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The effect of relaxation of interstate banking restrictions on the probability of bank failures and the expected value of FDIC liabilities

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**THE EFFECT OF RELAXATION OF INTERSTATE BANKING RESTRICTIONS
ON THE PROBABILITY OF BANK FAILURES AND THE EXPECTED VALUE
OF FDIC LIABILITIES**

Iowa State University

PH.D. 1985

**University
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International** 300 N. Zeeb Road, Ann Arbor, MI 48106

**The effect of relaxation of interstate banking restrictions
on the probability of bank failures
and the expected value of FDIC liabilities**

by

Donald John Bisenius

**A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
DOCTOR OF PHILOSOPHY**

Major: Economics

Approved:

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In Charge of Major Work

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**Iowa State University
Ames, Iowa**

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I. INTRODUCTION

A. The Deregulation Debate

The economic and political environment of the 1970's fostered a growing desire to reduce the involvement of government in the marketplace. This trend towards the removal of government interference was especially keen in the financial services industry. The collection of regulations and restrictions placed on certain participants in the industry after the turbulent 1930's was becoming a competitive obstacle for those firms subject to them.

One aspect of the financial services deregulation debate focuses on the appropriateness of relaxing interstate banking restrictions. Numerous researchers, including Benston, Godfrey, Gorinson, Horvitz, and Sinkey, have addressed issues related to geographic deregulation (2,16,17,19,40). One issue discussed concerns the relevant scope of deregulation - regional relaxation or full interstate banking (36). Another point of contention is the effect such deregulation would have on the structure, conduct, and performance of the banking industry. While these are important concerns, there is an additional factor which to date has not been adequately considered. That is, what effect will relaxation of interstate restrictions have on the safety and soundness of the banking industry? Furthermore, what implications will the altered level of safety have on the role of the Federal Deposit Insurance Corporation (FDIC)?

B. Current Geographic Restrictions

The current geographic restrictions on bank branching resulted from the McFadden Act of 1927. This Act, coupled with the Banking Act of 1935, set state lines as boundaries and relegated to the state the issue of branching within a state. By defining a branch as, "any place of business...at which deposits are received, or checks paid, or money lent", the McFadden Act limited the opportunities for making loans or taking deposits across state lines (17, p. 228).

Large banks have been relatively successful at circumventing the lending restrictions implied in this Act. Working through facilities known as loan production offices, these institutions establish a physical presence in various markets throughout the country. The loan production office then allows the non-domiciled bank to service a much wider clientele. They are thus able to obtain loan customers from a national market.

Horvitz (19), however, suggests that we do not observe the same utilization of loan production offices by smaller institutions. Furthermore, he asserts that the majority of small and medium-sized banks' loan customers are from the local market. Pierson notes that, "branching restrictions prohibit banks from operating on a nationwide basis, thus limiting their ability to compete effectively outside their base operating area" (32, p. 471). It seems then, that lack of an effective means for attracting non-local customers has resulted in smaller financial institutions facing a binding constraint from the

Act's geographic restrictions.

C. The Link Between Deregulation and Safety

The link between geographic deregulation and bank safety results from banks now undertaking new activities which alter their performance. In attempting to establish this link, it seems that two contentions must be supported.

First, it needs to be shown that geographic regions are somehow different. That is, that states or groups of states are heterogeneous, thus allowing banks access to new activities. A new activity might simply be characterized as a loan market where customers have a different default pattern from customers in the current market. Second, it must be shown that these heterogeneous characteristics have an affect on bank safety. Once these two arguments are established, the analysis can proceed.

The first contention is supported by recent studies that demonstrate that various states or groups of states make up relatively distinct economic regions in this country (5,6,7,8,30,42). Syron (42) suggests that while the entire country has an economic business cycle, so too, various areas may experience regional economic cycles. Furthermore, he argues that these regional cycles are becoming less, rather than more, similar. Browne (5) attributes much of these variations in regional economic cycles to the industrial mix which

compose various regions. In addition, she suggests that these regional cycles are not perfectly correlated with either the national economy or other regions. Given that these studies establish the existence of heterogeneous regions with unique business cycles, it must now be demonstrated that these local economic cycles influence bank performance.

Various studies can be cited to support this argument. Notably, Meyer and Pifer (29) in attempting to model bank failure identify local economic conditions as an important explanatory variable. Also, a study by Spong and Hoeng states that "economic conditions have been the main factor in the overall health of the banking industry and have also been an important factor in loan quality changes at the individual bank level" (41, p. 23). Finally, Kreps and Wacht suggest that the "soundness of banks...depends much more on conditions existing in the economic environment in which the bank exists and operates than on the regulation of their internal operations" (22, p. 605).

