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THE INTEREST RATE RISK OF COMMERCIAL BANKS

By

John Richard Phelps

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ABSTRACT

THE INTEREST RATE RISK OF COMMERCIAL BANKS

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The stock market values of depository institutions have become highly volatile because of the high level of interest rates in recent years. A number of controversies have unfolded as a result of this interest rate sensitivity. The first controversy involves the measurement of a depository institution's exposure to interest rate changes. The two common methods for measuring interest rate risk exposure are gap management and duration gap management. The second controversy involves the management of interest rate risk once exposure has been determined. A third controversy has recently developed through regulatory requirements. Some regulatory agencies are now developing risk-based capital requirements directly related to a depository institution's exposure to interest rate risk. The primary problem related to all of these controversies is that the interest rate risk of a depository institution has not yet been clearly defined.

In addition to redefining interest rate risk this study provides a value maximization model that is used to interpret the appropriateness of the various strategies available to manage interest rate risk. This model

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indicates that bank managers are in general ignoring a significant portion of their bank's interest rate risk exposure. The model also suggests that the appropriate strategy is simply a mild version of a borrow short and lend long strategy. That is, depository institutions should continue to profit from maturity intermediation but they should do so with less exposure to interest rate risk.

This study also includes an empirical test of the theoretical model. The empirical model is a two-index capital asset pricing equation. A two-step procedure is used. The first step generates interest rate sensitivity coefficients which are used as dependent variables in the second step. The empirical model supports the development and conclusions derived from the theoretical model. This study indicates that both gap and duration gap are necessary to determine a depository institution's interest rate risk exposure. Also, a zero gap or a positive gap will constrain the market value of a bank, thus, the optimal strategy is a negative gap position. Finally, an increase in capital requirements is found to reduce interest rate risk.

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CHAPTER I

INTRODUCTION

The stock market values of depository institutions have become highly volatile and have suffered from the high volatility in interest rates in recent years. Market experience and empirical studies have shown banks to be more sensitive to interest rate changes than non-financial firms, yet there are no hypotheses or theoretical models that fully explain the link between a bank's value and a change in interest rates. This interest rate sensitivity and the lack of theoretical hypotheses has left a number of controversies unsolved.

The first controversy involves the measurement of a depository institution's exposure to interest rate changes. The two common methods for measuring interest rate risk exposure are gap management and duration gap management. The second controversy involves the management of interest rate risk once the degree exposure has been determined. There are four asset-liability management strategies ranging from presumed elimination of interest rate risk to active maximization of interest rate risk. A third controversy has recently developed through regulatory requirements. Some regulatory agencies are now developing risk-based capital requirements directly related to a depository institution's exposure to interest rate risk.

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The primary problem related to all of these controversies and the lack of hypotheses and theoretical models is that the interest rate risk of a depository institution has not yet been clearly defined.

The focus of this study is to provide a better understanding of the interest rate risk of a depository institution. Specifically, the interest rate risk of a depository institution will be defined, a theoretical model is developed to provide information regarding the appropriate measurement techniques and strategies, and a number of hypotheses regarding interest rate risk are tested empirically. The following sections of this chapter will identify some of the key problems in the literature, define the main terminology in asset-liability management, state the purpose and contribution of this study, and will conclude with a plan of the dissertation.

INTEREST RATE RISK

An adequate definition of interest rate risk for a depository institution should have sexveral characteristics. First, the definition should relate interest rate uncertainty to the value of the firm. Second, the definition should allow for positive, negative or zero interest rate sensitivity. Third, it should be based on the balance sheet structure of the firm.[1] The following sections explain how the traditional and practitioner de

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definitions are lacking and concludes with a new definition of interest rate risk for a depository institution.

Traditional Definition

The traditional definition of interest rate risk involving price risk and reinvestment risk is as follows[2]:

> Interest rate risk is the uncertainty regarding the ending wealth position due to changes in market interest rates between the time of purchase and the target date. Interest rate risk comprises two risks, price risk and reinvestment risk.

Price risk represents the chance that interest rates will differ from the rates the manager expects to prevail between purchase and target date. Reinvestment risk arises because interest rates at which coupon payments can be reinvested are unknown. These two risks will have opposite effects on the investors' ending wealth position, and will offset each other if the portfolio is immunized. The portfolio is immunized if its "duration" (Macaulay type) is equal to the time remaining to the target date.

Duration is a common measure of the interest rate sensitivity of a portfolio and reflects the portfolio's price sensitivity to changes in market interest rates. This relationship is generally shown as follows:[3]

$$\% \Delta MV = \Delta i(-D)$$

where refers to changes, D is the Macaulay duration, MV is the market value of a portfolio, and i is the market interest rate. This formula implies that the relationship between interest rates and market value is always inverse.

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This traditional definition only addresses the interest rate sensitivity of a portfolio of assets or liabilities and not a portfolio of assets and liabilities. The distinction is obvious when it is realized that the traditional definition only observes negative interest rate sensitivity while the interest rate sensitivity of a depository institution may be positive, negative or zero.

Practitioner Definition

Practitioners view interest rate risk as the uncertainty about net interest income and define interest rate risk as follows[4]

> Interest rate risk is the risk of either gross income or money costs not responding absolutely to changes in the other as a result of money market conditions with possible decreases in net income.

Practitioners measure interest rate risk by identifying the potential sensitivity of net interest income to changes in money market interest rates. The technique is called gap management and is formulated as follows:

$$\Delta NII = \Delta i \ (GAP)$$

where NII is net interest income, i is the market interest rate, and the GAP is defined as rate-sensitive assets (RSA) minus rate-sensitive liabilities (RSL). Rate-sensitive assets and liabilities are those that have to be repriced or reinvested in the short-term (i.e., 3-month certificates of deposit, overnight fed funds, adjustable-rate loans). The remainder of the assets and liabilities are non-rate-sensitive (i.e., 30-year conventional mortgage, capital debe

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debentures, 5-year certificates of deposit), in that, the contracted interest rate does not change in the short-term. Thus, non-rate-sensitive assets (NRSA) and non-rate-sensitive liabilities (NRSL) will not be characterized by uncertain interest income or interest cost.

The claim from practitioners is that an institution operating with an identical amount of RSA and RSL (GAP = 0) would not incur any variation in net interest income due to changes in money market interest rates. The implication of their claim is that the bank could eliminate interest rate risk by operating with a zero GAP.

There are two problems with this view of interest rate risk. First, the non-rate-sensitive assets and liabilities are being ignored. If interest rate risk is to reflect the uncertainty regarding the market value of a depository institution due to changes in market interest rates, then all assets and liabilities must be considered. Even without the uncertainty about NII the market value of the NRSA and NRSL may not change in the same proportions and this will be reflected in the value of the institution.[5]

Secondly, the gap management technique assumes that interest rates on RSA and RSL change in equal amounts (Δi). The risk that these two interest rates do not change by equal amounts is called "basis risk." That is, basis risk reflects uncertainty about the spread between the interest rates on RSA and RSL. For example, if the interest rates

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on RSL increase by 2 percentage points and the interest rates on RSA increase by only 1 percentage point then NII will decline even if the institution is operating with a zero gap.

New Definition of Interest Rate Risk

In general, interest rate risk of a depository institution is the uncertainty regarding its market value due to changes in market interest rates. The interest rate risk of a depository institution is comprised of two risks, income risk and investment risk. These two risks arise because of a depository institution's holdings of rate-sensitive assets and liabilities and non-rate-sensitive assets and liabilities.

Income risk. Income risk is the uncertainty regarding the net interest income of a depository institution due to changing interest rates. This risk is a function of the relative amounts of RSA and RSL (the GAP) and basis risk. This component essentially reflects the narrow view of interest rate risk taken by practitioners.

Investment risk. Investment risk is the uncertainty regarding the market value of a depository institution's NRSA and NRSL due to changing interest rates. This risk is a function of the "duration gap" and basis risk. The basis risk is conceptually the same as for income risk, but when applied to investment risk, it reflects a change in the spread between the interest rates on NRSA and NRSL.

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The duration gap is approximately equal to the duration of a depository institution's assets minus the duration of a depository institution's liabilities.[6] The duration gap explains the effect of changing interest rates on the market value of the assets and liabilities as follows:

$$\% \Delta MV = \Delta i \, (-DG)$$

where MV represents the net market value of the assets and liabilities ($MV = MV_A - MV_L$), Δi reflects the change market interest rates, and DG is the duration gap. Note that since duration measures the relationship between market value and interest rate changes, and by definition the RSA and RSL reflect the market rate of interest, then the duration of a RSA or RSL is zero (since $\% \Delta MV = 0$). Thus, this technique ignores the income risk exposure of the depository institution, and only measures the interest rate risk exposure created by holding NRSA and NRSL (i.e., $MV = MV_{NRSA} - MV_{NRSL}$).

Similar to the gap management technique the proponents of the duration gap technique claim that an institution operating with a zero duration gap (DG = 0) will have eliminated interest rate risk. This is incorrect. The duration gap technique ignores both basis risk and income risk. For example, consider a depository institution with only RSA and RSL. In addition, the depository institution must have some formal capital position such that RSA are

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greater than RSL (gap > 0). If these assets and liabilities always adjust to reflect the market rate of interest then the duration gap of the depository institution's assets and liabilities will be zero. The depository institution is still exposed to interest rate risk as measured by its gap position and will still be exposed to basis risk.

A depository institution that holds rate-sensitive and non-rate-sensitive balance sheet items may be exposed to both components of interest rate risk. This definition of interest rate risk gives sufficient information to answer one of the controversies regarding interest rate risk. That is, both the gap and duration gap techniques are necessary in identifying exposure to interest rate risk, since each measures a different aspect of interest rate risk. The gap measures exposure to income risk and the duration gap measures exposure to investment risk. In addition, exposure to basis risk has to be considered in conjunction with both of these two measurement techniques.

ASSET-LIABILITY MANAGEMENT STRATEGIES

There are four primary strategies used by the banking industry to deal with interest rate risk: risk avoidance, intervention, traditional, and offset. Each strategy is independent and is adopted by management because of a belief in their own abilities (i.e., forecasting) or a belief in the stability of certain factors in the long-run (i.e., relationship between the business cycle and the term structure of interest rates).

Risk Avoidance Strategy

This strategy presumes that a zero gap will eliminate interest rate risk. That is, if RSA and RSL are of equal timing and magnitude then the bank's net interest margin will not vary. There are two problems with this strategy. First, it assumes the narrow definition of interest rate risk which only includes income risk. Second, the bank will still have basis risk if the spread between the interest rates on assets and liabilities is not constant.

Intervention Strategy

The underlying belief in this strategy is that management can predict interest rate changes accurately. If interest rates are expected to decrease then management will structure the balance sheet so that it is liability sensitive, that is, they will use a negative gap position. If interest rates are expected to rise then management will use a positive gap position.

This strategy is primarily concerned with maximizing short-run profits. Management is essentially maximizing risk to take advantage of their forecasted interest rate changes. Russian roulette may have better odds!

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Traditional Strategy

The underlying premise in this strategy is that the yield curve is inherently upward sloping. Thus, a strategy of borrowing short and lending long (or a negative gap position) is the best strategy in the long-run. The yield curve may become inverted for short periods and some losses may be incurred.

Interest rates will rise and then decline over a business cycle and any losses from the rise in rates will be offset later by a decline in rates. Thus, the net interest income over this cycle will come from the liquidity premium. Obviously, if there is to be an exact offset over the cycle the level of interest rates at the beginning of the cycle must equal the level at the end of the cycle and/or the bank's balance sheet structure can not change over the cycle. There is a natural tendency for the bank's balance sheet structure to change as interest rate expectations change. For instance, if interest rates are expected to decline, banks may have to offer relatively higher rates on short-term liabilities and relatively lower rates on long-term loans to maintain their short-term funding strategy. These adjustments will reduce the profitability of this strategy because the bank has created an artificial term structure with a lower liquidity premium. If interest rates are expected to rise the bank will be able to artificially increase the liquidity premium.

The advantages of this strategy are that the bank does not rely on interest rate forecasts to determine the sign of its gap, and with a negative gap the bank can be relatively confident that its duration gap will be positive. That is, borrowing short and lending long will produce assets with a longer duration than the duration of the bank's liabilities. The disadvantage is that the bank cannot be assured that the level of interest rates at the beginning of the cycle will be equal to the level of interest rates at the end of the cycle, and thus the offset over the cycle may not be exact.

Offset Strategy

This strategy suggests that a positive gap position always be taken. The underlying premise is that a positive gap and a positive duration gap will enable bank value to remain stable as interest rates change. Net interest income will have a direct relationship with interest rate changes and the market value of the banks non-rate-sensitive assets and liabilities will have an opposite and offsetting affect on stock prices. A major problem in utilizing this strategy is the requirement that the duration gap be positive. If the positive gap exceeds the book value of the banks equity then NRSL will be greater in amount than NRSA. Thus, the bank may have a negative duration gap and stock prices would not be stabilized as interest rates change.

WHICH STRATEGY SHOULD BE USED?

An asset-liability management strategy should have as its goal the maximization of the value of the bank. It is well recognized that a depository institution's value is a function of risk and return and that there is a tradeoff between the two. The degree of interest rate risk that a bank is justified in having is a function of its expected rate of return and the other types risk that affect the bank. The other types of risk that the bank faces in asset-liability management are credit risk, liquidity risk.[7]

Each of the strategies outlined above may fit a particular bank in a particular situation. The gap position taken will depend upon the volatility of interest rates which affects the ability to forecast, the relative durations of the assets and liabilities which determines the investment risk, the bank's relative stock market risk which is a function of the bank's asset portfolio (i.e., credit risk and liquidity risk), and the expected return provided by the relative spread in asset and liability interest rates. Ideally, a manager would like to find one strategy that is optimal under any conditions over the long-run.

If a bank is following a risk-avoidance strategy then it is assuming that interest rate risk outweighs any possible returns. The bank may be minimizing its income risk but is ignoring investment risk and could still have a significant amount of interest rate risk. If a bank follows an offset strategy it is assuming that income and investment risk will offset each other as interest rates change, and thus, the bank's stock price would be stable, ceteris paribus. The relative effects of these two risk components on stock prices are not known and could be significantly different. The relative importance of these two risk components may change over the business cycle. Thus, the relative importance and effects of these two components must be measured before the appropriate asset-liability management strategy can be chosen.

PURPOSE AND CONTRIBUTION

The purpose of this study is to provide a better understanding of interest rate risk as it relates to the value of a banking firm. The first contribution of this study has been to define interest rate risk for a depository institution. The second contribution has been to outline and identify the weakness of the various asset-liability management techniques and strategies used by practitioners. The third contribution is the development of a theoretical model that can be used to evaluate the appropriateness of the various asset-liability management techniques and strategies. There are no theoretical models in the literature that explain the interest rate risk of a depository institution. A fourth contribution is an empirical test of certain aspects of the theoretical model. Four hypotheses are tested regarding the existence of interest rate sensitivity, and the effect of term structure changes on a bank's interest rate sensitivity.

The relative importance to the bank's stockholders of the income risk and investment risk is not known. As stated in the four strategies of asset-liability management there can be a stock price stabilizing tradeoff between these two risk components or they can both change value in the same direction. Many banks ignore the investment risk component without knowing the policy's effect on the firm's market value. Many banks attempt to minimize income risk which may provide the bank with a lower market value than is optimal. A theoretical model based on value maximization can address these issues.

The theoretical and empirical models provide a basis for improved decision making in asset-liability management. The bank's stockholders and managers will benefit by knowing the process and tradeoffs that determine interest rate risk. In addition, the effect that bank regulators and monetary policymakers have on a bank's interest rate risk can be identified.

PLAN OF THE DISSERTATION

This research investigates the interest rate sensitivity of a bank and the hypotheses derived to explain it. Chapter II provides background for this study. It begins with a review of the empirical techniques used to measure interest rate sensitivity. Next, the theoretical hypotheses used to explain this sensitivity are outlined. Chapter III contains a theoretical model developed to explain the link between a bank's asset-liability structure and interest rate changes that create interest rate risk. Chapter IV is a description of the hypotheses and their relevant tests. Chapter V contains data analysis and Chapter VI follows with conclusions and recommendations.

