

BANK RISK CLASSIFICATION AND OPTIMAL REGULATORY CHOICE

by

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ABSTRACT

A theory of bank regulation is formed in this study by choosing an optimal classification scheme so as to minimize specific costs with assumed fixed regulatory instruments and relative costs.

The likelihood of failure of a financial institution can be estimated using the financial data of that institution. Previous research studies have attempted to predict the probability of failure by using one year of data or lagged data. In these studies, a bank on a failure trajectory was counted as a nonfailure until it actually failed. The estimation was biased in favor of nonfailures, meaning that a failing bank was more likely to be classified as a survivor.

This study develops a multinomial ordered logit model which uses several years of data to classify banks into a larger number of categories. Instead of just predicting banks that will fail in the following year, it can predict the probability of failure within multiple time periods.

The major empirical results of this study state that the probability of failure of financial institutions can be estimated using a multinomial ordered logit model. Financial ratios based on capital, assets, total loans, nonaccruing loans, loans 90 days past due and net income were found to be significant variables in predicting failure probabilities.

The results present evidence that banks can be classified into high or low risk categories which could be used by regulators to minimize the costs of regulation and bank failure. Better predictive ability would allow regulators to take action sooner to assist banks in maintaining solvency and reduce the number of failures and their associated costs.

CHAPTER 1

INTRODUCTION

The Federal Deposit Insurance System was first created after the Great Depression of the 1930s to help assure the stability of deposits and the entire financial system, by protecting insured depositors' funds in the event of bank failure.

The number of failures of financial institutions has increased tremendously since the 1980s, which paralleled the 1930s in terms of the crises of the commercial bank and savings and loan industries. The FDIC's insurance fund from collected premiums is not large enough to cover the losses on banks' portfolios, a fact that brings the stability of the overall financial system in question.

There have been heated debates on how to reform the financial system. Some individuals have argued that the financial system is inherently unstable, and that more strict regulations should be imposed on financial institutions in order to improve the stability of the system. Others suggest that regulatory control should be lessened and that the system should rely more on market forces. Essentially, the FDIC has two functions: regulation and insurance. Its major

regulatory functions are: admission, examination, supervision and handling of bank failures. Although a number of changes in the regulation and insurance programs have been made since the FDIC was founded, the pace of change has been slower than many expected.

This study consists of three parts. The first is a detailed discussion of some of the problems of the banking industry. This discussion will focus on perceived problems of financial system regulation and policy and banks' response. The second involves development and implementation of an econometric model which predicts the probability of failure. The estimation results permit banks to be placed into different categories of risk levels. The third part presents an optimal choice of classifications to minimize the overall costs.

Bank Failure and Regulation in Historical Perspective

Background

Deposit insurance was experimented with at the state level as early as 1829¹. The purposes of the various state plans were similar: to protect depositors from losses and communities from the economic disruptions caused by bank failure. New York was the first state to adopt a bank-

¹Historical Background was provided by the FDIC, the First fifty Years.

obligation insurance program. This program continued until 1917. Most of the state plans proved unworkable for two primary reasons. First, the emergence of the free banking movement in the 1830s caused the participation in state insurance programs to decline. The second reason was the establishment of the national bank system in 1863. In 1865, Congress levied a prohibitive tax on state bank notes causing many state-charted banks to convert to national banks in order to escape the tax, so the number of state banks declined and state insurance funds decreased. The last of these plans had stopped by the early 1930s.

Deposit insurance at the federal level has a history reaching back to 1886. During the periods from 1886 to 1933, there were 150 proposals for deposit insurance which were made in Congress. Many of the proposals were prompted by financial crises. The events during that period finally convinced the general public to consider the necessity, on a national level, of alleviating the disruptions caused by bank failures.

During the Great Depression in the 1930s, the financial system was on the verge of collapse and thousands of depositors were unable to retrieve their funds from the banking system. The crisis environment led to the call for deposit insurance. On June 16, 1933, the Banking Act, which created the Federal Deposit Insurance Corporation, was signed into law by President Franklin Roosevelt. The purpose of the

FDIC was to ensure the stability of the financial system and to protect the small depositors.

The Early Years

In the early years of the FDIC's existence, banks were not in the habit of risk taking because of the experience of the Great Depression. This was reflected in the massive liquidity buildup undertaken by banks. With the legislation in the 1930s, banks were insulated from competing with one another too aggressively. The Banking Act of 1933 outlawed the payment of interest on demand deposits and imposed a ceiling on time deposit rates offered by member banks. The Banking Act of 1935 was designed to provide more limitations on bank behavior. This act increased the supervisory power of the regulators and provided more rigorous standards for admission to the insurance fund. Through the legislation, the risks undertaken by the banks were controlled and the FDIC built up sufficient levels of funds to cover the losses in the early years.

The U.S. economic situation gradually recovered from the low point of 1933. Real GNP increased at an average annual compound growth rate of 9.5 percent between 1933 and 1937, and unemployment declined significantly. In the same period, the general price level increased moderately, leading to improvements in the banking industry. The recession of 1937-1938 interrupted this pattern. After the recession, economic

conditions improved once again. Due to the favorable economic conditions, the U.S. experienced continuous expansion in the banking industry. Banks were able to meet without difficulty the strains resulting from the decline in business activity and bank failures were almost nonexistent. The end of 1941 marked the completion of eight years of successful operation of the system of federal deposit insurance.

The Period 1942-1972

During World War II, government financial policies and private sector restrictions provided expanding opportunities for the banking industry. Banks played a major role in financing the war effort by lending to bond purchasers, by handling the large volume of war loan sales, and by purchasing government obligations. Bank assets increased significantly due to the large-scale war financing of the federal government and bank failures decreased sharply.

After the war, even though inflation was increasing and bank lending increased significantly, this resurgence of lending did not produce an increase in loan losses. Until about 1960, banks generally continued to operate profitably. International expansion in trade and world-wide economic cooperation forced the generation of bankers who came to power in the 1960s to abandon the traditional conservatism that had characterized the industry for many years. The

trend toward aggressiveness and risk taking was particularly true in large banks since the new bankers began to strive for growth in assets, deposits and income under these new conditions. Until the mid-1970s, banks were not noticeably harmed by the movement toward increased risk taking. Generally favorable economic conditions produced high levels of production, employment and income during most of this period, which led to reasonable repayment levels.

The Period 1973- Present

Significant changes occurred after 1973. Some institutions had invested heavily in long-term municipal bonds relying considerably on purchased deposits as a source of funds in anticipation of interest rate declines. But as interest rates rose, interest risk increased. Cheap deposits, in general, became scarce. Banks introduced new products which were more interest rate sensitive and broadened business through geographic expansion. With all these changes, banks had to be competitive in order to survive but the industry also became vulnerable to adverse economic conditions.

The first major recession occurred in 1973-1975. This recession contributed to a great increase in bank loan losses, problem banks and bank failures. The rapid increase in oil and gas prices during the mid-1970s contributed to high inflation and high interest rates leading to greater

risks for institutions. In 1978, interest rates on securities surpassed the rates payable by depository institutions for saving and time accounts causing deposit growth to slow markedly. In 1979 and early 1980, inflation increased greatly along with interest rates. In combination with a heavy emphasis on fixed-rate, long-term lending, this caused severe problems for the thrift industry.

In addition, the impression that financial regulation had reduced the competitiveness of the institutions in both domestic and international markets led a number of policy-makers to support major deregulation legislation. The Depository Institutions Deregulation and Monetary Control Act of 1980 mandated the elimination of the interest rate ceilings on deposits by 1986. This act increased competition for commercial banks although it also increased their ability to generate profits through more aggressive pursuit of deposits. In 1982, the Garn-St Germain Depository Institution Act took the deregulation even further and gave the regulators more flexibility in dealing with failing institutions. A severe recession in 1981-1982 combined with falling oil prices worsened the situation for those banks that invested heavily in the oil and gas industries. In some states, the health of other sectors of the economy depended on investments of oil and gas industries. Table 1 indicates the historic trends of bank failures in the U.S.

Table 1. Number of Closed Institutions and Value of Deposits

Year	Total Number of Banks	Total Number of Insured	Total Deposits	Assets
			(thousands of dollars)	
1945-1950	26	19	35,937	32,792
1955-1960	25	17	52,293	45,421
1965-1970	39	35	275,726	322,263
1975-1980	64	62	2,590,791	3,082,042
1985	120	120	8,059,441	8,741,268
1986	138	138	6,471,100	6,991,600
1987	184	184	6,281,500	6,850,700
1988	200	200	24,931,302	35,697,789
1989	206	206	24,090,551	29,168,596

Data Source: FDIC Annual Report (1989)

The number of bank failures increased greatly during the depression years. After that period, five year comparisons show a significant decline in failures. Between 1940 and 1945, only 26 banks suffered failures. These numbers parallel the failure rate seen during the 1950s. Substantial increases in the number of banks failing began in the mid 1970s and continued throughout the 1980s. Failures increased 200 percent between 1976 and 1987.

After the mid-1980s, there was almost no significant change within the Federal Deposit Insurance System until 1989. In December 1989, the Bush Administration put forward the Financial Institutions Reform, Recovery and Enforcement Act (FIRREA) which did not address the whole range of problems, but it was the first step of reform. Pressured by a continuing decline in the industry, regulators increased the flat rate premium and imposed a risk-adjusted capital requirement.

Current Assessment of the Federal Deposit

Insurance Corporation

The Federal Deposit Insurance System has served as an integral part of the nation's financial system since 1933. Its major contribution was the restoration of public confidence in banks. While it has grown and modified its operations in response to the changing economic conditions

and banking environment, the main goals have still remained the same: to ensure the stability of the banking industry and to protect depositors.

To build the insurance fund, the FDIC provided for a flat rate premium to be assessed based upon the total dollar value of deposits held by an institution. The historic assessment up until 1988 for commercial banks was 1/12 of 1 percent (8.3 cents per \$100) of total domestic deposits, whether insured or not. It increased to 12 cent per \$100 in 1989. The current assessment is 19.5 cents per \$100, and will increase to 23 cents per \$100 of deposits by July 1991. The annual percentage each bank paid each year has varied because the FDIC has granted an annual rebate depending on the actual expenditures each year. The percentage charged for each institution has been the same regardless of risk assumed by the banking institution.

Recent experiences have led to proposals that riskier institutions should bear the brunt of their risk exposure since along with increased profits the likelihood of failure is greater. A variety of changes in the FDIC have been suggested, such as changes in coverage, increased capital requirements, privatization, continuation of the present system with risk-adjusted capital requirements and/or risk-adjusted insurance premiums. Recently, there have been some significant problems brought to light about the Federal Deposit Insurance System. For example, the Federal Savings

and Loan Insurance Corporation (FSLIC) does not have enough money in its fund to bail out failing institutions. For this reason, questions about the ability of the FDIC to cover large losses have surfaced.

Objectives

This study will, within the context of the current system of deposit insurance in the United States, achieve the following objectives:

- a. Discuss proposed changes in financial institution insurance and assess their feasibility.
- b. Examine models that pertain to risk prediction for financial institutions.
- c. Propose a regulatory choice model of cost minimization, through proposing an econometric model to predict the probability of failure based on financial and structural variables and classifying riskier banks from less risky banks by setting the probability boundary classifications through minimization of costs.

The remainder of this study is organized in the following manner. Chapter 2 is a review of the literature which will discuss various types of regulation options, models of predicting riskiness and proposals while Chapter 3

will discuss a theory of bank regulation with an econometric model. Chapter 4 will summarize the empirical estimation of the risk model and an optimal regulatory choice followed by the results and conclusions of this study in Chapter 5.

CHAPTER 2

LITERATURE REVIEW

Federal Deposit Insurance System serves two major functions. One is to set the regulations for insured institutions. The other is to sell insurance to insured institutions. Recently, observers, regulators, and industry leaders have advocated widely differing modifications of regulatory practice. These proposals may be divided into two broad classes: those that increase the role of government in the regulation process, and those that increase the role of private market forces. Clearly, the question of how to devise "optimal" regulation procedures is open, though most would agree that steps must be taken to strengthen the system. The purpose of this chapter is to summarize the debate, and to present a review of the literature supporting the view of regulatory policy toward more market orientation.