Thus, it seems that the factors which influence loan performance (i.e., default rates) are tied to the regional economic business cycles. Furthermore, to the extent that regional cycles are uncorrelated, default rates on loans should not be perfectly correlated among banks in different regions. Therefore, geographical deregulation should provide an opportunity for banks to effectively change their portfolios. This may in turn influence their performance and ultimate safety.

D. Risk From the Banks' Perspective

It seems relatively straightforward that risk from a bank's perspective can be altered with a relaxation of lending restrictions. Notably, this conclusion can be reached from an elementary application of portfolio theory.

Portfolio theory demonstrates that when the returns on assets are not perfectly positively correlated, then holding combinations of the assets can lead to less variability in returns than could be achieved by holding any asset separately (27). Thus, by using the variance in asset returns as a measure of risk, the theory suggests that investors can achieve a less risky position by diversifying their portfolio. This implies that if the supposition of lack of perfect correlation among loan default rates is correct, then banks could achieve a lower risk position (i.e., less variance in returns) by holding a portfolio of loans to a number of economic regions than by simply lending to one area.

This line of reasoning is supported by Benston and Marlin who note, "...small banks tend to concentrate their loans over a compact geographical area, with the consequence that adverse economic conditions in the area may have a more serious impact on them than more widely diversified banks" (3, p. 36). Hence, restrictions on interstate lending may be increasing the risk exposure of banks. Benston argues, "it seems clear that the legal prohibition against banks diversifying their location--and consequently their assets and

liabilities--impairs their ability to survive a local economic crisis" (2, p. 32).

E. Risk From Society's Perspective

The conclusion derived from the application of portfolio theory rests on the premise that variability in returns is the appropriate measure of risk. While this might be adequate from the stockholders' standpoint, the same may not be true from society's perspective. Society, as represented by the FDIC, is primarily concerned about the downside vulnerability of a portfolio's worth. This notion of risk is consistent with one suggested by Domar and Musgrave (12). It argues that upward gains cannot be considered risky. Rather, it is the possibility of relatively low portfolio values which might invoke the need for FDIC redemption of the bank's liabilities.

Granted, if the bank's portfolio is a combination of assets with normally distributed returns, then the two notions of risk are compatible. That is, a reduction in variance implies that the chances for downside losses, as well as upward gains, are reduced. However, if the returns are not normally distributed, this compatibility is not as apparent. (See the Appendix for an example where the two notions are not completely compatible with each other.) Thus, portfolio theory in a mean-variance context may not provide the necessary information concerning the changes in social risk that potentially result from a

relaxation of lending restrictions.

A second measure of risk from society's perspective is the necessary size of an insurance fund to protect the banking system. The issue is whether geographical deregulation can reduce the necessary size of the fund. It might be argued that the FDIC already pools the risk of the banks and therefore a reshuffling of assets between banks would have no effect on the appropriate fund size. Whether this claim can be substantiated needs to be addressed.

F. Statement of Objective

The purpose of this research project then is to investigate some of the implications of removing geographical lending restrictions from banks. The implications to be considered are how such deregulation might affect individual bank safety, industry risk exposure, and the necessary insurance fund. Specifically, how will deregulation affect the probability of individual and multiple bank failures and how will it affect the expected payout by the FDIC in the event of a failure.

G. Review of the Literature

The literature germane to this study can be grouped under three categories. First, there are articles which deal with the effect of bank branching on deposit variability and bank safety. Second, there are studies that investigate the effect of expanded asset choices on

the probability of failure. Third, there are articles on the role and potential liability of the Federal Deposit Insurance Corporation.

1. Expanded liabilities

A 1968 article by Wacht (44) sets the tone for most of the research on the affect of increased branching on deposit expansion and variability. Wacht suggests that branching can lead to reduction in the variability of deposit outflows and thus a reduction in the riskiness of the bank. He invokes portfolio theory as a justification for his conclusion. His application of the theory argues that deposit outflows from different branches will offset one another, thus reducing the overall variability of the flows.

Lauch and Murphy (25) test Wacht's hypothesis. Their results suggest that, in fact, the variability of deposit flows is reduced by branching away from the base area. Thus, expanded branching can reduce the riskiness associated with deposit variability.

The inherent weakness with applying the results of these articles to the current issue is that it would confuse liquidity problems with solvency problems. Liquidity problems arise when a large number of depositors unexpectedly seek to withdraw their funds from a particular bank at the same time. The bank may temporarily have a shortage of liquid reserves to meet these unpredicted withdrawals. These studies show that branching can reduce the uncertainty associated with deposit

outflows and thus reduce the chances for such a liquidity crisis. However, solvency problems result from a deterioration of the underlying assets which support the deposit base. Bank safety ultimately rests on this support. A reduction in deposit variability will not affect this deterioration and thus will not affect bank solvency.¹

2. Expanded assets

The issue of expanded asset choices on individual bank safety has been addressed by Blair and Heggstad (4). Using a mean-variance framework, they applied the Roy's Safety-First model (34). In their application, Chebyshev's Inequality is utilized to determine the upper bound on the probability of bank failure.

