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DEPOSIT VARIABILITY AND BANK BEHAVIOR:
A THEORETICAL AND EMPIRICAL
ANALYSIS

by
Earl Gregory Hamilton

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Business Administration)
in The University of Michigan
1976

Doctoral Committee:

Professor Douglas A. Hayes, Chairman
Professor Thomas G. Gies
Professor Robert S. Holbrook
Associate Professor Roger L. Wright

DEDICATION

This dissertation is dedicated to my parents, Earl and Mabel Hamilton, who have sacrificed so much in my behalf.

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CHAPTER I
BACKGROUND OF THE PROBLEM

Introduction

A corporation is insolvent when it is unable to meet its cash obligations. Van Horne calls this technical insolvency, as opposed to legal insolvency which occurs whenever the assets of a firm are less than its liabilities--negative net worth.¹ As long as a firm can meet its cash obligations through its liquid assets, the earning assets of the firm are in no danger of being liquidated. Liquidation losses will be eliminated, and so will the alternative cost of borrowing to meet the cash demands.²

A bank's obligations are primarily in the form of deposit withdrawals. Kaufman states that the most important constraint for commercial banks is the need to accommodate withdrawals of deposits immediately upon demand for demand deposits, and at maturity for time deposits. Failure to satisfy such demands would result in insolvency and

¹James C. Van Horne, Financial Management and Policy, 2nd ed. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1971), p. 385.

²Instead of liquidating its earning assets, a firm may choose to borrow if it has cash obligations which cannot be met out of its liquid asset holdings. Cost is the major determinant of the alternative selected.

immediate bank closing.³ Chandler also states that the inability to meet these drains (withdrawals) promptly means failure or at least an impairment of confidence in the bank.⁴ Newly created deposits (inflows), inflows from maturing assets, available liquid reserves, and borrowing capacity must be sufficient to meet withdrawals (outflows); if not involuntary liquidation will occur.

If inflows from newly created deposits and maturing assets exactly equaled withdrawals at all times, there would be no need to hold precautionary cash balances or borrow to prevent involuntary illiquidity. If the two flows are not perfectly synchronized and withdrawals exceed deposits and normal asset liquidations at certain points, the bank must have liquid funds in reserve or unused borrowing capacity available to cover the deficiency.

Liquidity Versus Return on Investment

One solution to insolvency would, of course, be to hold highly liquid assets. Unfortunately excess liquidity has its cost. If all investable funds were held in liquid form, the risk of insolvency, with its subsequent cost, would be low. However, the effect on income would be disastrous. Writers in the area of corporate finance have

³George G. Kaufman, Money, the Financial System, and the Economy (New York: Rand McNally & Company, 1973), p. 64.

⁴Lester V. Chandler, The Economics of Money and Banking, (New York: Harper & Row, 1973), p. 165.

long established the goal of a profit-seeking firm as trying to maximize the value of shareholder wealth.⁵ This objective considers the return on investment, and the risk associated with that return. Some balance must be established between risk and return to maximize the value of shareholder wealth. Surplus liquidity reduces the rate of return on investment, while not significantly reducing the risk of insolvency. Insufficient liquidity subjects the bank to a greater risk of insolvency, and the cost associated with insolvency.

The trade off commercial banks make between earning potential and liquidity assumes that highly liquid assets (cash, federal funds, security repurchases, treasury bills and treasury securities maturing within one year) have lower earning potential (a lower net yield) than do less liquid assets (loans, mortgages, municipal bonds, and treasury securities maturing after one year).⁶ The higher yield supposedly characteristic of less liquid or "earning assets" may result from several characteristics of these assets. For one thing, all else being equal, the asset holder may be forced to pay a premium for liquidity. Studies by Meiselman and Kessel indicate that such a premium does exist. As such liquid assets can be expected to have

⁵Ezra Solomon, The Theory of Financial Management (New York: Columbia University Press, 1963), p. 19.

⁶Normally the yield curve depicting the term structure of interest rates is upward sloping.

a lower rate of return over the life of the investment than an identical asset which is less liquid.⁷

In addition, asset marketability has a cost. Since cash, federal funds, treasury securities and security repurchases are all much more marketable than loans, mortgages and municipal bonds, one would expect that, all other factors taken into consideration, the yield on the former group of assets would be lower due to their greater marketability.

Taking liquidity and marketability into consideration, one would expect that the earnings potential of less liquid assets would be greater than that of liquid assets. Although liquidity and marketability bring flexibility to a bank's portfolio, it can do without this flexibility if it can reduce the amount of uncertainty connected with its operations, i.e., the uncertainty of deposit changes. If a bank is able to reduce uncertainty but does not, it will be required to increase the flexibility of its portfolio at the expense of earning potential. Should it not acquire this flexibility through its assets, it could be forced to borrow or acquire flexibility by liquidating its earning assets. Both of these alternatives carry uncertain and possibly very high costs. It must therefore be determined

⁷David Meiselman, The Term Structure of Interest Rates (Englewood Cliffs, N.J.: Prentice-Hall, 1962).

Reuben Kessel, The Cyclical Behavior of the Term Structure of Interest Rates (New York: National Bureau of Economic Research, 1965).

whether the opportunity cost of holding flexibility in a bank's portfolio is greater or less than the expected cost of having to acquire flexibility given the bank's uncertain need for liquidity. It is on this basis that the trade off between liquidity and earning potential must be made. If a bank does not need asset flexibility, it is able to hold longer maturity and less marketable assets, allowing it to avoid whatever premiums are paid for liquidity and marketability. As shall be shown later forecasting or anticipating deposit changes is one way to reduce the need for asset flexibility without incurring significantly increased risk.

Table 1.1 gives some indication of the yield differential between what are referred to as liquid and earning assets. The yield differentials do not consider transactions cost or default risk which may be greater for earning assets such as loans, municipals and mortgages. As a result, the yield differential is a gross rather than a net figure. This tends to bias the yield differentials in favor of earning assets. On the other hand, the prime interest rate used to measure the yield on loans is a conservative estimate of the yield on business, and especially consumer loans. Given these reservations the results show that for the eleven-year period under observation, the average annual yield on earning assets is higher than that for liquid assets. The differential declines during the times of liquidity crises, for example, 1969 and 1973.

The trade off between risk and return must be considered

TABLE 1.1

Yields on Bank Assets¹

<u>Earning Assets</u>				<u>Liquid Assets</u>				<u>Avg. Ann. Yields</u>	
Year	Prime Rate	Terms on		Federal Funds	3 month		9 to 12 month	Earning Assets	Liquid Assets Yield Differ.
		30 year Conventional Mortgages	3 to 5 Year Treas. Bonds		Treas. Bills	Treas. Bonds			
1965	5.00	5.77	4.22	4.07	3.95	4.05	4.06	5.42	4.03 1.39
1966	5.75	6.40	5.16	5.11	4.88	5.08	5.07	6.28	5.04 1.24
1967	5.75	6.53	5.07	4.22	4.33	4.63	4.71	6.34	4.47 1.87
1968	6.44	6.83	5.60	5.66	5.35	5.48	5.45	6.96	5.49 1.47
1969	7.67	7.66	6.86	8.21	6.69	6.86	6.79	8.41	7.14 1.27
1970	7.31	8.27	7.34	7.18	6.44	6.54	6.49	8.94	6.66 2.28
1971	5.64	7.60	5.78	4.66	4.34	4.50	4.67	7.52	4.54 2.98
1972	5.50	7.45	5.85	4.43	4.07	4.46	4.77	7.33	4.43 2.90
1973	7.90	7.78	7.30	8.73	7.02	7.16	7.01	8.36	7.48 0.88
1974	10.94	8.68	7.81	10.50	7.87	7.91	7.70	9.95	8.50 1.45

Source: Board of Governors of the Federal Reserve System, Federal Reserve Bulletin.

¹Yields are averages of monthly rates. In the case of the prime interest rate, twelve monthly observations were not available for the years 1965, 1966, 1967 and 1968.

²The yield on municipals have been adjusted assuming a 50% tax rate. The yields on the municipal banks are based on a sample of General Obligations from Moody's Investor Service.

for optimal decisions to be made. This trade off must be measured and the disutility for risk incorporated. For commercial banks this could cause some problems as the disutility for risk may be different for bank managers, bank depositors, bank owners and bank regulators. If so, the question may be whose utility function should be maximized.⁸

The relationship between liquidity and the return on investment can be explained as follows. Given a fixed amount of investable funds, a bank must decide how these funds are to be distributed between liquid and earning assets. An individual bank could maximize its earnings potential by investing all available funds in higher earning assets, or it could minimize its risk of insolvency by investing all funds in liquid assets. Under normal conditions banks operate somewhere between these two extreme positions. The bank must be concerned not only with the effect of the level of liquid assets on return on investment, where the return on investment is measured by net earnings before taxes over total assets, but also with the risk of insolvency. It is obvious that both objectives cannot be met, as they conflict. What must be done is to maximize the trade off between the conflicting objectives. This can be done by first expressing both objectives in common terms. If we can express the risk of insolvency and

⁸Models developed in this study assume a linear utility function for risk. As will be shown later, this assumption can be modified.

the rate of return in dollar terms, we can select an asset structure which maximizes dollar return. This analysis would translate risk into expected costs, and would examine the expected profitability of trading liquidity for greater earning potential. The optimal asset structure is attained when the expected marginal benefit of a dollar in liquid form is equal to the expected marginal cost.

The optimal asset structure is affected by the ability of bank managers to forecast or anticipate demands for cash. Holdings of liquid assets may be reduced if management can structure earning assets to provide the needed liquidity. The next section focuses on the impact of anticipating deposit changes on bank behavior.

Deposit Variability and Bank Behavior

Deposits, with the exception of large negotiable certificates of deposits, are for the most part unmanageable liabilities. Net changes in deposits force banks to make adjustments in their asset and liability portfolios. The type of adjustment made by the bank is important because certain types of adjustments are more efficient than others. The efficiency of adjustments depends on the predictability of the deposit changes. The anticipation of possible deposit changes affords management time to react.

Adjustments to deposit changes may be in the form of liquid assets (federal funds sold, security repurchases, treasury bills and treasury securities maturing within one

year), manageable liabilities (large negotiable certificates of deposits, federal funds purchased, securities sold under agreements to repurchase, federal reserve borrowing, and other liabilities for borrowed money), and earning assets (loans, mortgages, municipal bonds, and treasury securities maturing after one year).⁹

Net deposit inflows could be used to obtain additional liquid assets, earning assets, or to reduce manageable liabilities. As stated before, the type of adjustment made by the bank depends to a great extent on its ability to anticipate the changes in deposits. Deposit changes in this study are viewed as having two components, a systematic or predictable component, and an unsystematic or random component. Chander, for example, states that some deposit changes are of such a regular seasonal or other cyclical nature that they can be predicted with fair accuracy and prepared against.¹⁰

Net outflows of deposits (withdrawals) are of greater concern to bank managers and bank regulators than inflows because they pose an immediate threat to bank solvency. Net outflows would force adjustments in the opposite direction. Liquid assets could be turned into cash, earning assets could be liquidated and not replaced, and/or

⁹Although liquid assets also earn interest, it is assumed that over the long run they are held more for their ability to provide liquidity, rather than their earning potential.

¹⁰Chandler, The Economics of Money and Banking, p. 165.

manageable liabilities would be increased to generate the necessary cash.

As has been mentioned, deposit changes can be viewed as having both a systematic and an unsystematic component. The systematic component would be due to variations (seasonal, cyclical, or secular) of such a regular nature that they can be anticipated with a fair degree of accuracy. The unsystematic component would be due to variations (random) of such a nature that they cannot be anticipated with a fair degree of accuracy. Although all deposit changes force some balance sheet adjustments, the type of adjustment may be affected by the nature of the deposit change. Since commercial banks have three options available for making adjustments, it would appear likely that given time to prepare the most efficient adjustments would be made. For inflows the most efficient method of adjustment would normally be through earning assets since they usually possess higher yields than do liquid assets and usually earn a greater return than can be saved by reducing manageable liabilities.

If a bank can make adjustments to outflows through its earning assets that mature it could reduce its holdings of liquid assets and thus increase its return on investment. Adjustments to deposit outflows through earning assets that mature would be more cost efficient only if no liquid assets are held for this purpose. If liquid assets are held to meet deposit outflows, then the bank would be unwise not to use them when the need arises.

In addition, with liquid assets available to meet deposit outflows the bank would be unwise to incur additional costs through borrowing. If the bank does not hold liquid assets to meet deposit outflows it must decide whether to make adjustments through earning assets or through manageable liabilities. The decision depends on the cost and availability of borrowed funds. If funds can be borrowed at a rate lower than the rate of return on investments, then the adjustments should be made by increasing manageable liabilities. If borrowing costs are unreasonably high or borrowed funds are unavailable, the most efficient adjustments would be through earning assets. Although borrowing may be a more efficient method of adjusting to outflows, a bank which depends on borrowing faces uncertainty in the form of cost and availability of funds. Unless a bank is willing to accept this risk, it forfeits what could be a more efficient means of adjustment.

The relevance of this discussion is that liquid assets are needed to reduce the risk of insolvency for a bank only if the bank cannot find more efficient means of adjusting to deposit outflows. If a bank can anticipate deposit changes it can generate liquidity through its earning assets, or through borrowing, and thus increase its rate of return while not significantly increasing its risk of insolvency. Thus, although deposits are unmanageable liabilities, a bank may use systematic variations in deposits to obtain a more favorable risk-return trade off. The next chapter outlines the hypotheses of this study.

CHAPTER II

PROPOSED RESEARCH AND HYPOTHESES

Deposit variability has been the subject of numerous empirical studies.¹ The impact of deposit variability on some aspects of bank behavior has been studied, as have the factors which determine deposit variability. The following hypotheses have been made about deposit variability and empirically tested:

¹Hugh Chairnoff, "Deposit Variability: A Banker's Headache," Business Review (Federal Reserve Bank of Philadelphia, September, 1967), pp. 9-15, and "Deposit Variability," Business Review (Federal Reserve Bank of Philadelphia, August, 1968), pp. 13-17; Donald R. Fraser, "Deposit Instability at Individual Banks," Monthly Review (Federal Reserve Bank of Dallas, March, 1967), pp. 3-7; William G. Dewald and G. Richard Dreese, "Bank Behavior with Respect to Deposit Variability," Journal of Finance, 25 (September, 1970), pp. 869-879; George G. Kaufman, "Deposit Variability and Bank Size," Journal of Financial and Quantitative Analysis, 7 (December, 1972), pp. 2087-2096; Lyle E. Gramley, "Deposit Instability at Individual Banks," in Essays on Commercial Banking (Federal Reserve Bank of Kansas City, 1962), pp. 41-53; Neil B. Murphy, "A Cross-Section Analysis of Demand Deposit Variability," Journal of Financial and Quantitative Analysis, 3 (March, 1968), pp. 87-95; C. Rangarajan, "Deposit Variability in Individual Banks," National Banking Review, 4 (September, 1966), pp. 61-71; Frederick M. Struble and Carrol H. Wilkerson, "Bank Size and Deposit Variability," Monthly Review (Federal Reserve Bank of Kansas City (November-December, 1967), pp. 3-9; Edward E. Kane and Burton G. Malkiel, "Bank Portfolio Allocation, Deposit Variability and the Availability Doctrine," Quarterly Journal of Economics, 76 (February, 1965), pp. 113-134; Donald D. Hester, "An Empirical Examination of a Commercial Bank Loan Offer Function," Yale Economic Essays, 2 (Spring, 1962), pp. 3-57.

1. Deposit variability is considered to be an important determinant of portfolio strategy. The more volatile a bank's deposits are, the more liquid its asset mix.^{2 3}
2. To the extent deposit variability affects both the mix of earning assets and the frequency of engaging in costly reserve adjustments, variability affects the profitability of individual banks.⁴
3. Deposit variability is an important factor influencing bank use of the Federal Reserve discount window and it thereby affects discount administrative policy.⁵
4. Deposit variability, it has been hypothesized, is a function of bank size, the season, the business cycle and deposit structure.^{6 7 8}

Of the above studies only one makes an attempt to differentiate between systematic and unsystematic deposit variability. As the discussion so far has indicated, systematic and unsystematic variations may have different

²Kane and Malkiel, "Bank Portfolio Allocation."

³Hester, "En Empirical Examination."

⁴Dewald and Dreese, "Bank Behavior."

⁵Ibid.

⁶Kaufman, "Deposit Variability and Bank Size."

⁷Rangarajan, "Deposit Variability."

⁸Murphy, "A Cross-Section Analysis."

implications for commercial bank behavior. To the author's knowledge little if any empirical research has been conducted to answer the following questions:

1. What impact does deposit forecasting have on reducing risk and increasing return on investment?
2. What is the probability that unexpected negative changes in deposits will exceed a bank's liquid asset holdings?

Measuring Deposit Variability

In order to study variability in deposits one must construct a measure of variability. In efforts to relate deposit variability to various aspects of bank behavior and to determine the factors which cause deposit variability, research studies have used several different measures of deposit variability. In his paper, Rangarajan⁹ used the ratio of the standard deviation of demand deposits to the mean demand deposit level, the coefficient of variation. The standard deviation and mean were determined from average monthly demand deposits for the year 1962. The sample banks numbered 114, and were drawn from the Federal Reserve District of Philadelphia. Hester's¹⁰ study was quite similar to Rangarajan's although he used the ratio of the variance of demand deposits to the mean value of demand

⁹Rangarajan, "Deposit Variability."

¹⁰Hester, "An Empirical Examination."

deposits as his measure of variability.

Realizing that variability for time series data may be affected by growth, Wilkerson¹¹ adjusted for trend in his study by fitting a least squares line to 52 weekly averages of daily demand deposits for each of a sample of 783 banks. The absolute difference between the actual and calculated weekly average was expressed as a percentage of the calculated values for each week. The average of these percentages was his measure of variability. Murphy¹² used a similar technique. A least squares line was fitted to 26 bi-weekly averages of daily demand deposit totals for each of 100 banks in the Federal Reserve District of Boston. All of the above measures of deposit variability are primarily measures of total demand deposit variability (systematic and unsystematic). If one hypothesizes that random or unexpected deposit variability has a different impact on bank behavior, then these measures of deposit variability are inappropriate.

Random Deposit Variability and Bank Behavior: An Empirical Analysis

Hypotheses. One of the most interesting studies which examines the relationship between deposit variability and bank behavior was conducted by William G. Dewald and G. Richard Dreese. Dewald and Dreese hypothesize that

¹¹Struble and Wilkerson, "Bank Size."