Bank Regulation and Policy

Recent problems with FDIC insurance funds and the increased number of bank failures have made it obvious that our banking system is in need of change. With the rapid

change in the financial environment, bank regulation and policy have not been kept up with the situation in the changing world. There have been a number of proposals to reform the regulation of financial institutions. These can be divided into two primary groups. One is intended to increase government regulation so as to control risk-taking; the other intends to rely more on market-incentive.

Those who favor an increased role for government in regulating financial institutions often point to the idea that banks are special. That is, financial institutions are inherently unstable and social costs of bank failures are high, government regulations should be used to improve stability and reduce costs to tax-payers, bank owners, and customers of financial institutions. Diamond and Dybvig (1983), for example, devised a model of a simple economy and found that government deposit insurance improves social welfare by removing or reducing bank runs that occur when depositors who expect the bank to fail rush to withdraw their deposits. In this case, regulation may serve to protect the insurance system.

The other argument has been made that the financial system should rely more on market forces. Proponents of market-based oversight and deregulation argue that such reforms would force the banks to consider the trade-off between potential gains and costs of excess risk-taking. Because of the incentives given by the regulatory policy, the

number of bank failures has increased so a immediate reform toward market incentives is needed. Thomson (1990) commented that restoring market discipline as an effective constraint on bank activities is the major purpose of deposit insurance reform. This mainly includes the reduction in the scale or scope of the federal safety net, market-value accounting, and the adaptation of a timely closure rule for banks. In that case, the efficiency and long-run stability of the banking system could be improved.

There is an ongoing debate in banking circles over whether banks, being very different businesses than those outside the financial sector, warrant very different governmental control. Some argue that the possibility of bank runs and the social externalities associated with bank failures make banking industry "special", therefore it requires more than the usual degree of regulatory oversight.

Others have stated that the financial industry is not much different, so why has the industry been chosen for heavy regulation. Thomson (1990) argued the assumption that banks are special because of possible bank runs and social externalities associated with their failures does not appear to be valid.

The debate is really about the balance between stability and efficiency. Thomson (1990) commented that increasing regulation will trade efficiency for stability. If the regulation or policy gives an incentive to financial

institutions which does not enhance social optimality, such as an incentive toward excessive risk-taking, this reduces the efficiency of the financial system.

Regulation is necessary to ensure stability and safety. This goal must be achieved even at the cost of reduced efficiency--resources flowing to less than their most valuable uses. Proper types of incentives will improve efficiency through market discipline and make the FDIC competitive with private insurance firms. Financial institutions would have to consider the trade-off between the gains and losses from high risk-taking in the long run, thus the number of bank failures may be reduced, and a more stable financial system promoted.

Prediction Models and Classifications

Predicting the probability of failure and classifying financial institutions are of primary importance to regulators who must make decisions about the condition of banks and actions to control. There have been a number of methods used to predict the probability of failure, many of which are based upon econometric techniques embodied in the probit and logit models.

Avery and Belton (1987) built a logit model for assessing bank risk using the same six predictor variables used by the FDIC in its risk-based insurance proposal. The

dependent variable is a dummy variable of bank failure or nonfailure. The explanatory variables are the ratios of primary capital to total assets, loans more than 90 days past due to total assets, nonaccruing loans to total assets, renegotiated loans to total assets, net loan charge-offs (annualized) to total assets, net income (annualized) to total assets. An index of risk was formed using historical data on bank failure to estimate weights that could then be used to transform values of the six variables.

All weights were statistically significant except those for the ratio of net loan charge-offs to assets and renegotiated loans to total assets. The authors concluded that the failed banks in the sample had an average predicted probability of failure of 0.24, a number 69 times larger than the average predicted failure probability of nonfailed banks in the sample, therefore the model does have some ability to discriminate between high and low risk banks.

Gajewski (1989) proposed a logit model to assess the risk of bank failure. The probability of failure for a certain year was estimated using the data from the year prior, which was a function of its financial condition, size, and multibank-holding company affiliation, as well as the dependency of the bank's headquarter county on the energy sector in 1982. The model also included the ratio of commercial-industrial loans to total loans, farm loans to total loans and the logarithm of total assets. The author

used the unweighted logit method with a choice-based sample. The model correctly identified 87.9 percent of the banks that actually failed in 1987, 71.2 percent in 1988, 78.7 percent in early 1989, at the cost of incorrectly classifying 11.7 percent of the survivors as predicted failures in 1987.

Gajewski concluded that the overall economic conditions, especially world oil prices, would affect the probability of bank failure and banks adopting a high-risk management strategy would face a high probability of failure. He suggested that results from the model could be used to provide information to either the regulators or the banks, but detecting risk-taking of a bank is difficult when delinquencies are surging and the value of assets is falling due to charge-offs.

Hanweck (1977) developed a model of the probability of bank failure using probit analysis methods. He used data from bank failures during 1974-76 and a random sample of continuously operating banks. The independent variables were net operating income/assets, capital/assets, change in assets, loan/capital, and natural logarithm of total assets.

This research focused on developing a general understanding of the factors leading to bank failure. Hanweck concluded that the variables of greatest statistical and algebraic importance in predicting failure are lagged net income to assets, loan to equity capital, and the rate of change in net income to assets over the two years prior to

the failure.

Abrams and Huang (1987) constructed a model predicting bank failures, emphasizing the role of structure in affecting the rate of failure in the U.S. They used a probit model which incorporates various bank structure variables such as holding company affiliation, as well as traditional financial ratios to explain bank failures during the 1982-1983 period. They utilized an ex post empirical approach to explain bank failures. They also suggested many factors as contributors to the rise in failures during that time: recession, oil price fluctuations, interest rate increases, increased competition from nonbank financial intermediaries. The dependent variable is constructed by classifying banks according to whether or not they failed and most of the independent variables are drawn from the banks' financial statements.

Abrams and Huang concluded from the empirical work that important information regarding a bank's likelihood of failure is contained in balance sheet and income accounting data. The evidence suggested that banks which depend heavily on Certificates of Deposit have a relatively higher probability of failure, and a relatively large loan portfolio is associated with greater likelihood of failure. Farm loans have no independent effect on failures and real estate loans appear to lead to a lower probability of failure. It was also found that banks which affiliate with holding companies

or are larger in size have a significantly lower probability of failure. They suggested that states which impose unit-banking rules or block holding company formation may be adding to failure risks.

There is not really much difference between logit and probit models. The distribution function for a logit model is the standard logistic while probit is standard normal.

Lane, Looney and Wansley (1986) proposed a Cox proportional hazards model as an early warning system. They applied this model to the prediction of bank failures. The principle difference between a Cox model and other models such as linear regression, probit and logit models is that Cox models predict the expected time to failure as opposed to failure probability in a given period. The results estimated from the model can be used by regulators to identify problem banks and institute action by on-site examination.

Looney, Wansley and Lane (1987) used the Cox proportional hazards model to examine bank failure misclassifications. The dependent variable is an estimated net worth of the financial institutions. They used a stepwise elimination method to estimate the model. The arbitrary classification system proposed by Looney, et al. resulted in a decrease in type I error, which was the misclassification of nonfailures as failures; however, there was an increase in type II error, which was the misclassification of failures as nonfailures. They commented

that when using statistical models to predict financial difficulty and failure in commercial banks, care must be exercised to assure the results are meaningful and contribute to the regulatory and managerial process. They concluded that the generally poor classification results show the need to rebuild these models frequently. They point out that major changes in the economy, such as the deterioration of the agriculture and energy sector, cannot be incorporated unless the model is re-estimated frequently. The Cox model would be improved by the inclusion of variables to measure agricultural loans and account for state branching laws. These omitted variables are most likely the source of Type I error in the study.

Avery and Hanweck (1984) performed a dynamic analysis of bank failure. The model was based on bank failures that occurred from 1979 to 1983 and a sample of nonfailed banks in continuous operation from 1976 through 1983. As it is a dynamic prediction of the probability of bank failure, the model used pooled cross-sectional data rather than averaged independent variables.

The authors stated that failure occurs if $L_t > PVCL_t$, where L_t is the liquidation value of the bank at time t to the chartering authority and $PVCL_t$ is the present value of the authority's contingent liability at time t . They assumed if a bank's condition is weak enough, the condition of $L_t > PVCL_t$ will result and the bank will fail. They developed a

logit model in the following form: $L_t - PVCL_t = FC_t + \alpha_1 FC_{t-1} + \alpha_2 FC_{t-2} + \alpha_3 FC_{t-3} + \epsilon_t$ where FC_t is the composite measure of the bank's financial condition at time t . The measure of a bank's financial condition at time t was estimated by a series of financial variables at time t . The authors concluded that the factors that were of most importance in predicting bank failure were the ratios of net income to assets, capital to assets, loans to assets, and commercial and industrial loans to total loans.

Most authors used a probit or logit model by using cross sectional data of one period or the average of the previous few periods. A panel data analysis which requires several years of data is more desirable because it gives more specific information about the condition of banks. The dynamic model by Avery and Hanweck used lagged variables with ten periods of data. Maddala (1986) pointed out the largest deficiency in their model is that a bank is treated as a nonfailure prior to the time it fails. When the variables were lagged, nonfailures were included more often which resulted in the data being weighted in favor of nonfailures. Another problem in their dynamic model is the restrictions on the coefficients over time. There is no reason to believe the estimates of financial conditions over time are the same and the negative signs of the α s suggests weak reliability of their estimation.

Maddala (1986) suggested performing a dynamic analysis

using the panel data. Because the transition from nonfailure to failure is not abrupt, a dynamic analysis seemed more appropriate than simple logit or probit analysis.

Estimation of Failure Cost

Avery, Hanweck and Kwast (1985) used an ordinary least squares model (OLS) to predict FDIC costs given that a failure occurs, using the same variables as those used in the model to predict the probability of failure.

Barth, Brumbaugh, Sauerhaft and Wang (1985) used an OLS model to study the determinants of and losses from failure. Barth, Brumbaugh and Sauerhaft (1986) used a tobit model to analyze the determinants of FSLIC losses and predicted the expected magnitudes of the losses. The tobit model is a censored normal regression model. For the econometric analysis of costs of failure, data on losses are available for only those institutions that were liquidated or experienced assisted mergers. Thus, some observations on the dependent variable are missing. Maddala (1986) pointed out that the tobit model would give consistent estimates of the parameters and also enable us to predict the magnitudes of the losses for the financial institutions.

Not only are the estimation procedures of importance, but also the goals of reform need to be clarified. In the next section, proposed treatments will be discussed.

Proposed Treatments

There are many proposed treatments to reform the financial system. Cost could be reduced if financial institutions were given the incentive to consider the trade off between profits and costs of excessive risk-taking.

Changes in Coverage

Limiting insurance coverage to less than 100 percent of the total deposits may introduce market discipline on bank behavior. This loss sharing by the depositors would force the depositors to monitor the health of the bank, and may restrain excessive risk-taking by the bank since if the depositors perceive unsoundness within the institution, they might withdraw their money. This option might not promote one of the goals of the deposit insurance system, namely, the stability of the system. Large depositors may withdraw their money if they perceive an increase in the risk of failure or when there is a rumor about the difficulties within the bank. This would make it difficult to manage the bank if large withdrawals occur without notice and this may lead to reduced profitability and possibly to additional failures. Another problem with this proposal is the access of small depositors to the type of information needed to monitor the health of their institutions if the coverage is only extended to a

percentage of each deposit. This transfer of monitoring responsibility to the depositors assumes a certain level of expertise that may not exist. Thomson (1990) commented that federal deposit insurance coverage must be limited, and remaining coverage must be priced and possibly co-insured.

Privatization of Insurance

A comparison of deposit insurance and some other insurance systems may lead to the question, "Why can't private insurance cover the financial institutions?". Currently, there are some state chartered or state regulated private insurance companies that primarily insure deposits in savings and loan associations. Private insurance may rely on market discipline to provide insurance according to the risk of the institution. But the private sector appears unlikely to provide all deposit insurance, and it may not have enough funds to back up its coverage. Further, private insurance alone may not provide a stable financial system, so it is likely to be infeasible.