FOOTNOTES

1. Empirical tests outlined in Chapter II have shown conclusively that interest rate sensitivity is a function of a financial institution's balance sheet structure.

2. See Hopewell and Kaufman, "Bond Price Volatility and Term to Maturity" for a derivation of the duration equation.

3. A depository institution still must be concerned with volatility in NII given prepayments and early withdrawls of NRSA and NRSL, respectively.

4. See Chapter III for the complete duration gap equation.

5. Credit risk is the risk that some loans may not repay all principal and interest as contractually stipulated. Many banks have reduced interest rate risk per se by creating variable rate loans. This was accomplished by increasing credit risk. Liquidity risk deals with the maturity of a bank's investment portfolio and the banks ability to create new loans. Either of these risks may be influenced by interest rate changes.

CHAPTER II

LITERATURE REVIEW

This chapter reviews the literature pertaining to the empirical tests of interest rate sensitivity and the hypotheses developed to explain interest rate risk. This review provides support and background for the remaining chapters in this study. In addition the deficiencies of the research on interest rate sensitivity are noted.

EMPIRICAL TESTS OF INTEREST RATE SENSITIVITY

In recent years there has been considerable research on the interest rate sensitivity of common stocks. There is little doubt that all common stocks are interest rate sensitive to some degree (Joehnk and Petty 1980, Lloyd and Shick 1977, Santoni 1985). Some common stocks are much more sensitive than others. Utilities have been shown to be more interest rate sensitive than financial institutions and financial institutions have been shown to be more interest rate sensitive than non-financial firms.

The sensitivity of utility stocks is well documented (Cohen et al., 1977, Dougall and Corrigan, 1978, Joehnk and Nielson, 1980) and is usually attributed to high dividend yields although Haugen, Stroyny, and Wichern (1978) have shown that the asset and liability characteristics of utilities may account for their interest rate sensitivity.

The purpose of this chapter is to review those articles that are concerned with the interest rate sensitivity of a financial institution's common stock.[1]

Stone's Two-Index Model

Most of the tests of interest rate sensitivity are based upon a two-index pricing equation developed by Stone (1974). Stone conjectured that the equilibrium returns of the common stocks of utilities and financial institutions could be explained by a model incorporating interest rates. Stone argues that the multi-period aspect of investing "forces one to recognize the existence of debt instruments with a series of maturities and the concomitant possibility of gains and losses from changes in interest rates analogous to the gains and losses from changes in the level of the equity market" (Stone 1974, p. 709). In other words, these common stocks are to some degree acceptable substitutes for fixed-income securities. To incorporate this additional possibility, Stone developed a two-index version of CAPM as follows:

$$R_j = A_j + B_j R_E + C_j R_B + e_j$$

where

R_j = the return on security j;
R_E = the return on an equity index;
R_B = the return on a bond index;
B_j = systematic equity risk;
C_j = systematic interest rate risk;
e_j = the error term.

Before the two betas can be estimated the indices must be adjusted for multicollinearity so that cov(R_E,R_D) = 0. The usual method is to orthogonalize the bond index.

It is unlikely that the common stock of a financial institution would be considered a substitute for a fixed-income security, at least not because of high dividend yields. None-the-less, Stone's two-index model was tested by Lloyd and Schick (1977), Chance and Lane (1980), and Flannery and James (1984). The results of these three tests yield mixed results as will be explained in the following sections.

Lloyd and Schick (1977). This study tested Stone's model finding mixed results for the sample period 1969 to 1972. The returns on the NYSE composite index and Salomon Brothers bond fund were used to generate the two beta coefficients. Two samples of securities were used as dependent variables--60 large commercial banks and the 30 firms included in the Dow-Jones Industrial Average. The results for the bank sample showed only marginal improvement in the explanatory power from the single-index CAPM model. Lloyd and Schick rationalize their results by stating that "the banks and their earnings should be more sensitive to short-term rather than long-term rates, and the index reflects primarily long-term rates. To the extent that short-term and long-term rates moved in different directions during the sample period, negative correlation is introduced between the bank's returns and the index" (p.367). In fact, Stone advocated that the bond index should be a portfolio of all maturities so that all term structure twists can be diversified away.

Chance and Lane (1980). This study provides an equivalent test of Stone's model using categories of financial institutions and a control group made up of utilities for the sample period 1972 to 1976. They used three different bond series to test if the maturity structure of the bond index made any difference. They did find significant differences in the results depending on the maturity of the bond index used, though they did not attempt to create a single index that included all maturities.

Chance and Lane found no extra-market sensitivity beyond that explained by the single-index model. They advocated that any sensitivity that does exist is by presumption of a relationship between interest rates and common stock prices that has created biased expectations. Thus, if investors would hold financial institution stocks, their returns would be no more interest rate sensitive than the returns from the common stock of non-financial companies.

Flannery and James (1984). This study estimated Stone's two-index model using weekly returns over the sample period 1976 to 1981. The returns were for a portfolio of 67 commercial banks and the equation was estimated using the residuals from an auto-regressive model with 3 lags. This series of residuals represented the unanticipated interest rate changes.[2] The results of the regressions showed the interest rate sensitivity coefficient to be positive and statistically significant for three interest rate indices (T-Bill, 7-year Treasury bonds, GNMA).

The interest rate indices represented the holding period return on the Treasury securities, and the dependent variable or the stock return series was the holding period return on common stocks, thus a positive relationship between these series would be expected. The interest rate series, which varied by maturity, were found to provide equivalent explanatory power in the two-index equation.[3] This implies that only a level change in interest rates will cause stock prices to vary.

The three interest rate sensitivity coefficients were significantly different. Flannery and James explain the differences in the magnitude of these coefficients using the fact that long-term bond prices respond more to a given change in the level of interest rates than do short-term bond prices. That is, to generate the same change in the holding period stock return caused by a change in the level of interest rates the multiple or coefficient on the holding period return of the T-Bill would have to be larger.

Other Interest Rate Sensitivity Studies

Joehnk and Petty (1980). Using a single-index model for the sample period 1962 to 1975 Joehnk and Petty found a significant relationship between stock prices and interest rates. The sample consisted of monthly return data on 126 firms in four classifications: Growth, Moderate Growth, Income, and Utilities. The interest rate series (6-month T-bills, 5-year Treasury notes, 30-year Treasury bonds, and Moody's average corporate bond yield) were computed as a relative change in the yield[4] and the findings were as follows:

1) The signs of the interest rate coefficients were negative and thus consistent with an expected inverse relationship[5], and
2) The maturity and type of interest rate series had a dramatic effect on the magnitude and significance of the mean stock price reaction. The Corporate bond series had the longest average maturity, the largest interest sensitivity coefficient and the greatest explanatory power.[6]

The study also showed that stock groups respond differently to interest rates. The sensitivity to interest rates increased with the dividend payout, though over time the relative difference in the interest rate sensitivity among the stock groups declined sharply. As stated earlier, a single-index model of interest rate sensitivity excludes the market index and thus does not attempt to show the interest rate relationship as extra-market covariance beyond that explained by the typical CAPM model.

Fogler, John, and Tipton (1981). This study tested a three-index model using monthly excess return data for the sample period 1959 to 1977. The difference from Stone's two-index model was the inclusion of two interest rate series, a Treasury bond index and a corporate bond index. The OLS coefficients for the two interest rates series were in general found to be insignificant. The data was also studied using principle components analysis where it was found that the Treasury bond index was significant in explaining stock market returns, though it was considerably less significant than the stock market index.

Folger et al., found that the lack of significance in the three-index model resulted from serious problems with multicollinearity and autocorrelation. That is, "bias in beta estimation would be expected in studies which used arbitrary periods for estimating beta if these periods did not provide an ex-post sample space which exactly coincided with ex-ante expectations" (Folger, et al. 1981, p. 333).

Most of the interest rate sensitivity studies have corrected for multi-collinearity by orthogonalizing the interest rate index. Of the studies reviewed only Flannery and James (1984) corrected for autocorrelation problems that are created through the relationship between current stock prices and expected interest rate changes. Any change in interest rates that is expected is already reflected in current stock prices, thus, studies that have not adjusted for autocorrelation have omitted at least one explanatory variable. The omission of this variable causes the OLS estimators to be inefficient and inconsistent resulting in upward bias in the variance estimators of the coefficients and thus conservative estimates of their significance (Maddala 1977, p. 156). Rather than adding the necessary explanatory variables it is best to eliminate the need for them. That is, rather than measuring the effect on the firm's share value from interest rate changes, the analysis should measure the effects from unexpected changes in the level of interest rates, and thus eliminate the need for an auto-regressive component in the equation. To find unexpected interest rates the indices must be transformed to white noise processes.

Santoni (1984). This study measured the effect of unexpected interest rate changes on the relative value of firms for the sample period 1961 to 1983. To investigate this issue, he found the interest elasticities[7] by regressing share price indices on the Aaa corporate bond rate and the growth rate of real GNP. The GNP variable was added to control for cyclical factors. The results show that the interest rate elasticity of the stock prices are both negative and statistically significant. That is, increases in the long-term interest rate are associated with decreases in the values of both industrial and financial firms.

The interest rate elasticity of Savings and Loan stocks was found to be six times that of the firms in the S&P 400, and three times that of commercial banks. In addition, Santoni attempted to control for changes in the term structure of interest rates by including the percentage change in the 3-month Treasury bill rate, the percentage change in the ratio of the 3-month Treasury bill rate to the Aaa bond rate, and the percentage change in the difference between one plus the 3-month Treasury bill rate and one plus the corporate Aaa bond rate. The results showed these variables to be insignificant and Santoni concluded that only the unexpected changes in the long-term rates were important in determining stock prices.

Summary

It has been found that common stock prices are indeed sensitive to unexpected interest rate changes, where unexpected is that portion of the interest rate change that cannot be explained by an auto-regressive model. As stated earlier, any change in interest rates that is expected is already reflected in current stock prices and will not affect the stock price when the expected change occurs.

Thus, rather than including an autoregressive component in the model the series are adjusted to exclude the need for the autoregressive component.

The studies have shown that interest rate sensitivity is related to the stock's grouping, for instance, commercial banks and savings and loans tend to be more interest rate sensitive than are non-financial firms. The significance of interest rates in explaining stock price changes is clear, though the importance of one rate maturity over another is not clear. The next section will sort out the varying hypotheses used to explain interest rate sensitivity.

HYPOTHESES OF INTEREST RATE SENSITIVITY

A common deficiency of the empirical research is the lack of a theoretical model to explain interest rate sensitivity. In fact, many of the articles lack any hypotheses or tests to explain the existence of interest rate sensitivity. There are, however, three hypotheses that have been put forth: the Substitution hypothesis, the Bias hypothesis, and the Asset-Liability Structure hypothesis. The Substitution hypothesis was the basis for Stone's (1974) two-index model. The Bias hypothesis was suggested by Chance and Lane (1980) as a rationalization for not finding any interest rate sensitivity in their empirical analysis. The Asset-Liability Structure hypothesis consists of a number of specific hypotheses concerning earnings, leverage, nominal contracting, charter value, and the "gap". The following section is an evaluation of each of these hypotheses.

The Substitution Hypothesis

Because of the interest rate sensitivity of utility stocks (Cohen et al. 1977, Dougall and Corrigan 1978, Joehnk and Nielson 1980) and a seemingly strong relationship between dividend yields and interest rate sensitivity (Joehnk and Petty 1980) the primary hypothesis has been that stocks with high dividend yields are acceptable substitutes for fixed income securities. In the case of financial institution stocks, their modest dividend yields suggest that they are unlikely to be perceived as substitutes for fixed income securities. In fact Haugen, Stroyny, and Wichern (1978) found that the asset and liability characteristics of utilities may account for their interest rate sensitivity.

The Bias Hypothesis

Chance and Lane (1980) hypothesized that any interest rate sensitivity that exists is simply biased expectations that have been created by a false assumption. They derived this hypothesis because of a lack of evidence from their empirical test. The results of this empirical test could not even prove that utilities were interest rate sensitive beyond that encompassed in the stock market index. As noted earlier and explained by Folger et al. (1981), Chance and Lane used a biased equation that would tend to understate reality. Also, since some banks are affected by interest rates significantly more than others it is doubtful that the interest rate sensitivity is being created by purely irrational behavior by investors.

The Asset-Liability Structure Hypothesis

A number of hypotheses have been tested using some element of the balance sheet as the basis for interest rate sensitivity. Some of these hypotheses can be easily ruled out (leverage and charter value), while others only tell half of the story (earnings and nominal contracting), and one hypothesis represents the basis for this study.

Leverage hypothesis. Several studies have examined a bank's share price volatility in relation to a variety of leverage ratios (Beighley et al., 1975, Reints and Vandenberg, 1977). These studies attempt to explain the bank's share price volatility as a function of their high leverage due to reliance on nominal liabilities (demand deposits, notes, etc.). Leverage is assumed to increase the bank's risk in a similar fashion to non-financial firms, yet a bank's asset returns and liability costs are correlated and this would tend to reduce the impact of leverage on the variability of a bank's stock returns. Also, a bank's balance sheet structure changes significantly when business conditions change. Since all banks have relatively the same degree of leverage this hypothesis cannot explain why banks have varying degrees of interest rate sensitivity.

Charter Value Hypothesis. Dermine (1985) argues that interest rates also affect the charter value or goodwill of the bank beyond the effect from nominal and real assets. Goodwill is defined as the present value of net income the bank would be expected to earn on new business if it were to retain only its offices, employees and customers. The key Dermine suggests is that all banks are not alike in authorized power, in the expertise of their employees, and the customer relationships that they have developed.

This hypothesis can be applied to all firms, financial and nonfinancial. Dermine does not suggest why goodwill would be more important for banks. Thus, this hypothesis can not explain why banks would be more interest rate sensitive than non-financial firms.

Earnings Hypothesis. This hypothesis states that the asset-liability structures of some firms transmit interest rate movements to the market which signal investors that earnings prospects have changed. For instance, if banks are more adept at forecasting interest rates than are the stockholders, the stockholders will recognize it and will watch for balance sheet changes that identify the bank's expected movement in interest rates. The expected interest rate changes then are used to project earnings changes.

Studies based on the earnings hypothesis have related a bank's accounting earnings to balance sheet factors (Wall 1985) and interest rates (Flannery 1983). These studies have found that there is a strong relationship between a bank's asset-liability structure and its net earnings. In addition, changing interest rates appear to be a major cause of earnings variability. These studies are not direct tests of interest rate sensitivity because they ignore the effect on interest rates on the firm's value.

Nominal Contracting Hypothesis. Flannery and James (1984) regressed the weekly holding period return on a portfolio of bank stocks to market risk (in the CAPM sense) and interest rate risk. The interest rate coefficient derived from this regression was then used as an dependent variable for a regression with a measure of the bank's asset-liability maturity structure. They demonstrated that the interest rate sensitivity of a bank's stock returns is related to its balance sheet composition. The authors base their study on the "nominal contracting" hypothesis, as discussed above, and tested for non-bank stocks by French, Ruback and Schwert (1983). The nominal contracting hypothesis suggests that a firm's holdings of nominal assets (non-rate-sensitive), those that stipulate fixed-dollar payments, explain the behavior of the common stock returns through a redistribution effect of unanticipated inflation and unanticipated changes in expected inflation.

The unanticipated inflation (ceteris paribis) affects the real value of the nominal assets because their cash flows do not change but the real asset's (rate-sensitive) market value is not affected because they are short-term or are repriced to reflect current market rates. The bank's liabilities face similar though opposite effects on the bank's value. Thus a firm with fewer nominal assets than nominal liabilities should benefit from unexpected inflation.

French et al. (1983) found little support for the effect of the nominal contracting hypothesis for the industrial firms they studied. Flannery and James suggest that this lack of support was due to inadequate balance sheet data for the industrial firms studied. As mentioned, Flannery and James provided support for this hypothesis and their balance sheet data for banks was more detailed than the data used by French et al. for industrial firms. This nominal contracting hypothesis does not explicitly consider the income risk component, and thus, does not explain all of a bank's interest rate risk.

The nominal contracting hypothesis is based on the assumption that any difference in the non-rate-sensitive assets and liabilities creates a difference in the rate-sensitive assets and liabilities. Thus, if a bank takes on investment risk through differing balances in the non-rate-sensitive categories it is by default taking on income risk. This is a very narrow view of what is really taking place. The difference in the balance sheet amounts of NRSA and NRSL is not nearly as important as their relative durations. The nominal contracting hypothesis does not explain basis risk or income risk. The following section provides an examination of those articles that in one form or another present both components of interest rate risk.