¹²Murphy, "A Cross-Section Analysis."

deposits vary cyclically and seasonally by substantial amounts. As such, deposit flows are predictable to some degree. Dewald and Dreese surmise that the predictability of deposits provides a basis for individual banks to acquire appropriate earning assets in terms of maturity and risk in order to meet expected deposit withdrawals. Despite the predictability of some deposit flows for individual banks, the authors see the existence of a substantial residue of risk of deposit withdrawals that requires banks to manage their portfolios carefully. According to Dewald and Dreese, to prepare for random deposit changes, banks hold liquid assets and borrow.¹³

Dewald and Dreese hypothesize that it is random deposit variability which forces banks to manage their portfolios carefully. Banks that face higher withdrawal risks as measured by random deposit variability should hold relatively higher balances of liquid assets and should exercise borrowing privileges more frequently.¹⁴

Methodology. In their study, Dewald and Dreese measure random deposit variability by using the standard error of the estimate associated with the regressing of total deposits (including certificates of deposit) on trend, and on a number of seasonal variables including days of the week, months of the year, parts of the month and weeks

¹³Dewald and Dreese, "Bank Behavior," p. 869.

¹⁴Ibid.

of the country bank's settlement period.¹⁵ The data for the study was derived from daily observations for a sample of banks in the Federal Reserve District of Cleveland. The sample consisted of 18 banks drawn from a population of 252 of the 271 Cleveland district banks. The sample period extended from May 4, 1961, through December 31, 1965. Only banks which had borrowed at least once over the period October 26, 1960 through December 31, 1965, were included in the sample.¹⁶ As such, the conclusions of the study only apply to banks that were at least willing to borrow from the Federal Reserve in some circumstances.

Empirical Findings. Through cross-sectional regression analysis Dewald and Dreese examined the relationship between average adjustment factors such as: excess cash reserves and Federal Reserve borrowing over the previously indicated time period, and two measures of deposit variability; total deposit variability (the ratio of the standard deviation of total deposits to average total deposits), and random deposit variability (the standard error of estimate of total deposits to average total deposits). Averages were of daily observations over the 1701 day study period. The results showed very little relationship between either measure of deposit variability and average excess cash reserves held by the banks.¹⁷ In effect, deposit variability

¹⁵Ibid., pp. 873-874.

¹⁶Ibid., p. 872.

¹⁷Ibid., pp. 876-877.

total or random did not affect a bank's holdings of excess cash reserves.¹⁸ It would appear very likely that the insignificant relationship is due to the fact that banks, as a matter of policy, have little if any excess cash reserves.

Although Dewald and Dreese include short-term interest-bearing securities as an adjustment factor for unexpected deposit variability in their theoretical discussion, they do not include these assets in their regression analysis. One would expect that these assets are much more likely to be held as precautionary balances than excess cash reserves.

Dewald and Dreese do find that Federal Reserve borrowing is significantly related to random deposit variability, however they do not include other types of borrowing such as eurodollars, federal funds purchased and negotiable certificates of deposits which could equally be affected by deposit variability.¹⁹

The authors use the standard error of estimate as their measure of random deposit variability. However, the authors present no information on the amount of systematic (nonrandom) variation found in total deposits. This information is important because the entire analysis revolves around the different impact that total and random variability have on bank behavior. Dewald and Dreese present no support

¹⁸Excess cash reserves include vault cash reserves with the Federal Reserve and/or deposits at other banks in excess of required services.

¹⁹Ibid., pp. 876-877

for a significant difference between the two measures of variability.

In their analysis, Dewald and Dreese aggregate demand, and time and savings deposits. As a result, any difference in variability, total or random, between the two different types of deposits is hidden. In addition negotiable certificates of deposits which are manageable liabilities are not excluded.

Proposed Research

Deposit Variability and Bank Behavior. In this research study the systematic variability in both demand, and time and savings deposits will be examined using Box-Jenkins time series analysis for a sample of commercial banks. The Box-Jenkins method offers greater flexibility and efficiency in removing systematic variation in deposits than does the regression analysis used by Dewald and Dreese.

Once a model has been fitted to the individual deposit series, deposit changes and residuals from the time series model (unexpected variations) will be regressed against certain balance sheet data for each bank. In this manner, the impact of size on bank behavior can be examined; banks examined will vary in size. In addition, as shall be shown later, this regression analysis of time series data allows for a greater number of observations than does the cross sectional analysis used by Dewald and Dreese. In the Dewald and Dreese study, only 18 observations are available, equivalent to the number of banks in the sample, with a

greater number of observations a greater efficiency can be obtained in the regression model and its coefficients.

This study will also look at the relationship between deposit variability and liquid assets, where liquid assets include: federal funds sold, security repurchases, treasury bills and treasury securities maturing within one year, instead of excess cash reserves as was used in the Dewald and Dreese study. In addition, the relationship is examined between manageable liabilities and deposit variables, where manageable liabilities include: negotiable certificates of deposits, federal funds purchased, securities sold under agreements to repurchase, Federal Reserve borrowing, and other liabilities for borrowed money, instead of just Federal Reserve borrowing as was used by Dewald and Dreese. Finally the relationship between deposit variability and earning assets will be examined. Earning assets include: loans, mortgages, municipal bonds and treasury securities maturing after one year.

Asset Portfolio Management. We have already discussed the alternatives available for obtaining liquidity. However, each of these alternatives involves costs: the opportunity cost of handling cash or highly liquid assets such as federal funds or treasury bills, the expected cost of borrowing, and the potential cost of liquidating earning assets at a loss due to unfavorable market conditions. The need for liquidity by banks depends on the customer demand for liquidity. The alternatives selected by banks to meet

liquidity demands should depend on the expected costs associated with each.

Models developed to optimize bank portfolios subject to liquidity constraints must consider the returns on different investments, the variability of deposits and the cost of meeting expected cash demands. Several theoretical models have been developed to optimize bank portfolios under liquidity constraints; however, these models have problems which make them operationally impractical. Some of these models^{20 21} do not consider the distribution of deposit changes, they simply constrain liquidity to a minimum level. Others^{22 23} discuss the distribution of deposits in general terms, Porter preferring to deal with numerous hypothetical distributions.

Since liquidity requirements for commercial banks are not known with certainty, it is important that a distribution of deposit changes be known to attach some probability to deposit changes and therefore the bank's liquidity needs. For operational purposes the shape of the distribution must

²⁰D. Chambers and C. Charnes, "Inter-Temporal Analysis and Optimization and Bank Portfolios," Management Science, VII, 4 (July, 1961), pp. 393-410.

²¹Kalman J. Cohen and Frederick S. Hammer, "Linear Programming and Optimal Bank Asset Management Decisions," Journal of Finance, XXII, 2 (May, 1967), pp. 147-168.

²²Michael A. Klein, "A Theory of the Banking Firm," Journal of Money, Credit and Banking, III, 2, Part 1 (May, 1971), pp. 205-218.

²³Richard C. Porter, "A Model of Bank Portfolio Selection," Yale Economic Essays, I, 2 (Fall, 1961), pp. 322-359.

be known as it affects the form of the model and the data requirements for using the model. One purpose of this study will be to develop an asset selection model which focuses on asset yields and the alternative costs of obtaining liquidity. The model will be inventory theoretic in nature, and will consider deposit variability through the use of a probability distribution. This probability distribution will be derived from historical data.

Hypotheses to be Tested

The major hypotheses of this study deal with the nature of deposit variability (systematic and unsystematic), and the impact of deposit variability on bank behavior.

1. It is possible to anticipate a significant amount of deposit variability due to its systematic nature.

Deposits vary cyclically, seasonally and secularly by substantial amounts. Such deposit flows are predictable to some degree.

2. It is possible to reduce borrowing and liquid asset holdings of commercial banks by anticipating deposit movements.

Banks adjust differently to expected and unexpected changes in deposits. They try to acquire appropriate earning assets in terms of maturity and risk in order to meet expected deposit changes.

Unexpected or unanticipated deposit changes are more likely to be handled through the liquid assets or manageable liabilities accounts.

The next chapter develops the models used in measuring a bank's need for liquidity and the expected return from the bank's portfolio.

CHAPTER III

MODEL CONSTRUCTION

The discussion up to this point has centered on the impact of deposit variability on bank liquidity and asset structure. Chapter III continues this discussion through the use of mathematical models which measure liquid asset adequacy, and views asset management under the threat of deposit withdrawals or unexpected negative changes in deposits.

A bank's liquidity requirements, and thus asset structure depend greatly on deposit variability. However, as has been theorized, the impact of deposit variability may be lessened by bank management. If management can anticipate deposit changes it can make adjustments more efficiently thus increasing return on investment. Deposit changes which the bank is unprepared for determine its need for short run adjustments, in the form of liquid assets and/or manageable liabilities. This chapter focuses on the distribution of unexpected deposit changes for commercial bank portfolio decisions for commercial banks. It shows how the distribution's shape and its dispersion can be used to determine need for liquidity, and thus asset structure.

Risk of Liquid Asset Exhaustion

The liquid assets available to a commercial bank are

its first line of defense against unexpected deposit losses. As a result it is important to measure a bank's ability to meet deposit changes with this source of liquidity, and thus the need to develop alternative sources of liquidity. Determining the risk of liquid asset exhaustion for a commercial bank requires two things: a distribution for deposit changes and the amount of liquid assets available to meet specific demands for liquidity. The nature of the distribution for random deposit changes is the most important element in the development of the model. Assuming that the distribution for deposit changes is normal, the probability density function of the distribution can be expressed as:

$$f(D_C) = \frac{1}{\sqrt{2\pi}\sigma} e^{-\frac{(D_C - \mu)^2}{2\sigma^2}} \quad (3-1)$$

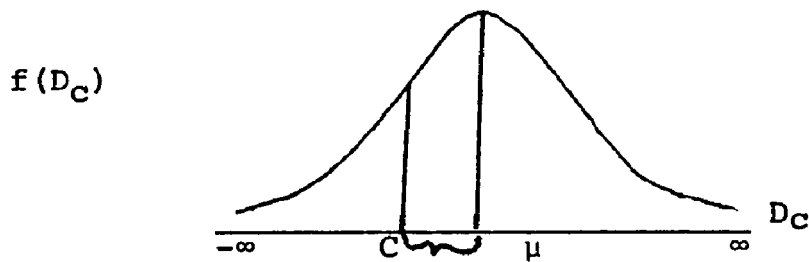
where $f(D_C)$ is the probability density function of random deposit changes, μ is the base of the natural logarithms ($e = 2.71828$), and D_C are individual deposit change values which can theoretically range from minus to plus infinity. Our analysis is greatly simplified if the deposit change distribution is normal, as once the parameters μ and σ^2 of the distribution are determined the entire distribution is known.

To determine the risk of liquid asset exhaustion it is necessary to determine the probability that deposit withdrawals will exceed the liquid assets held by the bank at any point in time. Once the liquid assets have been

exhausted, the bank is forced to liquidate its earning assets or borrow funds to meet deposit withdrawals, whichever is available and least costly.

Graphically the risk of liquid asset exhaustion can be depicted as follows:

Figure 3.1



The critical distance in Figure 3.1 is C to μ . Points to the left of this distance indicate random deposit withdrawals which cannot be handled through liquid asset balances, and which force the bank to liquidate earning assets or to borrow funds. The probability of this occurring is simply the integral of the density function from negative infinity ($-\infty$) to C which can be summarized in the following formula:

$$\text{Risk of Liquid Asset Exhaustion } (R_I) = \int_{-\infty}^C f(D_C) dD_C \quad (3-2)$$

Bank Asset Portfolio Management

In measuring the risk of liquid asset exhaustion for commercial banks, it was shown that a distribution of random deposit changes and the amount of liquid assets available in the bank's portfolio were needed. It was also shown that deposit variability has important implications for portfolio

management as it affects the amount of liquidity that a bank must keep on hand to protect itself against losses from being illiquid. If liquid assets are increased, the risk of liquid asset exhaustion declines, but the rate of return of investment also declines. The opposite holds true if liquid assets are decreased. This trade off between risk and return must be evaluated before an adequate or optimum decision can be made.

Bank Models Which Consider Liquidity. The question of how to handle bank liquidity needs has been handled in three ways:

1. Linear Programming Models: The best examples are Chambers and Charnes¹ and Cohen and Hammer.²
2. Markowitz Portfolio Models: See, for example, Russell³ and Fried.⁴
3. Inventory Models: The most important of which is Porter's.⁵

The linear programming models are essentially deterministic and not well suited to situations that involve uncertainty. As such, the uncertainty of deposit variability cannot be handled in this type of model. Liquidity problems are

¹Chambers and Charnes, "Inter-temporal Analysis."

²Cohen and Hammer, "Linear Programming."

³William R. Russell, "Commercial Bank Portfolio Adjustments," American Economic Review, LIV 2 (May, 1964), pp. 544-545.

⁴Joel Fried, "Bank Portfolio Selection," Journal of Financial and Quantitative Analysis, V, 2 (June, 1970), pp. 203-227.

⁵Porter, "A Model."

usually handled by setting minimum cash reserve constraints.

Most Markowitz models consider assets only and are inadequate for liquidity problems, which deal with the relationship between assets and liabilities, on this basis. In addition, all Markowitz models, by necessity, assume perfect financial markets, an assumption which minimizes the need for considering liquidity as a problem.⁶ Models of this type are unable to deal with liquidity except by means of constraints.

The inventory theoretic model is the type to be developed in this study as it allows for uncertainty in regards to deposit changes. Deposit variability can be handled in the objective function, and no perfect market assumptions need be made.

Porter's contribution to handling the liquidity problem is important because it captures the vital role of uncertainty in banking in a manner not accomplished before and incorporates liquidity considerations directly in the the objective function rather than in a constraint. Porter explains bank portfolio selection in terms of a precautionary motive for liquidity. He assumes that capital is fixed, deposits are exogenous and stochastic and borrowing opportu-

⁶In perfect financial markets there is complete and costless information available to everyone, no individual or firm is large enough to affect prices (interest rates) by his actions, and there are no transactions costs or taxes. The most important characteristic of perfect financial markets is that all individuals and firms can borrow or lend on the same terms.

nities exist at the central bank. The question of the optimal relationship between securities and loans is then addressed.⁷

Porter conceptualizes that the bank must be prepared for the possibility that withdrawals exceed additions to deposits and must consider the cost of adjusting to meet withdrawal demands.⁸ He assumes that at the beginning of the planning period, the bank recognizes that its level of deposits during the period may follow a myriad of possible paths, of which continuous rises or continuous falls are but two. It is assumed that one aspect of the shape of each of these possible paths is of great importance to the bank--that is the lowest point to which deposits fall in each of the paths.⁹ According to Porter it is at this "deposit-low" of the period that the bank is forced to make the most radical adjustment of its asset portfolio in order to meet the demands of its depositors.

Porter is concerned with a distribution of "deposit-lows" for myriad possible paths. As illustrated in Figure 3,2

These characteristics, if they existed, would tend to put all banks on the same footing, and would minimize the problem of inadequate liquidity since all available sources would be open to all banks on the same terms. Banking, however, is dominated by large money center banks which can influence interest rates and which do have advantages in securing funds through deposits, especially large, negotiable certificates of deposits, commercial paper, eurodollars and Federal Reserve borrowing.

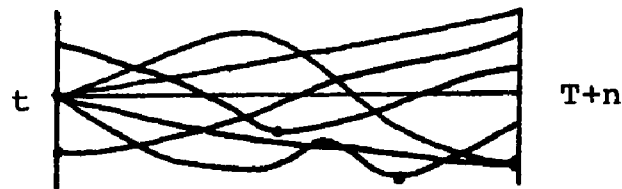
⁷Ibid.

⁸Ibid., p. 326.

⁹Ibid., p. 327.

these paths can take any possible shape from the beginning of period (t) to its end $(T+n)$.

Figure 3.2



Porter's interest is in the low point of each path; low points on the six paths in Figure 3.2 are indicated by the black dots.

The distribution of "deposit-lows" considered by Porter is of theoretical value but impractical for operational implementation. There is no way of determining the "deposit-lows" on myriads of possible paths, nor is Porter concerned with this problem. Porter considers the fact that the distribution of "deposit-lows" may take several shapes and proceeds to show that the conclusions of the model are not critically dependent upon the deposit distribution assumption.

Construction of the Portfolio Selection Model. Once the distribution of deposit variability which affects bank behavior has been determined, it becomes necessary to examine how a bank can and should react to this distribution. Porter describes this process by which banks meet deposit withdrawals. First, the bank meets withdrawals from its cash reserves. Secondly, should the cash reserves prove insufficient, the bank sells from its securities portfolio at the

market prices. Thirdly, should the sale of all of its securities also be inadequate to meet the deposit withdrawals, the bank borrows from the Federal Reserve Bank on the collateral of its outstanding loans. This it continues to do as long as necessary or until its stock of such collateral is depleted. Fourthly, should all of its assets be converted, to the greatest extent possible, into means of payment and still be insufficient to cover deposit withdrawals, the bank would then be in the throes of a liquidity crisis beyond its ability to handle. Porter assumes that such a "Stage 4" is so costly to the bank that no bank's optimum portfolio permits any possibility of this occurrence. To select a portfolio, the cost associated with each of these contingencies must be evaluated.

An inventory theoretic model to determine the cost of expected borrowing to meet withdrawal demands, the cost of expected securities liquidation to meet withdrawal demands, the cost of expected fixed assets liquidation to meet withdrawal demands and the expected return on a portfolio considering deposit variability can be developed with the following input:

1. A breakdown of the portfolio into asset categories with their expected net yields.
2. A distribution of deposit changes.
3. The expected unit cost of having to borrow or liquidate assets.

Porter's liquidity response scheme leads to the

following inventory theoretic model with bank behavior being a function of normally distributed deposit changes.

$$\begin{aligned}
 E(P) = & E(R_C)C + E(R_S)S + E(R_L)L - E(C_S) \int_{C+S}^C (D_C - C) f(D_C) dD_C \\
 & - E(C_B) \int_{C+S+B_C}^{C+S} [D_C - (C+S)] f(D_C) dD_C \\
 & - M \int_{-\infty}^{C+S+B_C} [D_C - (C + S + B_C)] f(d_C) dD_C \quad (3-3)
 \end{aligned}$$

For convenience, the variables are defined below:

C = liquid assets

S = securities

L = loans

$E(R_C)$ = expected yield on liquid assets (Given different types of assets which comprise this category, this is a net weighted average return.)