Increased Capital Requirements

The current system of capital requirements, which requires a minimum primary and total capital/asset ratio, dates back to the beginning of the 1980s. Setting of the capital/asset level by the regulators is somewhat arbitrary. If it is set too high, banks have to reserve more funds than

would actually be required, leading to inefficient resources allocation and reduce profitability. If it is set too low, the bank may not have enough capital to absorb losses, because capital provides a buffer to protect depositors and a high level of capital may be desirable to ensure that the institutions will have sufficient private reserves against periods of adverse earnings. Increasing the capital requirements for all the banks regardless of performance may not be fair for sound banks. So it may not achieve the goal of equity.

There are some crucial problems with the Federal Deposit Insurance System. There have been so many bank failures since the 1980s that the system may not have sufficient funds to cover the losses of the failed institutions. Some people have doubted that we should go on with the system. Meigs and Goodman (1990) concluded based on historic evidence in the 19th century, early part of the 20th century of the state deposit insurance system failures and the present crises of the financial system that we could live without federal deposit insurance.

Another serious problem facing the deposit insurance system is how to deal with the failure of one of the largest banks. Most people think that the large banks will not be allowed to fail since the system cannot provide a large enough amount of money to cover all deposits at a few very large institutions. The regulatory authorities seem

unwilling to accept the direct and indirect costs of the failure of the large institutions. If one or a few of the large institutions failed, not only could this affect the depositors but also some industries. The externalities are so large that it could affect the stability of the general economy. Most people seem to think that the present system should continue with some type of reform. Proposals for risk-adjusted capital requirements and risk-adjusted insurance premiums seem to be the most likely alternatives.

Risk-Adjusted Capital Requirements

Since early 1985, the FDIC has employed minimum supervisory ratios of primary and total capital to total assets in assessing the capital adequacy. Although the minimum capital requirements helped reverse the decline in bank capital, they failed to prevent an overall increase in risk within the banking industry. There have been a number of proposals for risk-based capital requirements. On March 14, 1989, the Board of Directors of the Federal Deposit Insurance Corporation approved a final statement of policy on risk-based capital. An explicit minimum risk-based capital ratio was put into effect on December 31, 1990.

The capital requirements would be assessed as a fraction of the on- and off-balance sheet activity of individual banks. Specifically, total risk-based capital should equal the ratio of total capital to total risk-weighted assets

which are defined as four asset categories with different degrees of credit risk. The first category includes assets that are deemed to have no credit risk and require no capital support, such as cash and claims in the Federal Reserve and therefore has a zero weight. The second category, which tends to have a very low risk, has a weight of 20 percent. This category includes items such as federal government securities. The third category, which tends to have moderate risk levels, is comprised of revenue bonds issued by state and local governments and has a weight of 50 percent. The last category carries the weight of 100 percent and lumps together all other balance sheet assets, such as cash items not in process of collection and most loans to private sector borrowers. The new capital standards will be phased in gradually, taking full effect at the end of 1992. Under this scheme, banks that hold a large proportion of risky assets will be forced to hold significantly higher capital balances.

In principle, risk-based capital requirements may improve control of the risk-taking of institutions. It would reduce the banks' incentive to engage in risky activities by forcing them to hold more capital and allowing them to reduce their capital as they move to less risky activities.

Keeton (1989) argued that the risk-based capital requirement plan will have significant favorable effects but that these beneficial effects will be limited by the imperfect measurement of capital and risk. He explained the

current FDIC plan and evaluated its likely effectiveness in controlling risks. The plan does not measure capital adequately since it relies on book-value accounting under which assets and liabilities are recorded at historical cost and capital is not adjusted for changes in their true market values. As a result, book capital may not reflect the true value of the capital. The plan only focuses on credit risk, where difficulties could develop which would either delay or prevent the repayment of loans or bring about losses. It ignores some other types of risk, primarily interest risk, the spread between interest earned on assets versus the interest paid on liabilities. Additionally, the plan also measures credit risk imperfectly. No distinction is made between loans to highly credit worthy borrowers and loans to borrowers with little history or collateral. Also, a highly diversified loan portfolio is treated the same as a loan portfolio that is concentrated in one region. Keeton concluded that the impact of the plan will vary greatly across banks. On balance, the plan should affect enough banks in a desirable way to improve the regulation of bank risk-taking. However, the full benefits of the plan will not be realized until the measurement of capital and risk are improved.

Risk-Adjusted Insurance Premium

Risk-adjusted deposit insurance premiums would

explicitly price risk-taking by the insured banks. One acceptable proposal would calculate the insurance premium based on the probability of bank failure times the costs to FDIC when a bank fails. Avery and Belton (1987) compared risk-based capital and risk-based deposit insurance. Their article pointed out that instead of setting a standard of capital, a risk-based deposit insurance system would give the institutions a more flexible and more efficient method of management. The insurance premium will reflect the expected cost since the institution would, in principle, bear the full expected cost of their actions, thus forcing them to either restrain from excessive risk-taking or pay the full expected costs to the FDIC.

The FDIC (1986) has developed a proposal for the insurance premium which utilizes two measures for assessing bank risk-taking. One is based on examiner-determined CAMEL ratings assigned to each bank which range from 1 through 5 (with 5 representing the least healthy bank). A bank's CAMEL rating is derived from the evaluation of its capital adequacy, asset quality, management, earnings, and liquidity. The other measure of bank risk which is a risk index developed by the FDIC is based on the Call Report data. The index is defined as follows:

$$I = .818 - .151 KTA + .211 PD90MA + .265 LNNACCA + .177 RENEGA + .151 NCOFSA - .347 NETINCA,$$

where KTA is defined as the ratio of primary capital to

total assets, PD90MA as ratio of loans more than 90 days past due to total assets, LNNACCA as ratio of nonaccruing loans to total assets, RENEGA as ratio of renegotiated loans to total assets, NCOFSA as ratio of net loan charge-offs (annualized) to total assets, and NETINCA as ratio of net income (annualized) to total assets. The variables included in the risk index measure capital, asset quality, and earnings. Under the FDIC proposal, premium would be adjusted by defining two premium classes. Banks having a positive value of risk index and a CAMEL of 3,4, or 5, would be classified as above-normal risk. These institutions would be charged an annual premium equal to one-sixth of one percent of domestic deposits. The rest of the institutions would be charged the current premium of one-twelfth of one percent (8.3 cents per \$100). Evidently, the FDIC proposal would solve the problem only incompletely because the premium, which has two levels, does not adequately reflect the expected costs to the FDIC.

Avery, Hanweck, and Kwast (1985) developed an insurance premium based on a two-part formula made up of statistical estimates of the probability of bank failure and the FDIC's actual costs when a bank fails. The probability of bank failure during a given time period was estimated to be a probit function of a set of financial variables which are based on ex post information and the costs to FDIC when a bank fails, where the ratio of losses incurred was estimated as a function of the same predictor variables by OLS. The

proposed premium is the FDIC's expected insurer costs, or the product of the two estimates. Because of the lack of available data, the authors used three models. For the "full model" which used the data through 1981-1984, measures of bank size, capitalization, earnings, loan charge-offs, loan-to-assets, commercial and industrial loans-to-total loans, liquid assets-to-total assets, interest income-to-interest expense, and deposit growth were used. For the 1983-1984 model, variables concerning past due, renegotiated, and nonaccruing loans, the ratio of interest sensitive assets to liabilities, and a revised capital ratio adjusted for non-performing loans were added. And for the model using data for 1984, variables such as brokered deposits and insider loans were added. The dependent variable for bank failure came from the FDIC annual report.

Through the empirical work, the authors concluded that a higher capital ratio (negatively) and a greater proportion of commercial and industrial loans (positively) appeared to be the strongest determinants of bank failure. The authors concluded that under the proposed model, they would divide banks into three distinct groups. First, some 85 percent of all banks are estimated to pay a lower insurance premium than the current flat premium. Second, some 14 percent of all banks would pay higher premia ranging from 8.3 to 100 cents per 100 dollars of total domestic deposits. This range appeared to be wide enough both to provide a strong incentive

to change risk taking behavior by banks and to deter excessive risk taking in the future. Third, one percent of all banks would pay a premium of 100 cents per 100 dollars or more of total domestic deposits. The future possibility of paying premiums of this size would likely help to deter banks from such risk-taking behavior.

The research analyzed in this chapter implied that increased use of market information is helpful in identifying problem banks. Procedures should be incorporated which would provide bank management with incentives to reduce risky activities. In adopting such an incentive scheme, procedures to accurately classify banks with respect to risk level would be important. In the prediction models, most authors used one period or averaged data to predict bank failure and the dynamic model treated banks as nonfailure prior to the time they fail. This leads to a serious problem in that even if a bank is in poor financial condition and on a failure trajectory, it is treated the same as a healthy bank. In the following chapter, a theoretical structure will be discussed that will provide information to the regulator with respect to potential risk classification which minimizes the misclassification error and reduces overall cost.

CHAPTER 3

A THEORY OF BANK REGULATION

Federal regulation of the nation's banking system was inaugurated by the creation of federal deposit insurance in 1933. During the period 1934 to 1980, there were few bank failures as heavy regulation, deposit insurance, and a relatively favorable economic situation made the banking industry relatively stable. In 1980, with the passage of the Depository Institutions Deregulation and Monetary Control Act, the system was deregulated. Many believed that, in the highly regulated environment, banks did not have sufficient flexibility to expand and compete in either domestic or international markets. The number of bank failures and FDIC losses have increased significantly since 1980. The total number of bank failures has increased to about 200 a year recently. The FDIC lost \$4,240.7 million in 1988, \$851.6 million in 1989 and \$4,854 million in 1990 according to FDIC's annual reports. The insurance fund dropped tremendously from \$18,300 by the end of 1987 to 8,356 by the end of 1990². These losses were a result of a widespread

²*The numbers come from Testimony of L. William Seidman, Chairman of the FDIC on the Condition of the Bank Insurance Fund and Recapitalization on April 11, 1991.*

bailout of troubled institutions. Easing of regulations may have allowed banks to become more competitive but may also have provided them with opportunities that contributed to the high failure rate and large taxpayer costs.

Three classes of decisions face the regulators: first, the categorization of banks with respect to probability of failure; second, the regulatory control that banks in each category must adhere to; and finally, remedial treatments that will make the overall system stronger. Each of these classes of decision is interesting and very important in the regulator's program. Remedial treatments would include the items such as a system of risk-based deposit insurance premia. It has been noted previously that remedial or preventive regulation can be important in ensuring the soundness of the banking industry. Likewise, the various control measures that banks in each category will be subject to are a very important part of the regulator's task. However, this thesis will not address these two classes of decision in any great detail. Rather, this study concerns the categorization of banks with respect to risk and an optimal regulatory choice based on relative costs.

It is apparent that there are at least two types of costs that society may incur as a result of bank regulation. The regulatory cost involves the potential inefficiencies associated with restricted flexibility and compliance with regulatory requirements. The other involves the costs

associated with closing down a failed bank. The relaxation of existing regulation, while maintaining insurance on deposits, apparently led to increased risk taking on the part of some banks as well as the associated increase in FDIC losses. In other words, deregulation has presumably reduced one cost (regulation cost), but has increased the other cost (failure cost). One of the regulator's challenges, then, is to choose a regulatory program that minimizes these two costs, or that minimizes the costs which will be borne both by the banking industry and tax-payers. Regulators will be forced to determine which of these costs should become the focus of future policy actions.

A number of assumptions are incorporated in this study. The objective of the regulator as stated above, is to minimize the sum of regulation and failure costs. Some costs can be explicitly accounted for while others cannot. Regulatory costs are assumed to increase with the level of regulatory control, or the degree of stringency of oversight, taken by the regulator. If a regulator mistakenly takes harsh action against a truly healthy bank, such "misclassification" error is assumed to be more costly than if the bank were correctly classified as being on a failure trajectory. Alternatively, if a regulator fails to take action against a bank on a trajectory toward failure, society incurs costs borne by depositors, borrowers, taxpayers, etc. A theory of bank regulation is developed in which the

regulator selects regulatory policies based on relative costs. The relative costs in this study are not the total dollar value. Costs considered will depend on the regulator's perspective, it may be only the cost to depositors and tax-payers that are included, and not the social cost. To accomplish this, the regulator will take differing actions depending upon the perceived riskiness of the bank.