The Two Component Hypothesis. Joehnk and Petty (1980) use an "operational version" of the present value stock valuation model to explain the two components of interest rate risk. The model is as follows:

$$V = \sum_{t=1}^{n} Ct \;/(1+i)^{t}$$

The bank's value can be affected through two components, the effect on cash flows (Ct) and the effect from a change in the discount rate (i). Mitchell (1985) defines these two components as income risk and investment risk. As previously defined, the income risk is the variability of income (Ct) created through the rate-sensitive assets and liabilities from interest rate changes. Investment risk is the variability of the net present value of the assets and liabilities created through the non-rate-sensitive assets and liabilities from a change in the discount rate (i). These two components are an integral part of the theoretical model developed in the next chapter where an example will be provided to further explain the distinction between income and investment risk.

Summary

In summary, banks are found to face two components of interest rate risk, income and investment risk. In fact, it is the banks holding of rate-sensitive assets and liabilities that creates income risk and the holding of non-rate-sensitive assets and liabilities that creates investment risk. The nominal contracting hypothesis argues that only investment risk is important in determining the interest rate sensitivity of stock returns, when in fact, there is also an indirect effect on value from the income risk component.

CONCLUSIONS

From the articles reviewed in this chapter a reasonable conclusion is that interest rate sensitivity exists and can be considered extra-market covariance since there is an obvious group effect. There is no consensus about which if any particular interest rate creates more interest rate sensitivity than the others. This may imply that only a level change in interest rates is important or that both short-term rates and long-term rates have an effect as might be expected when the two components of interest rate risk are considered. This is certainly a testable aspect of this study.

Flannery and James (1984) showed that the interest rate sensitivity of a bank is a function of its asset-liability structure. A bank's asset-liability structure creates interest rate risk or income and investment risk. Certainly a bank manager, the bank regulatory agencies, the Federal Reserve Board, and investors should be concerned with the relative importance of these two components. The following chapter develops a theoretical model based on these two interest rate risk components and will allow an analysis of the asset-liability management strategies outlined in Chapter I.

FOOTNOTES

1. Those articles that are concerned only with the interest rate sensitivity of a bank's net interest income are not reviewed.

2. The concept of unanticipated interest rate changes is explained in the next section under Folger, John, and Tipton (1981). If interest rate series are not adjusted in this manner significant error may be introduced into the regression.

3. The explanatory power (R^2) was .57 for the GNMA and T-bill regressions, and .56 for the 7-year Treasury bond regression.

4. The relative change in the yield was measured as $(Y_{t-1} - Y_t)/Y_t$ where Y_t is the specified percentage interest rate series.

5. Note that in the Flannery and James study the holding period returns were used for the interest rate series and a positive interest rate sensitivity coefficient was expected. Joehnk and Petty used the interest rate or yield and thus a negative relationship would be expected.

6. This is in obvious conflict with Flannery and James (1984) findings of a larger coefficient with short-term rates and no difference in the explanatory power of the individual rates.

7. The elasticities are calculated using the logarithm of the interest rate and stock price changes.

CHAPTER III

THEORETICAL MODEL

This chapter begins with an example of the two components of interest rate risk, income and investment risk. This example provides the foundation for the theoretical model of interest rate risk developed in this chapter. The theoretical model uses a value maximization framework to the analyze the relative importance of the two interest rate risk components. These two risk components enter the theoretical model through the "gap" and "duration gap", two common measures that banks use to assess their interest rate risk exposure. The conclusion of this chapter examines the effect that monetary policymakers and bank regulators have on the interest rate risk of a bank.

THE TWO COMPONENTS OF INTEREST RATE RISK

To date, no author has explicitly modeled both components of interest rate risk. As pointed out earlier, income risk is the risk of loss in net interest income that results from imperfectly synchronized movements in the funds available for repricing as well as the movements in borrowing and lending rates. This risk is a function of a bank's gap and the relative interest rates on RSA and RSL, and represents an adjustment to a bank's market value, by the stockholders, as compensation for uncertainty about net interest income.

The investment risk component of interest rate risk is the risk of loss[1] in the net market value of a bank's assets and liabilities from interest rate changes. This risk is created through a difference in the durations[2] of the non-rate-sensitive assets (NRSA) and non-rate-sensitive (NRSL) liabilities. Three factors are involved: 1) a difference in the relative amounts of NRSA and NRSL; 2) the relative maturities of NRSA and NRSL; and 3) the relative interest rates on NRSA and NRSL. Investment risk is measured by the difference in the durations of NRSA and NRSL which is called the "duration gap". A positive duration gap will mean that NRSA will be more interest rate sensitive than NRSL. A zero duration gap does not eliminate investment risk if movements in the borrowing and lending rates are not perfectly correlated. This risk represents the reduction in a bank's market value as compensation for uncertainty about the net market value of the banks NRSA and NRSL. Increasing either of these risks will reduce the market value of the bank, but these risks may be offset by a higher expected net interest income. The following example is used to illustrate the existence of the two interest rate risk components. Three scenarios are analyzed to show the relationship of income risk and investment risk to the bank's asset-liability structure.

The bank's interest rate risk is implied from its expected interest rate sensitivity.

Consider a hypothetical bank with the following balance sheet structure: a 1-year time deposit of $90 paying 8 percent, equity of $10, and a seasoned portfolio[1] of 3-year loans totaling $100 and earning 10 percent. The time deposit will be rolled over and repriced at the end of each year. Equity receives 50 percent of the net interest income while the other 50 percent is used to pay operating expenses. The 3-year loan cannot be prepaid, but one-third of the loan portfolio will mature in each year and will be invested in another 3-year loan.

The three scenarios are as follows: no interest rate change, a 100-basis point increase in interest rates, and a 100-basis point increase in interest rates with an alternative balance sheet structure. A table is provided for each of the scenarios and consists of the balance sheet and income statement at the end of years one and two.

Scenario I

Table 3.1 presents a scenario of stable interest rates. If interest rates do not change, the balance sheet and income statement will not change. All assets and liabilities will retain their initial market values and net interest income will be maintained.

The net interest income of $2.80 is the result of the difference between the return on the loan portfolio and the cost of the time deposit. Obviously, if interest rates do not change then the effect of interest rates on the bank's market value would be zero, and there would be no interest rate sensitivity, this does not imply zero income risk. A bank's interest rate risk is a function of its expected interest rate sensitivity, and even though interest rates did not change the bank's market value will be adjusted at time zero to reflect potential changes in interest rates as they relate to the bank's balance sheet structure.

Scenario II

Table 3.2 presents a scenario of an increase in interest rates of 100 basis points during the first year. The bank's initial balance sheet structure has a gap of -$57.67 (RSA - RSL = $33.33 -$90) and a difference in the NRSA and NRSL of $67.67 (NRSA -NRSL = $67.67 - $0). The gap implies income risk, and the difference in the non-rate-sensitive assets and liabilities implies investment risk. An increase in interest rates will decrease net interest income because of the negative gap position, and the market value of the bank's net worth will decline because the market value of the bank's NRSA will decline.

Table 3.1

Year-end balance sheets and income statements for a hypothetical bank

Balance Sheet (Market Value)	Begin Year 1	End of Year 1	End of Year 2
Assets(3-yr @10%)			
Time to Maturity			
1-yrs @10%	$ 33.33	$ 33.33	$ 33.33
2-yrs @10%	33.33	33.33	33.33
3-yrs @10%	33.33	33.33	33.33
Liability(1-yr @8%)	90.00	90.00	90.00
Net Worth	10.00	10.00	10.00
Income Statement			
Income		$ 10.00	$ 10.00
Expenses		7.20	7.20
Net interest income		$ 2.80	$ 2.80

As expected, Table 3.2 shows that the bank is exposed to both components of interest rate risk. The bank's net interest income would decrease by $ .57 and the market value of the bank's net worth would decrease by $ .87. If interest rates were to decrease net interest income and net worth would both have increased. These two effects represent the expected interest rate sensitivity of the bank. The bank's market value is adjusted today to reflect these expectations. The adjustment to market value is the bank's interest rate risk. The next scenario uses a balance sheet structure that reduces the interest rate sensitivity of the bank which implies that interest rate risk is reduced. A reduction in a bank's interest rate risk does not necessarily mean that the bank's value will be greater, since expected returns may also be lower.

Table 3.2

Year-end Balance Sheets and Income Statements for a Hypothetical Bank When Both Rates Increase

Balance Sheet (Market Value)	Begin Year 1	End of Year 1[b]	End of Year 2
Assets(3-yr @10%)[a]			
Time to Maturity			
1-yrs @10%	$ 33.33	$ 33.03[d]	$ 33.03
2-yrs @10%	33.33	32.76[c]	32.76
3-yrs @10%	33.33	33.33	33.33
Liability(1-yr @8%)	90.00	90.00	90.00
Net Worth	10.00	9.13	9.13
Income Statement			
Income		$ 10.00	$ 10.33
Expenses		7.20	8.10
Net interest income		$ 2.80	$ 2.23

a. Due to rounding assets do not sum to $100.

b. Remember that this is a seasoned portfolio. The market value indicated here is that of the loan that had 2-years to maturity at beginning of year 1. The 3-years to maturity asset is issued at the end of year 1 and thus its market value is $33.33 since it is issued at the market rate of 11%.

c. $$\$32.76 = \frac{\$3.33}{(1.11)} + \frac{\$36.67}{(1.11)^2}$$

d. $$\$33.03 = \frac{\$36.67}{(1.11)}$$

Table 3.3

Year-end Balance Sheets and Income Statements for a Hypothetical Bank When Both Rates Increase

Balance Sheet (Market Value)	Begin Year 1	End of Year 1[b]	End of Year 2
Asset (1-yr @9%)	$ 85.00	$ 85.00	$ 85.00
Assets(3-yr @10%)[a]			
Time to Maturity			
1-yrs @10%	$ 5.00	$ 4.96[e]	$ 4.96
2-yrs @10%	5.00	4.91[d]	4.91
3-yrs @10%	5.00	5.00	5.00
Liability(1-yr @8%)	90.00	90.00	90.00
Net Worth	10.00	9.87	9.87
Income Statement			
Income		$ 9.15	$ 10.05[c]
Expenses		7.20	8.10
Net interest income		$ 1.95	$ 1.95

a. Due to rounding assets do not sum to $100.

b. Remember that this is a seasoned portfolio. The market value indicated here is that of the loan that had 2-years to maturity at the beginning of year 1.

c. The shortest term 3-year asset matures and the bank receives the principle of $5.00 which is reinvested in a new 3-year loan at the new rate of 11%. The income is calculated as 9% on the 1-year asset, 10% on 2/3 of the 3-year assets, and 11% on the 3-year asset issued at the beginning of year 2. Expenses have increased to 9% on the liabilities.

d. $$\$4.91 = \frac{\$0.50}{(1.11)} + \frac{\$5.50}{(1.11)^2}$$

e. $$\$4.96 = \frac{\$5.50}{(1.11)}$$

Scenario III

Table 3.3 presents a scenario in which the bank begins with a balance sheet structure that is different from the first two scenarios. The adjustment in the balance sheet structure is such that the bank has a zero gap position [RSA - RSL = ($85+$5)-$90]. The rate-sensitive assets consist of $5.00 of 3-year loans and $85 of 1-year loans. This would be a risk-avoidance strategy and is an attempt to eliminate interest rate risk. Assuming a perfect correlation between the rate-sensitive interest rates this strategy would eliminate income risk, but as the example shows the bank would still be exposed to investment risk.

As expected, Table 3.3 shows that the increase in interest rates would not affect the bank's net interest income. This restructuring also reduces the bank's investment risk because there is a smaller gap in the amount of NRSA and NRSL. By structuring its balance sheet in this way the bank has reduced its interest rate risk but its average initial interest rate on its assets is 9.15% [9%(85/100)+10%(15/100)] which is lower than the 10% interest rate given in scenarios I and II. Does the lower level of interest rate risk in scenario III offset the lower return that it will generate? The next section will attempt to answer this question by analyzing this hypothetical bank's stock price given the various scenarios.

Stock Price Changes

The previous example has shown the relationship between a bank's balance sheet structure and changes in interest rates. How do these changes translate into a stock price change? Assume that there is one stockholder who receives 50 percent of the net interest income as dividend (100% dividend payout) with the remaining 50 percent used to pay operating expenses. Additionally, assume that the investors initial required rate of return is 15 percent and is adjusted according to the interest rate change. Using a present value stock valuation model the effect of the two interest rate risk components can be analyzed. The model with a zero growth assumption is as follows:

$$\text{Value} = D_1 / K$$

where D_1 = Expected Dividends
K = Required Rate of Return

There are two conclusions that may be derived from Table 3.4. First, the lower risk (and lower return) of scenario III gives it a lower initial market value than scenario II when both are evaluated at the same required rate of return (15%). Scenario IV is an analysis of scenario III when the required rate of return is lowered to reflect the lower risk. In fact, the required rate of return on scenario III would have to be lowered to 10.45% for it to have the same initial market value as scenario II. Is the reduction of risk in scenario III large enough to justify a 4.55% decline in the bank's required rate of return? This example can not measure the tradeoff between risk and return, but it is possible that scenario II would provide a higher market value for the bank than would scenario III.

Table 3.4

Market Value of Hypothetical Bank Under Alternative Scenarios and Isolating The Two Risk Components

	FORMULA	SCENARIO II	III	IV
(A) Initial MV	(D_1/K_0)	\$9.33	\$6.50	\$9.33
(B) Ending MV				
Change D	(D_2/K_0)	7.43	6.50	6.09
Change K	(D_1/K_1)	8.75	6.09	8.52
Change both	(D_2/K_1)	6.97	6.09	8.52

a. Scenario IV is based on the assumption that the required rate of return would be lower under a risk avoidance strategy. The required rate of return that would make the initial market value of scenario III equal to the market value of scenario II is 10.45 percent.

The second conclusion has to do with the relative changes in the bank's market value when income risk and investment risk are isolated. Obviously, not all of the factors that create interest rate risk can be considered in this simple valuation model, though the model does indicate that impact on value from income changes (proxy for income risk) may be larger than the impact on value from changes in the required rate of return (proxy for investment risk). This simplified model assumes that a bank's market value will change contemporaneously with interest rates when in fact the value of the bank is based on expectations which may change with the bank's balance sheet structure. That is, if a change in interest rates was within the stockholders expectations and further expectations are not affected there should be no need to adjust the bank's value, or if the bank adjusts its balance sheet so as to maintain the same interest rate risk it had prior to the interest rate change there should be no need to adjust the bank's value.

Summary

The results from the simple example and valuation model in this section cannot thoroughly explain interest rate risk, but they serve to demonstrate the existence of the income and investment risk components. The potential interest rate sensitivity of a bank was used to measure its interest rate risk. The example restricted the bank from changing its balance sheet structure as interest rates changed. This over-estimates the influence that interest rates have on the market value of a bank. Nonetheless this section has provided a basis for the theoretical model developed later in this chapter.

A bank must have an asset-liability management strategy to facilitate the control of interest rate risk, these strategies were outlined in Chapter I. In order to monitor these strategies the gap and/or duration gap must be measured. These two measures of interest rate risk exposure have problems that need to be overcome before they can be used. The next section defines these measures and addresses the difficulties that arise in their use.

PROBLEMS IN MEASURING INTEREST RATE RISK

Earlier the two measures of interest rate risk were briefly defined but the problems that arise when using them were not addressed. The data and informational requirements of these two measures can complicate asset-liability management. In this section, the two measures are defined in greater detail, the measurement problems are addressed, and then the use of these two measures are adapted to the theoretical model.

Gap Analysis

Gap analysis is used to measure the exposure of net interest income to fluctuations in interest rates (Mitchell 1985, Toevs 1982, Kaufman 1984). The Gap is defined in terms of assets or liabilities that either mature or are repriced within the decision period. These assets and liabilities are considered rate-sensitive and the gap is calculated as follows:

(3.1) $$Gap = RSA - RSL$$

A negative gap suggests a negative relationship between a change in the level of interest rates and net interest income, while a positive gap suggests a positive relationship, and a zero gap suggests that net interest income will be unaffected by changes in interest rates. This measure completely ignores investment risk.