$E(R_S)$ = expected yield on securities (Since securities have different characteristics, this is a net weighted average return.)

$E(R_L)$ = expected yield on loans (This return is also a net weighted average yield.)

$E(C_S)$ = expected cost of liquidating earning securities (This is a weighted average cost which includes transactions costs plus expected capital gains or losses plus interest forsaken over the book value of the securities.)

$E(C_B)$ = expected cost of having to borrow to meet withdrawal demands. (This cost is a weighted average interest rate for all borrowing sources.)

D_C = net negative deposit changes which may occur

B_C = borrowing capacity of the bank

M = cost of not being able to meet cash demands through liquid assets, through liquidating securities or through borrowing. (The cost of having to liquidate fixed assets)

$f(D_C)$ = probability density function of deposit changes

$E(P)$ = expected profits

Translated the model shows that expected profits depend on the expected returns and costs associated with a bank's asset portfolio. The first three terms in the model calculate the expected return on highly liquid assets, on securities, and on loans respectively. Loans and securities are the earning assets of a bank. Total assets (T) of a bank are composed of liquid assets (C), earning assets; (securities) (S) and loans (L), and fixed assets (F).

$$T = C + S + L + F \quad (3-4)$$

Liquid assets consist of Federal Reserve Bank reserves, vault cash, net balances with other banks and bills of very near maturity. Porter assumes that these assets provide no return and are completely free of risk of capital value change.¹⁰ These assets, such as federal funds, do offer a return, and for this reason the term $E(R_C)C$ is included in the model. Fixed assets are ignored by Porter, for as their name implies, they are not variable in the short run. Earnings in the short run cannot be increased nor risk decreased by shifting funds into fixed assets.

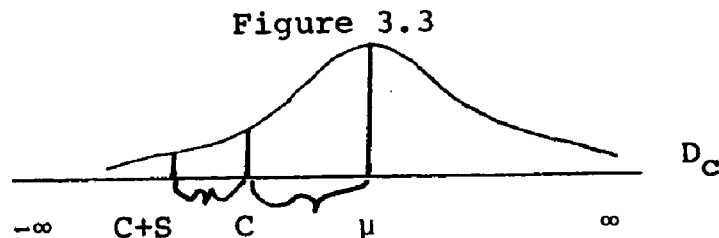
¹⁰Ibid., p. 325.

As was mentioned previously, the second and third terms in the objective function represent the return on securities and loans. With initial deposits and the distribution of deposit changes given, the greater the amount of total funds invested in earning assets the smaller the amount of funds invested in liquid assets. Although the expected return on earning assets may increase -- the risk of insolvency will also increase.

The fourth term in the model represents the total expected cost of liquidating securities to meet deposit withdrawals. If deposit withdrawals should exceed the liquid assets available, the bank is assumed to liquidate securities to meet this demand. The integral

$$\int_{C+S}^C f(D_C) dD_C$$

indicates the probability of deposit changes falling within the range $C + S$ to C on the density function as depicted in Figure 3.3. If we assume that $\mu = 0$, the area from μ to C



indicates the probability that deposit outflows can be met through liquid assets, the market value of available securities can provide additional cash as is indicated by the distance $(C+S)$ to C . The term $(D_C - C)$ when added to the

integral gives the amount of this potential cash source which is expected to be used; this is based on the deposit change distribution. The term $E(C_S)$, a rate, is the expected cost of acquiring this cash. The entire expression

$$E(C_S) \int_{C+S}^C (D_C - C) f(D_C) dD_C$$

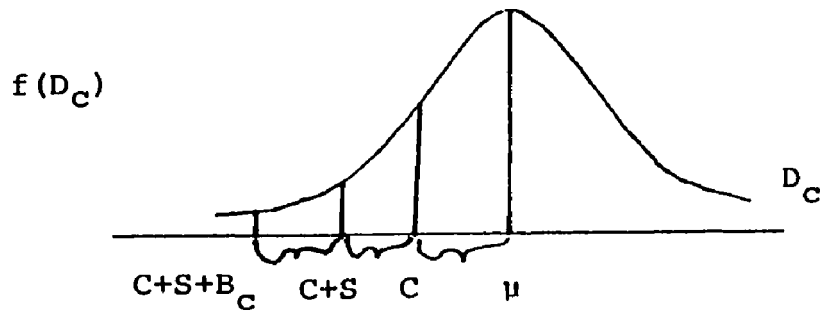
is simply the expected cost (rate) for acquiring funds through securities liquidation times the expected amount of cash which will be needed from this source given the deposit change distribution.

The fifth term represents the total expected cost of borrowing to meet deposit withdrawals. The integral

$$\int_{C+S+B_C}^{C+S} f(D_C) dD_C$$

indicates the probability of deposit changes falling within the range $(C + S + B_C)$ to $(C+S)$ on the density function. In other words, the probability that deposit changes will exceed cash reserves and the market value of securities, and will fall within the limits of the bank's borrowing capacity. The limits of the bank's borrowing capacity is indicated by the distance $(C + S + B_C)$ to $(C + S)$ in Figure 3.4. The term $[D_C - (C + S)]$ when added to the integral gives the amount of this potential cash source

Figure 3.4



which is expected to be used. As before the amount expected to be used depends on the deposit change distribution. The term $E(C_B)$ is the expected interest rate for acquiring this cash. The entire expression represents the total expected cost of borrowing.

$$D(C_B) \int_{C+S+B_C}^{C+S} [D_C - (C + S)] f(D_C) dD_C$$

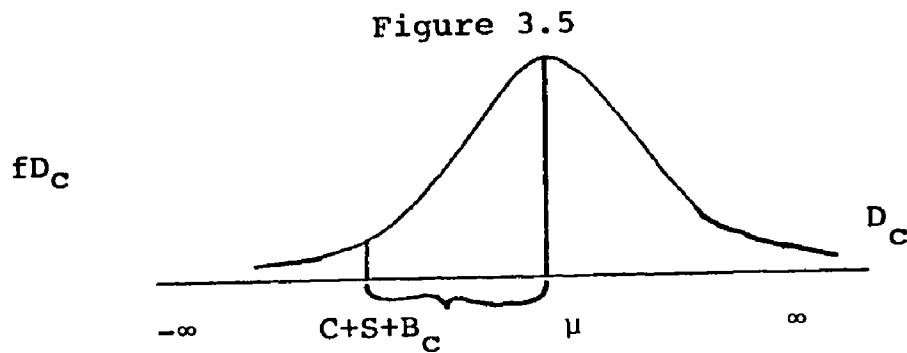
Once the bank has depleted its available liquid assets, liquidated all of its securities and exhausted its borrowing capacity, it is faced with the prospect of liquidating fixed assets. This would be the worst possible disaster and would indicate that the bank is in a liquidity crisis beyond its ability to handle.

The integral

$$\int_{-\infty}^{C+S+B_C} f(D_C) dD_C$$

indicates the probability of deposit changes falling within the range $-\infty$ to $(C+S+B_C)$ on the density function. It is the probability that deposit changes will exceed liquid assets,

the market values of securities, and the borrowing capacity of the bank. The distance $-\infty$ to $(C+S+B_C)$ on Figure 3.5 indicates the level of deposit changes which would force the bank to liquidate fixed assets.



The term $[D_C - (C + S + B_C)]$ when added to the integral gives the expected amount by which the bank's liquid assets, securities liquidation capacity, and borrowing capacity will be exceeded. The term M is the expected cost (rate) of liquidating fixed assets; M is assumed to be extremely large. The entire expression

$$M \int_{-\infty}^{C+S+B_C} [D_C - (C + S + B_C)] f(D_C) dD_C$$

represents the total expected cost of liquidating fixed assets.

Developing the model according to how Porter sees banks solving their liquidity problems leaves the model less than operationally satisfactory for the following reasons. Porter assumes that all securities are liquidated before the

firm borrows to meet withdrawals. David Pyle points out that as long as the real and opportunity cost of liquidating securities is less than or equal to the variable cost of borrowing, the liquidity response imposed by Porter's assumption is unobjectionable. However, if we allow for the possibility that $D(C_B)$ is less than $E(C_S)$, there is a deposit drain large enough that the optimal response at the time of the drain would be to borrow.¹¹

Pyle chooses to stick with a weighted cost approach forcing the bank to meet cash demands totally through borrowing or totally through liquidation of securities, whichever has the lowest expected weighted average cost. It would seem likely that commercial banks would benefit by using that mix (liquidation of securities and borrowing) which results in the lowest expected cost. It would not appear that the bank would desire to liquidate all of its securities first and then resort to borrowing to meet cash demands. In their study, Dewald and Dreese¹² theorize that commercial banks meet their liquidity needs through a mix of alternatives depending on cost and availability. Commercial banks are said to use a mix of liquid assets, borrowings and security liquidations to meet their cash demands from withdrawals. As such, the model should reflect this behavior,

¹¹David H. Pyle, "Descriptive Theories of Financial Institutions Under Uncertainty," Journal of Financial and Quantitative Analysis, 7 (December, 1972), p. 2015.

¹²Dewald and Dreese, "Bank Behavior."

which depends on the cost and availability of liquidity or cash sources.

It can be expected that the combination of securities liquidations and/or borrowing which result in the lowest cost will be used first and more costly means of securing liquidity will follow. If a range of possible costs for securing liquidity can be determined for a bank, then the amount of the total market value of securities and the amount of borrowing capacity which can be activated for liquidity reasons at each rate can be determined. Instead of weighing the cost of liquidating all securities and activating total borrowing capacity separately, the bank determines the amount of liquid funds it can activate at a number of different rates, regardless of the source.

The model would then include a term for each expected cost (rate) until all of the bank's securities and borrowing capacity has been exhausted. As the bank exhausts its least costly sources for securing cash, more costly sources are used until cash demands are met or until the firm is forced into bankruptcy.

Incorporating the new change, the model becomes:

$$E(P) = E(R_C) C + E(R_S) S + E(R_L) L \quad (3-5)$$

$$-E(C_1) \int_{C+S_1+B_{C_1}}^C (D_C - C) f(D_C) d D_C$$

$$-E(C_2) \int_{C+S_1+S_2+B_{C_1}+B_{C_2}}^{C+S_1+B_{C_1}} (C + S_1 + S_2 + B_{C_1}) f(D_C) d D_C$$

$$C+S_1+S_2+B_{C_1}+B_{C_2} \dots S_{N-1}+B_{C_{N-1}}$$

$$-E(C_N) \int_{C+S_1+B_{C_1}+S_2+B_{C_2} \dots S_N+B_{C_N}} [D_C - (C+S_1+B_{C_1}+S_2+B_{C_2} \dots S_{N-1}+B_{C_{N-1}})] f(D_C) dD_C$$

$$C+S_1+B_{C_1}+S_2+B_{C_2} \dots S_N+B_{C_N}$$

$$-M \int_{-\infty} [D_C - (C+S_1+B_{C_1}+S_2+B_{C_2} \dots S_N+B_{C_N})] f(D_C) dD_C$$

Terms not previously defined are:

$E(C_N)$ = expected cost (rate) of acquiring cash funds from whatever source

S_i = total market value of those securities which can be liquidated at the expected rate $E(C_i)$

B_{C_i} = total amount of funds which can be borrowed at the expected rate $E(C_i)$

$i = 1, \dots, n$

The above model assumes that portfolio decisions are affected by deposit changes. The distribution of these deposit changes, it has been hypothesized, is normal. Deposit changes may be negative and, of course, may be absorbed with available liquidity. If liquid assets are not sufficient, the bank resorts to the least costly means of obtaining cash; it either borrows or liquidates some of its securities. The bank will not be able to borrow an infinite sum at one interest rate nor can it liquidate all of its securities at one rate. It will borrow or liquidate what it can to meet cash demands at the lowest costs and will proceed to liquidate and borrow what it needs at

progressively higher costs until it has met cash demands or is forced into bankruptcy. The important point is that the bank tries to obtain cash at the lowest possible costs which it may do by liquidating all of its securities first and then borrowing, borrowing first and then liquidating all of its securities, or through some mix of the two, whichever results in the lowest costs.

The integral

$$\int_{C+S_1+B_{c_1}}^C f(D_c) d D_c$$

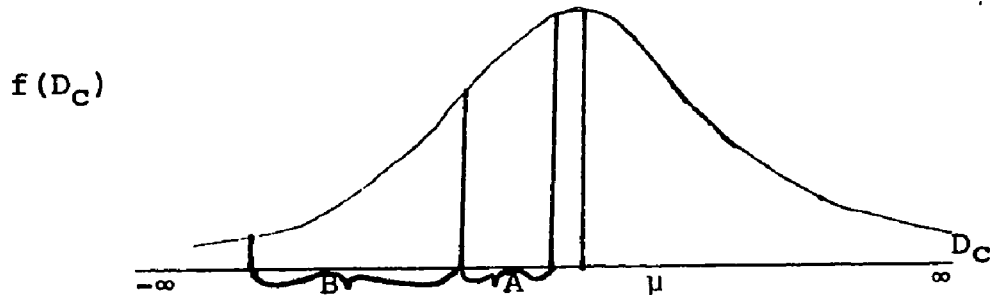
indicates the probability of deposit changes falling within the range $(C+S_1+B_{c_1})$ to C on the density function. The term $(D_c - C)$ when added to the integral gives the amount of this potential cash reserve which the bank may be forced to use. The term $E(C_1)$ indicates the expected cost of converting these reserves into cash. The entire expression

$$E(C_1) = \int_{C+S_1+B_{c_1}}^C (D_c - C) f(D_c) d D_c$$

gives the total expected cost of securing funds which are expected to be available at the rate C_1 . Those funds available at rates higher than C_1 bring about additional

expressions of the same form. The distribution is thus broken up into sections. Each section is represented by an integral which indicates the amount of funds available to cover cash demands at different rates. As Figure 3.6 indicates, the funds available at the lowest costs are activated first and lie furthest to the right. Assuming that $\mu = 0$, the least expensive funds are represented by those sections lying closest to μ . In Figure 3.6, the value of the least costly funds is represented by the distance $(C+S_1+B_{C1})$ to C . If these funds are exhausted, another pool is tapped at a higher rate. The distance $(C+S_1+B_C+S_2+B_{C2})$ to $(C_1+S_1+B_{C1})$ represents the amount of borrowing and liquidation of securities which takes place at the next lowest cost. No funds need be activated when net deposit changes are positive.

Figure 3.6



$$A = (C+S_1+B_{C1}) \text{ to } C$$

$$B = (C+S_1+B_C+S_2+B_{C2}) \text{ to } (C+S_1+B_{C1})$$

The final expression

$$C+S_1+B_C+S_2+B_{C2} \cdots S_N+B_{CN}$$

$$- M \int_{-\infty}^{D_C - (C+S_1+B_{C1}+S_2+B_{C2} \cdots S_N+B_{CN})} f(D_C) dD_C$$

represents the expected cost of not having sufficient liquidity potential, through borrowing and liquidation of securities, to meet deposit withdrawals.

It is, of course, important to note that the greater the dispersion of the distribution of deposit changes, the greater the need for liquidity, and the greater the likelihood of costly adjustments. Should a bank's management be able to anticipate deposit changes, the variance of this distribution may decline, thus the risk of liquid asset exhaustion declines, as does the cost of adjustment. Short run adjustments are a function of unexpected deposit changes. The variance of the distribution of unexpected deposit changes depends on the amount of systematic variation in deposit changes, and the bank management's ability to use this systematic variation to structure its earning assets. If no systematic variation exists in deposits, or banks do not make use of the systematic variability which does exist, all deposit changes are unexpected and the bank subjects itself to a distribution of deposit changes with greater variance than would be the case if systematic variation existed in deposits and was used to plan adjustments.

The need to hold liquid assets and make other short-run adjustments for deposit changes would depend on the accuracy of management's forecasts. Differences between what management predicted and prepared for, and what actually occurred would create a need for short-run adjustments due to their random or unexpected nature.

Selecting the Optimal Asset Portfolio. The form of the objective function makes clear the nature of the economic trade off. An increase in earning assets relative to liquid assets implies an increase in marginal revenue, but since it influences the potential size and the likelihood of a cash deficiency (the risk of liquid asset exhaustion), it also implies an increase in the marginal conditional expectation of liquidation or borrowing costs associated with a deficiency. By maximizing the objective function, taking the partial derivative of P with respect to S or L and setting it equal to zero, the optimal asset portfolio can be selected.

Limitations of the Model. The model explains the relationships and trade offs involved in making commercial bank portfolio decisions. Having selected a portfolio, a bank manager may use the model to measure the risk of liquid asset exhaustion and the expected returns and costs associated with that portfolio. The bank manager is thereby made aware of the risk involved in his decisions and is forced to think about alternatives available to meet this risk. Use of the model in this manner forces the manager to plan.

As a portfolio selection instrument, the model has two deficiencies. First, the model assumes a linear utility function. Given the commonly held belief that bank managers and regulators are risk averse, the optimal portfolio determined by the model will not be optimal for these

decision makers.¹³ The model does, however, allow the decision maker to consider portfolios other than the optimal one under the linear utility function assumption. The bank manager can constrain the risk of liquid asset exhaustion to a specified maximum. Secondly, the model cannot handle the loan deposit feedback commonly believed to exist for commercial banks.¹⁴ For portfolio selection purposes the model assumes that investment in loans and/or securities rather than in cash reserves has little or no impact on deposits. This assumption becomes less likely the greater the monopoly position of the bank in question. However, since the feedback relationship appears to be a nebulous concept and since incorporation of it would considerably complicate the analysis, it is assumed insignificant.

The methodology of testing and the sources of data must be specified. Chapter IV discusses methodology, data sources and interpretation of expected results.

¹³The quadratic utility function has been used for risk averse investors. However, it has properties which are not appealing from an economic point of view. Because a quadratic function implies negative marginal utility of wealth beyond some point, the quadratic is always at best an approximation to the true utility function of a risk averter. A second difficulty with quadratic utility is its inherently limited flexibility in describing the preferences of individuals. The quadratic tries to describe complex individual preferences by a single number. For a more complete discussion on the limitations of quadratic utility functions see Charles W. Haley and Lawrence D. Schall, The Theory of Financial Decisions (New York: McGraw-Hill Book Company, 1973), pp. 109-112.

¹⁴Donald R. Hodgman, Commercial Bank Loan and Investment Policy (Champaign, Illinois: Bureau of Economic and Business Research, University of Illinois, 1963).