A multinomial ordered logit model will be used to predict the probability of bank failure over an multi-period horizon. The estimated probabilities will then be used to categorize the riskiness of the bank. Using cross-sectional, time series data, a bank classification experiment is conducted by contrasting predicted bank failures to actual bank failures. Using various relative classification/misclassification costs, least cost classification boundaries are identified. Such information should be useful as the regulator attempts to balance the costs of increased versus decreased regulatory oversight.

The Theoretical Model

A model of cost minimization is built upon the following expression for regulatory cost:

$$C(\rho; \nu, X) = \sum_i \sum_j N_{ij}(\rho, X) * C_{ij}(\nu, X) \quad (3.1)$$

where C = total cost,

ρ = an $I \times 1$ vector of probability boundary levels,

ν = the regulator's regulatory instrument choice,

X = the explanatory variables of risk prediction,

i = the period that the regulator predicts a bank to fail,

j = the period that banks actually fails, and

$N_{ij}(\rho, X)$ = number of banks predicted to fail in period i that actually fail in period j .

There are N banks in the regulator's jurisdiction that are subject to regulatory oversight. Bank k ($k=1, 2, \dots, N$) consists of depositors, management, staff, and stock-holders. The assumed goal of the bank management and stock holders is to maximize profit. The set of all banks is denoted $B=\{1, 2, \dots, N\}$.

The regulator's planning horizon is divided into I periods. A bank may fail in one of these periods or survive past the planning horizon. The actual failure period is unknown by the regulator.

The primary goal of the regulator is to minimize total cost by picking ρ and ν so as to achieve this goal. A choice of ν amounts to selection of a regulatory regime that might include a battery of instruments ρ , which given the failure prediction model developed below, amounts to a choice of a

failure classification scheme. Although the possible regulatory decisions are likely to be important in the cost minimization problem, this choice is not the object of this thesis. However, given the importance of the instruments, a brief discussion of possible instruments is in order.

One of the regulatory instrument choices is the level of capital requirement. A high capital to asset ratio indicates a greater buffer against loan losses and adverse earnings. Presently, a risk-based capital requirement policy is being utilized in hope of controlling some of the risk-taking within institutions.

Another instrument that the regulator can use is auditing activity. That is resources devoted to financial examination may be directed in a variety of ways. Information obtained through auditing is useful in predicting failures for insured institutions and classifying riskiness of banks. At the same time, it allows the regulator to further allocate the limited time and resources of examination to the most risky banks.

Risk-adjusted insurance premiums are one of the plausible instrument choices that could control the risk-taking of troubled institutions in the long-run. Banks will be classified into different risk categories, with high risk banks paying high premia, low risk banks paying low premia, and so on. In the long-run, banks would have to consider the trade-offs of potential profits and costs of excessive risk-

taking.

Timely closure of banks is an important instrument choice for the regulator. Because of the existence of plunging activities within troubled institutions, any delay in disciplinary action is costly. This happened in the Savings and Loan industry during the 1980s when savings and loan institutions were given time to try to overcome their problems and many undertook very high risk activities in an effort to regain their profitability. When failure occurred, it was significantly more costly than if closure had been executed earlier.

In this study, although ν is talked about briefly, it is not a central feature of the model. An extended study of potential regulatory actions would permit a more accurate assessment of the net costs and benefits of the various regulatory options. This study has utilized a set of relative costs which could be significantly modified by the regulators depending upon their policy biases.

There are costs related to any kind of regulatory action. Let $C_{ij} \geq 0$ denote the cost of classifying a bank to fail in period i when it actually failed in period j . If $i \neq j$, C_{ij} , where C_{ij} is the total cost of incorrect regulatory response, based on the predicted failure and actual failure, plus the cost of failure. C_{ii} is the cost to society of a bank failing when it was correctly predicted to do so. Clearly, this value is not likely to be zero. With a two

period planning horizon, the following cost table can be constructed.

Table 2. C_{ij} -Corresponding Cost

		Actual Year of Failure or Survival		
		1	2	3
Predicted	1	C_{11}	C_{12}	C_{13}
Year of Failure or Survival	2	C_{21}	C_{22}	C_{23}
	3	C_{31}	C_{32}	C_{33}

When i equals j , misclassification costs are zero, although the remaining failure costs will likely be positive. C_{11} is the cost arising when a bank that is classified as a failure for the first period actually fails in the first period. C_{22} , likewise, is the regulation cost of correctly classifying a bank as a failure in the second period, when it actually fails in the second period. If i does not equal j , there will be additional misclassification costs. For instance, if a bank is predicted to fail next year, but actually it fails this year, that has the related cost of C_{21} . $C_{21} > C_{22}$, since C_{21} has some additional costs, such as the misclassification cost. As the estimation of $C_{ij}(\nu, X)$ is not the objective of this study, the effects of various relative costs will be examined. The costs are normalized so that all costs are at least zero and do not exceed one. In addition, it is assumed that the largest costs are incurred when a bank

is predicted to survive through the two periods and fail in the initial period. That is, it is assumed that $C_{31}=1$. Likewise the least costs are associated with banks that are predicted to survive past the two periods and actually survive past the two periods such that $C_{33}=0$.

The periodic probability of failure for each bank is estimated using a multinomial ordered logit model. Using data from I past periods (the regulator's planning horizon), the probabilities of failure in future periods $1, 2, \dots, I$ are predicted. The bank's predicted probability of failure in period i ($p_{k,i}$) is a function of the bank's current financial and structural characteristics (X_k). The estimated probability $p_{k,i}$ is the probability that bank k fails in period i for $i=1, 2, \dots, I$. The final estimated probability $p_{k,I+1}$ is the probability of nonfailure within the planning horizon and equals

$$1 - \sum_{i=1}^I p_{k,i} \quad (3.2)$$

With predicted probabilities in each category, banks can be classified according to an $I \times 1$ vector of classification boundary levels (ρ). If a lower probability boundary level ρ_i is chosen, more banks will be predicted to fail in period i . With a higher ρ_i level, fewer banks will be predicted to fail in period i . The extreme cases are that all banks are classified as failures if the boundary level ρ_1 is set to zero and all banks are classified as nonfailures if the

boundary levels ρ_1 through ρ_I are set equal to one.

One of the regulator's tasks is to select the appropriate $I \times 1$ vector ρ which minimizes the appropriate costs. A bank k is predicted to fail in period 1 if its predicted probability $p_{k,1}$ exceeds some level ρ_1 . If bank k is not predicted to fail in period 1 but its predicted probability of failure within period 2 exceeds ρ_2 , then it is predicted to fail in period 2, etc. If a bank is not predicted to fail in the first I periods, it will be predicted to survive at least I periods. More formally ρ is an $I \times 1$ vector with $\rho_i \in [0,1]$ and :

If $p_{k,1} \geq \rho_1$, then bank k is predicted to fail in period 1.

If $p_{k,1} < \rho_1$ and $p_{k,2} \geq \rho_2$, then bank k is predicted to fail in period 2.

If $p_{k,2} < \rho_2$ and $p_{k,3} \geq \rho_3$, then bank k is predicted to fail in period 3.

If $p_{k,I} < \rho_I$ then bank k is predicted to survive at least I periods.

Using the above classification scheme, the set of N banks B can be partitioned into I subsets PF_i where $PF_i \equiv \{k \in B \mid p_{k,i} \geq \rho_i \text{ and } p_{k,j} < \rho_j \text{ for all } j < i\}$. The partition of B is complete with

$$\bigcup_{i=1}^I PF_i = B \quad (3.3)$$

and $PF_i \cap PF_j = \emptyset$ for all $i \neq j$. The set PF_i thus contains all the banks predicted to fail in period i . The total number of banks predicted to fail in period i , N_i , can be described as $N_i = \#(PF_i)$.

If banks are classified using the above procedure, it is likely that some misclassification will occur. If the actual year of failure of banks were known, the set of banks B could be partitioned as $F_j = \{k \in B \mid \text{Bank } k \text{ actually fails in period } j\}$. The set F_1 contains all banks that would have survived at least I periods. Misclassification errors occur if $PF_i \cap F_j \neq \emptyset$ for $i \neq j$. Let $N_{ij} = \#\{k \in B \mid k \in PF_i \text{ and } k \in F_j\}$ or $\#\{PF_i \cap F_j\}$. That is, N_{ij} is the number of banks predicted to fail in period i that fail in period j .

Combining actual failures and nonfailures with predicted values yields an $I+1$ by $I+1$ table. For the above two failure period example, a 3 by 3 classification table can be constructed as follows:

Table 3. N_{ij} -Classification

		Actual Year of Failure or Survival		
		1	2	3
Predicted Year of Failure or Survival	1	N_{11}	N_{12}	N_{13}
	2	N_{21}	N_{22}	N_{23}
	3	N_{31}	N_{32}	N_{33}

N_{11} denotes the number of banks predicted to fail in the

first period that actually failed in the first period and N_{32} is the number of banks predicted to survive through the first two periods which actually failed in the second period.

The bank regulator can very likely affect the cost C_{ij} by modifying regulatory policies which we denote as ν . However for this paper, we assume that the regulator's regulatory instrument choice ν and the relative costs are fixed. With these assumptions, the overall cost will be minimized when the regulator chooses the optimal probability boundary level vector ρ .

Econometric Model

In order to minimize the overall cost, an econometric model predicting the probability of failure is needed. In predicting the probability of bank failure, it is important that the probabilities lie in the range 0-1. Several known functional forms have this property. The logit model is one alternative. To facilitate an understanding of the multinomial logit model used in this study, a discussion of the more well known binomial logit model will be helpful.

With the binomial logit model, the dependent variable takes two values:

$$y_k = \begin{cases} 1 & \text{if a bank fails, with probability } P_k \\ 0 & \text{otherwise, with probability } 1-P_k \end{cases}$$

which implies $E(y_k | X_k) = 1*(P_k) + 0*(1-P_k) = P_k$

The probability of failure is expressed as a function of explanatory variables such that $P_k = F(X_k)$, where $F(X_k)$ is equal to the cumulative standard logistic function:

$$P_k = F(X_k) = \int_{-\infty}^{X_k \beta} f(z) dz = \frac{1}{[1 + \exp(-X_k \beta)]} \quad (3.4)$$

The expression $f(z)$ is the standard logistic density function as

$$f(z) = \frac{\exp(-z)}{[1 + \exp(-z)]^2} \quad (3.5)$$

The logit analysis generates a set of probability estimates such that failed banks are attributed high expected probabilities of failure and nonfailed banks are attributed low probabilities. A good estimate of the β coefficients should approach this objective. To estimate the coefficients, a maximum-likelihood estimation technique is used. The binomial logit model has been used by previous researchers in estimating the probability that a bank fails in a given period (as opposed to surviving past the period). In these studies, banks were treated as nonfailures prior to the time they fail. This leads to a serious problem in that even if a bank is in a very poor financial condition and on a trajectory toward failure, it is counted as a nonfailure until the actual period of failure (Maddala 1986). This type of "all or nothing" classification does not separate banks that are experiencing significant difficulties from those that are prosperous. To address this criticism, a multinomial ordered logit function can be used which divides

banks into more than two categories.

The multinomial ordered logit model can be expressed by:

$$Y = F(\alpha_i + X'\beta) \quad \text{where } i=0, 1, 2, \dots, I$$

where $Y = 0$ if a bank fails within one year

1 if a bank fails within the second year

2 if a bank fails within the third year

.

.

$I-1$ if a bank fails within the I th year

I if a bank survives at least to period I

The expression $\alpha_i + X'\beta$ is a linear combination of the independent variables with α_i and the β s estimated from the data. The α s are the intercepts which are different for each category. The probability of failure is a function of observed independent variables.