Duration Gap Analysis

Duration Gap analysis is used to insulate net worth from investment risk and measures the exposure of net worth to interest rate fluctuations (Mitchell 1985, Toevs 1982). The duration gap is defined as follows:

(3.2) $$DG = D_A - D_L [MV_L / MV_A]$$

where
DG = Duration gap
D_A = the duration of the banks assets
D_L = the duration of the banks liabilities
MV_A = the market value of the banks assets
MV_L = the market value of the liabilities

Additionally,[2]

(3.3) $$\frac{\Delta NW}{MV_A} = (-DG)(\Delta r)$$

where
Δr = unexpected interest rate change
NW = net worth = $MV_A - MV_L$
ΔNW = change in net worth (i.e., market value)

The relationship between net worth and interest rates is negative (-DG) and the interest rate sensitivity of net worth increases with the difference between the asset and liability durations. For example, given the initial asset-liability structure in Table 3.2 the duration gap = .98 while in Table 3.3 the duration gap = .23. Thus, a 100-basis point change in interest rates would lead to an expected change in the bank's net worth of $ .98 and $ .23, respectively.

Duration gap analysis requires information on maturity dates, interest rates, payment schedules, estimated prepayments, early withdrawals, and seasonality of the cash flows. Some of the bank's deposits are subject to a high degree of variability and this which further complicates the measurement of duration. The data and informational requirements make duration analysis too complex for many financial institutions.

Many authors consider the duration gap to be a measure of both components of interest rate risk (Kaufman 1984, etc.). For instance, it is commonly shown that a zero duration gap will allow no change in net worth (implied market value of the bank's common equity) if interest rates change, yet the net interest income of the bank can change dramatically. Thus, it implies that a bank with all rate-sensitive assets and liabilities and a zero duration gap has the same amount of interest rate risk as a bank with all non-rate-sensitive assets and liabilities and a zero duration gap. This is an absurd notion! The duration gap is not capturing income risk, and is only a measure of the bank's exposure to the separate component of investment risk.

The Choice of Measures

The choice between these two measures of interest rate risk is dependent upon the relative importance of income risk and investment risk. Mitchell suggests that a bank with a small number of stockholders would most likely prefer stable income and therefore would choose gap analysis. A bank with a large number of stockholders would prefer stable stock values and would choose duration gap analysis. This view seems too simplistic. The goal of the firm is to maximize value. This goal is not necessarily attained by stabilizing income or stock values. Both risk components are important when maximizing the value of the banking firm, and both measures of interest rate risk exposure are required.

In the next section a theoretical model of interest rate sensitivity is developed. The model includes both components of interest rate risk in a value maximization framework. In addition, both measures of interest rate risk are incorporated and used to analyze a bank's optimal asset-liability structure. The purpose of the model is to identify the process whereby interest rates affect a bank's value, and to show the separate effects on value from investment and income risk.

THE BANK MODEL

The bank is assumed to operate in two primary segments, rate-sensitive and non-rate-sensitive, over a single-period horizon. The bank creates assets and raises liabilities in both segments. The return and interest cost in the rate-sensitive segment are uncertain. The return and interest cost in the non-rate-sensitive segment are fixed (ie certain) for the decision period. The bank issues a fixed amount of capital that affects the amount of liabilities the bank can raise given its maximum liability to capital regulatory requirement.[3] The bank's profit at the end of the decision period is

$$(3.4) \quad \tilde{\pi} = A_R\tilde{r}_R + A_N r_N - L_R\tilde{d}_R - L_N d_N$$

and the bank's expected profit is

$$(3.5) \quad E(\tilde{\pi}) = A_R r_R + A_N r_N - L_R d_R - L_N d_N$$

where

A_R = the amount of rate-sensitive assets
A_N = the amount of non-rate-sensitive assets
L_R = the amount of rate-sensitive liabilities
L_N = the amount of non-rate-sensitive liabilities
r_R = the expected rate of return on rate-sensitive assets
r_N = the expected rate of return on non-rate-sensitive assets
d_R = the expected money cost on rate-sensitive liabilities
d_N = the expected money cost on non-rate-sensitive liabilities

The bank is assumed to maximize its market value which is a function of the cash flows specified above and the riskiness of these cash flows. The valuation model used in this study is a certainty equivalent model within the Capital Asset Pricing Model framework.[4] The valuation model is explained in the following sections beginning with a basic version. This basic version of the valuation model is systematically expanded to generate a model that highlights the two components of interest rate risk.

Certainty-Equivalent Model

The following equation is the present value of the certainty-equivalent of the end-of-the-period profit within the capital asset pricing model (CAPM). This objective function is appropriate since the stock of the banking firm is traded in perfect securities markets.[5]

$$(3.6) \qquad V = \frac{1}{R}\left[E(\tilde{\pi}) - \lambda CV(\tilde{\pi}, \tilde{M}) \right]$$

where

R = one plus the risk-free rate
M = aggregate cash flow of all firms in the market and all bonds on the market
$CV(\pi, M)$ = covariance between the cash profit of the bank and the aggregate cash flow of all firms in the market and all bonds on the market systematic risk within the two index CAPM framework
λ = the market price of bearing risk

This model depicts the market value of a firm's common stock as the present value of the expected cash profit at the end of the period less an adjustment for risk. The risk adjustment includes the aggregate cash flows of all firms and all bonds in the market. These aggregate cash flows are composed of the cash flows of the bank, the cash flows of all other firms, and the cash flows of all bonds in the economy. The aggregate cash flows can be shown as follows:

$$\tilde{M} = \tilde{\pi} + \tilde{E} + \tilde{B},$$

where E = the aggregate cash flow of all other firms, and B = the aggregate cash flow of all bonds in the economy. Therefore, in Equation (3.6) the covariance term can be written as

$$CV(\tilde{\pi},\tilde{M}) = CV(\tilde{\pi},\tilde{E}) + CV(\tilde{\pi},\tilde{B}) + CV(\tilde{\pi},\tilde{\pi})$$

The systematic risk of the firm has been split into two major components: internal risk and external risk (Lam and Chen 1985). The internal risk is the variance of the cash profit of the bank and represents the weighted average of the variances and covariances of the bank's asset returns and money costs. The remaining two covariance terms represent the bank's external risk. Thus, the external risk of the bank includes the interest rate sensitivity index developed by Stone (1974) and the equity index. The inclusion of interest rate sensitivity term incorporates the bank's investment risk into the certainty-equivalent model.

Expanded Certainty-Equivalent Model

Expanding the certainty-equivalent model to include the covariance term given above creates the following equation for the value of the bank

$$(3.7) \quad V = \frac{1}{R}\left[E(\tilde{\pi}) - \lambda CV(\tilde{\pi},\tilde{E}) - \lambda CV(\tilde{\pi},\tilde{B}) - \lambda CV(\tilde{\pi},\tilde{\pi})\right]$$

where

R = one plus the risk-free rate E = aggregate cash flow of all firms in the market

B = aggregate cash flow of all bonds on the market

$CV(\tilde{\pi}, \tilde{E})$ = covariance between the cash profit of the bank and the aggregate cash flow of all firms in the market systematic equity risk within the two index CAPM framework

$CV(\tilde{\pi}, \tilde{B})$ = covariance between the cash profit of the bank and the aggregate cash flow of all bonds on the market systematic interest rate risk within the two-index CAPM framework

$CV(\tilde{\pi}, \tilde{\pi})$ = variance of the cash profit of the bank; the internal risk of the firm

λ = the market price of bearing risk

The objective of the bank is to maximize its value subject its expected cash flows, risk premiums, and operating constraints. The bank has three constraints. The first constraint reflects the fact that assets must equal liabilities plus equity. The second is a regulatory capital constraint that limits the amount of liabilities the bank can raise since the bank is assumed to have a fixed amount of capital (K). This constraint is the maximum number of times (C) that liabilities can be relative to capital (K). Practitioners refer to this constraint as the "capital multiplier". The third constraint is a policy variable that requires the bank to operate with a gap that is a certain percentage, P, of Total Assets. The next section develops the optimization of the expanded certainty-equivalent model.

Value Maximization

The key decision facing the bank is the relative proportions of rate-sensitive and non-rate-sensitive assets and liabilities that should be held over a single decision period. This decision will determine the amounts of income and investment risk that the stockholders of the bank will face. The objective function for optimizing the value of the bank is as follows:

$$(3.8) \quad \max V = \frac{1}{R}\left[E(\tilde{\pi}) - \lambda CV(\tilde{\pi}, \tilde{E}) - \lambda CV(\tilde{\pi}, \tilde{B}) - \lambda CV(\tilde{\pi}, \tilde{\pi}) \right]$$

subject to

i. $A_R + A_N = L_R + L_N + K$

ii. $L_R + L_N \leq CK$

iii. $A_R - L_R = PK(C+1)$

Equation (i) is the balance sheet constraint, Equation (ii) is the liability to capital constraint, and Equation (iii) is the gap policy constraint. Equation (ii) is treated as an inequality because most commercial banks do not hold the maximum amount of liabilities allowed.[6] The extra capital held by banks is small enough on average that it is probably held for flexibility and growth, and with recent increases in the capital requirements it is reasonable to assume that this constraint is binding.[7] The gap policy of banks is generally a requirement that the gap be within a target range. Naturally, during an operating period the bank's gap will vary and thus the actual policy constraint may not be as stringent as implied by Equation (iii). It is necessary for Equation (iii) to be in the form of an equality so that the sensitivity of a particular gap can be analyzed relative to the risk it creates. This approach enhances the model by allowing the sensitivity of the risk-return relationship to be evaluated for specific gap positions.

The three covariances are as follows (see APPENDIX A):

(3.9)

a. $CV(\tilde{\pi}, \tilde{E}) = A_R\sigma_{AE} - L_R\sigma_{DE}$

b. $CV(\tilde{\pi}, \tilde{\pi}) = A_R^2\sigma_{AA} - 2A_RL_R\sigma_{AD} + L_R^2\sigma_{DD}$

c. $$CV(\tilde{\pi}, \tilde{B}) = \frac{R}{\lambda}\left[K + A_N\left[r_N \sum_{t=1}^{m-1} \frac{t}{(1+r_{Nt})^t} + \frac{m}{(1+r_{Nm})^m} - 1\right] - L_N\left[d_N \sum_{t=1}^{n-1} \frac{t}{(1+d_{Nt})^t} + \frac{n}{(1+d_{Nm})^n} - 1\right]\right]$$

where

σ_{AE} = the covariance between the rate of return on rate-sensitive assets and the cash flows of all other firms

σ_{DE} = the covariance between the money cost on the rate-sensitive liabilities and the cash flows of all other firms

σ_{AA} = the variance of the returns on rate-sensitive assets

σ_{DD} = the variance of the money cost on the rate-sensitive liabilities

σ_{AD} = the covariance of the returns on rate-sensitive assets and the money cost on the rate-sensitive liabilities

Note that the contractual interest rates on the NRSA and NRSL do not change over the decision period (ie certainty), by definition they stipulate fixed rates, therefore any covariances with these interest rates will equal zero. Equation (3.9c) is derived by assuming that the covariance provides the relationship between net worth and interest rates given in Equation (3.3). Thus, the following relationship is assumed to hold (see Appendix A):

$$(\lambda/R)CV(\tilde{\pi},\tilde{B}) \equiv \Delta NW/\Delta r = (-DG)MV_A.$$

<u>First Order Conditions</u>

Let L represent the Lagrange function, and let i, i_1, and i_2 denote the Lagrange multipliers associated with Equation (i), Equation (ii), and Equation (iii), respectively. The first-order necessary conditions are:

(3.10)

a. $$\frac{\partial L}{\partial A_R} = \frac{1}{R}\left[r_R - \lambda(\sigma_{AE} + 2A_R\sigma_{AA} - 2L_R\sigma_{AD})\right] - \Theta - \Theta_2 = 0$$

b. $$\frac{\partial L}{\partial A_N} = \frac{1}{R}\left[r_N - R\left[r_N \sum_{t=1}^{m-1}\frac{t}{(1+r_{Nt})^t} + \frac{m}{(1+r_{Nm})^m} - 1\right]\right] - \Theta = 0$$

c. $$\frac{\partial L}{\partial L_R} = \frac{1}{R}\left[-d_R - \lambda(-\sigma_{AE} - 2A_R\sigma_{AD} + 2L_R\sigma_{DD})\right] + \Theta - \Theta_1 + \Theta_2 = 0$$

d. $$\frac{\partial L}{\partial L_N} = \frac{1}{R}\left[-d_N + R\left[d_N \sum_{t=1}^{n-1}\frac{t}{(1+d_{Nt})^t} + \frac{n}{(1+d_{Nn})^n} - 1\right]\right] - \Theta - \Theta_1 = 0$$

e. $$\frac{\partial L}{\partial \Theta} = A_R + A_N - L_R - L_N - K = 0$$

f. $$\frac{\partial L}{\partial \Theta_1} = L_R + L_N - CK = 0$$

g. $$\frac{\partial L}{\partial \Theta_2} = A_R - L_R = PK(C+1)$$

Solving these first order conditions provides a equation for the optimal amount of rate-sensitive assets that a bank should hold. This optimality equation can be broken into three components: the relative interest rate spreads, investment risk, and income risk.[8] Once the rate-sensitive assets are determined all other assets and liabilities can be derived since they are a function of the amount of rate-sensitive assets. The following section provides the solution of the optimality equation.

The Optimality Equation

The following equation (see Appendix B) determines the optimal amount of rate-sensitive assets that the bank should hold given the relative interest rate spreads, the operating constraints, the policy of the bank, and the variance-covariance structure of returns and money costs.

(3.11)

$$A_R = \frac{1}{2\lambda(\sigma_{AA} + \sigma_{DD} - 2\sigma_{AD})} \Bigg[(\alpha_R - \alpha_N) \quad \text{<== Relative Interest rate Spread}$$

$$\text{Income Risk ==>} \quad + \lambda[2PK(\sigma_{DD} - \sigma_{AD}) - (\sigma_{AE} - \sigma_{DE})]$$

$$\text{Investment Risk ==>} \quad + R\left[\left[r_N \sum_{t=1}^{m-1} \frac{t}{(1+r_{Nt})^t} + \frac{m}{(1+r_{Nt})^m}\right] - \left[d_N \sum_{t=1}^{n-1} \frac{t}{(1+d_{Nt})^t} + \frac{n}{(1+d_{Nt})^n}\right]\right]\Bigg]$$

where

(12) $\alpha_R = r_R - d_R$ and (13) $\alpha_N = r_N - d_N$

The relative variability adjustment. The first term of the optimality equation is an adjustment for the relative variability of the interest rates on rate-sensitive assets and liabilities. This adjustment is made to all three components named in the equation. It is a function of the correlation of the rate-sensitive interest rates, which is one of the expected factors that create income and investment risk. This term is always positive and greater than one.[9] Thus, an increase in the correlation between the rate-sensitive interest rates will intensify the effect of each component. The effect of these three components on the amount of RSA that should be held is addressed next.

The relative interest rate spread. The first component of the optimality equation is the relative interest rate spread. This component is the difference between the interest rate spread on the RSA and RSL (Equation 3.12) and the interest rate spread on the NRSA and NRSL (Equation 3.13). This component represents the relative profitability of the two types of assets.

The relationship between the amount of rate-sensitive assets and the relative interest rate spread is direct. That is, the greater the interest rate spread of rate-sensitive assets and liabilities relative to the interest rate spread of non-rate-sensitive assets and liabilities the more profitable it is to hold rate-sensitive assets.

Note that there is no indication that the term structure of interest rates has an influence on the amount of rate-sensitive assets that a bank should hold, or the bank's market value. It is the relative margins on the two types of assets that determine the bank's market value and not the relative level of the individual rates (ie term structure). There is the risk that the relative spread may change over the period. However, an adjustment for this risk is made through the relative variability adjustment.

Income risk. The second component in the optimality equation is an adjustment for income risk. This component consists of two terms. The first term is a function of the bank's policy gap, the second term is a function of the relative covariances of the rate-sensitive interest rates with the equity portfolio return. Thus, the first term represents an internal income risk component since it is a function of a bank's gap policy. The second term is an adjustment for income risk relative to all other firms or an external income risk component. The relationship between the amount of rate-sensitive assets and these two terms will depend on the relationship between the variances and covariances contained in the two terms.