CHAPTER IV
RESEARCH METHODOLOGY, DATA SOURCES
AND
INTERPRETATION OF EXPECTED RESULTS

As discussed in earlier chapters, this study is concerned with the nature of deposit variability, bank behavior in response to deposit variability and the risk of liquid asset exhaustion. This chapter describes the methodology to be used for measuring the amount of systematic variation in deposits, bank behavior in response to deposit variability and the risk of liquid asset exhaustion. In addition, data sources and the manipulation of data for carrying out the empirical analysis will be discussed, and an interpretation of expected results presented.

Determining the Nature of Deposit Variability

Data Requirements. To determine if commercial bank deposits possess sufficient systematic variability so that deposit changes can be forecasted, requires that time series models be fitted to series of demand, and time and savings deposits for individual banks. These models will determine the nature of deposit variability. Development of these models requires deposit observations over a representative time period.

Data Sources and Manipulation. The data used in the study were collected by the Federal Reserve Board of Governors. They were collected on a weekly basis for a national sample of banks, which fell into two size classes: under \$300 million in total assets, and over \$500 million in total assets. The data collected were basic balance sheet accounts (assets, deposits and other liabilities for individual banks). All data were multiplied by an unknown constant to maintain the anonymity of the banks used in the study.

Research Methodology for Determining the Nature of Deposit Variability. Deposits for individual banks is subject to the influence of secular (trend), seasonal, cyclical factors, and random forces. The secular, seasonal and cyclical factors may contribute to systematic variability in deposits which can be used by bank management to predict or anticipate deposit changes, and used to reduce the occurrence of unexpected and more costly adjustments in the bank's asset and liability portfolios. The existence of systematic variability can be determined through the use of the Box-Jenkins times series approach. This technique eliminates the systematic components of deposit data, leaving a residual component which can be examined to determine if bank behavior is related to these unexpected deviations. The Box-Jenkins method is especially useful since it allows for experimentation with different time series models so that those models which are most efficient in removing

systematic variation in deposits can be selected. The alternative models which were examined for the deposits will be discussed in Chapter V.

Analysis of the Expected Results. In determining the nature of deposit variability, it has been hypothesized that sufficient systematic variability exists in bank deposits to allow banks to forecast deposit changes. For models fitted to the individual deposit series the amount of systematic variation in deposits can be measured by the coefficient of determination (R^2). Sufficient systematic variability would exist if banks are able to reduce the amount of unexpected changes in deposits, and the dispersion of the distribution of unexpected changes. By forecasting, the bank is subject to forecasting errors (residuals) for which it must make costly short run adjustments. If the bank does not attempt to forecast or anticipate deposit changes, it must make the costly short run adjustments to the actual deposit changes which occur. The greater the amount of systematic variation in deposits (as a percentage of total variation), the greater the difference will be between the size of the residuals and the actual deposit changes, and the greater the difference in the amount of dispersion in the distributions of the two series. Residuals should be smaller in size and have distributions with less dispersion.

Bank Behavior in Response to Deposit Variability

Data Requirements. Analysis of the relationship between deposit variability (total and random) and bank behavior requires observations of total deposit changes, random deposit changes, and the accounts which adjust to these changes (liquid assets, earning assets and manageable liabilities).

Data Sources and Manipulation. The data used in this analysis have been obtained from the Federal Reserve Board of Governors.

Actual deposit changes are simply the differences between total deposits for successive weeks. Random deposit changes are the residuals from the models used to remove systematic variation in deposits. The adjustment accounts simply respond to changes in deposits, and are, therefore, the week-to-week differences in liquid assets, earning assets and manageable liabilities.

Research Methodology for Testing Bank Response to Deposit Variability. The methodology for testing bank behavior in response to deposit variability is simple regression analysis. Two independent variables:

A = Actual deposit changes (the total change in demand, and time and savings deposits)

R = Random deposit changes (the sum of the residuals or forecasting errors for the demand, and time and savings deposit series)

will be regressed individually against each of three independent variables:

C = Liquid asset changes

E = Earning asset changes

L = Manageable liabilities

The analysis will show which measures of deposit variability affects which adjustment accounts, and to what extent. In this manner it can be determined if management can anticipate systematic variations in deposits, and if it can use this knowledge to make its adjustments more efficient.

Analysis of the Expected Results. It is expected that banks which can correctly anticipate significant changes in deposits will be able to make most of their adjustments to actual deposit changes through their earning asset account. In addition, the adjustment in the liquid asset and manageable liability accounts will be more closely related to random deposit changes than actual deposit changes. As Dewald and Dreese have hypothesized, the unexpected, or random, deposit changes force the short run and less efficient adjustments in liquid assets and manageable liabilities.

The regression coefficient, β , will be the focal point of the analysis. It indicates the relationship between deposit changes and changes in the adjustment accounts, in dollar terms. The size of the coefficient and its level of significance will determine the importance of the two deposit change variables on the adjustment variables.

Risk of Liquid Asset Exhaustion

Data Requirements. Measuring risk of liquid asset exhaustion requires the following data:

1. Deposit changes from which a probability distribution can be obtained.
2. The amount of liquid assets, which can be used to protect against unexpected losses in deposits.

Data Sources and Manipulation. The data required to determine deposit changes and liquid asset holding, as has previously been stated, were made available by the Federal Reserve Board of Governors.

As has been a recurrent theme in this paper, two measures of deposit changes are important: actual deposit changes and random changes. Actual deposit changes are simply the week-to-week differences in total deposits, whereas random changes are the residuals, or forecasting errors caused by an inability to predict exactly how deposits will change. If management cannot or does not anticipate the systematic flow of deposits, then all deposit changes are in effect random or unexpected. Differences in the size and dispersion of the distributions for these two series reflect different needs for liquid assets.

Liquid assets holdings are measured as the bank's average holdings over a given period of time.

Research Methodology for Risk of Liquid Asset Exhaustion

tion. Once the data for the distributions were in their final form and the normality of the distribution has been tested, probability theory will be applied to determine the risk of liquid asset exhaustion for the individual banks. Risk of liquid asset exhaustion has been defined as the probability that unexpected deposit changes (withdrawals or negative residuals) exceed the average liquid assets of the commercial bank. The distributions are assumed to be stationary over time.¹

Analysis of the Expected Results. In determining the risk of liquid asset exhaustion the distributions of deposit changes and residuals have been hypothesized to be normally distributed with means of zero. The normal hypothesis can be tested with a chi-square goodness-of-fit test. Hypothesis testing can be used to determine if the means of the series are significantly different from zero. By finding the variate value of the goodness-of-fit test, one can determine how closely the distribution of deposit changes approximates normality.

Once the shape of the distribution has been tested, the probability that deposit reductions exceed a certain value, average liquid assets, can be determined. If the distribution is normal, as it is expected to be, knowledge of the

¹This assumption is definitely valid for the residual series, and for time and savings deposit series. Deposit changes for demand deposits tend to have slight upward, or downward, drift, however.

mean and standard deviations of the distribution permits computation of the probability that deposit withdrawals or negative residuals will be greater than the average liquid assets for a given period of time.

Once the risk of liquid asset exhaustion has been determined for each bank in the sample, the hypothesis about how it varies on the basis of bank size can be determined by using analysis of variance.

Chapter V shows the results of the empirical analysis.

CHAPTER V

EMPIRICAL RESULTS

This chapter explains the Box-Jenkins time series analysis technique, and shows how it was applied to demand, and time and savings deposit series for 40 individual banks during the years 1971 through 1973. The Box-Jenkins technique was used to determine the amount of systematic and unsystematic (random) variation that exists in deposits. Having determined the nature of deposit variability, the chapter reports on the behavior of banks in response to deposit variability. The chapter concludes with a summary of the empirical findings.

The Box Jenkins Applied Time Series Analysis

To determine if it was indeed possible to predict deposit changes accurately enough to reduce the size and dispersion of unexpected deposit changes (deposit changes which are not predicted), the Box-Jenkins time series analysis was applied to the weekly deposit series of 40 Federal Reserve Banks.¹

¹The forty banks were chosen from a national sample of four hundred and sixteen banks from which the Federal Reserve obtains weekly financial reports. The data were masked, multiplied by an unknown constant to maintain the anonymity of the sampled banks. Of the forty banks used in the analysis twenty possessed total assets less than \$300 million dollars and twenty possessed total assets above \$500 million dollars.

Since demand deposits and time and savings deposits are thought to differ in terms of variability it was decided to handle each as a separate series.² In effect each of the forty banks was to have two times series models developed for it, one for the demand deposit series, the other for the time and savings deposit series.

In determining and fitting time series models to deposit changes for the sample banks it was first necessary to identify, from the alternative types of models available, that model which best fit the individual time series. The Box-Jenkins approach relies on the mathematical relationship between autoregressive or moving average series and the serial correlation coefficients of those series. To be beneficial for forecasting purposes, it is in addition necessary that the model and its parameters be stable over time.

Alternative Time Series Models

The Box-Jenkins method of intrinsic time-series analysis provides a technique for identifying the most appropriate model.³ Variables in time series may be represented as a function of intrinsic variables (functions of past values of the same series) or extrinsic variables

²Large negotiable certificates of deposits were excluded from time and savings deposit series due to their much greater manageability.

³G.E.P. Box and G.M. Jenkins, Time Series Analysis, Forecasting and Control (San Francisco: Holden-Day, 1970).

(all other variables). Since in this study we are concerned with the former only, variations in the observed values of time series caused by extrinsic variables are assumed to occur randomly -- that is, in a way that is not predictable from past values in the series. This section relies heavily on the work of Box and Jenkins.

A time series, like the deposit series used in this study, can be viewed as a set of random variables which occur over time. Each random variable may be viewed as having a probability distribution, and the moments of the distributions for each random variable may be different. What is important in time series analysis is not that the distributions are identical, but the extent to which successive variables in the time series are statistically dependent.

If Z_t is defined as a time series observation in period t , it may be dependent on past observations and on a randomly distributed error term, e :

$$Z_t = f_t (Z_{t-1}, Z_{t-2}, \dots, e_t) \quad (5.1)$$

and the sequence of observations (Z_t) may be viewed as a set of jointly distributed random variables:

$$f_{1 \dots n} (Z_1, Z_2, \dots, Z_n) \quad (5.2)$$

Through time series analysis this joint distribution is used to predict future observations with an attached degree of certainty or uncertainty.

As the name implies, an autoregressive process is essentially a regression equation in which Z_t is related

to its own past values instead of to a set of independent variables. An autoregressive process may be expressed in the form:

$$Z_t = \delta + \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \dots + u_t \quad (5.3)$$

where δ and the ϕ_i are fixed parameters and u_t is a random variable with mean zero and is statistically independent of all other u_{t-k} , $k \neq 0$. When $\phi_i = 0$ for $i > p$, the process is:

$$Z_t = \delta + \phi_1 Z_{t-1} + \phi_2 Z_{t-2} + \dots + \phi_p Z_{t-p} + u_t \quad (5.4)$$

and is called an autoregressive process of order p , or $AR(p)$.

A first-order autoregressive process, $AR(1)$

$$Z_t = \delta + \phi_1 Z_{t-1} + u_t \quad (5.5)$$

is called a Markov process. When $\phi_1 > 1$, the development of the Z_t would display explosive growth and the process is referred to as "nonstationary." When $|\phi| < 1$ the process is stationary. When $\phi = 1$, (5.5) becomes

$$Z_t = \delta + Z_{t-1} + u_t \quad (5.6)$$

which is a random walk (or strictly speaking, a random walk with drift when $\delta \neq 0$).

For deposit changes the most important consequence of the random walk model is that, apart from the trend term, today's deposits are the best predictor of tomorrow's deposits, or of future deposits. In addition the deposit series would contain no repetitive, systematic component such as a seasonal pattern. The only "systematic" component in the

random walk series is δ .

The Box-Jenkins technique also makes it possible for Z_t to be expressed as a weighted sum of the current and all past disturbances. By substituting in (5.3) for Z_{t-1} and Z_{t-2} and so forth successively, an expression of the form:

$$Z_t = \mu + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \dots \quad (5.7)$$

is obtained. In the above equation μ and the θ_i are fixed parameters and the time series u_t is a series of independently distributed random disturbances.

When $\theta_i = 0$ for $i > q$, the process becomes

$$Z_t = \mu + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \dots + \theta_q u_{t-q} \quad (5.8)$$

where is referred to as a moving average process of order q or MA(p).

A further extension of the AR and MA models would be a class of models having both autoregressive and moving average terms. In other words processes of the form

$$Z_t = \delta + \phi_1 Z_{t-1} + \dots + \phi_p Z_{t-p} + u_t - \theta_1 u_{t-1} - \dots - \theta_q u_{t-q} \quad (5.9)$$

Such processes are referred to as autoregressive-moving-average processes of order p and q or just ARMA (p, q). For many series encountered in practice, the inclusion of both autoregressive and moving-average terms results in a model that has fewer parameters than would be necessary for a satisfactory model of pure AP or pure MA form.

Box-Jenkins analysis is dependent on the existence of covariance stationarity in a time series.⁴ A time series is

⁴For a justification see Charles R. Nelson, Applied Time Series Analysis (San Francisco: Holden-Day, 1973), pp. 19-20.

strictly stationary only if the joint distribution of the variables $D_1, \dots, D_N$ is invariant with respect to any displacement.⁵ That is,

$$f_{t \dots t+k}(D_t, \dots, D_{t+k}) = f_{t+m \dots t+m+k}(D_{t+m}, \dots, D_{t+m+k}) \quad (5.10)$$

where t is any time point and k and m are any integers. Covariance stationarity, which is implied by strict stationarity, is a weaker condition, requiring only that the mean, variance and covariance matrix be invariant with time:

$$E(D_t) = E(D_{t+m})$$

$$\text{VAR}(D_t) = \text{VAR}(D_{t+m})$$

and $\text{cov}(D_t, D_{t+k}) = \text{cov}(D_{t+m}, D_{t+m+k})$, where k

and m are any integers.

A deposit series is not, in general, stationary. However, a stationary series can be obtained by making certain transformations on the data. For example the demand deposit series could be reduced to stationarity by taking the first and seasonal differences (assuming a 52 week seasonal cycle) of the actual series. The time and savings deposit series

⁵Ibid., pp. 20-23. Strict stationarity requires the invariance over time of all moments. Weaker forms of stationarity require only the invariance with time of moments up to some given degree.

would be reduced to stationarity by simply taking the first differences of the actual time series.

If the series is stationary, it can be shown that there is a one-to-one mathematical correspondence between the model generating a series and the autocorrelation function of the series. The autocorrelation is the correlation coefficient between a member of a series and a lagged member of the same series. If the autocovariance is defined as

$$\gamma_j = E[(Z_t - \mu)(Z_{t+j} - \mu)] \quad (5.11)$$

where μ is the mean, then the autocorrelation function, ρ_j , is the set of autocovariances divided by the variance:

$$\rho_0 = \gamma_0 / \gamma_0 = 1$$

$$\rho_1 = \gamma_1 / \gamma_0$$

$$\rho_2 = \gamma_2 / \gamma_0$$

etc.

We can express each autocorrelation coefficient in terms of the parameters of the model it is generated from. By the same token: if one knows the true autocorrelation function, the parameters of the model may be obtained. Since estimates of the autocorrelation function may readily be computed from a data series, one may use the sample autocorrelation function to identify a model or models as likely candidates for the "best" model.

Model Development

The question of stationarity was solved for the demand, and time and savings deposit series by taking the first and seasonal differences and the first differences respectively. For the individual demand deposit series autoregressive models of varying orders proved to be the best models for determining the systematic variations in the deposit series. The order of the autoregressive model was determined by examining the shape of the estimated autocorrelation function ρ_k . In addition, the autocorrelation function gives insight into the degree of differencing needed to obtain stationarity. Autoregressive models are indicated by plots in which ρ_k gradually damps off as the lag K increases.⁶

The time and savings deposit series for 24 of the 40 individual series proved to be completely random after the first differences were taken.⁷ In effect the deposit changes themselves acted like a random walk. In those cases where some systematic variation was found in the time and savings deposit changes, the amount was usually very small ranging from a high of 21.1% to a low of 2.7%. Table 5.1 shows the amount of systematic variation, as indicated by the coefficient of determination (R^2), for each individual series. Notice that larger banks, on the average, possess a greater

⁶For greater detail the reader should see, Nelson, Applied Time Series Analysis, or Box and Jenkins, Time Series Analysis.

⁷In addition the variability of time and savings deposits was shown to be relatively small compared to that for demand deposits.

TABLE 5.1
Systematic Variations in Deposits (R^2)¹

<u>Large Banks</u>			<u>Small Banks</u>		
<u>Bank ID</u>	<u>Demand Deposits</u>	<u>Time and Savings Deposits</u>	<u>Bank ID²</u>	<u>Demand Deposits</u>	<u>Time and Savings Deposits</u>
1	.337	.0	11	.175	.0
5	.369	.0	13	.414	.187
7	.348	.129	26	.281	.0
12	.337	.0	29	.197	.0
14	.405	.26	31	.314	.184
15	.275	.065	34	.129	.0
19	.427	.0	46	.100	.0
39	.368	.0	49	.250	.064
42	.273	.0	51	.147	.0
48	.247	.049	55	.201	.0
65	.307	.044	56	.222	.034
66	.268	.098	70	.300	.0
67	.377	.136	71	.097	.0
72	.200	.069	73	.302	.211
76	.179	.0	81	.341	.0
79	.179	.054	84	.220	.0
82	.436	.0	86	.287	.0
89	.288	.067	87	.292	.0
94	.288	.107	96	.399	.0
100	.405	.152	98	.349	.027
Average (R^2)	.316	.055		.250	.035

¹Analysis of variance showed a significant difference between average coefficients of determination (R^2) for large and small bank demand deposits at the .05 level of significance. Time and savings deposits did not differ significantly.

²Identification numbers for individual banks.

amount of systematic variation in deposits, than do smaller banks.

