X_d\ \sigma_{cd})\}/2\ \lambda_1\ \sigma_c^2$

2) $X_i = \{R_i - R_{NA} - \lambda(\sigma_{iw} - \sigma_{NAw}) - 2\lambda_1(X_1\sigma_{1c} + X_c\sigma_{ic}$

$- X_d\ \sigma_{id})\}/2\ \lambda_1\ r_i^2$

3) $X_1 = \{R_1 - R_{NA} - \lambda(\sigma_{cw} - \sigma_{NAw}) - 2\lambda_1(X_c\sigma_{1c} + X_i\sigma_{i1}$

$- X_d\ \sigma_{1d})\}/2\ \lambda_1\sigma_1^2$

4) $X_d = \{-R_d + R_{NL} - \lambda(-\sigma_{dw} + \sigma_{NLw}) - 2\lambda_1(-X_1\sigma_{1d}$

$- X_i\sigma_{id} - X_c\ \sigma_{cd})\}/2\ \lambda_1\ \sigma_d^2$

THE OPTIMAL GAP

To find the optimal proportion of rate-sensitive loans given a change in rate-sensitive deposits yields the following solution.

1) $\delta X_1 / \delta X_d = \sigma_{d1} / \sigma_1^2$

If all rate-sensitive assets are grouped together in the original model, then the optimal proportion of rate-sensitive assets would be

APPENDIX A (Continued)

$$2)\ X_{RSA} = \{ R_{RSA} - R_{NA} - \lambda(\sigma_{RSAw} - \sigma_{NAw}) - 2\lambda_1(X_d \sigma_{RSAd})\}/2\ \lambda_1\ r_{RSA}^2$$

Taking the change in rate-sensitive assets given a change in rate-sensitive deposits gives:

$$3)\ \delta X_{RSA}/\delta X_d = \sigma\ d\ RSA\ /\sigma_{RSA}^2$$

APPENDIX A (Continued)

HESSIAN MATRIX OF SECOND PARTIAL DERIVATIVES

δ V/	δX_1	δX_i	δX_c	δX_d	$\delta \theta$
δ X 1	$-2\ \lambda_1\ \sigma^2{}_1$	$-2\ \lambda_1\ \sigma_{1i}$	$-2\ \lambda_1\ \sigma_{1c}$	$-2\ \lambda_1\ \sigma_{1d}$	0
δX_i	$-2\ \lambda_1\ \sigma_1 i$	$-2\ \lambda_1\ \sigma_i{}^2$	$-2\ \lambda_1\ \sigma_{ci}$	$-2\ \lambda_1\ \sigma_{di}$	0
δX_c	$-2\ \lambda_1\ \sigma_{1c}$	$-2\ \lambda_1\ \sigma_{ci}$	$-2\ \lambda_1\ \sigma^2{}_c$	$-2\ \lambda_1\ \sigma_{dc}$	0
δX_d	$-2\ \lambda_1\ \sigma_{d1}$	$-2\ \lambda_1\ \sigma_{di}$	$-2\ \lambda_1\ \sigma_{dc}$	$-2\ \lambda_1\ \sigma^2{}_d$	0
$\delta \theta$	0	0	0	0	0

APPENDIX B

TEST DATA

Equation 1 (Three-Month Level)*

Gap/Total Assets = [Rcon(1425 + 1426 + 1546 + 1547 + 1554 + 1556) - Rcon(2459 + 2460 + 2466 + 2467 + 2492 + 2493)]/Rcon 2170
Net Interest Income/Total Assets = Riad 4074/ Rcon 2170
Rate-Sensitive Assets/Total Assets = [Rcon(1425 + 1426 + 1546 + 1547 + 1554 + 1556)]/Rcon 2170
Rate-Sensitive Liabilities/Total Assets = [Rcon (2459 + 2460 + 2466 + 2467 + 2492 + 2493)]/Rcon 2170
Size = 1 if specified size; 0 if not.
LDC Loans = 1 if invested in LDC loans, 0 if not.

Equation 2 (Three-Month Level)

Gap/Total Assets = [Rcon(1425 + 1426 + 1546 + 1547 + 1554 + 1556) - Rcon(2459 + 2460 + 2466 + 2467 + 2492 + 2493)]/Rcon 2170
Fee Revenue/Total Assets = Riad 4079/Rcon 2170
Rate-Sensitive Assets/Total Assets = [Rcon(1425 + 1426 + 1546 + 1547 + 1554 + 1556)]/Rcon2170
Rate-Sensitive Liabilities/Total Assets = [Rcon (2459 + 2460 + 2466 + 2467 + 2492 + 2493)]/Rcon 2170
Size = 1 if specified size; 0 if not.
LDC Loans = 1 if invested in LDC loans, 0 if not.