The first term contains the bank's gap adjusted by the difference between the variance of the interest rate on the RSL minus the covariance of the rate-sensitive interest rates. The relationship between the first term and the amount of rate-sensitive assets would be positive if the gap is positive and the variance of the interest rate on RSL is greater than its covariance with the interest rate on RSA. The same would hold true if the gap is negative and the variance of the interest rate on RSL is less than its covariance with the interest rate on RSA. In this case, the rate-sensitive item with the least risk of an interest rate change is being held in a larger amount and thus the bank should increase its gap by increasing the total amount of rate-sensitive items held. The relationship between the first term and the amount of RSA would be negative if the gap is negative (positive) and the variance of the interest rates on RSL is greater (less) than its covariance with the interest rates on RSA. In this case, the rate-sensitive item that has the greater risk of an interest rate change is being held in a larger amount and thus a bank should increase its gap by reducing the total amount of rate-sensitive items that are held. That is, the bank should not increase its income risk by increasing the risker of the two rate-sensitive items.

This first term also includes the capital multiplier (C). A decrease in the capital multiplier may increase or decrease the amount of RSA that a bank should hold, depending on the relative variances and the policy gap. For example, a bank with a traditional balance sheet structure facing a more stringent capital requirement (a decrease in C) has two choices: increase its capital ratio or decrease liabilities and assets. Assume that the bank can not increase its capital thus the bank will have to decrease its size. The bank has a negative gap and the change in (C) is negative so the effect on the amount of RSA will depend on the relative variability of the rate-sensitive interest rates. If the interest rate on RSL is more variable, the bank should hold less RSA, the dollar gap [PK(C+1)] will decrease, and RSL will decrease (the change in RSL > the change RSA). If the interest rate on RSA is more variable, the bank should hold more RSA, the dollar gap will decrease, RSL may increase or decrease. In any event, the reduction in the bank's dollar gap should lead to a reduction in the bank's income risk and the smaller gap in the NRS items should reduce investment risk. Naturally, the reduction in the size of the bank will reduce its expected net interest income and depending on the offset with the reduction in risk the value of the bank may increase or decrease.[10] The effect of a change in the capital multiplier and a change in the bank's capital is discussed in the conclusion to this chapter.

The second term in the income risk component is the difference between the covariances of the equity cash flows and the interest rates on RSA and RSL. These covariances are expected to be negative, because the bank's RSA are the non-financial firm's RSL (lines of credit, etc.) and the bank's RSL are the non-financial firm's RSA (MMF, CD's, etc.). If there is an increase in the $CV(r_R, E)$, then non-financial firms will hold less RSL which will increase their relative amount of RSA, ceteris paribus. Therefore, the bank can hold more RSA.

Since this second term has a negative sign, and the $CV(r_R, E)$ is negative there is a positive relationship between the amount of RSA and the $CV(r_R, E)$. The relationship of RSA and $CV(d_R, E)$ is negative for similar reasons. Thus, this second term implies that a bank should adjust its balance sheet structure and its income risk in relation to that of other firms. This income risk component then determines the bank's holdings of RSA given its gap but adjusted for its position relative to other firms.

The investment risk. The third component of the optimality equation is an adjustment for investment risk. This component contains two terms, the risk-free interest rate, and a weighted maturity term. As defined, investment risk is measured through the duration gap which is a function of the relative amounts of NRSA and NRSL, their relative maturities, and the relative interest rates. The primary term in this component is the second term which is the relative weighted maturities of the NRSA and NRSL. If the maturity of NRSA is greater than the maturity of the NRSL ($m > n$) then this term will be positive, if $n > m$ then this term will be negative.[11] Thus, the relationship between the investment risk component and the amount of RSA that a bank should hold is positive if m > n and negative if n > m. The relationship of the parameters in the investment risk component with the amount of RSA that should be held is shown in Table 3.5.

Table 3.5

THE RELATIONSHIP OF INVESTMENT RISK
COMPONENT PARAMETERS TO RATE-SENSITIVE ASSETS

Parameter	Relative Maturities (m > n)	(n > m)
Interest rates	-	+
Maturity:		
Assets	+	+
Liabilities	-	-
Net Result ==>	+	-

A level change in interest rates will affect three parameters in the investment risk component, the risk-free rate, r_{Nt}, and d_{Nt}. The relationship between an interest rate change that affects this component, and the amount of RSA depends on the relative maturity structure of NRSA and NRSL. If m > n an increase in interest rates will reduce the difference between the two weighted maturities, this would reduce investment risk and allow the bank to increase the amount of NRSA and NRSL that it is holding (decrease amount of RSA and RSL). If n > m an increase in interest rates will increase the difference in the two weighted maturity terms, this would increase investment risk and the bank should increase the amount of RSA and RSL that it is holding. An increase in the risk-free rate will intensify the effect provided by the weighted maturity term. This relationship between interest rates and a bank's balance sheet structure is consistent with a common recommendation that investments should be long-term when interest rates are high and short-term when interest rates are low.

An increase in the maturity of the NRSA or a decrease in the maturity of the NRSL will increase the amount of RSA a bank should hold. Either of these would increase investment risk and thus the bank should hold more RSA and RSL to reduce the portion of the bank's assets and liabilities that are exposed to investment risk. Similarly, an increase in the maturity of the NRSL or a decrease in the maturity of the NRSA will decrease the amount of RSA and RSL that should be held.

RSA and the Bank's Market Value

Maximizing the value of the bank involves a tradeoff between risk and return. The covariances of this model represent the risk and the expected profit represents the return. The relationship of the covariances with the amount of RSA held depends on the gap. The relationship between the bank's value and the amount of rate-sensitive assets will depend on the relative change in risk and return. An increase in RSA with no change in RSL would generally reduce the bank's net interest income when the yield curve is upward sloping. Thus, if the market value of the bank has a positive relationship with the amount of RSA that are held, the risk of the bank must be reduced enough to offset the loss in expected income.

An analysis of the covariance terms relative to an increase in RSA indicates an ambiguous change in the risk of a bank. The equity covariance would be reduced (equation 9a), the variance of the bank's net interest income or income risk would increase (Equation 3.9b), the bank's investment risk would decrease (Equation 3.9c). The additional income risk from the larger gap and the reduction in expected net interest income will reduce the value of the bank, but the change in the equity risk and investment risk will increase the value of the bank. Thus, there is a tradeoff between the income risk and the investment risk components of the bank when a change in the bank's gap is proposed. Which implies that there is an optimal gap in RSA and RSL that a bank should have.

Minimizing Interest Rate Risk

If a bank attempts to reduce its income risk to zero (Equation 3.9b), then RSA must equal RSL and the variability of the rate-sensitive rates and their covariance must, all three, be equal. That is, a zero gap alone will not eliminate income risk as shown by Equation (3.9b). The level of income risk with a zero gap is as follows:

$$A_{R2} (\sigma_{AA} + \sigma_{DD} - 2\sigma_{AD}) > 0 \text{ where } A_R > 0$$

Since the covariance is always closest to the lower of the two variances, income risk can not be negative and will only be zero if the three variance-covariance terms are equal.

A non-zero gap may, in fact, provide the bank with less income risk. The difference in the level of income risk between a zero gap and a non-zero gap is as follows:

$$P[PK(C+1)\sigma_{DD} + 2A_R(\sigma_{AD} - \sigma_{DD})]$$

Since the policy gap (P) may be positive or negative and the difference between the covariance and the variance of the interest rate on RSL may be positive or negative there are four situations to be analyzed. If both are positive or both are negative income risk will be higher than under a zero gap. If one of the terms is positive and the other is negative then the level of income risk with a non-zero gap may be greater than or less than the level of income risk under a zero gap. Thus, it is possible that a zero gap will increase the bank's level of interest rate risk.

In summary, a risk-avoidance strategy of having a zero gap may in fact leave the bank with a higher level of income risk than a non-zero gap. In addition, a large portion of the interest rate risk of a bank may come from the investment risk component and should not be ignored. It may be possible to eliminate interest rate risk but this would probably result in a significant loss in net interest income.

The Relationship Between Interest Rates and Market Value

In most examples used to explain interest rate risk, the balance sheet structure of a bank is held constant as interest rates change. Thus, the current balance sheet structure is assumed to explain the change in market value that occurs as interest rates change. Their are two problems with this approach. First, the bank's market value will only be sensitive to unexpected interest rate changes. Secondly, if interest rates change unexpectedly stockholders will re-evaluate expected net interest income and risk but a bank may also restructure its balance sheet. That is, as interest rates change the optimal balance sheet structure of a bank may change also and thus the future change in market value that results from an interest rate change may not be related to the bank's current balance sheet structure. For instance, if the balance sheet adjustment is rapid it will offset expected changes in value.

In Equation (3.10) the optimal amount of RSA is determined. Assuming that the expected variability of interest rates and the relative spread in interest rates do not change, interest rates will have an inverse relationship with the amount of RSA a bank should hold. For example, if interest rates rise a bank should hold less RSA (less RSL also given P) which leads to a decrease in income risk, an increase in investment risk and an ambiguous change in expected net interest income. Thus, the relationship between interest rates and the value of a bank is ambiguous. It depends on the relative tradeoff in income risk, investment risk and net interest income. The initial balance sheet structure will explain the change in market value only if the change in interest rates is unexpected and the bank does not adjust its balance sheet.

This implies that an asset-liability management strategy must be optimal based on current expectations of interest rate changes. If interest rates change unexpectedly the balance sheet structure must be adjusted appropriately. The effect on a bank's value from unexpected interest rate changes will depend on the response through asset-liability management. The appropriate response will depend on the tradeoff between the two interest rate risk components and the effect on expected net interest income.

The Shadow Price of the Policy Gap Constraint

Solving the model for the value of the policy gap constraint (its Lagrangian multiplier) gives the constraint's shadow price. The shadow price of this constraint indicates the effect on a bank's market value from a change in the constraint and is the marginal opportunity cost of constraining the solution. If the shadow price is positive then the solution is constrained and a higher market value can be achieved by increasing the constraint, ceteris paribus.[12]

Only one scenario provides an unambiguous conclusion about the shadow price. If the variability of r_R is less than the variability of d_R, and the covariance is between the two, a positive or zero gap will constrain the solution. Thus, only a negative gap will maximize value under this scenario, ceteris paribus. This conclusion favors the traditional strategy that a bank should make more profit over the long-run by playing the yield curve. Again, this conclusion only holds for one scenario and the relationship between the variability of the interest rates on RSA and RSL may change since the variability of interest rates maybe non-stationary over extended periods of time. However, the relationship between the two variances may not change significantly and thus a long-run strategy may be appropriate. In fact, rate-sensitive items of the bank are now being pegged to the same index which would suggest that the relationship of the two variances would remain relatively stable.[13]

Regulatory and Monetary Policy Issues

It was stated in the introduction that this study is of interest not only to bank managers and their stockholders but also to bank regulators and monetary policymakers. The bank regulators influence the bank in a number of ways but of most recent importance is the increase in equity capital requirements. The model includes the capital requirements through the capital multiplier, C. It was found that an decrease in this multiplier which is, in effect, an increase in the equity requirement of the bank, will lead to a reduction in the gap being used by the bank and thus a reduction in its interest rate risk if the bank maintains the same amount of capital. If the bank increases its capital (K) to maintain the same amount of assets its investment risk will increase as NRSL are traded for equity. Thus, those banks that have poor equity values should contract in size rather than sell equity to reduce risk. Those banks with strong equity values will maintain their size and accept higher investment risk. If bank managers are rational these conclusions should be the result of an increase in capital requirements and are the responses that are desired by the bank regulators.

The monetary policymakers affect on a bank's interest rate sensitivity is second only to the managers influence. The Federal Reserve Board can have a significant influence on the market level of interest rates either directly through changes in the money supply or indirectly through reserve requirements. The model shows that it is the relative volatility of asset and liability rates that influences the interest rate risk of a bank. Thus, if a bank links its asset and liability rates to the same external index the relative volatility will be more predictable and interest rate risk will be easier to control. Banks will still have difficulty forecasting interest rates but with proper asset-liability management, forecast errors can be reduced significantly.

CONCLUSION

In Chapter II it was concluded that banks are interest rate sensitive and tend to be more so than non-financial firms. It was hypothezied that a bank's balance sheet structure creates this interest rate sensitivity. In this chapter a theoretical model was developed to explain the relationship between interest rates, the market value of the bank, and the bank's balance sheet structure. As hypothesized, the relationship between interest rates and the market value of the bank will vary depending on the bank balance sheet structure. The balance sheet structure of banks will vary by the gap position taken relative to total assets, the duration gap, and the relative amounts in rate-sensitive and non-rate-sensitive accounts. The theoretical model was only able to derive unambiquous conclusions under certain scenarios, although even the ambiquities provide some significant conclusions.

The expanded certainty-equivalent valuation model contains all of the factors that create interest rate risk. The model exposes the two components of interest rate risk, income and investment risk. In addition, the model is based on the two interest rate risk management techniques used to measure a bank's exposure to interest rate risk. The first measure is the "gap" and is brought into the model as a policy constraint. The second measure is the "duration gap" which represents the relationship between a change in the bank's net worth and a change in interest rates. These two measures represent the bank's exposure to income risk and investment risk, respectively.

The theoretical model is not able to determine a single optimal asset-liability management strategy that would fit all situations. However, it does provide conclusions about each strategy and when each may be best. A risk-avoidance strategy which is an attempt to minimize income risk may actually provide the bank with higher income risk under certain conditions. Those banks that use this strategy generally ignore the investment risk component which may represent a large portion of a bank's interest rate risk. Even if a zero gap is appropriate a bank can not know the relative amount of rate-sensitive and non-rate-sensitive items to hold without knowing its exposure to both interest rate risk components.

Since bank managers are unable to forecast interest rates with certainty, the question arises--should banks base there allocation decisions totally on interest rate forecasts (Interventionist strategy) or does the optimality condition hold for an increase or a decrease in interest rates? Obviously, investors are valuing the bank based on expected interest rates and the bank manager should structure the balance sheet based on managerial expectations. The manager must consider the tradeoff between the potential return if the forecast is correct and the potential loss if the forecast is wrong. This issue is addressed in the model through the relative variability of the rate-sensitive interest rates, and the relative profitability of the rate-sensitive and non-rate-sensitive items.

The model also shows that in one scenario only a negative gap is appropriate. That is, if the variability of the interest rate on RSA is greater than that of RSL then only a negative gap will allow the bank to maximize its value. If this relationship holds its would lend support for the traditional balance sheet structure.

The main focus of this study is to identify and measure the two interest rate risk components, income and investment risk. Measuring the relative importance of these two components will help determine the degree of analysis required to manage interest rate risk and profitability. The next chapter outlines the methodology that will be used measure the two components of interest rate risk.

FOOTNOTES

1. It is necessary and practical to assume the bank maintains a seasoned portfolio of loans. It is necessary because the use of just a single 3-year loan would bias the change in market value over time by increasing in value as it approaches maturity, the seasoned portfolio will only change in value over time if market parameters change. The seasoned portfolio is practical because it is what we would expect the bank to hold.

2. See Kaufman (1984) for further discussion about the duration gap.

3. Generally the capital requirement is the ratio of capital to total assets. The capital requirement used in this model is the ratio of liabilities to equity (c) and is linearly related to the capital to total asset ratio. The liability to equity ratio is used for simplicity and because it shows the capital restrictions more directly.

4. A theoretical model of the inflationary effects on a bank's behavior was developed by Landskroner and Ruthenberg (1985). The objective function was profit maximization and they could not deal with both of the effects of interest rate risk. Lam and Chen (1985) used a certainty-equivalent CAPM model to analyze the anticipated effects from deregulation. They did not attempt to identify the a separate process that causes banks to be more interest rate sensitive than other firms, thus assuming that the process was inherent in the single index CAPM model. This study begins with the certainty-equivalent model which is the main similarity with Lam and Chen (1985). The primary deviations from their model is the assumption of two asset-liability segments and the inclusion a second index to identify the interest rate sensitivity of the bank.