The multinomial ordered logistic model differs from a simple logit model in two aspects: first, the response variable can take more than two values instead of just 0 and 1. Second, the response variable is an ordered value where the logistic estimation procedure fits a parallel line regression model that is based on the cumulatively distributed probabilities of the response categories. The model has the following form:

$$\Pr(Y_i \leq i) = \frac{1}{[1 + \exp(-\alpha_i - X'B)]} \quad (3.6)$$

The dependent variable is discrete, 0 to I as defined above. The definition of bank failure usually is the occurrence of negative present value of net worth. That is, the present value of total assets minus the present value of total liabilities is negative. However in this case, market value data were not available. Thus for this study, a bank is defined to fail if the bank ceased business in a particular year, even if the cessation of business resulted from merger. The independent variables of the regression analysis consisted of financial and structural variables.

In the selection of financial variables for a failure prediction model, major factors that are indicative of potentially serious risks in commercial banks are considered: capital adequacy, asset quality, interest risk and earnings profitability. A list of variables is provided in Table 4.

Bank capital ratios indicate the degree of capital which banks are required to maintain to protect against risk of loss in their security or loan portfolios. The FDIC has established an equity capital to asset ratio goal of 7.0 percent for commercial banks. The erosion of capital can easily lead to bank insolvency. Negative signs on the estimated coefficients are expected, that is an increase in capital will decrease the probability of failure because high capital ratios make a bank less vulnerable to adverse earnings and loan losses.

Table 4. Independent Variables

Variable	Definition
X1	Primary capital / total assets
X2	Total capital / total assets
X3	The natural log of total assets
X4	Total loans and lease / total assets
X5	Commercial & industrial loans / total loans
X6	Nonaccruing loans / total assets
X7	Restructured loans / total assets
X8	Loans 90 days past due / total loans
X9	Net loan charge-offs / total loans
X10	Net income / total assets
X11	Total certificate of deposits over \$100,000 / total deposits

The natural logarithm of total assets as an indicator of bank size is included to reflect the ability to raise new capital (Avery and Hanweck, 1984). A negative sign on the estimation coefficient is expected because of the following reasons. First, a bank's ability to raise new capital depends on the investors' view of the rate of return and

banks' scope of business. Larger banks are often viewed as being more diversified and having a stronger ability to raise new capital. Secondly, a large bank may be viewed as if the "too large to fail" perception is the dominant factor, i.e. the regulators are less likely to let large banks fail.

Asset quality includes commercial and industrial loans, loans 90 days past due, net loan charge-offs over total loans and total loans, nonaccruing loans, restructured loans over total assets. Total loans, commercial and industrial loans, loans 90 days past due, nonaccruing loans, and restructured loans all provide measures of riskiness in the bank's asset portfolio. These categories are riskier than other asset categories to some extent. The probability of bank failure is expected to increase with an increase in these variables. As a result, the estimated coefficients are expected to be positive. Net loan charge-offs measure the amount of loans written off as losses, net of recoveries, giving an indication of past loan quality. A positive relationship would also be expected for this ratio.

Net income over total assets, indicating earning profitability, is expected to be negatively related to bank failures. Increasing net income tends to decrease the likelihood of failure because it would provide income to cover adverse earnings periods. Total deposits of large CDs over total deposits indicates susceptibility to withdrawal of funds. Those who heavily depend on large CD's will meet

greater likelihood of failure because these accounts are a volatile source of funds and interest rate risk is higher.

The dummy variable used here relates to whether a bank is a unit bank or not. Unit banks are expected to have a higher probability of failure since unit banks draw depositors from and make loans to borrowers in a relatively small geographic area which tends to increase risks.

In summary, the probability of failure for each bank is predicted using a multinomial ordered logit model based on financial and structural characteristics of each bank as independent variables.

Regulatory Policy

With predicted probability of failure from a multinomial logit model, fixed relative costs and regulatory instrument choices, an optimal policy of minimization is reached by choosing bank classification levels (ρ) which minimize overall cost of $C(\rho; \nu, X)$ as in equation 3.1.

In the next chapter, the empirical estimation procedure and results as well as a detailed explanation of classification choice using the dynamic data will be presented.

CHAPTER 4

EMPIRICAL ESTIMATION OF THE MODEL

The objective of this chapter is to present the empirical results of an estimation model based on the econometric model presented in chapter 3. The procedure used in estimating the model is presented and the results of estimation of the multinomial logit model are examined. Finally, classification accuracy and inferences are discussed.

Estimation Model

As stated earlier, the multinomial ordered logit model is built in the form:

$$Y = F(\alpha_i + \beta'X) \quad (4.1)$$

where X is a vector of financial ratios of capital to assets, the logarithm of total assets, total loans to assets, total nonaccruing loans relative to assets, loans 90 days past due over total loans and net income over assets for the years of 1985 and 1986.

The dependent variable takes the following form:

$$Y = 0 \text{ if a bank fails within the first year}$$

= 1 if a bank fails within the second year

= 2 if a bank fails within the third year

= 3 if a bank does not fail within three years

The probability of failure in each category is a logistic function of the following type:

$$\Pr(Y_i \leq i) = \frac{1}{[1 + \exp(-\alpha_i - X_i' B)]} \text{ for } i=0,1,2,3. \quad (4.2)$$

Estimation Procedure

Data from 1209 commercial banks from Montana, Washington, Nebraska and Colorado for five years from 1985 to 1989 are used. The data were obtained from Sheshunoff, a consulting company in Texas who compiled the data from the Call and Income Report of the Federal Reserve System. The model yields the probabilities of failure for a given institution in the next three periods which is assumed to be a logistic function of the financial variables measured in the most recent year.

The model was first estimated using a simple logit model to eliminate the correlated and insignificant variables. Some violations of the basic econometric properties were inherent in the model. First, the endogenous explanatory variables such as the primary capital and total capital asset ratios were highly correlated. This is because there is very little statistical difference between the two variables. As

a result of high correlation, only the primary capital asset ratio was retained in the model. There was also negative correlation between net income and net charge-offs. This is because the net income plus the net charge-offs equal gross income. As a result, only the net income to asset ratio was included in the model. The commercial & industrial loans to total loans, restructured loans to total assets and net loan charge-offs to total loans were not included because they were not shown to be statistically significant in the original estimation. The reason might be the correlation among the loan variables. Total large CDs to total deposits and the structural variable did not prove to be significant and were also excluded from later regressions. The financial ratio of capital to assets, the natural log of total assets, total loans to assets, total nonaccruing loans relative to assets, loans 90 days past due over total loans and net income over assets remained in the model.

The presence of heteroskedasticity was checked for by a simple method of ordinary least square estimation. The residuals were plotted against each of the independent variables, and the plots visually examined. There appeared to be no heteroskedasticity problem with the data.

The data set from 1985 was used to estimate the probability of failure in 1986, 1987, 1988 and probability of survival beyond three years. The 1986 data set was used to estimate the probability of failure in 1987, 1988, 1989 and

probability of surviving past 1991. Banks which did not exist due to failure or new charter in 1985 or 1986, were deleted, so data from 1092 banks were used in the model of 1985 and 1069 banks in the model of 1986.

The multinomial ordered logistic model was used to estimate the cumulative probabilities for each response category using maximum likelihood procedures. The predicted probabilities were obtained from the predicted cumulative density functions. These probability densities were used to classify banks into three categories; predicted failure within one year; predicted failure within the next two years; and survival beyond the third year by choosing different probability boundary levels. That is, any bank with a predicted probability of failure within the first year greater than the probability level for the first year (ρ_1) is predicted as a failure in the first year. Any remaining banks with predicted probability of failure for the next two years greater than the probability level for the next two years (ρ_2) was counted as a predicted failure within the next two years. The remaining banks are then classified as survivors within the three years. As ρ_1 and ρ_2 are changed, the classification sets PF_1 , PF_2 and PF_3 will change as well. The optimal ρ_1 and ρ_2 levels will depend upon the relative costs of misclassification.

The value of the probability boundary level of one year (ρ_1) and of the following two years (ρ_2) were varied from 0.02

to 0.50 in steps of length 0.02. For each combined probability level, there is a N_{ij} table. This table shows the number of banks predicted in each category and the actual values of failure from data. The value of N_{11} , is the number of banks predicted to fail in the first year which actually failed in the first year, N_{21} is the number of banks predicted to fail in the following two years, but that actually failed in the first year, and N_{13} is the total number of banks predicted to fail in the first year, but that actually survived throughout the three year period, etc.

Estimation Results

The estimation coefficients of the multinomial logistic models of 1985 and 1986 models are presented in Table 5 and Table 6 along with their standard errors.

The different intercepts of the estimation were used to calculate the cumulative functions for different year.

Six financial ratio coefficients are significant at the 5 percent level with the expected signs. They are the CA - capital to asset ratio, TA - the natural log of total assets, TLO - total loan to asset ratio, TNL - total nonaccruing loans to asset ratio, L90 - loans 90 days past due, NI - net income to asset ratio.

Table 5. Estimation Results of 1985 Model

Variable	Parameter Estimate	Standard Error	T-Statistics
Intercept 1	2.3125	2.0422	1.1323
Intercept 2	3.2165	2.0390	1.5775
Intercept 3	3.6369	2.0395	1.7832
CA	-30.0147	6.6054	-4.5440
TA	-0.7022	0.1726	-4.0684
TLO	4.8007	1.2819	3.7450
TNL	12.9592	4.8640	2.6643
L90	12.0577	4.5334	2.6597
NI	-12.7270	5.7021	-2.2320

Table 6. Estimation Results of 1986 Model

Variable	Parameter Estimate	Standard Error	T-Statistics
Intercept 1	1.0689	1.8090	0.5909
Intercept 2	1.8067	1.8060	1.0003
Intercept 3	2.3819	1.8063	1.3187
CA	-33.9398	6.8452	-4.9582
TA	-0.4823	0.1636	-2.9480
TLO	3.8038	1.1000	3.4580
TNL	9.7822	5.4652	1.7899
L90	12.3383	3.9846	3.0965
NI	-15.0548	5.3199	2.8299

The negative signs of CA, TA and NI suggest that an increase in capital level and net income could reduce the probability of failure. This coincides with our theory that capital acts as a buffer against loan losses and adverse earnings, asset as an indicator of bank size reflecting the ability to raise new capital and high net income levels indicating increasing profitability, all these could reduce the likelihood of failure.

The positive signs of TLO, TNL, L90 suggest that an increase in total loans, total nonaccruing loans, loans 90 days past due would increase the probability of failure. These results are in line with our theory about asset quality.

The estimated coefficients were inserted into equation 3.6 with the independent variables for each institution to get the estimated cumulative probabilities of failure for each period.

Bank classification accuracy depends on the number of misclassifications, i.e., the number of N_{ij} when i does not equal to j . For simplicity, we will start with predicting just one year of failure, that is the classification matrix which is a 2 by 2 table. It is a type I error when a nonfailure was misclassified as a failure, and it is a type II error when a failure was misclassified as a nonfailure. For any model, there will generally be a trade off between type I and type II errors if a different probability boundary

level (ρ_i) is chosen. The regulator should choose the probability level which would minimize the combined cost.

Compared with a simple logit model for predicting probability of failure just one year ahead, one cannot conclude that using a multinomial ordered logit model to predict one year of failure does a better job than using a simple logit model in classifying banks. Comparisons are included in Table 7.

For the simple logit model with probability boundary level of 0.1, 20 banks were predicted to fail, 9 actually failed while 11 survived, 1057 banks were predicted to survive, 15 actually failed while 1042 actually survived. For the probability boundary level of 0.1, the multinomial logit model does no better job, but for the case of classification boundary level of 0.2, for the simple logit model, the type I error (misclassified a nonfailure as a failure) is 6 and type II error (misclassified a failure as a nonfailure) is 16, for the multinomial logit model of 1985, the type I error is 5 and type II error is 16. In the multinomial logit estimation, type I error was reduced, i.e., the number of banks misclassified as nonfailures was reduced. So the combined cost could be reduced. More importantly, the multinomial logit model can be used to predict the probability of failure a few years prior to the time it fails, thus allowing the regulator to take action sooner.