Once the model has been (tentatively) selected, the unknown parameters may be estimated by minimizing the sum of squares $\sum u_t^2$, using nonlinear least squares methods.⁸ This method also allows the specifications of confidence intervals for the true parameter values. Under fairly general conditions, maximum-likelihood estimators in large samples are normally distributed with mean value equal to the true parameter value, so that if $\hat{\beta}_i$ is the estimate of the true value β_i one has:

$$\frac{\hat{\beta}_i - \beta_i}{SE(\hat{\beta}_i)} \sim N(0, 1) \text{ approximately} \quad (5.12)$$

where $SE(\hat{\beta}_i)$ is the standard error of the parameter estimator. Hence

$$\text{Prob} \left(-1.96 < \frac{\hat{\beta}_i - \beta_i}{SE(\hat{\beta}_i)} < 1.96 \right) = .95 \quad (5.13)$$

and a 95% confidence interval for β_i is given by

$$\hat{\beta}_i - 1.96 SE(\hat{\beta}_i) < \beta_i < \hat{\beta}_i + 1.96 SE(\hat{\beta}_i) \quad (5.14)$$

⁸G.E.P. Box and D.A. Pierce, "Distribution of Residual Autocorrelations in Autoregressive Moving Average Time Series Models," Journal of the American Statistical Association, LXV (December, 1970), 1509-26; cited in Nelson, Applied Time Series Analysis, p. 115.

Thus if a second sample gives a value $\hat{\beta}_i^*$ outside these limits, one would have to reject the null hypothesis
 $H_0 : \beta_i^* = \beta_i$ in favor of the alternative $\beta_i^* \neq \beta_i$ at the .05 level.

After a model is chosen and the parameters estimated, the residuals u_t should be examined. If the objective of finding a transformation that has reduced the observed data to purely random fluctuations (white noise) has been achieved, the residuals will not be correlated to any significant degree. Visual examination of the sample autocorrelation function of the residuals will usually enable one to spot any serious remaining deviations from randomness. A statistical test of the smallness of the set of sample autocorrelations of the residuals for lags 1 through k is given by Box and Pierce:

$$Q = N \sum_{j=1}^k \hat{p}_j^2 \quad (5.15)$$

where N is the number of observations. Q is approximately chi-square distributed with (k-p-q) degrees of freedom. One may thus compare the calculated Q statistic with values for χ^2 tables.

Another means of detecting significant nonrandomness in the residuals from an estimated model is an examination of a plot of the cumulative normalized periodogram of the residuals.⁹ This technique comes with the Box-Jenkins time

⁹Box and Jenkins, Time Series Analysis

series estimator program and is used in spectral analysis to detect the presence of periodic components, buried in noise, in a series.

The periodogram provides an estimate of the "power spectrum" of a series. The power spectrum indicates how much a particular range of frequencies contributes to the total variance of the series. In a purely random series, all frequencies make equal contributions to the variance; hence the power spectrum has a constant value for each frequency. Thus if the series is white noise (random fluctuations), the plot of the cumulative periodogram against frequency (or its inverse, period) would be scattered closely about a straight line. One may assess deviations of the actual periodogram from that expected if the $\hat{u}_t$ are white noise, by use of the Kolmogorov-Smirnov test.

The residuals for the individual banks' demand deposit series were tested using both the Q statistic and the periodogram. Both tests indicate that the final models produced residuals which could be considered white noise.

For the time and savings deposit series the tests used were dependent on whether or not any systematic variation was found in the deposit changes. For those series which did possess systematic variations, both the Q test and the periodogram were used to test the randomness of the residuals. When the deposit changes themselves appeared to be random as indicated by the autocorrelation coefficients, the Q test alone was used to determine if the deposit changes

themselves were white noise. This was done because of the high cost of conducting the periodogram test outside of the Box-Jenkins program, and its repetitive nature given the Q test. In all cases the final form of the residual series tested satisfactorily as white noise.

Stability of the Time Series Models

The amount of systematic variation in deposit changes is important for forecasting purposes. If bank management can predict deposit changes, they can make adjustments in the most cost efficient manner, usually through structuring of the earning asset portfolio. The existence of systematic variations in deposit changes is important only if the model for predicting the changes is relatively stable over a period of time. If the model and its coefficients are not stable, then very few benefits may arise from trying to forecast deposits based on their historical structure.

The question to be asked is whether a time series model, identified and fitted by means of Box-Jenkins analysis, on a deposit series, is stable throughout the series. Do the estimated parameters differ significantly over time? How can the stability of the model and its parameters be determined? An idea of the stability of the model and its estimated parameters can be gleaned by estimating the model for different parts of the time series. The total series includes weekly deposit observations for the years 1971, 1972, and 1973, years which differ greatly in terms of the

growth of monetary and banking aggregates for the system. For example in 1971 M_2 (demand deposits, currency and time deposits other than large negotiable certificates of deposits) grew rapidly at a rate of 14.9% in the first half of the year and declined to a growth rate of 7.8% in the second half. In 1972 the rate of growth in M_2 stabilized. It grew at a rate of 10.8% in the first half of 1972 and 10.9% in the second half. In 1973 the rate of growth in M_2 declined to a rate of 9.1% in the first half and 8.5% in the second half. A model and its parameters can be estimated for the total period, and for combinations of two out of the total three year period. For example the model can be fitted for the years 1971 and 1972, 1972 and 1973, and 1971 and 1973. If the model is stable its parameters should not differ significantly when different years of the series are excluded. One would expect that if the model's parameters are stable, given a period of extreme changes in the growth rate of monetary and banking aggregates, the model's parameters should be stable given less extreme variations.

Since we are dealing with a sample of 40 banks which have two deposit series each, the time and cost of estimating the model for each of the additional series would indeed be great. The time and savings deposit series have been shown to have little if any systematic variations, as such little can be gained by trying to forecast time and savings deposits. The question of stability is therefore irrelevant.

Excluding the time and savings deposit series we are

confronted with the problem of how to handle the 40 demand deposit series. Three alternatives were available:

1. Estimate the models for all 40 individual series.
2. Estimate models for a sub sample of the banks.
3. Estimate models for an aggregate series.

The third alternative was selected because it was less costly and would have general implications for all commercial bank demand deposit series. The aggregate series used was the demand deposit series from large weekly reporting banks of the Federal Reserve System.¹⁰ As was the case for the individual bank series a stationary series was produced by taking the first and seasonal differences of the total demand deposit series for the years 1971 and 1973. A third order autoregressive model with parameters at the first, second and thirteenth lags was found to be the best model for the series.¹¹

Table 5.2 gives the estimates ϕ_1 , ϕ_2 , ϕ_3 and δ (the constant) for the different series. These results lead

¹⁰The aggregate series does not appear to have significantly more systematic variability than does the individual bank series. For the aggregated demand deposit series the coefficient of determination was .41, meaning that 41% of the total variation was explainable by the regression model. For the aggregate time and savings deposit series the coefficient of determination was .21. It would appear that diversification beyond a certain point has very little impact on variability. Further evidence of these findings can be seen in table 5.1 where coefficients of determination are compared for both large and smaller banks.

¹¹The autocorrelation at the thirteenth lag appears to indicate a relationship at the end of each quarter.

one to conclude that even extreme changes in monetary aggregates do not significantly change the model or its parameters. Applying a significance test with the null hypothesis $\phi_k = \phi_k^*$ to any pair of estimates in Table 5.2 leads one to reject the alternative hypothesis $\phi_k \neq \phi_k^*$ at the 95% significance level. For this aggregate demand deposit series at least, the problem of identification and of bias in estimation do not appear to be especially troublesome; if the confidence interval testing that has been undertaken is any indication

One minor problem had to be resolved before models could be fitted to the deposit data. Although there were 156 weeks in the 3 year period for which data were taken, only 155 observations were given by the Federal Reserve Board. Data for the week of June 30, 1971 were deleted. These data were omitted because of their availability on Call Reports, and because of the Board's desire to maintain the anonymity of the banks for which data were provided. If the omitted data had been made available, it may have been possible to learn the identity of the banks in the sample.

Omission of data for the week of June 30, 1971, left a gap in the middle of each deposit series. It was decided to examine the sensitivity of the models to the missing data point by substituting different values into the gap. For example the value preceding (June 23, 1971) and following (July 7, 1971) the missing observation were inserted into

TABLE 5.2
ESTIMATES OF PARAMETERS FROM FOUR DATA SETS

Name	Data	N	ϕ_1	95%		95%		ϕ_3	95%		ϕ_4	Confidence Interval
				Confidence Interval	ϕ_2	Confidence Interval	ϕ_3		Confidence Interval	ϕ_4		
Whole	1971, 1973	156	-.595	-.613 to -.375	-.200	-.436	-.024	.283	.114	.462	-78.9	-1023 to 865
Last Year Excluded	1971, 1972	104	-.801	-1.156 to -.446	-.405	-.742	-.067	.300	.013	.586	209.	-1372 to 1790
Middle Year Excluded	1971, 1973	104	-.522	-.924 to -.120	-.306	-.745	.073	.207	.096	.509	-75.8	-1258 to 1106
First Year Excluded	1972, 1973	104	-.704	-1.024 to -.384	-.244	-.554	.065	.297	.040	.554	178.	-1603 to 2039

the gap, as well as the average of the two values. Models were developed for demand deposit series for two different banks. The banks (1 and 3) were selected for a purpose. Bank 3 had an extreme variation of 36% between the points preceding and following the missing observation. Bank 1 had a lower than normal variation of 4% (normal being around 10% for banks in the sample) between the two points. In addition one bank had total assets of less than \$300 million and the other had assets of over \$500 million. The parameters of the model changed only slightly for even the series with the extremely large variation. Since any reasonable value would have little impact on the model's parameters, it was decided to use the average of the values immediately preceding and following the missing data point to fill the gap.

Time and savings deposit series were not included in this analysis since the variability in these deposit series was so small. There would have been very little difference among the three values inserted into the gap. As a result the models would have changed very little. In addition very little systematic variation existed in time and savings deposits to begin with, so that in most cases no models were needed.

Bank Response to Deposit Changes

As our inventory theoretic model, developed and explained in Chapter III, shows banks must adjust to deposit changes and usually do so in three different ways.

1. Adjustments may be made in the form of earning assets. Cash is generated to handle net deposit outflows through the maturing of earning assets, and net deposit inflows are channeled into earning assets.¹²
2. Adjustments may be made in the form of manageable liabilities. A bank borrows when net deposit outflows occur, and reduces its liabilities when net deposit inflows occur.¹³
3. Adjustments may be made in the form of liquid assets. Liquid assets are acquired when net deposit inflows occur, and assets are liquidated when net deposit outflows occur.^{14 15}

The manner in which commercial banks make portfolio adjustments should be dependent not only on total deposit

¹²Earning assets include total securities held minus treasury bills and treasury securities maturing within one year, other loans, and all other assets.

¹³Manageable liabilities includes large negotiable certificates of deposits, federal funds purchased and securities sold under agreement to repurchase, Federal Reserve borrowing, other borrowings.

¹⁴Liquid assets include treasury bills, treasury securities maturing within one year and federal funds sold and securities resale agreements.

¹⁵A fourth type of adjustment can be made by banks, when unexpected deposit outflows occur. Banks may be forced to liquidate earning assets before maturity. This action cannot be determined by viewing the banks balance sheet as they cannot be differentiated from normal liquidations. In addition this type of adjustment may take considerable time to arrange and can be very costly. As such, in most cases, this would be an adjustment of last recourse.

variability, but also on the mix of systematic and unsystematic variability in deposits. In other words, the greater the amount of total variability in deposits the greater the need for adjustment. The greater the systematic component in deposit variability, the more control banks have over the type of adjustment made. Our analysis will determine whether the adjustments made in response to unexpected (unsystematic) deposit changes differs from those adjustments made in response to total deposit changes (systematic and unsystematic). In addition our analysis will indicate whether or not size has any impact on the manner in which banks adjust to deposit changes.

Dewald and Dreese hypothesized that banks use the systematic variability in past deposits to predict future deposit movements, and as such provide a basis for acquiring appropriate earning assets in terms of maturity and risk in order to meet expected deposit changes.¹⁶ That residual which according to Dewald and Dreese cannot be predicted, is more likely to result in adjustments in the form of liquid assets and manageable liabilities.¹⁷ Thus if it is true that systematic variability is used by banks to acquire appropriate earning assets then total changes, which include both the systematic and unsystematic changes, should show a

¹⁶William G. Dewald and G. Richard Dreese, "Bank Behavior with Respect to Deposit Variability," Journal of Finance, 25 September 1970, p. 896.

¹⁷Ibid.

closer relationship to earning assets than would a random series of deposit changes. In addition if unsystematic (random) variability causes adjustment in liquid assets and manageable liabilities due to its unexpected nature, then the residual (random) series should show a closer relationship to the liquid assets and manageable liabilities than would a series with sizable systematic and unsystematic components.

Regression analysis will be used to determine the relationship between deposit changes and bank behavior. Through regression analysis we can determine the relationship between actual deposit changes (with systematic and unsystematic components) and bank behavior; and the relationship between unexpected deposit changes, caused by errors in the forecasting of deposit changes, and bank behavior. The predicted deposit changes result from the use of past movements in deposits to predict changes in the future. Since in most cases past movements in deposits will not be a perfect predictor of future movements (due to certain unsystematic or random factors) anticipated deposit changes will vary from actual deposit changes to some extent. The variance between predicted deposits and actual deposits, forecasting errors, should force a bank to make portfolio adjustments. As explained earlier, it is the nature of these adjustments which warrants our attention.

A total of six simple regression analyses were performed for twenty sample banks. Ten banks from each of the

size categories were chosen for the sample. The selection was based on the amount of systematic variability in demand deposits. The coefficient of determination (R^2) was the measure of systematic variability used, and the ten banks with the highest coefficients of determination in each size category were selected for the sample. It was felt that a significant amount of systematic variability in demand deposits would be desirable from a bank forecasting point of view.¹⁸ Table 5.3 shows which banks were selected for the sample. In addition table 5.4 indicates the amount of total variability in total deposits (excluding certificates of deposits) for each of the banks in the sample. The coefficient of variation is used to measure deposit variability.¹⁹

For the regression analysis three dependent variables were employed: liquid asset changes, earning asset changes and changes in manageable liabilities. Two independent variables: actual deposit changes (the total change in demand, and time and savings deposits) and random deposit changes (the sum of the forecasting errors for the demand,

¹⁸The sample was chosen on the basis of systematic variation in demand deposits due to the small amount of systematic variation in time and savings deposits. It was decided to view changes in time and savings deposits as basically random.

¹⁹The coefficient of variation is a relative measure of dispersion. It is obtained by expressing the standard deviation as a percentage of the arithmetic mean.

Table 5.3

Banks with the Highest Amount of Systematic Variation
in Demand Deposits (R^2)¹

<u>Bank ID</u> <u>(Large)</u>	<u>R^2</u>	<u>Bank ID</u> <u>(Small)</u>	<u>R^2</u>
1	.337	13	.414
5	.369	26	.281
7	.348	31	.314
12	.337	70	.300
14	.405	73	.302
19	.427	81	.341
39	.368	86	.287
67	.377	87	.292
82	.436	96	.399
100	.405	98	.349

¹ Analysis of variance showed a significant difference between sample means (R) for large and small bank demand deposits at the .05 level of significance.

Table 5.4
Deposit Variability¹

<u>Large Banks</u>		<u>Small Banks</u>	
<u>Bank ID</u>	<u>Coefficient of Variation %</u>	<u>Bank ID</u>	<u>Coefficient of Variation %</u>
1	6.96	13	5.49
5	5.91	26	4.94
7	6.31	31	7.44
12	3.91	70	4.38
14	4.06	73	6.30
19	5.30	81	4.53
39	5.59	86	6.60
67	4.66	87	5.42
82	5.76	96	20.71
100	<u>5.30</u>	98	<u>3.95</u>
Mean	5.39%		6.98%

¹Analysis of variance showed no significant difference between sample means (coefficients of variation) for large and small bank demand deposits at the .05 level of significance.

and time and savings deposit series) were employed.²⁰

The regression coefficient, β , is the focal point of the analysis, as it indicates in dollar terms the amount of change in each of the three dependent variables, associated with an actual or a random change in deposits. The regression coefficient can thus be used to determine which deposit changes are associated with which adjustments, a cause and effect relationship although not proven by the association can be inferred, given some theoretical backing.

Large Bank Behavior in Response to Actual Deposit Changes. Large bank adjustments in response to actual deposit changes were primarily in the form of earning assets. Table 5.5a shows that the average regression coefficient for the 10 banks in the sample was .7435, indicating that each \$1.00 change in total deposits is associated with a \$.7435 change in earning assets. The inference is that large commercial banks are highly successful at structuring their earning assets to meet these deposit changes.

The average regression coefficient which relates manageable liabilities to deposit changes was -.1887, indi-

²⁰When no forecasting errors were available, in cases where the changes in the time and savings deposit series were random, the actual changes were used. Due to differencing for some series (first and seasonal for demand deposits) 103 observations were used for each regression. First differencing reduced the total series, which included 156 observations by 1, and the seasonal differencing, with a 52 week cycle, reduced the number of observations by 52.

cating that each \$1.00 change in actual deposits was associated with a $-.1887$ adjustment in manageable liabilities. The average coefficient associating liquid assets with actual deposit changes was negligible. It can thus be inferred that large banks prefer to make adjustments through their manageable liabilities when they cannot do so through earning assets. In addition if they do hold liquid assets, results to be exhibited later on in this study show that they do, it is not for the purpose of adjusting to deposit changes.

Small Bank Behavior in Response to actual Deposit Changes. The results in table 5.5b show that for smaller banks each \$1.00 change in total deposits is associated with only a $$.4702$ change in earning assets. In addition each \$1.00 change in total deposits is associated with a $$.3636$ change in liquid assets and a $-.0982$ change in manageable liabilities. It is interesting to note that smaller banks rely heavily on liquid assets for adjustment and very little on manageable liabilities; this is in complete contrast to the larger banks. It can thus be inferred that smaller banks have somewhat less success at meeting deposit changes through earning assets and as a result rely heavily on liquid assets for adjustment purposes.

Large Bank Behavior in Response to Random Deposit Changes (Residuals and Forecasting Errors). Expectations were that the nature of deposit variability would determine bank behavior. Changes in actual deposits would be asso-

ciated with greater changes in earning assets than would changes in unexpected or random deposit changes. In contrast random deposit changes would be associated with greater changes in liquid assets and manageable liabilities than would actual deposit changes. The results as seen in table 5.5a show that greater earning asset changes are associated with actual deposit changes than with random deposit changes for each of the 10 larger banks in the sample. The average regression coefficient declines from .7444 to .2889 when random deposit changes are substituted for actual deposit changes.

The relationship between liquid assets and actual deposit changes was negligible. When random deposit changes are substituted for actual deposit changes the average regression coefficient rises slightly to .0465. Only in the case of bank 39 do the results indicate a stronger relationship between liquid assets and random deposit changes than between liquid assets and actual deposit changes. By comparison banks 7, 14 and 19 show a significant and stronger relationship between liquid assets and actual deposit changes than between liquid assets and random deposit changes.