5. The fact that a bank's common stock sells in a perfect market does not imply that the bank operates in a perfect market.

6. See Lam and Chen (1985) for details about relaxing the capital constraint.

7. See Gilbert, et. al. (1985) for more details on the capital adequacy of Commercial banks.

8. The income risk and investment risk components in the optimality equation are named so because their characteristics fit the previous definitions.

9. The market price of risk is given by the market risk premium divided by the variation of the market returns, which on average would be less than one. In addition, a covariance will always be closest to the lower of the two variances.

10. Because of the reduction in the bank's expected profit they may take on a risker portfolio of loans thus offsetting the reduction in interest rate risk (see Lam and Chen 1985).

11. Given that both of the weighted maturity terms are multiplied by their respective interest rates since $r_N > d_N$ this weighted maturity term could be positive for some of $n > m$.

12. See Lee, et al., 1981 for a discussion about shadow prices.

13. Brady (1985) found that in recent years large business loans are being priced based on fed funds or certificate of deposit rates. These loans are not very frequent but are dominating the dollar volume of business credit. Thus, a higher correlation between RSA and RSL should exist today and the sensitivity of the components that determine the amount of rate sensitive assets is greater.

CHAPTER IV

METHODOLOGY

In Chapter III, the relationship between a bank's balance sheet structure and its market value was modeled. It was found that the market value is a function of its end-of-the-period profits and three risk components, external risk, income risk, and investment risk. The risk components are all contained within the systematic risk of a CAPM framework. By separating the risk components in this way the two components of interest rate risk can be identified. The bank's income risk is the variability of its cash flows and investment risk is identified by the duration of its assets and liabilities.

The thesis of this study is that a bank's balance sheet structure determines its relative interest rate risk. Any adjustment to the balance sheet will lead to an adjustment in interest rate risk and thus an adjustment in the bank's market value. The following sections outline the methodology that will be used to test four hypotheses regarding the theoretical model in Chapter III. The four hypotheses are as follows:

H_1 : Commercial banks have "extra-market" sensitivity created by interest rate changes.

H_2 : The interest rate sensitivity of a commercial bank is a function of both income and investment risk.

H_3: The market beta for a particular bank is positively related to its gap position.

H_4: The term structure of interest rates affects "extra-market" sensitivity through relative interest margins rather than the relative levels of short-term versus long-term interest rates.

MEASURING EXTRA-MARKET SENSITIVITY

Hypothesis 1 is tested for three reasons. First, the theoretical model implies that a second index is important in the CAPM return generating model. Secondly, accepting hypothesis 1 suggests that banks are more interest rate sensitive than the average firm listed on the New York Stock Exchange. Thirdly, this step in the analysis provides the dependent variable for the empirical test regarding hypotheses 2 through 4.

A number of procedures have been used for measuring the interest rate sensitivity of a financial institution. These procedures vary by the type of index used to represent interest rates, whether or not a stock market index was included, and the adjustments that have been made to these indices. As concluded in Chapter II, Flannery and James (1984) used the most appropriate procedure. They found a negative relationship between unexpected interest rates changes and the holding period returns of the common stock of banks. That is, as interest rates rise the value of a bank decreases.

The return on bank j is assumed to be given by the following two-index model:

(4.1) $\tilde{R}_{jt} = \beta_0 + \beta_{mj}\tilde{R}_{mt} + \beta_{Ij}\tilde{R}_{It} + \tilde{e}_{jt}$

where

$\tilde{R}_{jt}$ = the holding period return to the j^{th} stock over the period ending at time t;

$\tilde{R}_{mt}$ = the holding period return on an equally weighted portfolio of common stocks over the period ending at time t;

$\tilde{R}_{It}$ = the holding period return on an equally weighted portfolio of default-free bonds over the period ending at time t;

$\tilde{e}_t$ = the firm-specific random variable such that $CV(R_I, e_{jt}) = CV(R_m, e_{jt}) = E(e_{jt}) = 0$.

Beta(Ij) represents the interest rate sensitivity coefficient and provides the estimated effect of interest rate changes on the j^{th} bank's stock. Beta(mj) is the standardized covariance of the j^{th} bank's returns and all firms in the market. Naturally, the j^{th} bank is one of the firms and thus this coefficient should include the variability of the j^{th} bank's returns. As usual, firm-specific risk is assumed to be unimportant in a CAPM type return generating process.

In this study, Equation (4.1) will be estimated using weekly returns data from January 1, 1980 to December 31, 1985. Equation (4.1) will be estimated as a portfolio for summary purposes, but its main purpose is to generate an interest rate sensitivity coefficient for each bank in each year of the sample (61 banks times 6 years). The weekly common stock returns were obtained from Data Resources

Incorporated (DRI) Security Price File. The return data consists of 61 banks (see APPENDIX C for list of banks) which were included in the sample if they met the following criteria[1]: (1) they were in the list of the top 300 banks in total assets over the sample period; (2) they traded at least weekly during the sample period; (3) they had an identifiable lead bank (in the case of multi-bank holding companies); and (4) the lead bank reflected 75 percent or more of the bank holding companies assets. Criterion (3) is necessary to ensure that the balance sheet structure and return information represents the lead bank.

The market portfolio return and the interest rate indices were also obtained from DRI. The weekly returns on the New York Stock Exchange (NYSE) composite index is used to represent the equity market index (R_m). Three interest rates series are used to create a fourth interest rate series. This portfolio of multi-maturity interest rates will eliminate the unsystematic component of term structure effects[1], and can provide insight into the relevance of term structure effects in the pricing of commercial bank securities (a partial test of Hypothesis 4). The four interest rate series are as follows:

1. The return on Government National Mortgage Association (GNMA) securities issued in 1978 at 9 percent, calculated as the weekly holding period return[2];
2. The weekly holding period return on 7-year Treasury bonds; and
3. The weekly holding period return on 90-day T-bills.
4. An equally weighted portfolio of the holding period returns on GNMA, Treasury bonds, and T-bills.

Note that the holding period return of a bond moves inversely with the level of interest rates. Also, since any changes in interest rates that were expected would have created repricing in a previous period, only the unexpected changes in interest rates will be used. Thus, the interest rate index used to estimate Equation (4.1) will be a white noise process. The interest rate index will also be orthogonal with the stock market index to identify the interest rate risk as "extra-market"[3] sensitivity.

The theoretical model developed in Chapter III concludes that the relationship between interest rates and a bank's value could be positive or negative. Flannery and James found that about 30 percent of the banks in their sample had a direct relationship between market value and interest rates. The next section outlines the empirical model that will be used to identify and measure a bank's income risk and investment risk.

Empirical Model of the Balance Sheet Link

This section outlines the empirical tests of Hypotheses 2 and 3. In addition, this section states the reasons for testing these two hypotheses. The theoretical model in Chapter III provides the link between the balance sheet structure and the interest rate risk of a bank. A bank's value is influenced directly by interest rate changes through two factors in the model: a change in net interest income, and the investment risk component. The change in net income is directly observable, the investment risk component produces a change in the market value of the bank's NRSA and NRSL. A third factor is the expected variability of the bank's net interest income determined by its current balance sheet structure. This third factor is not affected directly by a change in interest rates per se, but rather through an adjustment in a bank's balance sheet structure created by a change in interest rates. This factor should be captured in the market index (R_m), as shown in the Expanded Certainty Equivalent model in Chapter III.

Flannery and James found evidence that the gap explains a large portion of the interest rate sensitivity in their model. They found that an increase in the gap (positive being high) will make the bank's stock return more positively correlated with market interest rates, as would be expected. The gap to total assets measure they used is only capturing the investment risk component, thus an income risk measure must be included.

A direct measure of income risk is the change in the bank's net interest income, which is obviously related to a bank's balance sheet structure.[2] Without the details of the bank's maturity structure it is difficult to fully test the investment risk component. A measure of investment risk which is related to the duration gap is the net market value of the bank's non-rate-sensitive assets and liabilities.

In testing Hypothesis 2, that is, identifying the presence of income and investment risk the following equations are estimated cross-sectionally over time:

(4.2)
$$\hat{\beta}_{Ijt} = \alpha_0 + \alpha_1\left[\frac{(MVj - Gapj)^t}{TA_{jt}}\right] + \alpha_2\left[\frac{(NIIjt)}{TA_{jt}}\right] + \mu_{jt}$$

where

$\hat{\beta}_{Ijt}$ = the interest rate sensitivity coefficient for the j^{th} bank estimated for period t;

Gap = RSA - RSL;

NII = the change in net interest income in time period t for the j^{th} bank;

TA = total assets in time period t for the j^{th} bank;

MV = market value in time period t for the j^{th} bank.

Equation (4.2) explains the direct effect of interest rates on the value of a bank. As interest rates change net income will change as will the market value of the bank's NRSA and NRSL. The sign of the first coefficient is expected to be negative. That is, the larger (more positive) the net market value of the non-rate-sensitive assets and liabilities the smaller (more negative) the interest rate sensitivity coefficient. A negative interest rate sensitivity coefficient implies a positive relationship between the bank's value and interest rate changes. This is consistent with a positive duration gap (refer to Equation 3.2).

The sign of the second coefficient will depend on the bank's gap position and the direction of the change in interest rates (refer to Equation 3.1). If the bank's gap position is positive and interest rates are rising (declining) then the sign of the second coefficient will be positive (negative).

The test of Hypothesis 3 is accomplished by estimating the following equation cross-sectionally over time:

$$(4.3) \quad \beta_{mjt} = \alpha_0 + \alpha_1 \left[\frac{Gap_{jt}}{TA_{jt}} \right] + \mu_{jt}$$

where

β_{mjt} = the market beta coefficient for the j^{th} bank estimated for time period t;
Gap = RSA - RSL

Equation (4.3) reflects the effect of a balance sheet change on the expected variability of the bank's net interest income and thus a change in the value of the bank. The coefficient in Equation (4.3) is expected to be positive. That is, the larger (more positive) the gap position of the bank the larger (more positive) the interest rate sensitivity coefficient. A positive interest rate sensitivity coefficient implies a negative relationship between the bank's value and interest rate changes. Again, this is consistent with a positive gap (refer to Equation 3.1).

In this study annual observations are used for the balance sheet and net interest income variables. The balance sheet data was obtained from the FDIC Report of

Condition and provided by the University of Missouri-St. Louis (See APPENDIX D for a list of the data items obtained.) Each of these observations are adjusted by a scale variable (Equity). Thus, it is hypothesized that the change in a bank's interest rate sensitivity over time can be explained by the change in its balance sheet structure and the change in its net interest income.

CONCLUSION

Using the two proxies for income risk and investment risk to explain the bank's interest rate risk will be a test of the relationship between the bank's balance sheet structure and its returns. This test will also provide an indication of the relative importance of the two interest rate risk components.

The sign of the interest rate sensitivity coefficient could be positive or negative depending on the bank's balance sheet structure. Thus, the coefficients will be estimated for each bank in each sample year. The size of the interest rate sensitivity coefficient will vary depending on the term to maturity of the interest rate index used. This study will estimate the equation using a portfolio of three different maturities of government bonds. This is the procedure recommended by Stone (1974) which will diversify away the term structure effect. The term structure of interest rates is not expected to affect the explanatory power of the interest rate index in a cross-sectional model. To test this hypothesis the equation will also be estimated using each of the interest rate series. The next Chapter presents the results of the data analysis as applied to the empirical models outlined above.

FOOTNOTES

1. The procedure for estimating equation one is identical to the criteria set forth by Flannery and James (1984).

2. See Michael Smirlock (1986) for a discussion on the relationship between a bank's net interest margin and balance sheet structure.

CHAPTER V

RESULTS

This chapter presents the results generated from the empirical equations developed in Chapter IV. The first section of this chapter provides a statistical description of the data series. The remaining sections present the regression results from equations (1) thru (3).

STATISTICAL DESCRIPTION OF DATA

This section is a statistical description of the two data sets used to test the hypotheses developed in Chapter IV. The first set of data contains six holding period return series: the NYIC index, the bank portfolio, and four interest rate series. The second set of data is the balance sheet information used to develop proxies for income risk and investment risk.

Holding Period Returns

The holding period returns for the banks, the NYIC index and GNMA series were all calculated based on weekly price changes. The holding period returns on the T-Bill and T-Bond series were calculated using the relative yield[1]. The interest rate portfolio series was calculated as an equally weighted portfolio of the holding period returns on the T-Bill, T-Bond and GNMA series. Each of the interest rate series were then orthogonalized with the NYIC index to insure that the interest rate series did not contain information already found in the NYIC index[2].

Figure 1 presents the T-Bill and T-Bond yields over the sample period. Casual observation of Figure 5.1 (see graph) indicates that there are at least two distinct time periods in the sample. The period 1980 thru 1982 (period 1) is characterized by highly volatile interest rates with several changes in the term structure. The period 1983 thru 1985 (period 2) has less volatility and a stable relationship between long-term and short-term yields. In general, period 1 reflects a high level of interest rates while period 2 reflects a low level of interest rates[3]. Descriptive statistics for the orthogonal series are provided in Table 5.1.[4]

Balance Sheet Information

The estimation of equations (2) and (3) is dependent on three variables, the bank's annual gap position (GAP), the market value of the bank's non-rate-sensitive assets and liabilities (MV_{NRS}), and the change in the bank's net interest income (CHGNII). A statistical description of these variables is presented in Table 5.2.

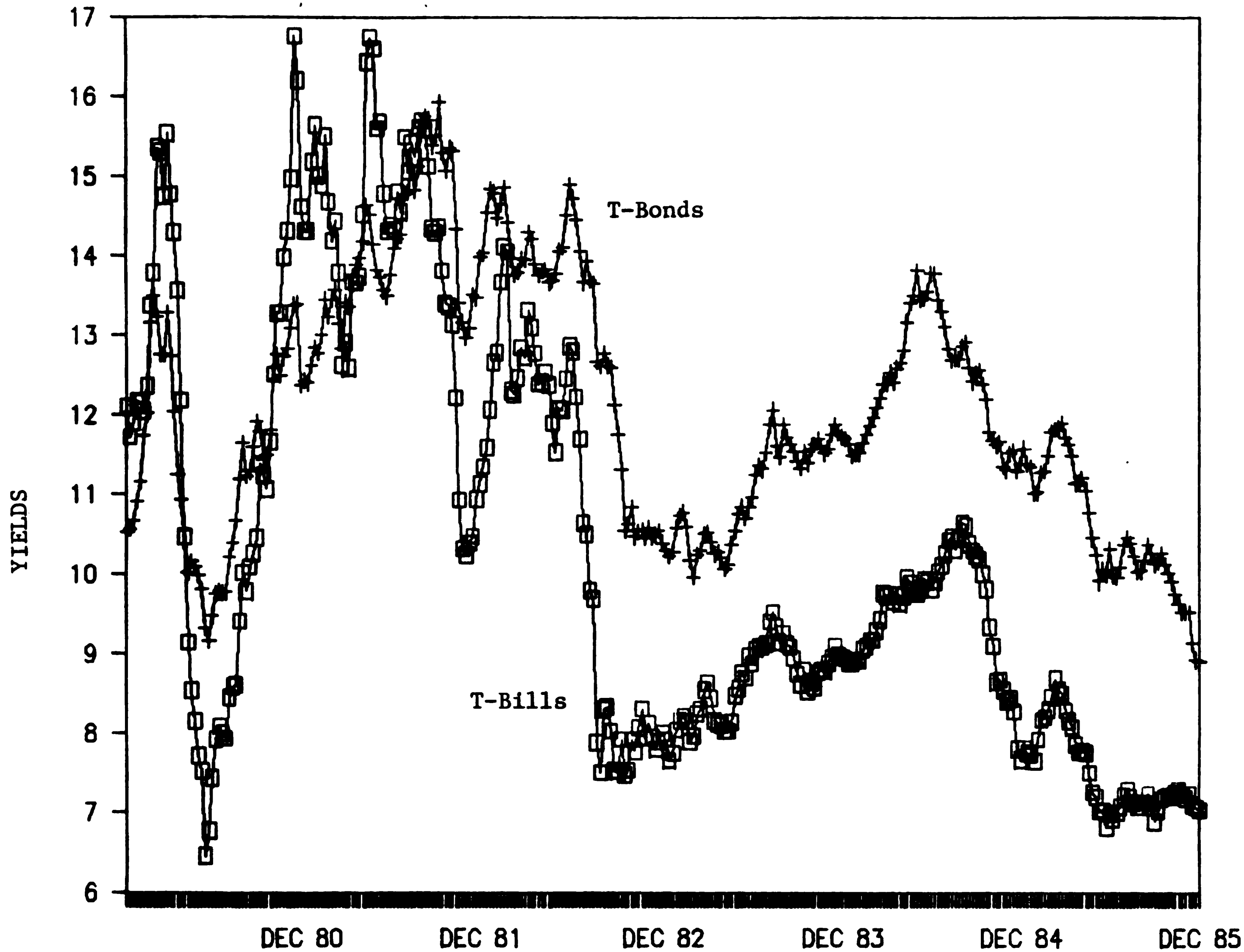

Figure 5.1 Yields on Government Securities

TABLE 5.1

Interest Rate Indices[a]
Descriptive Statistics

Index	Mean[b] Weekly Return	Std. Dev.	Correlation Coefficients R_{GNMA}	R_{G7}	R_{TB}	R_{PORT}
1980-1982 (Period 1)						
R_{GNMA}	-.06%	.020	1.00	.86	.63	.96
R_{G7}	-.13%	.026	.86	1.00	.63	.97
R_{TB}	.003%	.0015	.63	.63	1.00	.67
R_{PORT}	-.06%	.015	.96	.97	.67	1.00
1983-1985 (Period 2)						
R_{GNMA}	-.01%	.010	1.00	.91	.50	.97
R_{G7}	-.04%	.015	.91	1.00	.58	.98
R_{TB}	-.004%	.0005	.50	.58	1.00	.56
R_{PORT}	-.02%	.008	.97	.98	.56	1.00

[a]All series are orthogonal with the NYIC series.
[b]The means are significantly different from zero.