Equation 4 (Three-Month Level)

Gap/Total Assets = [Rcon(1425 + 1426 + 1546 + 1547 + 1554 + 1556) - Rcon(2459 + 2460 + 2466 + 2467 + 2492 + 2493)]/Rcon 2170
Rate-Sensitive Assets/Total Assets = [Rcon(1425 + 1426 + 1546 + 1547 + 1554 + 1556)]/Rcon2170
Rate-Sensitive Liabilities/Total Assets = [Rcon (2459 + 2460 + 2466 + 2467 + 2492 + 2493)]/Rcon 2170
Size = 1 if specified size; 0 if not.
LDC Loans = 1 if invested in LDC loans, 0 if not.

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* For the six-month level add
Rcon(1427 + 1548 + 1557) to rate-sensitive assets and
Rcon(2461 + 2471 + 2495) to rate-sensitive liabilities.
For the twelve-month level add
Rcon(1428 + 1549 + 1558) to rate-sensitive assets and
Rcon(2462 + 2471 + 2497) to rate-sensitive liabilities.

APPENDIX C

A SAMPLE LIST OF BANKS

	BANK	LOCATION	ASSETS (000,000)
1.	Bank of Hawaii	Honolulu, Hawaii	4,800
2.	Bank of Delaware	Wilmington, Delaware	1,300
3.	Bank South	Atlanta, Georgia	2,396
*4.	Bank East	Manchester, New Hampshire	415
5.	California First Bank	San Francisco, California	5,500
6.	Centerre	St. Louis, Missouri	3,900
7.	Central Trust;	Cincinnati, Ohio	304
8.	Central Bank	San Francisco, California	1,200
9.	City National Bank	Beverly Hills, California	3,100
10.	City Trust	Bridgeport, Connecticut	2,300
11.	Comerica	Detroit, Michigan	7,490
*12.	Commerce Union	Nashville, Tennesse	2,376
13.	The Commercial Bank	Salem, Oregon	158
*14.	Commonwealth Bank and Trust Company	Williamsport, Pennsylvania	806
15.	Connecticut National Bank	Hartford, Connecticut	9,327
16.	Fifth Third Bank	Cincinnati, Ohio	2,200
*17.	First Alabama Bank	Birmingham, Alabama	2,400
18.	First America Bank	Nashville, Tennessee	5,000
19.	First Florida Bank	Tampa, Florida	4,800
20.	First Hawaiian Bank	Honolulu, Hawaii	3,380
21.	First National Bank of Louisville	Louisville, Kentucky	4,200
22.	First National Bank of Maryland	Baltimore, Maryland	5,195
*23.	First National Bank	Cincinnati, Ohio	2,582
24.	First National Bank	Toledo, Ohio	820
25.	First Tennessee Bank	Memphis, Tenessee	5,500
*26.	First Union National Bank	Charlotte, North Carolina	15,700
27.	Florida National Bank	Jacksonville, Florida	6,800
28.	Indiana National Bank	Indianapolis, Indiana	3,800
29.	Maryland National Bank	Baltimore, Maryland	6,700
30.	Mercantile Bank	St. Louis, Missouri	4,360
31.	Merchant's Bank and Trust	Norwalk, Connecticut	280
32.	National Bank of Alaska	Anchorage, Alaska	1,170
33.	National City Bank	Minneapolis, Minnesota	441

APPENDIX C (Continued)

34. Union Trust Company	Stanford, Connecticut	2,280
*35. Old National Bank	Spokane, Washington	786
36. Bank of Virginia	Richmond, Virginia	5,971
37. Rainier National Bank	Seattle, Washington	8,270
38. Santa Monica Bank	Santa Monica, California	616
39. Security Bank and Trust Company	Southgate, Michigan	1,200
40. Shawmut Bank of Boston	Boston, Massachusetts	5,880
*41. Society National Bank	Cleveland, Ohio	5,000
42. South Carolina National Bank	Columbia, South Carolina	4,700
43. State Street Bank and Trust Company	Boston, Massachusetts	7,100
44. First National Bank of Toms River	Toms River, New Jersey	1,900
*45. United Bank of Denver	Denver, Colorado	2,860
46. United Carolina Bank	Whiteville, North Carolina	1,460
47. United States National Bank of Oregon	Portland, Oregon	8,470
48. United Virginia Bank	Richmond, Virginia	7,000
49. Valley National Bank Arizona	Phoenix, Arizona	9,400
50. Valley National Bank	Passaic, New Jersey	1,500
51. Bank of Boston	Boston, Massachusetts	20,000
52. The Bank of New York	New York, New York	19,450
53. Bankers' Trust	New York, New York	54,000
54. Chase Manhattan Bank	New York, New York	80,800
55. Chemical Bank	New York, New York	56,580
56. First National Bank of Chicago	Chicago, Illinois	33,400
57. First Pennsylvania Bank	Philadelphia, Pennsylvania	5,860
*58. First Wisconsin National Bank	Milwaukee, Wisconsin	4,100
59. Manufacturers Hanover Trust Company	New York, New York	60,600
60. Citizens First National Bank of New Jersey	Glen Rock, New Jersey	2,000
*61. Wachovia Bank and Trust Company	Winston Salem, North Carolina	9,500