The average regression coefficient indicating the relationship between manageable liabilities and actual deposit changes is $-.1887$. When random deposit changes are substituted for actual deposit changes the average regression coefficient rose to $-.0776$, indicating that on the

average banks do not respond to our measure of random deposit variability. Only bank 1, shows a significant and stronger relationship between manageable liabilities and random deposit changes than between manageable liabilities and actual deposit changes. Banks 12, 14, 19, 82 and 100 show the opposite to be true.

Small Bank Behavior in Response to Random Deposit Changes. For the 10 smaller banks in the sample the average regression coefficient indicating the relationship between deposit changes and earning asset changes declined from .4702 to .2255 when random deposit changes were substituted for actual deposit changes. In addition the coefficients for each individual bank in the sample declined when the substitution was made. These results were consistent with expectations.

The average regression coefficient indicating the relationship between actual deposit changes and liquid asset was .3636. The expected increase in the average beta coefficient when random deposit changes were substituted for actual deposit changes did not occur. In fact the average regression coefficient for the 10 smaller banks in the sample declined from .3636 to .1455 when the substitution was made. None of the banks in the sample show a significant and stronger relationship between liquid assets and random deposit changes than between liquid assets and actual deposit changes.

For the sample of smaller banks the average beta

Table 5.5a

Regression Results for Large Banks

<u>Beta Coefficients Independent</u> <u>Variable-Deposit Changes</u> ^{1 2}				<u>Beta Coefficients Independent</u> <u>Variable-Random Deposit</u> <u>Changes</u>		
<u>Dependent Variables</u>				<u>Dependent Variables</u>		
<u>Bank</u> <u>ID</u>	<u>Liquid</u> <u>Assets</u>	<u>Earn-</u> <u>ing</u> <u>Assets</u>	<u>Manage-</u> <u>able</u> <u>Liabi-</u> <u>lities</u>	<u>Liquid</u> <u>Assets</u>	<u>Earning</u> <u>Assets</u>	<u>Manage-</u> <u>able</u> <u>Liabi-</u> <u>lities</u>
1	NS	.932 (.160)	NS	NS	.436 (.245)	-.508 (.270)
5	NS	.983 (.148)	NS	NS	.428 (.191)	NS
7	.226 (.090)	.534 (.132)	NS	.205 (.115)	.360 (.174)	NS
12	-.575 (.338)	.961 (.299)	-.580 (.256)	NS	.554 (.332)	NS
14	.116 (.051)	.609 (.103)	-.283 (.112)	NS	.246 (.109)	NS
19	.094 (.035)	.504 (.071)	-.265 (.086)	NS	NS	-.268 (.114)
39	.094 (.035)	.744 (.157)	NS	.391 (.184)	NS	NS
67	NS	1.018 (.142)	NS	NS	NS	NS
82	NS	.584 (.182)	-.348 (.176)	NS	.346 (.205)	NS
100	NS	.567 (.152)	-.306 (.145)	-.131 (.053)	.519 (.182)	NS

¹Standard errors given in parentheses below coefficients.²The abbreviation NS means not significant at 10% level.

Table 5.5b

Regression Results for Small Banks

<u>Beta Coefficients Dependent Variable-Deposit Changes</u> ^{1 2}				<u>Beta Coefficients Dependent Variable-Random Deposit Changes</u>		
<u>Independent Variables</u>				<u>Independent Variables</u>		
<u>Bank ID</u>	<u>Liquid Assets</u>	<u>Earning Assets</u>	<u>Manage-able Liabilities</u>	<u>Liquid Assets</u>	<u>Earning Assets</u>	<u>Manageable Liabilities</u>
13	.131 (.065)	.6771 (.137)	NS	NS	NS	NS
26	.319 (.072)	.649 (.081)	-.052 (.026)	.43 (.07)	.477 (.09)	-.071 (.02)
31	.542 (.102)	.570 (.091)	.120 (.068)	.428 (.133)	NS	NS
70	.354 (.084)	.683 (.098)	NS	.330 (.144)	.470 (.188)	NS
73	NS	.334 (.157)	-.461 (.111)	NS	.297 (.161)	NS
81	.404 (.140)	NS	-.361 (.071)	NS	NS	-.167 (.080)
86	.325 (.070)	.505 (.083)	-.166 (.048)	.150 (.074)	.289 (.091)	-.110 (.049)
87	.414 (.113)	.571 (.133)	NS	NS	.471 (.141)	NS
96	.626 (.047)	.310 (.054)	-.062 (.018)	.304 (.126)	.251 (.101)	NS
98	.509 (.128)	.403 (.143)	NS	NS	NS	NS

¹Standard errors given in parentheses below coefficients.

²The abbreviation NS means not significant at the 10% level.

coefficient relating manageable liabilities to actual deposit changes was $-.0982$. Contrary to expectations this coefficient also rose to $-.0348$ when random deposit changes were substituted for actual deposit changes. Only bank 26 shows a significant and stronger relationship between manageable liabilities and random deposit changes than between manageable liabilities and actual deposit changes. The coefficients for banks 31, 73, 81, 86 and 96 show the opposite to be true.

Summary. The results of our empirical study on bank behavior in response to deposit variability show that the bulk of the adjustment that commercial banks make in response to actual deposit changes appears to be in the form of earning asset changes. Large bank response in the form of earning assets appears to be significantly greater than the response that smaller banks make in this form. Manageable liabilities appear to be the second most frequently used method of adjustment for larger banks, whereas smaller banks appear to favor liquid asset adjustments.

On the average, the banks in the sample seem to respond to random deposit changes in much the same manner as they respond to actual deposit changes. Although the type of deposit change affects the size of the coefficients, the relative importance of each adjustment account in the total adjustment scheme seems to be independent of the type of deposit change. In effect the nature of deposit variability (systematic or unsystematic) does not affect bank adjustment.

Since the Box-Jenkins technique effectively removes systematic variability from deposits it can be inferred that commercial banks have not been able to use systematic variability in deposits to make adjustments differently from those made in response to unexpected (unsystematic) deposit changes. One possible explanation for these findings may be that systematic variability in deposits is insufficient to enable bank management to anticipate deposit changes with any degree of accuracy. As a result banks may accept all deposit changes as random, adjusting to them, as they occur, in the most efficient manner possible.

Asset Liquidity and Deposit Variability

Having seen how commercial banks adjust to deposit changes, we can now take a look at the impact of unexpected deposit losses on bank liquidity. Deposit losses are extremely serious because of their threat to bank solvency. To protect bank solvency, bank regulatory agencies have placed a great deal of emphasis on bank liquidity which provides a more certain reservoir of cash than do earning assets or borrowing. We can therefore examine the degree of protection provided through liquid asset holdings, and the importance of this protection given a bank's ability to generate cash by other means.

Before determining the protection provided by liquid assets against deposit losses some preliminary testing was done on the actual and random deposit change series for each

of the 20 banks in the sample. The results show that when goodness-of-fit tests (against the normal hypothesis) were conducted on each of the actual deposit change and random (residual) change series all but three of the series, the exceptions being both deposit series for bank 96, and the residual series for bank 26, approximated the normal distribution at the .05 level of significance.²¹ At the .02 level of significance the normal hypothesis would be rejected only for the actual deposit change series of bank 96.

Tables 5.6a and 5.6b show both the calculated and table values for the individual series. The results of this analysis indicates that the vast majority of actual and random deposit change series approximate a normal distribution.

In addition hypothesis testing about the means of the individual series showed that at a .05 level of significance each series had a distribution with a mean not significantly different from zero (see tables 5.7a and 5.7b). As such it is easy to determine the probability that negative deposit changes will deplete the liquid asset reserves of the bank. By dividing the standard deviation into the mean liquid asset holdings for each bank one can determine the bank's ability to meet deposit variations through liquid assets.

²¹The Goodness-of-fit test was conducted by placing observations into ten intervals, five to the right of the mean and five to the left. The intervals ran consecutively each having a range of .5 standard deviation from the mean. The fifth interval on each side of the mean was open ended.

Table 5.6a

Goodness-of-Fit Tests (Against Normal Hypothesis)Actual Deposit Change Series

<u>Large Banks</u>				<u>Small Banks</u>			
<u>Bank ID</u>	<u>Table X (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis</u>	<u>Bank ID</u>	<u>Table X (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis</u>
1	16.919	7.691	Accept	13	16.919	5.481	Accept
5	"	8.438	Accept	26	"	12.450	Accept
7	"	6.987	Accept	31	"	11.748	Accept
12	"	7.671	Accept	70	"	13.991	Accept
14	"	9.953	Accept	73	"	12.119	Accept
19	"	7.057	Accept	81	"	10.111	Accept
39	"	17.289	Reject	86	"	3.522	Accept
67	"	5.313	Accept	87	"	3.651	Accept
82	"	11.002	Accept	96	"	121.086	Reject
100		7.700	Accept	98	"	5.002	Accept

Table 5.6b

Goodness-of-Fit Tests (Against Normal Hypothesis)Random [Residual] Deposit Change Series

<u>Large Banks</u>				<u>Small Banks</u>			
<u>Bank ID</u>	<u>Table X (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis</u>	<u>Bank ID</u>	<u>Table X (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis</u>
1	16.919	7.315	Accept	13	16.919	4.754	Accept
5	"	3.887	Accept	26	"	17.534	Reject
7	"	9.495	Accept	31	"	3.495	Accept
12	"	12.073	Accept	76	"	13.112	Accept
14	"	8.320	Accept	73	"	10.339	Accept
19	"	1.272	Accept	81	"	9.000	Accept
39	"	12.047	Accept	86	"	8.092	Accept
67	"	3.130	Accept	87	"	6.612	Accept
82	"	7.770	Accept	96	"	19.277	Reject
100	"	11.020	Accept	98	"	7.768	Accept

Table 5.7a

Tests of Sample Means (Actual Deposit Change Seires)

<u>Bank ID</u>	<u>Table Value (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis H:X=0</u>	<u>Bank ID</u>	<u>Table Value (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis H:X=0</u>
1	1.980	.217	Accept	13	1.980	.020	Accept
5	"	.710	Accept	26	"	1.170	Accept
7	"	.300	Accept	31	"	.000	Accept
12	"	1.210	Accept	70	"	.739	Accept
14	"	.404	Accept	73	"	.090	Accept
19	"	.012	Accept	81	"	.740	Accept
39	"	1.170	Accept	86	"	.017	Accept
67	"	.263	Accept	87	"	.224	Accept
82	"	.177	Accept	96	"	.314	Accept
100	"	.364	Accept	98	"	.535	Accept

Table 5.7b

Tests of Sample Means (Random [Residual]
Deposit Change Series)

<u>Large Banks</u>				<u>Small Banks</u>			
<u>Bank ID</u>	<u>Table Value (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis</u>	<u>Bank ID</u>	<u>Table Value (.05)</u>	<u>Calculated Value</u>	<u>Hypothesis</u>
1	1.980	.040	Accept	13	1.980	.060	Accept
5	"	.530	Accept	26	"	.790	Accept
7	"	.050	Accept	31	"	.058	Accept
12	"	.960	Accept	70	"	.524	Accept
14	"	.005	Accept	73	"	.050	Accept
19	"	.133	Accept	81	"	.568	Accept
39	"	.255	Accept	86	"	.044	Accept
67	"	.008	Accept	87	"	.276	Accept
82	"	.068	Accept	96	"	.228	Accept
100	"	.060	Accept	98	"	.199	Accept

The Z statistic when applied to the Standard Normal Probability Distribution tables can be used to determine the probability that liquid assets will be insufficient to meet deposit variations (5.8a and 5.8b). Assuming a stable distribution of deposit changes, table 5.8a gives the probability of a bank having insufficient liquidity to meet variations in deposits. On the average, commercial banks appear to hold sufficient liquidity to meet most deposit variations. The probability of a shortage is only 3.37% for the sample of large banks and 5.49% for the sample of small banks when actual deposit changes are considered. Six of the banks (13, 19, 82, 96 and 100) have average liquid asset holdings which do not cover 2 standard deviations beyond the mean.²² To the extent that these banks rely on liquid assets for adjustment purposes, problems may arise.

Of the six banks with average liquid asset holdings insufficient to cover two standard deviations to the left of the mean, three are large banks (19, 82, 100). None of these banks rely heavily on liquid assets for adjustment purposes (see Table 5.4). Of the three small banks (13, 86, 96) two (86, 96) rely heavily on the liquid asset portfolio for adjustment purposes. Bank 86 makes 32.5% of its adjustments through its liquid assets, 50.5% through earning

²²Bank 96 has the highest probability of shortage, however its actual deposit change series was not normally distributed. Appendix C shows that more of its observations lie within two standard deviations from the mean than is true for the normal distribution. As a result the probability of shortage is somewhat overstated.

Table 5.8a
Probability of Liquid Asset Shortages¹
Actual Deposit Changes

<u>Large Banks</u>			<u>Small Banks</u>		
<u>Bank ID</u>	<u>Z Statistic</u>	<u>Probability of Shortage</u>	<u>Bank ID</u>	<u>Z Statistic</u>	<u>Probability of Shortage</u>
1	4.94	.0000	13	1.30	.0968
5	2.09	.0183	26	2.52	.0059
7	3.61	.0000	31	4.87	.0000
12	12.71	.0000	70	2.22	.0139
14	2.06	.0197	73	2.11	.0194
19	.89	.1867	81	2.89	.0019
39	2.95	.0016	86	1.01	.1562
67	2.63	.0043	87	2.48	.0066
82	1.71	.0446	96	.78	.2482
100	<u>1.54</u>	<u>.0618</u>	98	<u>5.85</u>	<u>.0000</u>
Average	3.51	.0037		2.60	.0549

¹Analysis of variance showed no significant difference between sample means (probability of shortage) for large and small banks at the .05 level of significance.

Table 5.8b

Probability of Liquid Asset Shortages¹Random (Residual) Deposit Changes

<u>Large Banks</u>			<u>Small Banks</u>		
<u>Bank ID</u>	<u>Z Statistic</u>	<u>Probability of Shortages</u>	<u>Bank ID</u>	<u>Z Statistic</u>	<u>Probability of Shortages</u>
1	6.66	.0000	13	1.26	.1038
5	2.30	.0107	26	2.61	.0047
7	4.52	.0000	31	5.92	.0000
12	13.62	.0000	70	3.58	.0000
14	1.93	.0268	73	2.15	.0158
19	1.13	.1314	81	2.61	.0045
39	3.76	.0000	86	1.00	.1587
67	3.30	.0000	87	2.55	.0054
82	1.86	.0314	96	1.29	.0985
100	<u>1.79</u>	<u>.0367</u>	98	<u>5.78</u>	<u>.0000</u>
Average	4.09	.0292		2.91	.0391

¹Analysis of variance showed no significant difference between sample means (probability of shortage) for large and small banks at the .05 level of significance.

assets and 16.6% through manageable liabilities. As such the 15.6% probability it runs of having its liquid assets exhausted through deposit changes does not appear to be a serious problem, given its historical options. Bank 96 makes over 60% of its adjustments through its liquid asset portfolio. It runs a sizable risk, estimated at 24.82% under the assumption of normality, of not being able to meet its obligations through this means. As such it will be forced to utilize unused borrowing capacity, it makes only 6.2% of its adjustment through manageable liabilities; structure its earning asset portfolio to generate more cash for adjustment purposes, it makes 31% of its adjustments through the earning asset portfolio; or face the danger of having to liquidate its earning asset portfolio.

Having examined the relationship between liquid asset holdings and deposit changes we have seen that in several cases there exists a sizable probability that liquid assets could be exhausted by deposit variations. For this reason it is important that banks be able to tap borrowing sources, and generate cash through their earning assets. If a bank can forecast with some degree of accuracy it can structure its earning asset portfolio so as to generate more cash for adjustment purposes, reducing its need for liquid assets, and/or reducing the possibility of shortages.

If banks were to forecast deposits the unexpected deposit change distribution which liquid assets would be used to protect against would be the series of forecasting errors or

residuals; that variation in deposit changes which could not be determined by using the forecasting model. The systematic change would be expected, and restructuring of the asset portfolio would allow adjustment through earning assets.

The goodness-of-fit tests against the normal hypothesis when applied to the residual or forecasting error series shows that only the series for bank 26 did not approximate the normal distribution at the .05 level of significance. The normal hypothesis would be accepted for even that series at a .02 level of significance (see Table 5.6b). Hypothesis testing about the mean of the individual series showed that at a .05 level of significance each series had a distribution with a mean not significantly different from zero (see Table 5.7b).

The standard deviations for the random distributions should be smaller than the standard deviations for the actual distributions due to the finding of explainable or predictable variance in modeling the series. As a result the probability of exceeding the average liquid asset holdings will be less, the necessity to borrow for banks which prefer to handle adjustments through manageable liabilities, will be less and the need for liquid assets to cover deposit variations will be less. Table 5.9 shows the comparison of the standard deviations for each series. On the average each random deposit change should be smaller than the actual deposit change since the autoregressive models fitted to each demand deposit series and some of the time and savings

deposit series showed coefficients of determination above zero.²³ This indicates that some of the total variance in total deposit changes was explained by the model. Table 5.9 also shows how the standard deviations of the actual deposit change series can be reduced if the bank can use the systematic component in these series to structure their portfolios. By doing so they are left with a random series of forecasting errors which show greater stability over a period of time than actual deposit changes, and on the average have lower standard deviations. Due to its stability over time the distribution of random deposit changes (forecasting errors) can be used to determine what preparations in liquid asset holdings and in borrowing should be made for unexpected deviations from the forecasts. The lower standard deviation allows the bank greater flexibility in structuring its asset portfolio because it can reduce its need for liquidity to meet unexpected deposit variations.²⁴

²³For a more detailed explanation see Morris Hamburg, Statistical Analysis for Decision Making, pp. 488-94.

²⁴In some cases the standard deviations of the residual series are larger than those of the actual deposit change series. This however is due to a few extreme deviation which greatly affect the standard deviation. These extreme errors are produced when certain deposit changes go against the normal cycle.