Table 5.2

Balance Sheet Information
Descriptive Statistics

Variable[a]	1980-1982 Mean	1980-1982 Standard Deviation	1983-1985 Mean	1983-1985 Standard Deviation
MV_{NRS}	- .58	2.27	- .38	2.25
CHGNII	.11	.29	- .38	.42
GAP	1.43	2.07	1.49	2.04

[a]All series are scaled by the banks annual equity.

On average the sample of banks selected had a positive gap and MV_{NRS} was negative. Each period consists of 183 observations (61 banks times 3 years). The average position in Table 5.2 reflected 119 and 103 observations in the two sample periods, respectively. The gap was negative in 41 and 38 of the observations for the two sample periods, respectively. The sample does not contain any observations with a negative gap and negative MV_{NRS}. On average the sampled banks had a higher gap and lower MV_{NRS} in period 2.

BANK INTEREST RATE SENSITIVITY ESTIMATES

Table 5.3 contains the results of estimating equation (1) for an equally weighted portfolio of commercial bank stocks. The estimated value of the interest rate sensitivity coefficient represents the cross-sectional time series average of the coefficients for all banks. The results indicate that commercial bank stock returns were very sensitive to interest rate changes in period 1, though insensitive in period 2. That is, on average, the sampled banks were not affected by "extra-market" interest rate sensitivity in period 2.

The interest rate sensitivity coefficient for the T-Bill estimates are significantly larger than the other series. The difference in the interest rate sensitivity coefficients is consistent with the fact that short-term bonds prices respond less to a given change in interest rates than do long-term bond prices. The intercept terms are significant in period 2, they are insignificant in period 1. The R^2 is higher in period 2 than in period 1. Within each period the R^2 is virtually identical across all of the interest rate series, including the interest rate index portfolio. Thus, there does not seem to be a loss of explanatory power when the term structure effects are diverified away.

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TABLE 5.3

Interest Rate Sensitivity Estimates
Portfolio of Commercial Banks

Index	β_0	β_m	β_I	R^2	Durbin-Watson Statistic
1980-1982 (Period 1)					
R_{GNMA}	.002*	.612*	.166*	.58	1.80
	(.001)	(.044)	(.046)		
R_{G7}	.002*	.617*	.168*	.60	1.78
	(.001)	(.043)	(.035)		
R_{TB}	.002*	.602*	2.092*	.58	1.79
	(.001)	(.044)	(.614)		
R_{PORT}	.002*	.612*	.268*	.60	1.79
	(.001)	(.043)	(.060)		
1983-1985 (Period 2)					
R_{GNMA}	.003*	.756*	.094	.62	1.82
	(.001)	(.048)	(.064)		
R_{G7}	.003*	.756*	.064	.62	1.82
	(.001)	(.048)	(.045)		
R_{TB}	.003*	.773*	1.230	.62	1.80
	(.001)	(.056)	(1.729)		
R_{PORT}	.003*	.756*	.118	.62	1.82
	(.001)	(.048)	(.081)		

[a] All series are orthogonal with the NYIC series.
[b] An asterisk reflects significance at the 1% level.

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ESTIMATES OF THE BALANCE SHEET LINK

Interest rate sensitivity coefficients were estimated for each bank in each sample year. Table 5.4 contains the results from the estimation of equation (2). In period 1, the investment risk proxies were significant in explaining interest rate sensitivity, while in period 2 the income risk proxies were significant. The constant term was significant only in period 1. In period 1, both of the variables were significant in explaining the T-Bill interest rate sensitivity coefficients. The interest rate portfolio in period 1 is consistent with only the T-Bond series.

Table 5.5 contains the results from the estimation of equation (3). The gap is significant in explaining the market beta in both time periods. The R^2 was significantly higher in period 2. The constant term was significant in both periods.

TABLE 5.4

Estimates of the Balance Sheet Link Identifying Income and Investment Risk

$\beta_{IJ} = \alpha_0 + \alpha_1 MV_{NRS} + \alpha_2 CHGNII$

Index	α_0	α_1	α_2	R^2	F-STAT
1980-1982 (Period 1)					
R_{GNMA}	.131*	-.009	.132*	.05	4.53*
	(.016)	(.007)	(.050)		
R_{G7}	.141*	-.022*	-.011	.08	8.11*
	(.005)	(.005)	(.041)		
R_{TB}	1.268*	-.280*	2.542*	.15	15.12*
	(.201)	(.081)	(.621)		
R_{PORT}	.218*	-.026*	.060	.05	4.73*
	(.022)	(.009)	(.069)		
1983-1985 (Period 2)					
R_{GNMA}	.013*	-.007	-.129*	.05	4.18*
	(.028)	(.009)	(.050)		
R_{G7}	.011	-.004	-.099*	.05	4.17*
	(.021)	(.007)	(.037)		
R_{TB}	.817	-.014	-.637	.01	.15
	(.684)	(.081)	(.621)		
R_{PORT}	.018	-.007	-.178*	.05	4.65*
	(.036)	(.012)	(.063)		

[a] An asterisk reflects significance at the 1% level.

TABLE 5.5

Estimates of the Balance Sheet Link
Adjustment in the Balance Sheet

$$\beta_M = \alpha_0 + \alpha_1 \text{ GAP}$$

Period	α_0	α_1	R^2	F-STAT
Period 1 1980-1982	.509* (.025)	.025* (.010)	.04	6.45*
Period 2 1983-1985	.656* (.040)	.060* (.016)	.07	14.29*

[a] An asterisk reflects significance at the 1% level.

CONCLUSION

Through observation and statistical analysis two distinct periods were identified in the six-year sample. The two periods were different in terms of the "extra-market" sensitivity and the relative amount of interest rate sensitivity found in the market beta. The income and investment risk proxies were both important in explaining the interest rate sensitivity of a commercial bank. The relative importance of these proxies varied between the two time periods. The next and final chapter of this study provides the conclusions to the hypotheses developed in Chapter IV.

FOOTNOTES

1. The relative yield was calculated as follows: $(Y_t - Y_{t-1})/Y_{t-1}$

2. Refer to Chance and Lane (1984) for an explanation of "extra-market" sensitivity.

3. Estimates of equation (1) provided a test for homogeneity between these two periods and also the interim years within each period. The F statistics were significant at the 1 percent level for the test between the two periods in regressions involving GNMAs, T-Bonds, and the portfolio, while the T-Bill series homogeneity test was not significant at the 5 percent level. The tests for homogeneity within the periods were insignificant at the 5 percent level for each year within both periods, except for T-Bonds in 1985 which was insignificant at the 1 percent level.

4. The autocorrelations were examined for each of the interest rate series. A Box-Pierce Q statistic was calculated for each series for 20 and 50 lags and neither of the lag periods were significant for any of the four interest rate series. However, the autocorrelation coefficient at lag 1 for the T-Bill series was significant. This series was adjusted and used to estimate all subsequent regressions. The results were virtually identical whether the series was adjusted using a one-period moving average, a one-period autoregressive, or the orthoganalized series. Thus the results for all subsequent regressions reflect those using the unadjusted but orthoganalized T-bill series.

CHAPTER VI

CONCLUSIONS

This chapter presents the conclusions of this study. Each of the hypotheses developed in Chapter IV are analyzed against the results in Chapter V. Then, some caveats regarding the interpretation of the results are discussed. The conclusion to this chapter highlights the implications of accepting the theoretical model and, in addition, contains areas for future research.

HYPOTHESIS TESTS

HYPOTHESIS I: **Commercial Banks have "extra-market" sensitivity created by interest rate changes.**

The interest rate series used in this study were orthogonalized with the stock market index (NYIC) so that any sensitivity identified by the interest rate series could not be explained by the typical measure of return covariance (the market beta). The results from estimating equation (1) show that an investor holding a portfolio of large commercial bank common stocks in period 1, would have incurred significant interest rate sensitivity beyond that for an investor holding the NYIC portfolio. In period 2, the "extra-market" sensitivity was insignificant.

The lack of "extra-market" sensitivity in period 2 does not imply that the commercial banks were any less interest rate sensitive. Results from equation (3) show that a significantly higher portion of the interest rate sensitivity was captured by the NYIC index in period 2 relative to period 1. This is consistent with banks having a larger gap position in period 2 (refer to Table 5.2). In addition, commercial banks on average had less exposure to investment risk in period 2 (refer to Table 5.2) as measured by the MV_{NRS}. Thus, the "extra-market" sensitivity should be less important in period 2.

HYPOTHESIS II: **The interest rate sensitivity of a commercial bank is a function of both income and investment risk.**

The basis of the empirical testing in this study is to provide support for the theoretical model. Acceptance of Hypothesis II will provide a strong foundation for the theoretical model. Measurement of the two risk components for an empirical test is limited by the available data, but the proxies used have a strong theoretical basis for high correlation with both of these risk components. That is, income risk is measured using the change in a bank's net interest income, and investment risk is measured using the market value of a bank's non-rate-sensitive assets and liabilities.

In analyzing the results from the estimation of equation (2) and providing an answer to Hypothesis II three questions must be addressed. First, is interest rate sensitivity a function of both interest rate risk components? Secondly, are the signs of the coefficients as predicted? Finally, what consistency is there between the four interest rate series?

Both Risk Components are Significant. The results from estimating equation (2) over the two time periods (refer to Table 5.4) indicate that both risk components are important. However, income risk was significant in both periods while investment risk was only significant in the first period. The lack of significance of investment risk in period 2 may be justified by the large reduction (movement towards zero) in MV_{NRS} relative to period 1 (refer to Table 5.2). Thus, the fact that the "extra-market" interest rate sensitivity was not significant in period may be due to lower investment risk on average.

Another difference between the two periods is the significance of the constant term. The constant term was significant in period 1 and insignificant in period 2. This difference may have been due to the high volatility of interest rates in period 1, this may have forced investors to add an additional risk premium not explained by the bank's balance sheet. For example, in period 1 banks were shifting interest rate risk by increasing the number of adjustable-rate loans. Thus, banks were more exposed to credit risk as interest rates rose and remained high. This higher credit risk is related to interest rate changes and may have been captured by the constant term.

<u>Are the Signs of the Coefficients as Predicted?</u> The investment risk component is negative as predicted. That is, a negative MV_{NRS} position leads to a positive interest rate sensitivity coefficient, and thus a negative relationship between market value and interest rate changes. The coefficient of CHGNII is positive in period 1 and negative in period 2. As indicated in chapter IV the sign of CHGNII will depend on the bank's gap position and the direction of change in interest rates [CHGNII = Δi(GAP)]. Given the average change in net interest income and the average gap position, the average change in interest rates can be implied. The average gap position was positive in both periods, while the average change in net income was positive in period 1 and negative in period 2. Thus, interest rates were rising on average in period 1 and declining on average in period 2. A positive CHGNII in period 1 leads to a positive interest rate sensitivity coefficient as does the negative CHGNII in period 2. Therefore, the two time periods are consistent with respect to the interest rate sensitivity coefficient even though the two periods have opposite signs.

<u>Consistency Between the Interest Rate Series?</u> There are two expectations regarding the relationship between the results of the different interest rate series. First, short-term rates should explain income risk and long-term

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rates should explain investment risk. Second, since the interest rate series are correlated, some correlation between the estimations of equation (2) should exist.

The results from estimation of equation (2) indicate two instances where the expectations above are not met. First, in period 1 the interest rate sensitivity explained by the GNMA series is not significantly explained by investment risk. Second, in period 2 the interest rate sensitivity explained by the T-Bill series is not significantly explained by income risk. Thus, the most important risk (determined by R_{PORT}) in either period did not explain the expected interest rate sensitivity coefficient. Thus, the inconsistency is consistent. The results from equation (3) indicate that the missing information here tends to be captured by the market beta. Therefore, long-term interest rates were affecting all firms in period 1 as were short-term rates in period 2, and thus were not identified as "extra-market" sensitivity.

A potential problem in interpreting the results from equation (2) and equation (3) is inherent in the two step procedure. Using equation (1) to estimate the interest rate sensitivity betas may introduce measurement error into equations (2) and (3). It is possible that these errors are contemporaneously correlated, and thus would overstate the significance of the coefficients in these equations. Since the source of this problem is the contemporaneous correlation in the residuals from equation (1), a random sample of 10 banks was chosen and a correlation matrix for the residuals was created. The average correlation was small and not significantly different from zero in either period. Thus, the loss of efficiency is likely to be small.

It is also possible that the beta coefficients understate the coefficients in equations (2) and (3). That is, the estimates of the interest rate sensitivity betas were not all significant and thus a lot of the variance in these coefficients could be erroneous. Each of the interest rate sensitivity coefficients was adjusted by 1 minus the significance level. The results indicate a slightly higher R^2 but the significance of the coefficients in equations (2) and (3) were approximately the same as those reported in Table 5.4.

HYPOTHESIS III: **The market beta for a particular commercial bank is directly related to its gap position.**

This hypothesis is confirmed by the results from the estimation of equation (3). The expected variability of net interest income as indicated by a bank's gap position is captured by the bank's market beta. The larger a bank's gap position (more positive) the more inversely related its market value is with interest rate changes.

HYPOTHESIS IV: **The term structure of interest rates affects "extra-market" sensitivity through relative interest margins rather than the relative levels of short-term versus long-term interest rates.**

The theoretical model implied that as long as the term structure effects do not change the relative interest margins on rate-sensitive versus the non-rate-sensitive assets and liabilities then there should not be an effect on the risk position of the bank. The results from estimation of equation (2) regarding RPORT give some insight into this question. Since only period 1 had significant changes in term structure the analysis is based there.

The results for period 1 indicate that the income risk identified was primarily due to term structure effects. That is, if we eliminate the term structure changes in interest rates then income risk was not significant in period 1. Thus, term structure effects are important but they are probably related to a change in the bank's relative interest margins and not the relative level of short-term interest rates versus long-term interest rates. Otherwise, the investment risk component would have been significantly affected along with the income risk.

MANAGERIAL IMPLICATIONS

In the introduction to this dissertation three controversies were mentioned. The first controversy involves the particular technique that should be used in measuring interest rate risk. This study indicates that both gap and duration gap should be used to identify a financial institution's exposure to interest rate risk. A manager attempting to maximize the value of a financial institution can not ignore the effect of interest rate changes on the non-rate-sensitive component of the firm. The declining market value of non-rate-sensitive assets reflects opportunity losses that extend for years into the future. These losses can be made up immediately if depositors through non-rate-sensitive liabilities suffer similar losses, otherwise, the value of the firm falls.