APPENDIX C (Continued)

62. Wells Fargo Bank	San Francisco, California	39,000
63. Morgan Guaranty Trust Company of New York	New York, New York	67,800
64. Citibank	New York, New York	138,000
*65. National Bank of Detroit	Detroit, Michigan	12,900
*66. NCNB National Bank of North Carolina	Charlotte, North Carolina	12,000
*67. Fleet National Bank	Providence, Rhode Island	5,700

* The assets of the lead bank listed comprises 50% to 74% of the assets of the balance sheet of the bankholding company which owns it rather than 75% or more.
The assets of the other banks represent over 75% of the assets of the bank holding company .

APPENDIX D

TEST RESULTS: HYPOTHESIS 3 USING AGGREGATE INDEXES

Equation

Market Risk = $\alpha + \beta_1$ Gap/Total Assets + β_2 Rate-Sensitive Assets/Total Assets + β_3 Dummy LDC Loans + β_4 Size + ϵ

Three-Month **467 Observations**

No Index

α	β_1	β_2	β_3	β_4	R^2	F
.2	-1.23**	1.98*	.16	4.00**	.036	4.3
.2	.75	1.98*[b]	.16	4.00**	.036	4.3
.2	-.23	.99*[c]	.16	4.00**	.036	4.3

Three-Month Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.103	-.51	1.85*	.20	4.97**	.03	3.96
.103	1.34**	1.85*[b]	.20	4.97**	.03	3.96
.103	.41	.92*[c]	.20	4.97**	.03	3.96

One-Year Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.16	-1.1	1.9**	.12	1.2	.012	1.41
.16	.81	1.9**[b]	.12	1.2	.012	1.41
.16	-.15	.96**[c]	.12	1.2	.012	1.41

Long-Term

α	β_1	β_2	β_3	β_4	R^2	F
.042	-2.6*	2.56*	-.013	1.84	.015	1.78
.042	-.029	2.58*[b]	-.013	1.84	.015	1.78
.042	-1.32**	1.29*[c]	-.013	1.84	.015	1.78

APPENDIX D (Continued)

Six-Month

No Index

α	β_1	β_2	β_3	β_4	R^2	F
.02	-.598	1.897*	.18**	3.23	.036	4.3
.018	1.3*	1.897*[b]	.18**	3.23	.036	4.3
.018	.35	.95*[c]	.18**	3.23	.036	4.3

Three-Month Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.029	.28	1.51	.23**	3.49	.035	4.22
.029	1.79*	1.51[b]	.23**	3.49	.035	4.22
.029	1.04**	.76[c]	.23**	3.49	.035	4.22

One-Year Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.103	-.19	1.47	.158	-.0085	.01	1.27
.103	1.29**	1.47[b]	.158	-.0085	.01	1.27
.103	.55	.74[c]	.158	-.0085	.01	1.27

Long-Term

α	β_1	β_2	β_3	β_4	R^2	F
-.11	-1.58**	2.18**	.03	1.35	.009	1.05
-.11	.61	2.18**[b]	.03	1.35	.009	1.05
-.11	-.49	1.09**[c]	.03	1.35	.009	1.05

APPENDIX D (Continued)

Twelve-Month

No Index

α	β_1	β_2	β_3	β_4	R^2	F
.69*	.48	.01[b]	.24*	2.09	.02	2.9
.18	.998	1.27	.22*	3.22	.03	3.43
.17	.66	.59[c]	.2**	2.48	.027	3.25

Three-Month Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
1.09*	.98	-1.01	.32*	3.25	.03	3.62
.47	.996	.34[b]	.27*	3.34	.02	3.27
.79	.8	-.2[c]	.29*	2.9	.028	3.27

One-Year Treasury Bill

α	β_1	β_2	β_3	β_4	R^2	F
.37	.6	.78	.18	.48	.006	.74
.84**	.33	-.32[b]	.21	-.15	.006	.67
.5	.35	.21[c]	.18	-.08	.006	.66

Long-Term

α	β_1	β_2	β_3	β_4	R^2	F
-.2	.39	2.26**	.05	2.55	.008	.74
1.04*	-.44	-.69[b]	.13	.69	.003	.36
.43	-.42*	.33[c]	.07	.76	.002	.29

** Statistically significant at the 10% level
* Statistically significant at the 5% level
b Rate-Sensitive Liabilities/Total Assets
c (Rate-Sensitive Assets + Rate-Sensitive Liabilities)/Total Assets

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