Table 7. Classification Comparison of 1985 Model

Prob. Level		Simple Logit Model		Multinomial Logit Model	
		Actual Failure	Actual Non- failure	Actual Failure	Actual Non- failure
0.1	Predicted Failure	9	11	9	19
	Predicted Non- failure	15	1042	15	1034
0.2	Predicted Failure	8	6	8	5
	Predicted Non- failure	16	1047	16	1048

Relative Costs

Assumptions about relative costs were made because actual data were not available since the two types of costs are hard to quantify. The cost of inefficiency associated with heavy regulation is very difficult to evaluate. The failure costs related with excessive risk-taking consist of costs to the stock-holders, depositors, the FDIC and the externalities. The externalities are very difficult to measure. So costs can be normalized upon the regulators' particular goal. In this study, the costs are normalized so $C_{33}=0$ and $C_{31}=1$. C_{21} is one fourth of C_{31} , C_{32} is one half of C_{31} , because it is believed that the cost of predicting a bank to survive when it actually failed in the first year (C_{31}) is the greatest, the cost of predicting it to survive when it actually failed in the second period (C_{32}) is less than C_{31} , and the cost of predicting it to fail in the second period when it failed in the first period (C_{21}) is less than C_{32} . C_{12} is one fourth of C_{13} , C_{23} is one half of C_{13} , because it is believed that the cost of predicting a bank to fail in the second period when it actually survived (C_{23}) is less than the cost of predicting it to fail in the first period when it actually survived (C_{13}) and greater than C_{12} , the cost of predicting it to fail in the first period when it failed in the second period (C_{12}). C_{13} is less than C_{31} , ratios of C_{13}/C_{31}

as 0.1, 0.2, 0.4, 0.6, 0.8, 1.0 were used to test the results. Different ratio of C_{13}/C_{31} depends on the regulator's assumption of the relative cost of inefficiency due to regulation and failure cost. C_{11} is one half of C_{12} , C_{22} is one half of C_{11} . The relative cost could be changed according to the particular goals that the regulator seeks to achieve. If the regulator's goal is to achieve safety, he/she will not care about the efficiency occurring to banks, thus perceived relative cost of C_{13}/C_{31} by the regulator will be large. If the regulator's goal is to seek efficiency, he/she will not care about the externalities associated with failure cost, the perceived relative cost of C_{13}/C_{31} will be small. Usually, the regulator will consider the trade-off of efficiency versus safety. Since the actual relative costs are unknown, the effects of varying the relative costs upon the optimal ρ values were examined. Table 8 presents the various cost ratios examined.

Each row represents one set of relative costs, the first cell of which is the relative cost of C_{13} over C_{31} . C_{13} is a percentage of C_{31} , which is the cost of predicting a bank to survive the entire 3 periods that actually fails in period 1. C_{31} is felt to be the highest cost since no action of any type would be undertaken. C_{13} is solved for and all subsequent costs are determined as a percentage of C_{31} and C_{13} . This provides the table of relative costs.

Table 8. Relative Cost

$C_{13}/$ C_{31}	C_{12}	C_{13}	C_{23}	C_{21}	C_{31}	C_{11}	C_{22}	C_{33}	C_{32}
0.1	0.025	0.1	0.05	0.25	1	0.0125	0.006	0	0.5
0.2	0.050	0.2	0.10	0.25	1	0.0250	0.013	0	0.5
0.4	0.100	0.4	0.20	0.25	1	0.0500	0.025	0	0.5
0.6	0.150	0.6	0.30	0.25	1	0.0750	0.038	0	0.5
0.8	0.200	0.8	0.40	0.25	1	0.1000	0.050	0	0.5
1.0	0.250	1.0	0.50	0.25	1	0.1250	0.063	0	0.5

Total cost is the sum of the number of classifications in each cell times the corresponding cost in each cell for different probability boundary levels, that is

$$TC = \sum_{i,j=1}^I N_{ij} * C_{ij} \quad (4.3)$$

Optimal Regulatory Choice

For each of the six different relative costs, a 25 by 25 total cost matrix was derived, each matrix indicating a different set of relative costs. In a matrix, the value in each cell indicates the total cost associated with particular probability boundaries ρ_1 and ρ_2 . Three dimensional plots

with ρ_1, ρ_2 - the probability boundaries for the first year and the next two years and the total cost combination TC concerned with each combination of two boundary levels are provided in Figure 1 through Figure 6. In the figures, the horizontal plane is the classification boundary level, the vertical axis is the total cost, and the minimum of the total cost is the lowest point of the vertical axis which could be identified. In this way, the minimum of total cost for each relative cost could be identified with corresponding ρ_i which are the regulator's optimal classification choice. For example, in Figure 2, the minimum cost is 36.42 with $\rho_1=0.42$ and $\rho_2=0.20$.

With the increase of relative cost of C_{13}/C_{31} , the optimal ρ 's have also increased, together with minimum cost. With relatively high ratios of C_{13}/C_{31} , the minimum cost is not sensitive to small changes in C_{ij} values.

The surfaces of the plotting have several trenches and peaks. This is different than the usual cost function in production theory, which is convex and smooth. The difference might be due to the trade-offs among types of errors when different ρ s are chosen and discontinuity of the ρ s. For the case of Figure 2, holding ρ_2 fixed at 0.40, and letting ρ_1 be value of 0.18, 0.20, 0.22 respectively, the cost decreases and then increases. Table 9-11 of N_{ij} s presents the classifications varying ρ s and will be useful in explaining the trench.

Table 9. N_{ij} -Number of Banks Predicted to fail in Year i that Actually failed in Year j with $\rho_1=.40$ and $\rho_2=.18$

		Actual Year of Failure or Survival		
		1	2	3
Predicted Year of Failure or Survival	1	6	3	1
	2	10	7	27
	3	9	33	973
		Total Cost:31.291		

Table 10. N_{ij} -Number of Banks Predicted to fail in Year i that Actually failed in Year j with $\rho_1=.40$ and $\rho_2=.20$

		Actual Year of Failure or Survival		
		1	2	3
Predicted Year of Failure or Survival	1	6	3	1
	2	10	6	21
	3	9	34	979
		Total Cost:31.178		

Table 11. N_{ij} -Number of Banks Predicted to fail in Year i that actually failed in Year j with $\rho_1=.40$ and $\rho_2=.22$

		Actual Year of Failure or Survival		
		1	2	3
Predicted Year of Failure or Survival	1	6	3	1
	2	7	4	16
	3	12	36	984
		Total Cost:33.902		

From the tables, it can be seen that changing ρ_2 from .18 to .20 has shifted 6 banks from N_{23} to N_{33} (973 to 979) and one bank from N_{22} to N_{32} (7 to 6). This resulted in a cost reduction because more banks are classified correctly and the one misclassification did not override the reduced cost of correct classification. Changing ρ_2 from .20 to .22 shifts 5 banks from N_{23} to N_{33} (979 to 984), 2 more banks from N_{22} to N_{32} (34 to 36) and 5 more banks from N_{21} to N_{31} (9 to 12). Because N_{31} is a more costly mistake, a cost increase occurred as could be seen clearly from the plotting of Figure 2.

One objective of this study is to give the regulator a risk classification scheme which can be utilized in conjunction with different cost information in determining an optimal regulatory position.

In order to examine the potential effectiveness of the risk classifications to the regulator, a set of relative costs was derived to examine overall cost changes.

In Figure 1, with the relative cost of C_{13}/C_{31} equal to 0.1, there is clearly a best choice in this case. For the given parameter values, such as C_{ij} , overall cost is minimized when the regulator chooses $\rho_1=0.10$; $\rho_2=0.06$.

Any other choice, given this set of parameters, leads to higher costs. If ρ_1 is made larger, more banks that are going to fail in the first period will be classified as surviving at least the first period. If ρ_1 is made small

(approximate 0), then costs go up as all banks are called probable failures. If ρ_2 is made larger, more banks that are going to fail in the second period will be classified as sound. If ρ_2 is made smaller, then costs go up as greater numbers of banks are called probable failures in the second period.

If the relative cost parameters are different, then the figure changes, and the optimal ρ_1 and ρ_2 will be different. But the strategy of choosing the least cost combination of regulatory control is the same. For the case of Figure 2, with the relative cost of C_{13}/C_{31} , the optimal choice of $\rho_1=0.14$ and $\rho_2=0.10$.

Actual implementation of this model would be much more complicated. The regulator would be expected to assess C_{ij} for each bank in an accurate manner. As has been noted, such an elaborate accounting exercise is beyond the scope of this thesis.

Nevertheless, picking "which banks are which" is crucial to regulation of banking industry. The techniques and insight developed here-- both theoretical and empirical, will be helpful to those charged with the regulation of the financial system.

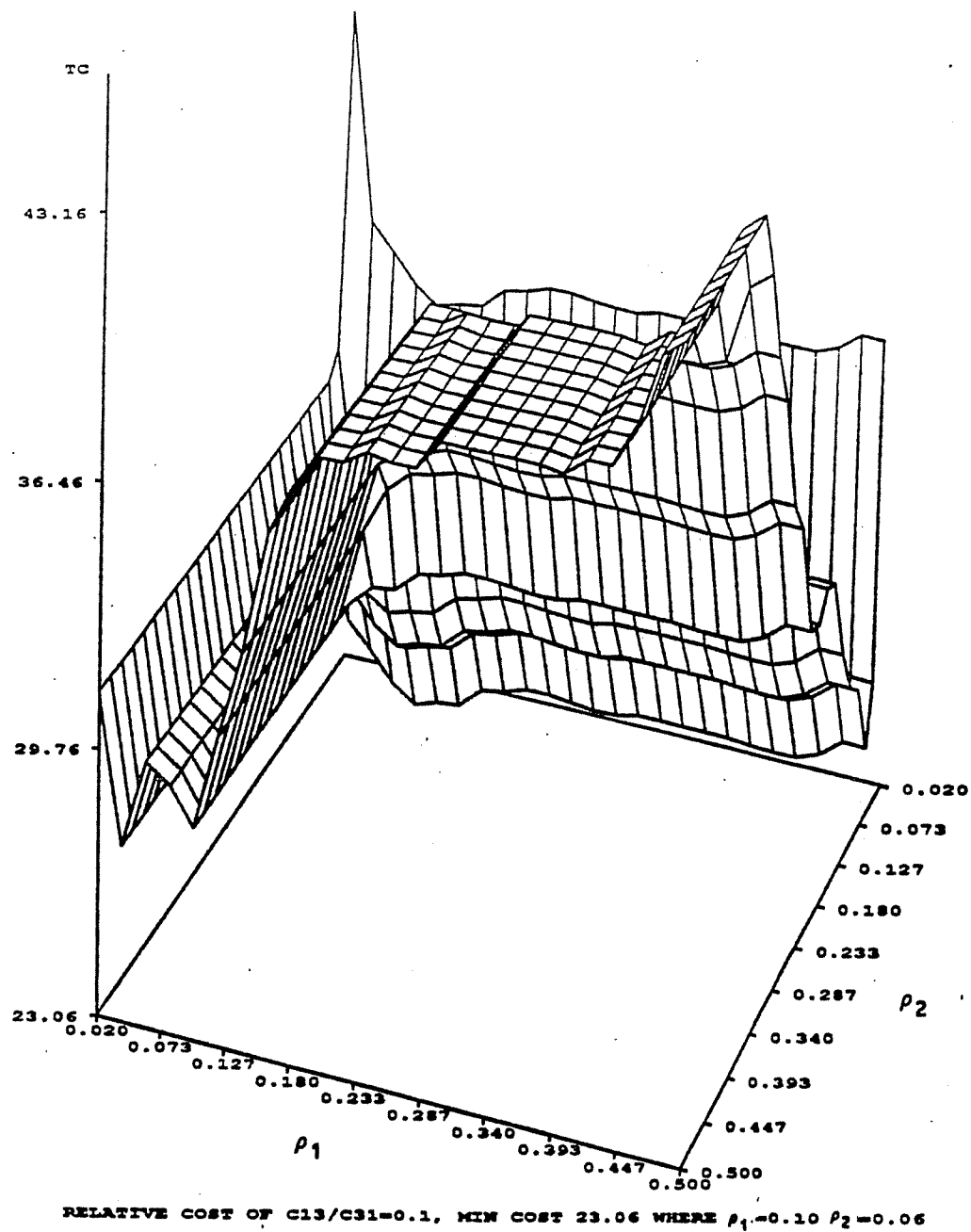


Figure 1. A Three Dimension Plotting of Total Cost with Different Classification Levels in the 1986 Model. (Relative cost of $C_{13}/C_{31}=0.1$)