The second controversy involves the selection of an asset-liability management strategy that will maximize the financial institution's value. This study concludes that a financial institution's value will be constrained if it operates with a positive or zero gap. In addition to the theoretical model a number of other factors suggest a negative gap position. First, this position will generate profits from the term structure liquidity premium. Second, when interest rates decline prepayments will occur and many NRSA will quickly become RSA. Therefore, a non-zero gap position is necessary to offset prepayments in a falling rate environment. Third, a negative gap position implies a positive duration gap position. As interest rates decline this duration gap is also reduced towards zero because of the reduction in NRSA. Fourth, in a rising interest rate environment the depository institutions profits from the liquidity premium should more than offset the losses in net interest income from the negative gap.

This study also indicates that managers should be concerned with maintaining interest rate spreads and not attempting to profit form term structure changes. The only adjustments relative to term structure will be in the relative amount of rate-sensitive versus non-rate-sensitive assets and liabilities. If interest rates are rising a manager should allow the relative amount of rate-sensitive assets and liabilities to increase, and the opposite is true if interest rates are declining. In addition, managers should attempt to reduce the firm's exposure to basis risk. To the extent possible, managers should use the same external index to adjust RSA and RSL, this will reduce some basis risk exposure.

The third controversy involves the use of risk-adjusted capital requirements. This study indicates that depository institutions with depressed equity values relative to peer group institutions will reduce interest rate risk if their capital requirements are increased. Common sense suggests that a reduction in leverage will reduce the variability of net income (an implied reduction in income risk). If regulators base the capital requirements only on a depository institution's gap position the regulation may have little effect on interest rate risk. First, this regulation would ignore investment risk and basis risk.

Secondly, it would eliminate the offset strategy which has unproven potential in the management of interest rate risk. In fact, many of the banks in this study did follow an offset strategy.

CONCLUSION

The empirical results support to the theoretical model developed in chapter III. Managers of large commercial banks must control both components of interest rate risk, because they both explain the interest rate sensitivity of a bank. The results did not allow for inferences about the absolute tradeoff between the two risk components, this is reserved for future research.

Given support for the theoretical model there are a number of important implications for bank managers, bank stockholders and regulatory authorities. First, the term structure does not affect the bank because of a change in the relative levels of interest rates but rather through a change in the relative margins. That is, term structure changes affect the interest rate risk of the bank through basis risk. Basis risk is the uncertainty about relative interest rate spreads. If bank managers can eliminate or reduce basis risk then the term structure changes should not have an impact. One method for reducing basis risk is to tie the rates on assets and liabilities to the same external index and thus effectively creating a constant spread between the interest rates on assets and liabilities. This technique is generally only possible for the rate-sensitive assets and liabilities. Additional research must be conducted to develop techniques for handling basis risk.

A second implication of the theoretical model is that stockholders evaluate the gap position of the bank relative to the market portfolio. In fact, ceteris paribus, a negative gap will reduce the bank's market beta. In addition, the theoretical model indicates that value maximization will only occur if the bank operates with a negative gap position.

The model also implies that increases in capital requirements proposed by bank regulators will have the desired risk reducing effects, at least in terms of interest rate risk. Additional research should be conducted to determine the effects of higher capital requirements on a bank's value and the relative tradeoff between capital risk and interest rate risk.

Some additional areas for future research include further empirical tests, and extensions of the theoretical model. A number of empirical tests can be done. First, this study could be repeated for large savings and loans. Second, beginning in 1984 banks were required to provide a much more detailed breakdown of the maturity structure of their assets and liabilities. This will provide data for improved empirical studies on interest rate risk and liquidity risk. Another potential study would require the cooperation of a number of banks to provide a more in-depth analysis of the theoretical model. In addition, the theoretical model can be extended to include external sources of hedging (i.e. futures and options).

Finally, the contributions of this study include a better definition of interest rate risk for a depository-type institution, a theoretical model useful in evaluating the various asset-liability management strategies, and empirical results that support the model. The moral is that managers have been ignoring a significant portion of their firm's interest rate risk exposure and must develop tools that measure both components of interest rate risk.

APPENDICES

APPENDIX A

APPENDIX A

Derivation of Covariances

a. $$CV(\tilde{\pi},\tilde{E}) = \sum_{t=1}^{n} (E_t - E(E))(\tilde{\pi}_t - E(\pi))$$

$$= \sum_{j=1}^{n} \Big[(E_t - E(E))(A_R \tilde{r}_{Rt} - A_R E(r_R))$$

$$- (E_t - E(E))(L_R \tilde{d}_{Rt} - L_R E(d_R)) \Big]$$

NOTE: Rates on NRSA and NRSL do not vary.

$$= A_R \sum_{j=1}^{n} \Big[(E_t - E(E))(\tilde{r}_{Rt} - E(r_R)) \Big]$$

$$- L_R \sum_{j=1}^{n} \Big[(E_t - E(E))(\tilde{d}_{Rt} - E(d_R)) \Big]$$

$$CV(\tilde{\pi},\tilde{E}) = A_R\sigma_{AE} - L_R\sigma_{DE}$$

b. $$CV(\tilde{\pi},\tilde{\pi}) = \sum_{t=1}^{n} (\pi_t - E(\pi)(\tilde{\pi}_t - E(\pi))$$

$$= A_R^2 \sum_{t=1}^{n} (r_{Rt} - E(r_R))^2 + L_{R2} \sum_{t=1}^{n} (d_{Rt} - E(d_R))^2$$

$$- 2A_R L_R \sum_{t=1}^{n} (r_{Rt} - E(r_R))(d_{Rt} - E(d_R))$$

$$CV(\tilde{\pi},\tilde{\pi}) = A_R^2\sigma_{AA} - 2A_R L_R\sigma_{AD} + L_R^2\sigma_{DD}$$

c. Derivation of $CV(\tilde{\pi},\tilde{B})$

Assume:

1. All assets and liabilities pay only interest until term and principal is paid in lump sum

2. $(\lambda/R)CV(\tilde{\pi},\tilde{B}) = \Delta NW/\Delta r$

3. $\Delta NW/\Delta r = (-DG)MV_A$ where DG = Duration Gap

4. $DG = \sum_{j=1}^{k} w_j D_j \qquad \sum_{j=1}^{k} w_j = 1$

5. $D_j = \sum_{t=1}^{n} \frac{tC_t}{(1+r_j)^t} \div MV_j$

First Calculate Duration Gap (DG):

$$DG = \frac{A_R}{MV_A} D_{AR} + \frac{A_N}{MV_A} D_{AN} - \frac{L_R}{MV_A} D_{LR} - \frac{L_N}{MV_A} D_{LN}$$

where $D_{AR} = D_{LR} = 0$ since both are repriced at t=1.

$$CV(\tilde{\pi},\tilde{B}) = \frac{R}{\lambda}\left[K + A_N\left[r_N \sum_{t=1}^{m-1} \frac{t}{(1+r_{Nt})^t} + \frac{m}{(1+r_{Nm})^m} - 1\right] - L_N\left[d_N \sum_{t=1}^{n-1} \frac{t}{(1+d_{Nt})^t} + \frac{n}{(1+d_{Nm})^n} - 1\right]\right]$$

APPENDIX B

APPENDIX B

Value Maximization

$$\underset{A_j, L_j}{\text{Max}\ V} = \frac{1}{R}\left[E(\tilde{\pi}) - \lambda\, CV(\tilde{\pi}, \tilde{E}) - \lambda CV(\tilde{\pi}, \tilde{B}) - \lambda CV(\tilde{\pi}, \tilde{\pi})\right]$$

Subject to

i. $A_R + A_N = L_R + L_N + K$

ii. $L_R + L_N \leq CK$

iii. $A_R - L_R = PK(C+1)$

Where:

a. $CV(\tilde{\pi}, \tilde{E}) = A_R\sigma_{AE} - L_R\sigma_{DE}$

b. $CV(\tilde{\pi}, \tilde{\pi}) = A_R{}^2\sigma_{AA} - 2A_RL_R\sigma_{AD} + L_R{}^2\sigma_{DD}$

c. $$CV(\tilde{\pi}, \tilde{B}) = \frac{R}{\lambda}\left[K + A_N\left[r_N \sum_{t=1}^{m-1} \frac{t}{(1+r_{Nt})^t} + \frac{m}{(1+r_{Nm})^m} - 1\right] - L_N\left[d_N \sum_{t=1}^{n-1} \frac{t}{(1+d_{Nt})^t} + \frac{n}{(1+d_{Nm})^n} - 1\right]\right]$$

Where

σ_{AE} = the covariance between the rate of return on rate-sensitive assets and the cash flows of all other firms;

σ_{DE} = the covariance between the money cost on the rate-sensitive liabilities and the cash flows of all other firms;

σ_{AA} = the variance of the returns on rate-sensitive assets;

σ_{DD} = the variance of the money cost on the rate-sensitive liabilities;

σ_{AD} = the covariance of the returns on rate-sensitive assets and the money cost on the rate-sensitive liabilities.

First Order Conditions

a. $$\frac{\partial L}{\partial A_R} = \frac{1}{R}\left[r_R - \lambda(\sigma_{AE} + 2A_R\sigma_{AA} - 2L_r\sigma_{AD})\right] - \Theta - \Theta_2 = 0$$

b. $$\frac{\partial L}{\partial A_N} = \frac{1}{R}\left[r_N - R\left[r_N \sum_{t=1}^{m-1} \frac{t}{(1+r_N)^t} + \frac{m}{(1+r_N)^m} - 1 \right]\right] - \Theta = 0$$

c. $$\frac{\partial L}{\partial L_r} = \frac{1}{R}\left[-d_R - \lambda(-\sigma_{AE} - 2A_R\sigma_{AD} + 2L_r\sigma_{DD})\right] + \Theta - \Theta_1 + \Theta_2 = 0$$

d. $$\frac{\partial L}{\partial L_N} = \frac{1}{R}\left[-d_N + R\left[d_N \sum_{t=1}^{n-1} \frac{t}{(1+d_N)^t} + \frac{n}{(1+d_N)^n} - 1 \right]\right] - \Theta - \Theta_1 = 0$$

e. $$\frac{\partial L}{\partial \Theta} = A_R + A_N - L_r - L_N - K = 0$$

f. $$\frac{\partial L}{\partial \Theta_1} = L_r + L_N - CK = 0$$

g. $$\frac{\partial L}{\partial \Theta_2} = A_R - L_R = PK(C+1)$$

Step 1: Solve (b) for Θ and substitute into (a).

Step 2: Solve (d) for Θ_1 and substitute into (b).

Step 3: Solve step 2 for Θ_2 and substitute into step 1.

Step 4: Substitute $L_R = A_R - PK(C+1)$.

Step 5: Solve for A_R. Where $\alpha_R = r_R - d_R$ and $\alpha_N = r_N - d_N$.

$$A_R = \frac{1}{2\lambda(\sigma_{AA} + \sigma_{DD} - 2\sigma_{AD})} \Bigg[\Bigg[(\alpha_R - \alpha_N) \quad \text{<== Relative Interest rate Spread}$$

Income Risk ==> $$+ \lambda[2PK(C+1)(\sigma_{DD} - \sigma_{AD}) - (\sigma_{AE} - \sigma_{DE})]$$

Investment Risk ==> $$+ R\left[\left[r_N \sum_{t=1}^{m-1} \frac{t}{(1+r_{Nt})^t} + \frac{m}{(1+r_{Nt})^m} \right]\right.$$

$$\left. - \left[d_N \sum_{t=1}^{n-1} \frac{t}{(1+d_{Nt})^t} + \frac{n}{(1+d_{Nt})^n} \right]\right]\Bigg]\Bigg]$$

APPENDIX C

APPENDIX C

List of Sampled Banks

BANK	CITY
Bank of New England NA	BOS
First National Bank of Boston	BOS
Fleet Nat Bank	PROV
Bank of New York	NY
Chase Manhattan Bank NA	NY
Citibank NA	NY
Chemical Bank	NY
Morgan Guaranty Trust Co.	NY
Manufacturers Hanover Trust CO.	NY
Irving Trust Co.	NY
Bankers Trust Co.	NY
United States Trust Co.	NY
CityTrust	BRIDGE
Union Trust Co.	STAM
First Fidelity Bank NA	NEWARK
Heritage Bank NA	JAMES
Nat Community Bank	RUTH
Manufact & Traders Trust Co.	BUF
Republic National Bank	NY
Philadelphia Nat Bank	PHI
First Penn. Bank NA	PHI
Wilmington Trust Co.	WIL
New Jersey Nat Bank	TRE
Fidelity Bank NA	MALVERN
Fifth Third Bank	CIN
Mellon Bank NA	PITT
Bank of Virginia	RICH
First Nat Bank of Maryland	BAL
Maryland Nat Bank	BAL
NCNB Nat Bank of North Caro	CHAR
First Union Nat Bank	CHAR
Northwestern Bank	WIL
South Carolina Nat Bank	COLUM
Bankers Trust of S. Carolina	COLUM
American Security Bank NA	DC
Suburban Bank	BETH
First Nat Bank of Atlanta	ATL
Trust Co Bank	ATL

Citizens & South Nat Bank	ATL
Commerce Union Bank	NASH
First Nat Bank of Commerce	N.O.
Whitney Nat Bank	N.O.
First National Bank of Chicago	CHIC
Northern Trust Co.	CHIC
Comerica Bank	DET
National Bank of Detroit	DET
American Fletcher NB&T Co.	IND
Indiana National Bank	IND
First Wisconsin National Bank	MILW
Mercantile Trust Co NA	ST.L.
First Nat Bank of Louisville	LOUIS
Union Planters Nat Bank	MEM
Norwest Bank Minneapolis NA	MINNE
First Nat Bank of Minneapolis	MINNE
Fourth Nat Bank & Trust Co.	WICHITA
United Bank of Denver NA	DEN
MBank Dallas NA	DAL
Republic Bank Dallas NA	DAL
First City Nat Bank of Hous	HOU
Crocker National Bank	SF
Wells Fargo Bank NA	SF
Bank of America NT&SA	SF
Sumitomo Bank of Cal	SF
Central Bank	SF
First Hawaiian Bank	HONO
Bank of Hawaii	HONO
Security Pacific National Bank	LA
First Interstate Bank of Cal	LA
City National Bank of Bev Hills	BEVERLY
United Bank of Arizona	PHEN
Imperial Bank	LA
US Nat Bank of Portland	PORT
Zions First Nat Bank	SALT
Idaho First Nat Bank	BOISE
First Security Bank of Utah NA	OGDEN
Rainier National Bank	SEATTLE

APPENDIX D

APPENDIX D

List of Data Fields

FIELD NAME
I. SHORT
A. NET FED FUNDS SOLD:
1. Federal funds sold and securities purchased under agreements to resell.
2. Federal funds purchased and securities sold under agreements to repurchase.
B. INVESTMENTS MATURING IN LESS THAN ONE YEAR:
1. Debt securities--adjustable rate
2. Debt securities--3 months or less
3. Debt securities--3 months thru 6 months
4. Debt securities--6 months thru 12 months
C. FIXED-RATE LOANS MATURING IN LESS THAN ONE YEAR:
1. All loans and all leases--3 months or less
2. All loans and all leases--3 months thru 6 months
3. All loans and all leases--6 months thru 12 months
D. ADJUSTABLE-RATE LOANS AND LEASES:
E. ASSETS HELD IN TRADING ACCOUNTS:
F. CUSTOMERS' LIABILITY TO THIS BANK ON ACCEPTANCES OUT:
G. DOMESTIC AND FOREIGH CDs IN EXCESS OF $100,000 AND MATURING IN LESS THAN ONE YEAR:
1. Time CDs--adjustable rate
2. Time CDs--3 months or less
3. Time CDs--3 months thru 6 months
4. Time CDs--6 months thru 12 months
H. OTHER BORROWED MONEY:
I. BANK'S LIABILITY ON ACCEPTANCES OUTSTANDING
II. NET INTEREST INCOME
A. TOTAL INTEREST INCOME:
B. TOTAL INTEREST EXPENSE:
C. TOTAL NON-INTEREST INCOME:
D. TOTAL NON-INTEREST EXPENSE:
E. NET INCOME (LOSS):
III. EQUITY CAPITAL--End of current period:
IV. TOTAL ASSETS

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