Table 5.9

Comparison of the Standard Deviations

<u>Bank ID</u>	<u>Actual Deposit Changes SD</u>	<u>Random Deposit Changes (Forecasting Errors) SD</u>	<u>% Change</u>
1	76272	56603	-25.79
5	242520	220210	- 9.20
7	140230	112030	-20.11
12	52375	48874	- 6.68
13	5687.9	5842.4	2.72
14	36373	38844	6.79
19	80808	64421	-20.28
26	5106.1	4942	- 3.21
31	9275.6	7634.8	-17.69
39	67989	53400	-21.46
67	43528	34642	-20.41
70	5931.4	3672.9	-38.08
73	8447.6	8296.8	- 1.79
81	3188.9	3135.5	1.67
82	84838	78060	- 7.99
86	6488.3	6602.3	1.76
87	4466.1	4345.3	- 2.70
96	26223	15799	-39.75
98	4059.4	4106.4	1.16
100	49300	42304	-14.19

Summary of Empirical Findings

In summary the empirical results show the following:

1. Systematic variation does exist in the deposits of commercial banks.
2. The amount of systematic variation and the amount of total variation differs between demand deposits, and time and savings deposits. Demand deposits have greater systematic variation and greater total variation.
3. Smaller banks appear to have less systematic variation and more total variation in deposits than do larger banks.
4. The models developed for the demand deposit series and their estimated parameters appear to be stable over time.
5. With few exceptions the bulk of the adjustments that large and smaller banks make in response to actual deposit changes appears to be in the form of earning assets.
6. Large banks have more success in meeting deposit changes through their earning asset portfolio than to smaller banks.

It is possible that the deposit change which produced the extreme error was rare but predictable. As a result the bank would have time to adjust and unexpected adjustments would not be required. Given the anonymity of the bank data it is not possible to determine why these extreme errors occurred.

7. When unable to meet deposit changes through earning assets, smaller banks seem to rely heavily on liquid assets while large banks rely more heavily on manageable liabilities. Larger banks therefore appear more willing to accept the uncertainties involved in adjustment through manageable liabilities.
8. In most cases commercial banks show little response to forecasting errors. The indication is that these banks are unable to forecast, or unable to forecast with any significant degree of accuracy.
9. Deposit changes and residuals, with few exceptions, are normally distributed with a mean not significantly different from zero.
10. Deposit variability, as measured by the coefficient of variation is greater for smaller than it is for larger banks. In addition, the risk of liquid asset exhaustion is slightly greater for smaller banks. In neither case is the difference significant.
11. On the average the liquid asset holdings of commercial banks are sufficient to cover 95% of the net outflows that have historically occurred.

CHAPTER VI

CONCLUSIONS

Review

The purpose of this study has been to examine bank behavior in response to deposit variability. It has been theorized that banks, as profit maximizing enterprises, make adjustments to deposit changes in the most cost efficient manner. Given this theory, an inventory theoretic model was developed which allows an examination of the trade offs (return versus risk) involved in making portfolio adjustments in response to deposit variability. Deposit variability was shown to have an impact on a bank's need for liquidity, and the manner in which these needs were satisfied was shown to have an impact on a bank's profits. Since there are alternative methods for obtaining liquidity, and the cost associated with each alternative differs, banks should seek those alternatives which are least costly. This, of course, is a somewhat simplistic way of determining bank behavior, since there are obviously other factors, besides cost, which have an impact on how a bank meets its liquidity needs. For example, a bank would probably not completely exhaust any one alternative even if it were less costly. These other factors are extremely difficult to quantify, and cost is obviously the most

important consideration, thus other factors are not explicitly considered in the model.

In the model deposit variability is considered through the use of a probability distribution of unexpected deposit changes. Since this distribution has been shown to be normal knowledge of its mean and standard deviation allows one to determine the need for liquidity to meet possible unexpected losses of deposits, and the probability that deposit changes will exceed the liquidity obtainable from any or all sources.

One source from which liquidity is obtainable, and which has great significance due to its certainty, and the importance attached to it by bank regulatory agencies is liquid asset holdings. The probability that these assets will be exhausted by unexpected deposit losses has been defined as the risk of liquid asset exhaustion and is measured for a sample of commercial banks.

The distribution of unexpected deposit changes has additional significance in that dispersion, measured by the standard deviation, may be reduced if banks management can anticipate accurately some deposit changes. It has been hypothesized and to some extent empirically supported by Dewald and Dreese that it is unexpected deposit changes which affect certain types of bank behavior, short run adjustments. By anticipating deposit changes through forecasting, the size of unexpected deposit changes and the standard deviation of their probability distribution may be

reduced. As a result, the risk of unsolvency declines and/or the return on investment increases. The possibility of this was shown to depend on the amount of systematic variation in deposits.

If systematic variation is significant, management can anticipate deposit changes and as a result, make adjustments in the form of earning assets. If not, these adjustments must be made through less efficient alternatives such as: liquid assets and/or manageable liabilities.

By considering systematic variations in deposit, unexpected deposit changes may be reduced to forecasting errors. This allows bank management to reduce the size of deposit changes, and the standard deviation of their probability distribution. As a result, the need to make unexpected and possibly costly short run adjustments may decline.

Two major hypotheses formed the basis for the theoretical discussion and empirical analysis for this study.

They are:

1. It is possible to anticipate a significant amount of deposit variability due to its systematic nature. Deposits vary cyclically, seasonally and secularly by substantial amounts. Such deposit flows are predictable to some degree.
2. It is possible to reduce borrowing and liquid asset holdings of commercial banks by anticipating deposit movements.

Banks adjust differently to expected and unexpected changes in deposits. They try to acquire appropriate earning assets in terms of maturity and risk in order to meet expected deposit changes. Unexpected or unanticipated deposit changes are more likely to be handled through the liquid assets or manageable liabilities accounts.

The empirical findings which surfaced as a result of testing the above hypotheses can be summarized as follows:

1. Systematic variation does exist in the deposits of commercial banks.
2. The amount of systematic variation and the amount of total variation differs between demand deposits, and time and savings deposits. Demand deposits have greater systematic variation and greater total variation.
3. Smaller banks appear to have less systematic variation and more total variation in deposits than do larger banks.
4. The models developed for the demand deposit series and their estimated parameters appear to be stable over time.
5. With few exceptions the bulk of the adjustments that large and smaller banks make in response to actual deposit changes appears to be in the form of earning assets.
6. Large banks have more success in meeting deposit

changes through their earning asset portfolio than do smaller banks.

7. When unable to meet deposit changes through earning assets, smaller banks seem to rely heavily on liquid assets while large banks rely more heavily on manageable liabilities. Larger banks, therefore, appear more willing to accept the uncertainties involved in adjustment through manageable liabilities.
8. In most cases commercial banks show little response to forecasting errors. The indication is that these banks are unable to forecast, or unable to forecast with any significant degree of accuracy.
9. Deposit changes and residuals, with few exceptions, are normally distributed with a mean not significantly different from zero.
10. Deposit variability, as measured by the coefficient of variation is greater for smaller than it is for larger banks. In addition, the risk of liquid asset exhaustion is slightly greater for smaller banks. In neither case is the difference significant.
11. On the average, the liquid asset holdings of commercial banks are sufficient to cover 95% of the net outflows that have historically occurred.

Implications

The empirical findings of this study have certain

general implications for bank management. The analysis shows that whether or not banks forecast deposit changes, they are able to meet a significant amount of their deposit adjustments through earning assets. The implication is that there is a significant safety factor already built into most commercial bank earning asset portfolios which allows the bank to make most adjustments, or a significant part of each adjustment, through its earning asset portfolio as indicated in tables 5.5a and 5.5b. This built-in safety factor determines how important forecasting will be for a particular bank. If a bank's earning asset portfolio is flexible enough to absorb a high percentage of total deposit changes, or a significant amount of each deposit change, then forecasting will not make the bank's adjustments significantly more efficient. As evidenced in tables 5.5a and 5.5b, this built-in safety factor seems to be greater for larger banks than it is for smaller banks. Thus, ironically, it would appear that smaller banks which have less systematic variation in their deposits to ensure accurate forecasting would benefit the most from forecasting. The dimensions of the benefits from forecasting depend, of course, on the yield differential involved in shifting funds from liquid to earning assets. Table 1.1 provides some insight into the magnitude of this yield differential. In addition, benefits are derived from a more efficient use of borrowing capacity to meet deposit changes.

Although this analysis gives special emphasis to liquid assets as a means of adjusting to unexpected deposit changes,

only smaller banks appear to rely heavily on liquid assets as a means of adjustment. Larger banks, when forced to make short run adjustments, tend to prefer adjustments through the manageable liabilities account. Although larger banks do not hold smaller amounts of liquid assets relative to deposit variability, they choose not to make adjustments through liquid assets. The implication is that larger banks either have better borrowing opportunities, or simply choose to exercise their borrowing opportunities more often than do smaller banks. Since greater uncertainties are associated with borrowing than holding liquid assets, it indicates that larger banks are more willing, or more capable of, dealing with these uncertainties than smaller banks.

A Suggestion for Future Research

Although this study has provided some interesting insight into the manner in which commercial banks adjust to deposit variability, at least one avenue for future research remains open. Adjustments in the form of liquid assets, earning assets and manageable liabilities may depend on the direction of the deposit change. Commercial banks may adjust to deposit gains in one manner and to deposit losses in a different manner. This study, because it deals with the variance of deposits as opposed to semi variance tends to camouflage any adjustment differences that may exist. Future research may examine this issue by focusing on the semi variance of deposits instead of the variance of deposits.

APPENDICES

APPENDIX A

Model Parameters and Statistics for 10 Individual Bank
Demand, and Time and Savings Deposit Series

1. For certain banks no model statistics are indicated for time and savings deposit series. This indicates an absence of systematic variation.
2. The first five large and smaller banks were chosen for illustration purposes in the appendix.

DEMAND DEPOSITS 1

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.3252E+10

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.3252E+10

R-SQUARED = 0.343 F(1,101) = 52.8 ADJ. R-SQUARED = 0.337

AUTOREGRESSIVE PARAMETERS

-0.588975E+00

CONSTANT TERM

-0.139528E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2
-0.4269E+00	0.9875E+04
-0.7511E+00	-0.1267E+05

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2
0.8105E-01	0.5835E+04

T-STATISTIC FOR EACH PARAMETER 101 DEGREES OF FREEDOM

1	2
-0.7267E+01	-0.2476E+00

DEMAND DEPOSITS 5

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.4857E+11

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.4850E+11

R-SQUARED - 0.400 F(5, 97) - 12.0 ADJ. R-SQUARED = 0.369

AUTOREGRESSIVE PARAMETERS

-0.681991E+00 -0.297586E+00 -0.274156E+00 -0.297484E+00 -0.3;3092E+00

CONSTANT TERM

0.598789E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3	4	5	6
-0.4894E+00	-0.6861E-01	-0.4480E-01	0.6956E-01	-0.1213E+00	0.5019E+05
-0.8746E+00	-0.5266E+00	-0.5035E+00	-0.5254E+00	-0.5049E+00	-0.3822E+05

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3	4	5	6
0.9629E-01	0.1145E+00	0.1147E+00	0.1140E+00	0.9591E-01	0.2210E+05

T. STATISTIC FOR EACH PARAMETER 97 DEGREES OF FREEDOM

1	2	3	4	5	6
-0.7082E+01	-0.2599E+01	-0.2391E+01	-0.2610E+01	-0.3264E+01	0.2709E+00

DEMAND DEPOSITS 7

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.1203E+11

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.1201E+11

R-SQUARED = 0.374 F(4, 98) = 14.6 ADJ. R-SQUARED = 0.348

AUTOREGRESSIVE PARAMETERS

-0.747383E+00 -0.587322E+00 -0.409913E+00 -0.232560E+00

CONSTANT TERM

0.601688E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3	4	5
-0.5510E+00	-0.3548E+00	-0.1777E+00	-0.3683E-01	0.2796E+05
-0.9436E+00	-0.8199E+00	-0.6421E+00	-0.4283E+00	-0.1593E+05

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3	4	5
0.98151E-01	0.1163E+00	0.1161E+00	0.9787E-01	0.1097E+05

T-STATISTIC FOR EACH PARAMETER 98 DEGREES OF FREEDOM

1	2	3	4	5
-0.7614E+01	-0.5052E+01	-0.3530E+01	-0.2376E+01	0.5484E+00

TIME AND SAVINGS DEPOSITS 7

VARIANCE OF RESIDUALS (BANK FORECAST RESIDUALS INCLUDED) = 0.2889E+09

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.2888E+09

R-SQUARED = 0.184 F(1, 158) = 23.7 ADJ. R-SQUARED = 0.129

AUTOREGRESSIVE PARAMETERS

-0.366721E+00

CONSTANT TERM

0.235063E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2
-0.2164E+00	0.5198E+04
-0.5171E+00	-0.2972E+03

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2
0.7517E-01	0.1374E+04

T - STATISTIC FOR EACH PARAMETER 153 DEGREES OF FREEDOM

1	2
-0.4879E+01	0.1784E+01

DEMAND DEPOSITS 12

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.2286E+10

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.2286E+10

R-SQUARED = 0.350 F(2, 100) = 27.0 ADJ. R-SQUARED = 0.337

AUTOREGRESSIVE PARAMETERS

-0.674036E+00 -0.387015E+00

CONSTANT TERM

0.130816E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3
-0.3895E+00	-0.2021E+00	0.1080E+05
-0.8585E+00	-0.5719E+00	-0.8181E+04

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3
-.9225E-01	0.9245E=01	0.4745E+04

T-STATISTIC FOR EACH PARAMETER 100 DEGREES OF FREEDOM

1	2	3
-0.7306E+01	-0.4186E+01	0.2757E+00

DEMAND DEPOSITS 13

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.3557E+08

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.3530E+08

R-SQUARED = 0.437 F(4, 98) = 19.0 ADJ. R-SQUARED = 0.414

AUTOREGRESSIVE PARAMETERS

0.844769E+00 -0.554336E+00 -0.413025E+00 -0.205156E+00

CONSTANT TERM

0.461853E+02

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3	4	5
-0.6485E+00	-0.3081E+00	-0.1671E+00	-0.7789E-02	0.1240E+04
-0.1041E+01	-0.8006E+00	-0.6590E+00	-0.4025E+00	-0.1147E+04

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3	4	5
0.9815E-01	0.1231E+00	0.1230E+00	0.9868E=01	0.5968E+03

T-STATISTIC FOR EACH PARAMETER 98 DEGREES OF FREEDOM

1	2	3	4	5
-0.9607E+01	-0.4503E+01	-0.3358E+01	-0.2079E+01	0.77939E-01

TIME AND SAVINGS DEPOSITS 13

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.1968E+07

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.1968E+07

R-SQUARED = 0.192 F(1, 153) - 36.4 ADJ. R-SQUARED = 0.187

AUTOREGRESSIVE PARAMETERS

-0.438464E+00

CONSTANT TERM

0.101976E+03

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2
-0.2931E+00	0.3280E+03
-0.5838E+00	-0.1241E+03

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2
0.7266E-01	0.1130E+03

T-STATISTIC FOR EACH PARAMETER 153 DEGREES OF FREEDOM

1	2
-0.6035E+01	0.9023E+00

DEMAND DEPOSITS 14

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.1315E+10

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.1313E+10

R-SQUARED = 0.417 $F(2, 100) = 35.8$ ADJ. R-SQUARED = 0.405

AUTOREGRESSIVE PARAMETERS

-0.793317E+00 -0.384263+00

CONSTANT TERM

0.171751E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3
-0.6050E-00	-0.1981E+00	0.8917E+04
-0.9794E+00	-0.5704E+00	-0.5482E+04

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3
0.9359E-01	0.9308E-01	0.3600E+04

T-STATISTIC FOR EACH PARAMETER 100 DEGREES OF FREEDOM

1	2	3
-0.8465E+01	-0.4128E+01	0.4771E+00

TIME AND SAVINGS DEPOSITS 14

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.1743E+09

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.1743E+09

R-SQUARED = 0.138 F(2. 152) = 12.1 ADJ. R-SQUARED = 0.26

AUTOREGRESSIVE PARAMETERS

-0.232438E+00 -0.288396E+00

AR PARAMETERS SUPPRESSED

2 3

CONSTANT TERM

0.160984E+04

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3
-0.8179E-01	-0.1366E+00	0.3756E+04
-0.3831E+00	-0.4402E+00	-0.5360E+03

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3
0.7533E-01	0.7591E-01	0.1073E+04

T-STATISTIC FOR EACH PARAMETER 152 DEGREES OF FREEDOM

1	2	3
-0.3086+01	-0.3799E+01	0.1500E+01

DEMAND DEPOSITS 26

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.1930E+08

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.1929E+08

R-SQUARED = 0.310 F(4, 98) = 11.0 ADJ. R-SQUARED = 0.281

AUTOREGRESSIVE PARAMETERS

-0.570863E+00 -0.200014E+00 -0.265194E+00 -0.285821E+00

CONSTANT TERM

0.342687E+03

95% CONFIDENCE LIMITS (+ -TWO STD. ERRORS)

1	2	3	4	5
-0.3772E+00	0.1889E-01	-0.4645E-01	-0.9176E-01	0.1223E+04
-0.7645E+00	-0.4189E+00	-0.4839E+00	-0.4799E+00	-0.5378E+03

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3	4	5
0.9682E-01	0.1095E+00	0.1094E+00	0.9703E+01	0.4402E+03

T-STATISTIC FOR EACH PARAMETER 98 DEGREES OF FREEDOM

1	2	3	4	5
-0.5896E+01	-0.1827E+01	-0.2425E+01	-0.2946E+01	0.7784E+00

DEMAND DEPOSITS 31

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.5841E+08

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.5841E+08

R-SQUARED = 0.320 F(1, 101) = 47.6 ADJ. R-SQUARED = 0.314

AUTOREGRESSIVE PARAMETERS

-0.570784E+00

CONSTANT TERM

-0.134965E+03

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2
-0.4053E+00	0.1376E+04
-0.7362E+00	-0.1646E+04

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2
0.8272E-01	0.7553E+03

T-STATISTIC FOR EACH PARAMETER 101 DEGREES OF FREEDOM

1	2
-0.6900E+01	-0.1787E+00

TIME AND SAVINGS DEPOSITS 31

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.3035E+07

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.3035E+07

R-SQUARED = 0.195 F(2, 152) = 18.4 ADJ. R-SQUARED = 0.184

AUTOREGRESSIVE PARAMETERS

-0.468466E+00 -0.259470E+00

CONSTANT TERM

0.188343E+03

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3
-0.3111E+00	-0.1021E+00	0.4705E+03
-0.6259E+00	-0.4168E+00	-0.9380E+02

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3
0.7870E-01	0.7868E-01	0.1411E+03