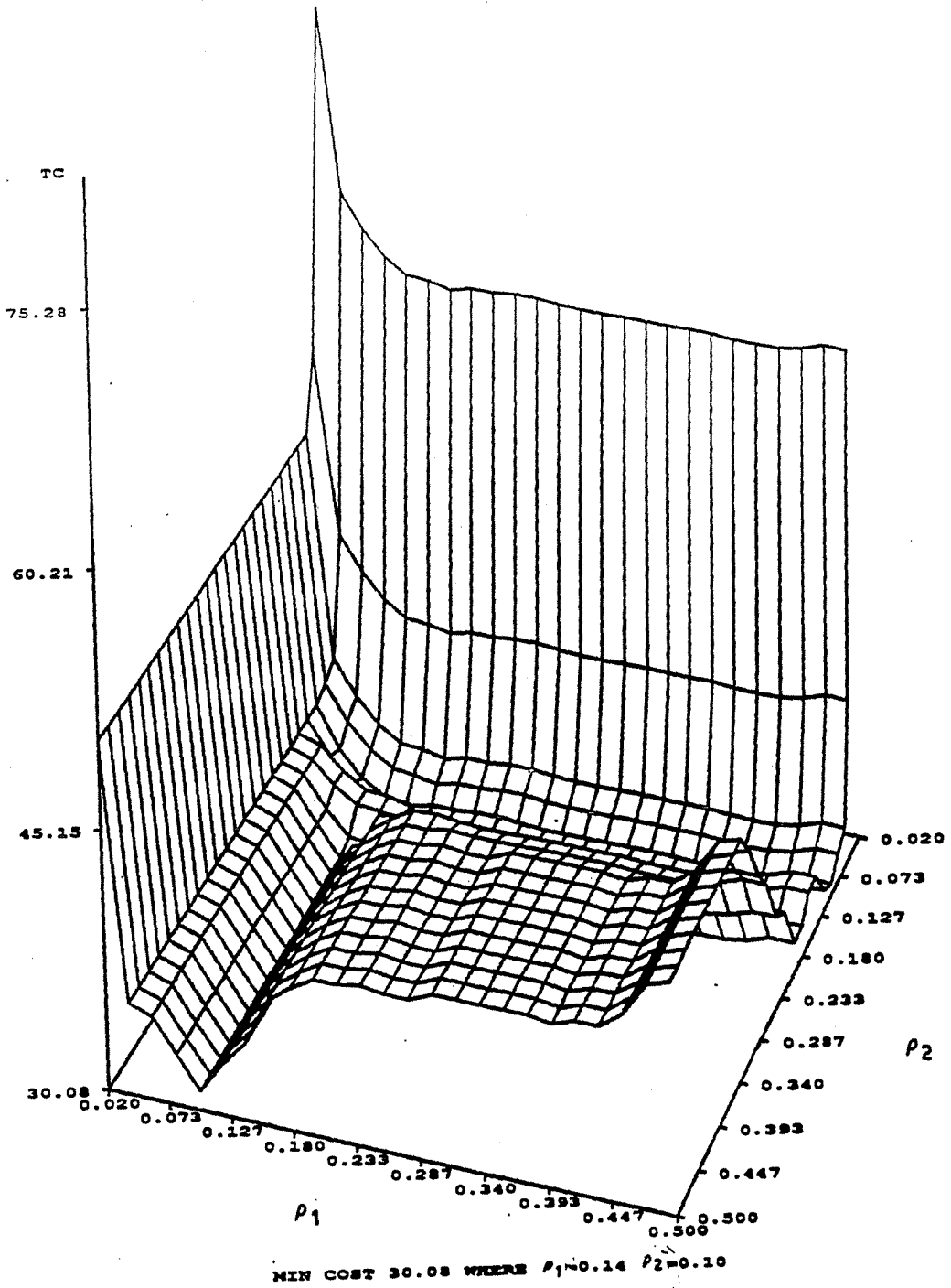


Figure 2. A Three Dimension Plotting of Total Cost with Different Classification Levels in the 1986 Model. (Relative cost of $C_{13}/C_{31}=0.2$)

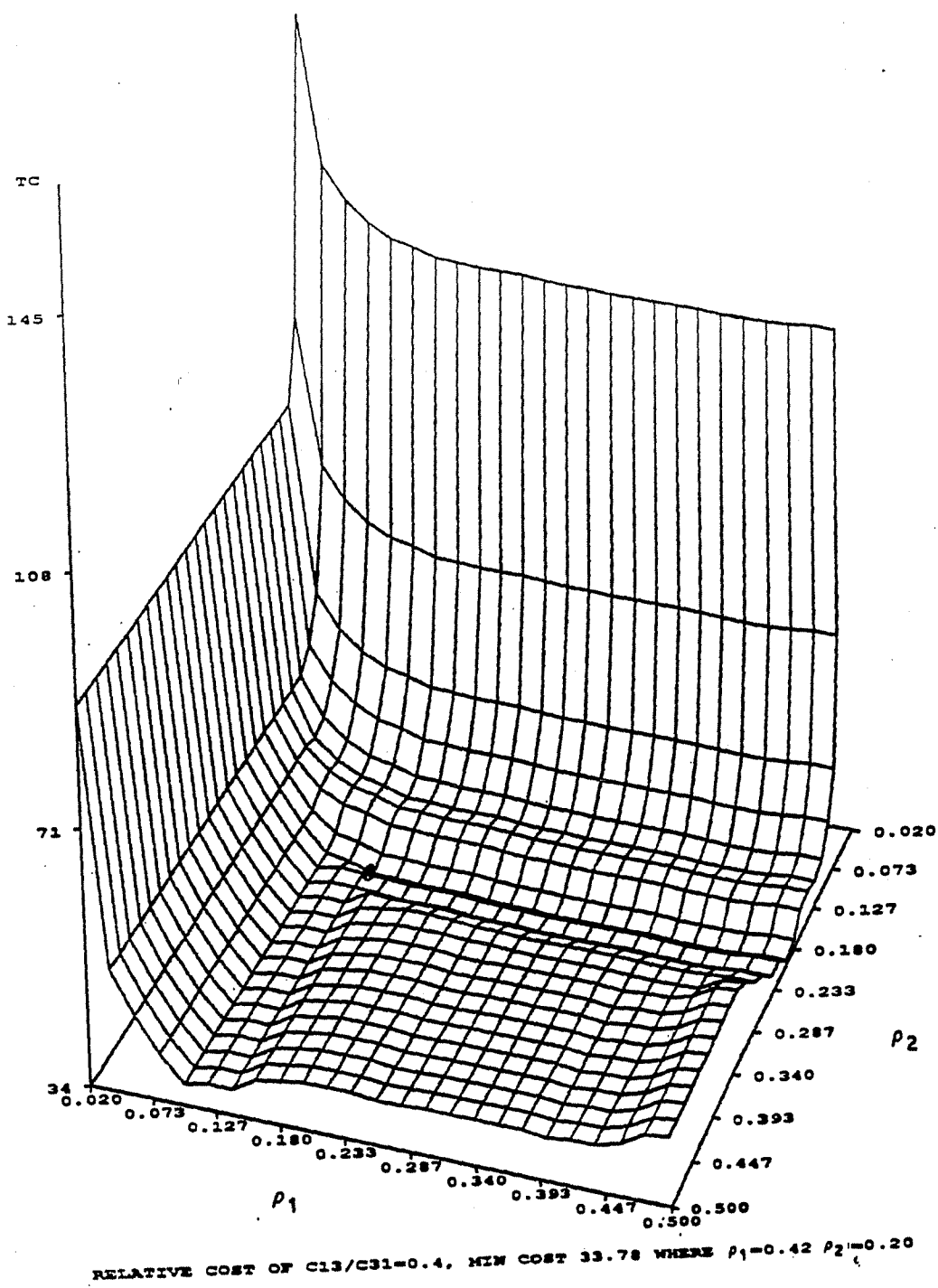


Figure 3. A Three Dimension Plotting of Total Cost with Different Classification Levels in the 1986 Model. (Relative cost of $C_{13}/C_{31}=0.4$)

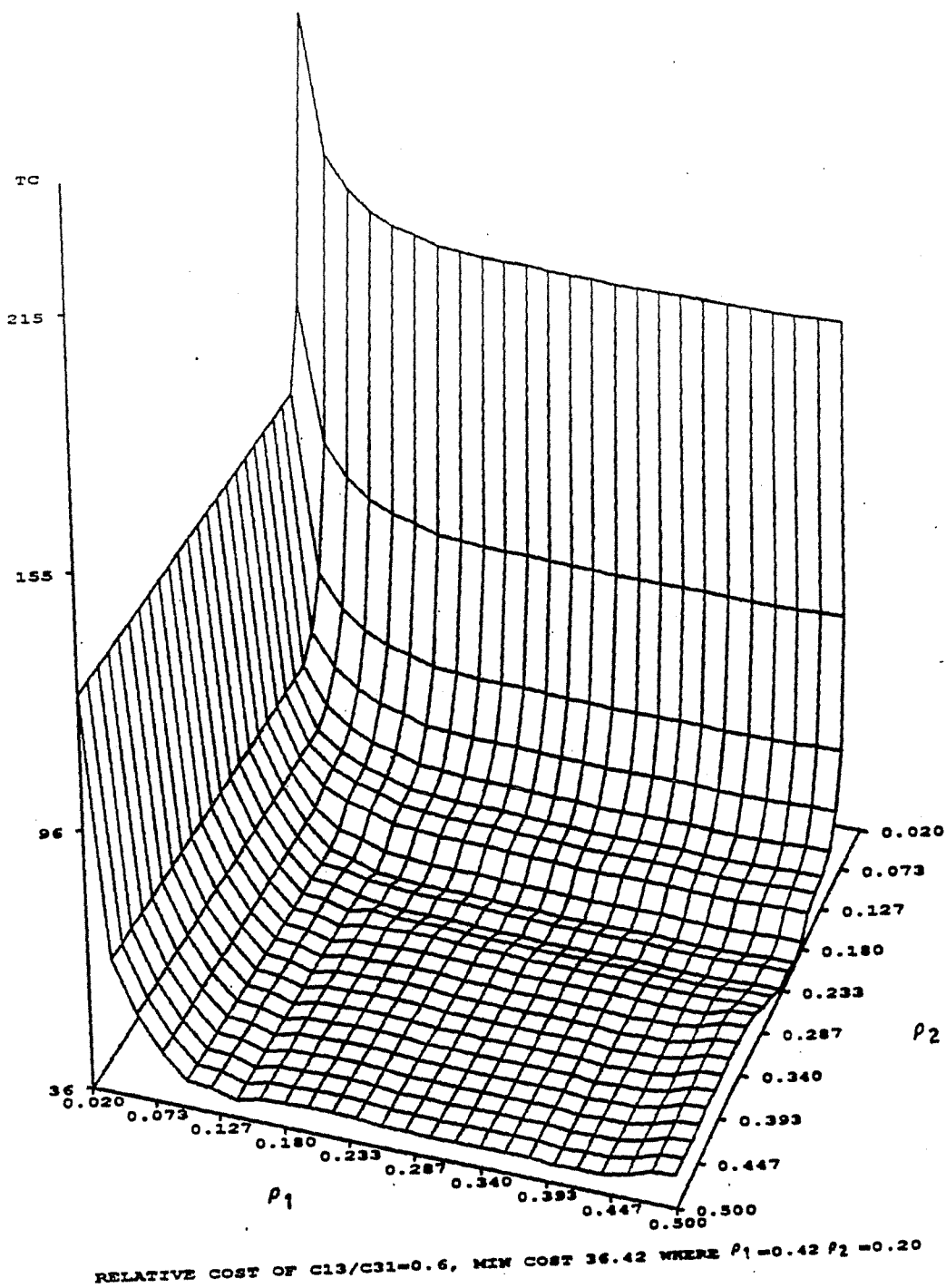


Figure 4. A Three Dimension Plotting of Total Cost with Different Classification Levels in the 1986 Model. (Relative cost of $C_{13}/C_{31}=0.6$)