T-STATISTIC FOR EACH PARAMETER 152 DEGREES OF FREEDOM

1	2	3
-0.5953E+01	-0.3298E+01	0.1335E+01

DEMAND DEPOSITS 70

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.1034E+08

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.1026E+08

R-SQUARED = 0.320 F(3, 99) = 15.5 ADJ. R-SQUARED = 0.300

AUTOREGRESSIVE PARAMETERS

-0.67144E+00 -0.453269E+00 -0.200735E+00

CONSTANT TERM

0.168875E+03

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3	4
-0.4752E+00	-0.2316E+00	0.2038E-02	0.8097E+03
-0.8677E+00	-0.6749E+00	-0.4035E+00	-0.4720E+03

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3	4
0.9810E-01	0.1108E+00	0.1014E+00	0.3204E+03

T-STATISTIC FOR EACH PARAMETER 99 DEGREES OF FREEDOM

1	2	3	4
-0.6844E+01	-0.4089E+01	-0.1980E+01	0.5270E+00

DEMAND DEPOSITS 73

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.6823E+08

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.6758E+08

R-SQUARED = 0.329 F(4, 98) = 12.0 ADJ. R-SQUARED = 0.302

AUTOREGRESSIVE PARAMETERS

-0.668479E+00 -0.486223E+00 -0.404533E+00 -0.235187E+00

CONSTANT TERM

-0.646504E+03

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3	4	5
-0.4737E+00	-0.2670E+00	-0.1846E+00	-0.4091E-01	0.1009E+04
-0.8632E+00	-0.7054E+00	-0.6244E+00	-0.4295E+00	-0.2302E+04

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3	4	5
0.9738E-01	0.1096E+00	0.1100E+00	0.9714E-01	0.8276E+03

T-STATISTIC FOR EACH PARAMETER 98 DEGREES OF FREEDOM

1	2	3	4	5
-0.6865E+01	-0.4436E+01	-0.3679E+01	-0.2421E+01	-0.7812E+00

TIME AND SAVINGS DEPOSITS 73

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS INCLUDED) = 0.2736E+07

VARIANCE OF RESIDUALS (BACK FORECAST RESIDUALS EXCLUDED) = 0.2736E+07

R-SQUARED = 0.221 F(2, 152) = 21.6 ADJ. R-SQUARED = 0.211

AUTOREGRESSIVE PARAMETERS

-0.517549E+00 -0.233239E+00

CONSTANT TERM

0.303856E+03

95% CONFIDENCE LIMITS (+ - TWO STD. ERRORS)

1	2	3
-0.3598E+00	-0.7542E-01	0.5746E+03
-0.6753E+00	-0.3911E+00	0.3308E+02

STANDARD ERROR FOR EACH PARAMETER (ON LINEAR HYPOTHESIS)

1	2	3
0.7889E-01	0.7891E-01	0.1354E+03

T-STATISTIC FOR EACH PARAMETER 152 DEGREES OF FREEDOM

1	2	3
-0.6560E+01	-0.2956E+01	0.2244E+01

APPENDIX B

Histograms of Residuals and Deposit Changes for 10 Individual Banks

Two histograms are presented for each of the 10 banks examined.

1. Top histograms, deviations from forecasted values.

(Total residuals from demand, and time and savings deposit models or residuals from demand deposit models and actual changes from time and savings deposit series, when no systematic variation exists in time and savings deposit series.)

2. Bottom histograms, actual deposit changes.

(Total changes from demand and time and savings deposit series.)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	3 +XXX	
-1.7500	3 +XXX	
-1.5000	7 +XXXXXXXX	
-1.2500	4 +XXXX	
-1.0000	3 +XXX	
-.75000	11 +XXXXXXXXXXXX	
-.50000	9 +XXXXXXXXXXXX	
-.25000	12 +XXXXXXXXXXXX	
0.	12 +XXXXXXXXXXXX	
.25000	9 +XXXXXXXXXXXX	
.50000	4 +XXXX	
.75000	5 +XXXXX	
1.0000	6 +XXXXXX	
1.2500	5 +XXXXX	
1.5000	7 +XXXXXXX	
1.7500	0 +	
	1 -2.0000	
	2 3.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 1

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(Each X = 1)
-2.0000	1 +X	
-1.7500	3 +XXX	
-1.5000	3 +XXX	
-1.2500	6 +XXXXXX	
-1.0000	8 +XXXXXXXX	
-.75000	10 +XXXXXXXXXXXX	
-.5000	7 +XXXXXXX	
-.25000	9 +XXXXXXXXXXXX	
0.	9 +XXXXXXXXXXXX	
.25000	7 +XXXXXXX	
.50000	13 +XXXXXXXXXXXX	
.75000	8 +XXXXXXXXXX	
1.0000	6 +XXXXXX	
1.2500	5 +XXXXX	
1.5000	1 +X	
1.7500	1 +X	
	3 -2.0000	
	3 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	2 +XX	
-1.7500	2 +XX	
-1.5000	3 +XXX	
-1.2500	4 +XXXX	
-1.0000	9 +XXXXXXXXXX	
-.75000	8 +XXXXXXXXXX	
-.50000	10 +XXXXXXXXXXXX	
-.25000	11 +XXXXXXXXXXXXXX	
0.	15 +XXXXXXXXXXXXXXXXXX	
.25000	6 +XXXXXX	
.50000	8 +XXXXXXXXXX	
.75000	8 +XXXXXXXXXX	
1.0000	5 +XXXXXX	
1.2500	1 +X	
1.5000	6 +XXXXXX	
1.7500	1 +X	
	2 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 5

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	) +X	
-1.7500	2 +XX	
-1.5000	5 +XXXXXX	
-1.2500	9 +XXXXXXXXXX	
-1.0000	3 +XXX	
-.75000	9 +XXXXXXXXXX	
-.50000	8 +XXXXXXXXXX	
-.25000	9 +XXXXXXXXXX	
0.	14 +XXXXXXXXXXXXXXXXXX	
-.25000	9 +XXXXXXXXXX	
.50000	6 +XXXXXX	
.75000	6 +XXXXXX	
1.0000	4 +XXXX	
1.2500	9 +XXXXXXXXXX	
1.5000	3 +XXX	
1.7500	1 +X	
	4 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	0 +	
-1.7500	1 +X	
-1.5000	4 +XXXX	
-1.2500	2 +XX	
-1.0000	10 +XXXXXXXXXX	
-.75000	10 +XXXXXXXXXX	
-.50000	11 +XXXXXXXXXX	
-.25000	9 +XXXXXXXXXX	
0.	10 +XXXXXXXXXX	
.25000	11 +XXXXXXXXXX	
.50000	9 +XXXXXXXXXX	
.75000	8 +XXXXXXXXXX	
1.0000	3 +XXX	
1.2500	3 +XXX	
1.5000	5 +XXXXX	
1.7500	1 +X	
	4 -2.0000	
	2 3.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 7

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	3 +XXX	
-1.7500	2 +XX	
-1.5000	3 +XXX	
-1.2500	4 +XXXX	
-1.0000	5 +XXXXX	
-.75000	8 +XXXXXXXXXX	
-.50000	5 +XXXXXX	
-.25000	12 +XXXXXXXXXXXX	
0.	11 +XXXXXXXXXXXX	
.25000	14 +XXXXXXXXXXXX	
.50000	11 +XXXXXXXXXXXX	
.75000	9 +XXXXXXXXXX	
1.0000	2 +XX	
1.2500	5 +XXXXX	
1.5000	2 +X	
1.7500	1 +X	
	4 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	1 +X	
-1.7500	1 +X	
-1.5000	2 +XX	
-1.2500	8 +XXXXXXXXXX	
-1.0000	9 +XXXXXXXXXX	
-.75000	5 +XXXXXX	
-.50000	11 +XXXXXXXXXXXX	
-.25000	7 +XXXXXXX	
0.	7 +XXXXXXX	
.25000	15 +XXXXXXXXXXXXXXXXXX	
.50000	13 +XXXXXXXXXXXXXXXXXX	
.75000	6 +XXXXXX	
1.0000	6 +XXXXXX	
1.2500	2 +XX	
1.5000	3 +XXX	
1.7500	0 +	
	4 -2.0000	
	3 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 13

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	2 +XX	
-1.7500	2 +XX	
-1.5000	4 +XXXX	
-1.2500	4 +XXXX	
-1.0000	11 +XXXXXXXXXXXX	
-.75000	9 +XXXXXXXXXX	
-.50000	9 +XXXXXXXXXX	
-.25000	13 +XXXXXXXXXXXXXXXXXX	
0.	9 +XXXXXXXXXX	
.25000	10 +XXXXXXXXXXXX	
.50000	9 +XXXXXXXXXX	
.75000	6 +XXXXXX	
1.0000	3 +XXX	
1.2500	5 +XXXXX	
1.5000	1 +X	
1.7500	1 +X	
	1 -2.0000	
	4 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	2 +XX	
-1.7500	0 +	
-1.5000	3 +XXX	
-1.2500	9 +XXXXXXXXXX	
-1.0000	9 +XXXXXXXXXX	
-.75000	11 +XXXXXXXXXXXX	
-.50000	10 +XXXXXXXXXXXX	
-.25000	10 +XXXXXXXXXXXX	
0.	13 +XXXXXXXXXXXXXX	
.25000	4 +XXXX	
.50000	11 +XXXXXXXXXXXXXX	
.75000	4 +XXXX	
1.0000	2 +XX	
1.2500	6 +XXXXXX	
1.5000	3 +XXX	
1.7500	0 +	
	1 -2.0000	
	5 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 14

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	1 +X	
-1.7500	1 +X	
-1.5000	7 +XXXXXXX	
-1.2500	7 +XXXXXXX	
-1.0000	6 +XXXXXX	
-.75000	5 +XXXXXX	
-.50000	9 +XXXXXXXXXX	
-.25000	9 +XXXXXXXXXX	
0.	14 +XXXXXXXXXXXXXXX	
.25000	10 +XXXXXXXXXXXX	
.50000	11 +XXXXXXXXXXXX	
.75000	2 +XX	
1.0000	3 +XXX	
1.2500	6 +XXXXXX	
1.5000	7 +XXXXXXX	
1.7500	1 +X	
	3 -2.0000	
	1 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	1 +X	
-1.7500	0 +	
-1.5000	3 +XXX	
-1.2500	12 +XXXXXXXXXXXXX	
-1.0000	5 +XXXXX	
-.75000	7 +XXXXXXX	
-.50000	9 +XXXXXXXXXX	
-.25000	14 +XXXXXXXXXXXXXXXXX	
0.	13 +XXXXXXXXXXXXXXXXX	
.25000	15 +XXXXXXXXXXXXXXXXX	
.50000	8 +XXXXXXX	
.75000	4 +XXXX	
1.0000	2 +XX	
1.2500	1 +X	
1.5000	4 +XXXX	
1.7500	0 +	
	1 -2.0000	
	4 2.0000	
TOTAL	103 (.250000	= INTERVAL WIDTH)

BANK 26

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	4 +XXXX	
-1.7500	1 +X	
-1.5000	2 +XX	
-1.2500	3 +XXX	
-1.0000	10 +XXXXXXXXXXXXX	
-.75000	7 +XXXXXXX	
-.50000	9 +XXXXXXXXXX	
-.2500	17 +XXXXXXXXXXXXXXXXXXXXX	
0.	16 +XXXXXXXXXXXXXXXXXXXXX	
.25000	10 +XXXXXXXXXXXXX	
.50000	6 +XXXXXX	
.75000	2 +XX	
1.0000	10 +XXXXXXXXXXXXX	
1.2500	1 +X	
1.5000	1 +X	
1.7500	1 +X	
	1 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	4 +XXXX	
-1.7500	1 +X	
-1.5000	3 +XXX	
-1.2500	7 +XXXXXXXX	
-1.0000	7 +XXXXXXXX	
-.75000	7 +XXXXXXXX	
-.50000	11 +XXXXXXXXXXXX	
-.25000	11 +XXXXXXXXXXXX	
0.	12 +XXXXXXXXXXXX	
.25000	12 +XXXXXXXXXXXX	
.50000	6 +XXXXXX	
.75000	7 +XXXXXX	
1.0000	3 +XXX	
1.2500	5 +XXXXX	
1.5000	1 +X	
1.7500	2 +XX	
	1 -2.0000	
	3 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 31

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	0 +	
-1.7500	3 +XXX	
-1.5000	3 +XXX	
-1.2500	3 +XXX	
-1.0000	9 +XXXXXXXX	
-.75000	10 +XXXXXXXX	
-.50000	17 +XXXXXXXXXXXXXXXX	
-.25000	11 +XXXXXXXXXXXX	
0.	10 +XXXXXXXXXXXX	
.25000	4 +XXXX	
.50000	7 +XXXXXX	
.75000	6 +XXXXXX	
1.0000	1 +X	
1.2500	6 +XXXXXX	
1.5000	5 +XXXXX	
1.7500	3 +XXX	
	3 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	0 +	
-1.7500	2 +XX	
-1.5000	4 +XXXX	
-1.2500	4 +XXXX	
-1.0000	11 +XXXXXXXXXXXX	
-.75000	11 +XXXXXXXXXXXX	
-.5000	15 +XXXXXXXXXXXXXXXX	
-.25000	7 +XXXXXXX	
0.	6 +XXXXXXX	
.25000	9 +XXXXXXXXXX	
.50000	14 +XXXXXXXXXXXXXXXX	
.75000	9 +XXXXXXXXXX	
1.0000	3 +XXX	
1.2500	2 +XX	
1.5000	2 +XX	
1.7500	1 +X	
	1 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 70

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	1 +X	
-1.7500	2 +XX	
-1.5000	4 +XXXX	
-1.2500	7 +XXXXXXX	
-1.0000	13 +XXXXXXXXXXXX	
-.75000	5 +XXXXX	
-.50000	8 +XXXXXXX	
-.25000	20 +XXXXXXXXXXXXXXXXXXXX	
0.	13 +XXXXXXXXXXXX	
.25000	6 +XXXXXX	
.50000	4 +XXXX	
.75000	4 +XXXX	
1.0000	4 +XXXX	
1.2500	4 +XXXX	
1.5000	0 +	
1.7500	3 +XXX	
	5 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 22	(EACH X = 1)
-2.0000	2 +XX	
-1.7500	2 +XX	
-1.5000	2 +XX	
-1.2500	7 +XXXXXXX	
-1.0000	15 +XXXXXXXXXXXXXXXXXX	
-.75000	7 +XXXXXXX	
-.50000	10 +XXXXXXX	
-.25000	7 +XXXXXXX	
0.	7 +XXXXXXX	
.25000	11 +XXXXXXXXXXXXX	
.50000	6 +XXXXXXX	
.75000	6 +XXXXXXX	
1.0000	5 +XXXXXX	
1.2500	5 +XXXXXX	
1.5000	6 +XXXXXXX	
1.7500	3 +XXX	
	1 -2.0000	
	2 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

BANK 73

HISTOGRAM/FREQUENCIES

LEFT-END	COUNT FOR VAR 39	(EACH X = 1)
-2.0000	3 +XXX	
-1.7500	2 +XX	
-1.5000	5 +XXXXXX	
-1.2500	2 +XX	
-1.0000	4 +XXXX	
-.7500	6 +XXXXXXX	
-.50000	18 +XXXXXXXXXXXXXXXXXXXXX	
-.25000	12 +XXXXXXXXXXXXXXX	
0.	6 +XXXXXXX	
.25000	7 +XXXXXXX	
.50000	11 +XXXXXXXXXXXXX	
.75000	6 +XXXXXXX	
1.0000	6 +XXXXXXX	
1.2500	6 +XXXXXXX	
1.5000	3 +XXX	
1.7500	2 +XX	
	3 -2.0000	
	1 2.0000	
TOTAL	103 (.25000	= INTERVAL WIDTH)

APPENDIX C

Tape Description

MEDIA	RECORD TYPE	RECORD LENGTH	BLOCKING FACTOR	BLOCK SIZE	RET CYCLE	ACCESS METHOD
TAPE	FIXED	64	10	640	INDEFINITE	SEQUENTIAL
ELEMENT NUMBER	ELEMENT LABEL	POSITION From To BYTE BYTE		CLASS	FIELD LENGTH	
1	BANK ID NUMBER.....	1.....	4..	Binary...	4 Bytes	
2	DATE (YR-MO-DA).....	5.....	8..	"	...4 Bytes	
3	OTHER LOANS (TOTAL).....	9.....	12..	"	...4 Bytes	
4	TOTAL INVESTMENTS (SECURITIES).....	13.....	16..	"	...4 Bytes	
5	ALL OTHER ASSETS (TOTAL)....	17.....	20..	"	...4 Bytes	
6	U.S. TREASURY BILLS.....	21.....	24..	"	...4 Bytes	
7	U.S. TREASURY NOTES & BONDS MATURING WITHIN 1 YEAR.....	25.....	28..	"	...4 Bytes	
8	FEDERAL FUNDS SOLD & SEC. PURCHASED UNDER AGREE- MENTS TO RESELL (TOTAL)...	29.....	32..	"	...4 Bytes	
9	DEMAND DEPOSITS (TOTAL).....	33.....	36..	"	...4 Bytes	
10	TIME AND SAVINGS DEPOSITS (TOTAL).....	37.....	40..	"	4 Bytes	
11	LARGE NEGOTIABLE CD's (TOTAL).....	41.....	44..	"	4 Bytes	
12	FEDERAL FUNDS PURCHASED & SEC. SOLD UNDER AGREE- MENTS TO REPURCHASE.....	45.....	48..	"	4 Bytes	
13	BORROWINGS FROM FR BANKS....	47.....	52..	"	4 Bytes	
14	BORROWINGS FROM OTHERS.....	53.....	56..	"	4 Bytes	
15	NET OPERATING EARNINGS.....	57.....	60..	"	4 Bytes	
16	LOSSES ON SECURITIES TRANSACTIONS.....	61.....	64..	"	4 Bytes	
TOTAL COLUMN					64 Bytes	

Data Media1. Binary

- Recording Mode - Fixed blocked - binary
- Bytes per Record - 64
- Records per Block - 10
- Bytes per Block - 640
- Label Record - Standard IBM System/370 Operating
(OS) Tape Labels System
- Sort Fields (Ascending) - Major 1. Date
2. Bank Number
- Density - 1600 BPI
- Parity - Odd
- Fields - Financial Data - 4 Byte Binary
Structure Data - 4 Byte Binary

<u>TAPE NUMBER</u>	<u>PERIOD COVERED</u>	<u>DSNAME</u>	<u># OF RECORDS</u>
M99989	1/6/71 - 12/26/73	Hamilton	15,600

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