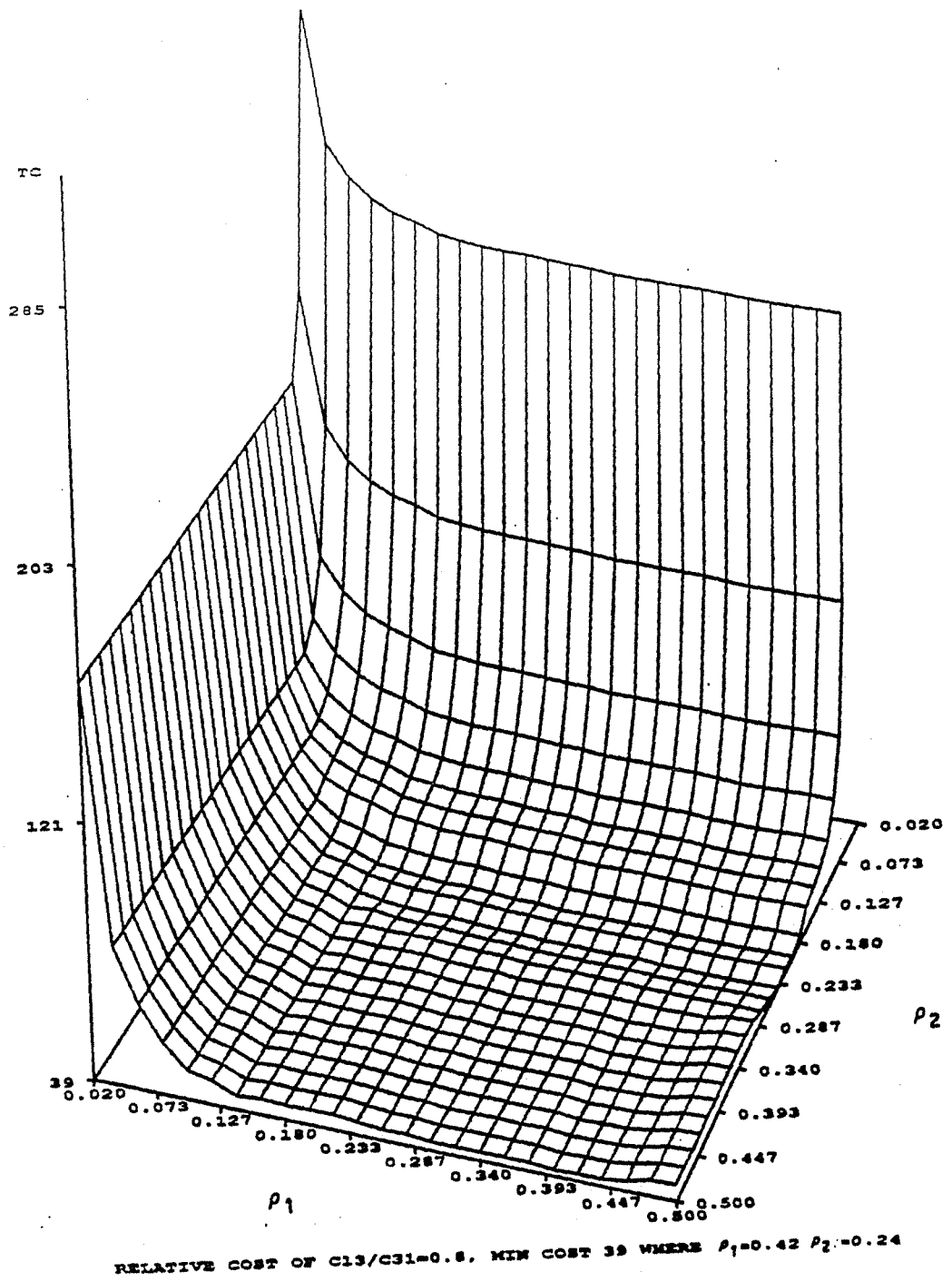


Figure 5. A Three Dimension Plotting of Total Cost with Different Classification Levels in the 1986 Model. (Relative cost of $C_{13}/C_{31}=0.8$)

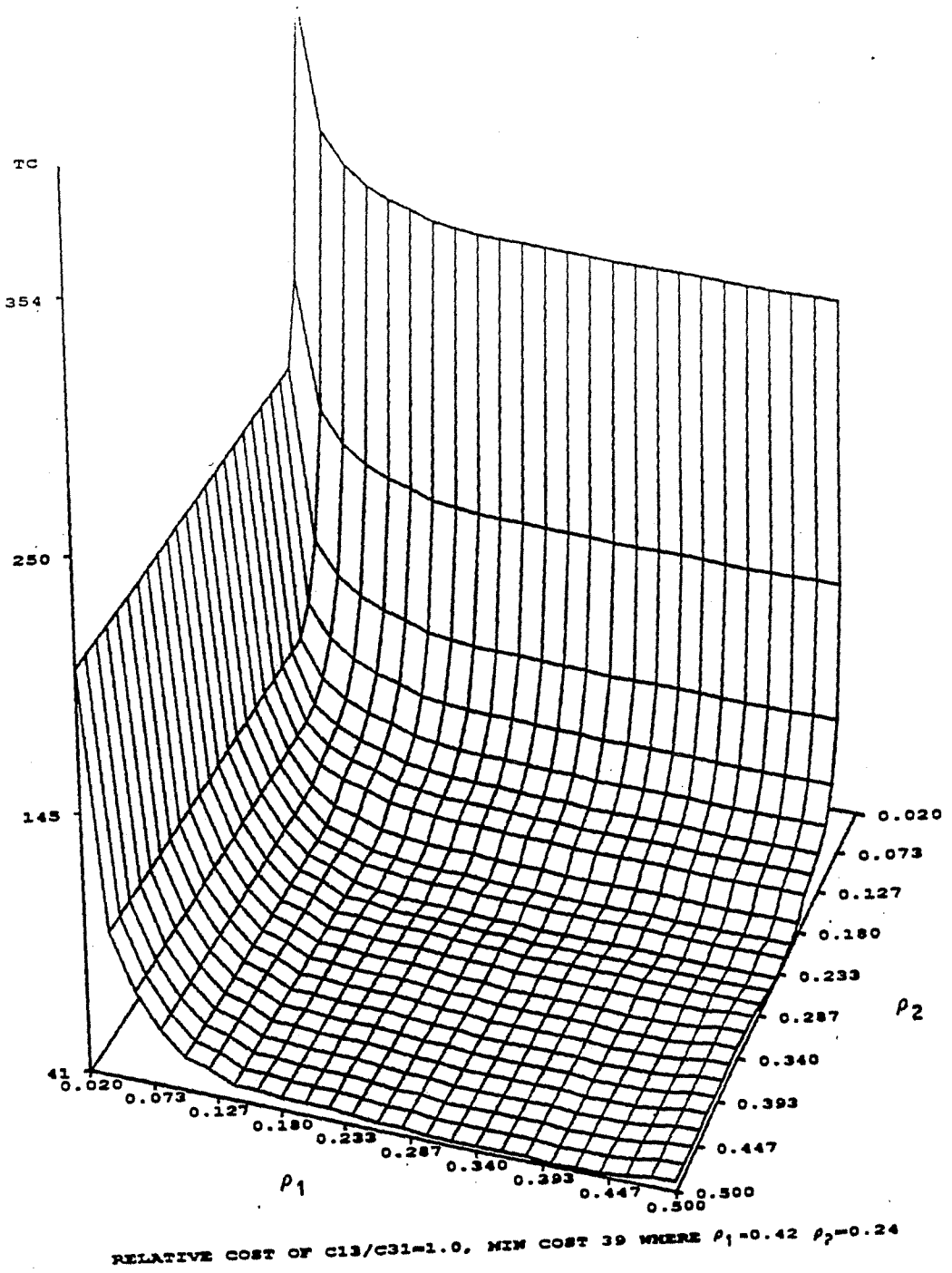


Figure 6. A Three Dimension Plotting of Total Cost with Different Classification Levels in the 1986 Model. (Relative cost of $C_{13}/C_{31}=1.0$)

CHAPTER 5

SUMMARY AND CONCLUSION

The main objectives of this study were to predict the probabilities of bank failures and to classify banks according to their riskiness and to propose optimal classification choice levels for regulators so as to reduce overall costs.

The Federal Deposit Insurance System was originally created during the Great Depression of the 1930s to help assure the stability of financial system and protect small depositors in the event of bank failure. The system had operated fairly smoothly until the 1980s when a number of banks began to fail. The number of failures has increased to about 200 a year recently. It is apparent that society faces at least two types of costs as regulatory policy is changed. One involves the potential inefficiencies associated with restricted flexibility and compliance with regulatory requirements. In contrast, the relaxation of regulation, in conjunction with a continuation of deposit insurance, apparently leads to increased risk taking on the part of some banks as well as the associated increase in FDIC losses. The regulator's challenge is to minimize the cost which will be

borne by the banking industry and by tax-payers.

Various proposals to reform the Federal Deposit Insurance System exist but most do not seem likely to solve the problem. There are two groups of thought on reform of the financial system. One seeks to increase government regulation while the other prefers to rely more on market discipline. The biggest challenge to regulators is to be able to effectively evaluate risk so as to propose an optimal regulatory policy.

There have been a number of econometric models suggested to predict the probability of failure for financial institutions. The most widely used ones are probit and logit models. Most studies used data from a single year or averaged data over a few years. Some studies used dynamic models which included lagged explanatory variables. The greatest deficiency of these types of models is that banks were treated as nonfailures prior to the time they fail regardless of their condition at the current time.

This study developed a theory of regulation by choosing optimal bank classification levels assuming fixed regulatory instrument choices and relative costs. A multinomial ordered logit model which utilizes several years of data to estimate the probability of failure for financial institutions in a multi-period framework was used. The estimated probabilities could be used to classify banks by optimizing the probability boundary levels in order to minimize the overall cost. The

major advantages of this type of model are: the model incorporates the dynamic nature of data; each bank is only included once in the data set which avoids the problems of repetition that increased the weight of nonfailures. The multinomial ordered logit model categorizes banks into several states which corrects for the problem of banks being treated as nonfailures prior to the time they fail.

The model estimation used a maximum likelihood logistic procedure. One model used data of 1985 to predict the probability of failure during 1986, during 1987, and surviving throughout these periods. The other model used data of 1986 to predict the probability of failure during 1987, during 1988, and surviving throughout these periods. Cumulative probabilities obtained from the estimation were converted into probability densities. These probability densities were used to classify banks into three different categories: those predicted to fail within one year; those predicted to fail within the following year; and those predicted to survive throughout these periods. These predictions were compared to actual data to determine the usefulness of the model. A relative cost table was obtained through multiplying the classification table times the relative cost.

The major empirical results of this study are as follows. First, an increase in the capital asset ratio, the natural log of total assets and net income to assets ratio

significantly reduced the probability of failure. Secondly, an increase in the ratio of total loans to assets, nonaccruing loans to assets and loans 90 days past due to total loans have significant and positive effects on the probability of failure, that is an increase in the value of these variables will increase the probability of failure.

For some classification levels, a multinomial ordered logit model does a better job in predicting probability of failure one period ahead than the simple logit model, so total cost could be reduced. Another benefit of the multinomial logit model is that it could be used to predict the probability of failure a few periods prior to failure.

The results of this study could be used by regulators to choose optimal classification levels in order to minimize the overall costs depending upon relative costs of actions and regulatory instrument choices. Quicker intervention by regulators could reduce bank failures and lessen the cost to society of these problems. Regulators would have the flexibility to examine the level of total costs associated with a variety of different policies and then be able to choose the optimal policy combination that would satisfy their goals.

Further research could be realized through utilizing the most recent data with the dynamic risk model and estimating the cost of bank failures and examining the actual cost of misclassification. Additionally, conflict of interest and

lobbying forces among different interest groups could also be extended.

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