Note first that Chebyshev's Inequality (24) states:

$$\Pr (\tilde{\pi} < \pi - k\sigma) < 1/k^2 \quad (1.1)$$

where: $\tilde{\pi}$ is a random variable,

π is the expected value of $\tilde{\pi}$,

σ is the standard deviation of $\tilde{\pi}$,

k is a positive constant.

¹There is an exception to this statement. To the extent that a reduction in deposit variability reduces the need for a bank to liquidate assets in an imperfect secondary market, bankruptcy potential may be reduced.

If α is then defined as

$$\alpha = \pi - k\sigma, \quad (1.2)$$

then solving for k yields

$$k = \frac{\pi - \alpha}{\sigma}. \quad (1.3)$$

Substituting (1.2) and (1.3) into (1.1) produces

$$\Pr(\tilde{\pi} < \alpha) < \frac{\sigma^2}{(\pi - \alpha)^2}. \quad (1.4)$$

Equation (1.4) corresponds with Blair and Heggstad's equation 1 (4, p. 90). Now, if $\tilde{\pi}$ is allowed to represent the return on the bank's portfolio and α to represent the lowest value $\tilde{\pi}$ can take and still allow the bank to remain solvent, certain conclusions can be drawn. Specifically, $\tilde{\pi} < \alpha$ would represent a situation where the portfolio had generated such a negative return that all the capital was eroded. This situation implies bankruptcy.

By utilizing a mean-standard deviation diagram, a graphical representation of the probability suggested in equation (1.4) is possible (see Diagram 1). Allow AB to represent the available portfolio locus, and allow point D to be the portfolio selected by the bank. Observe, that a ray drawn from α to D has a slope equal to $(\pi - \alpha)/\sigma$. Furthermore, note that this slope is equal to k where k was defined in equation (1.3). Recall that the probability that $\pi < \alpha$ is less than or equal to $1/k^2$. Thus, this probability is represented by the square of the reciprocal of the slope of a ray from α to D (4, p. 90). In addition, as k increases, (i.e., the slope gets steeper), the probability that $\pi < \alpha$, $1/k^2$, declines. That is, a steeper ray

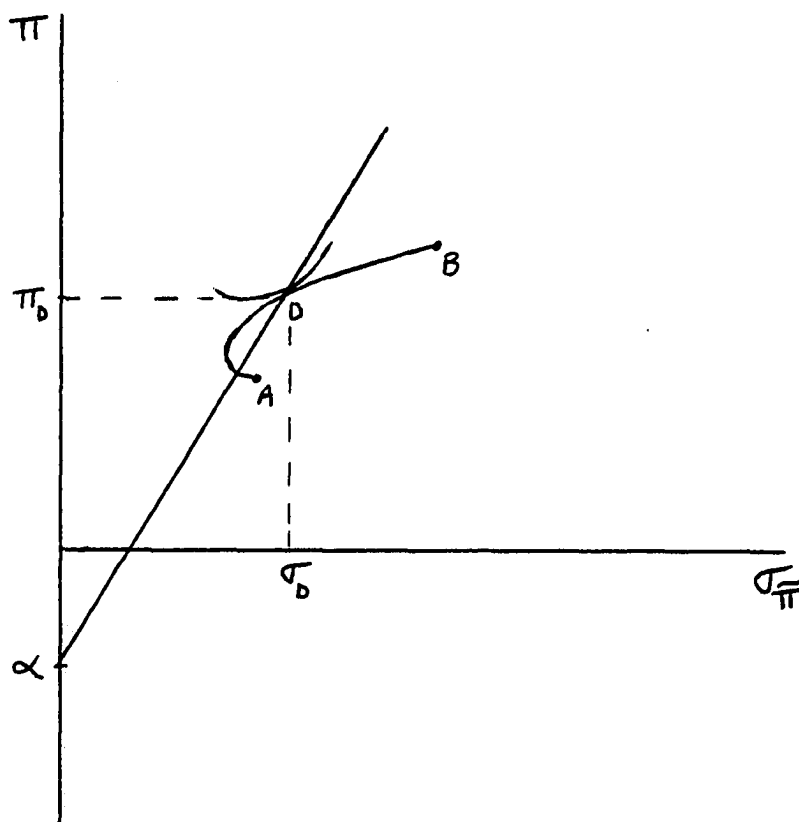


Diagram 1. Restricted Portfolio Locus

implies a lower upper bound on the probability of failure.

Expanded asset choices may change the position of the investment opportunity locus. Specifically, if change occurs, it will make the locus more desirable. Increasing desirability implies that for any given variance, the attainable expected return on the efficient portion of the locus will be greater. Diagram 2 includes the former portfolio locus bounded by points A and B, and the new locus bounded by points A

and C.

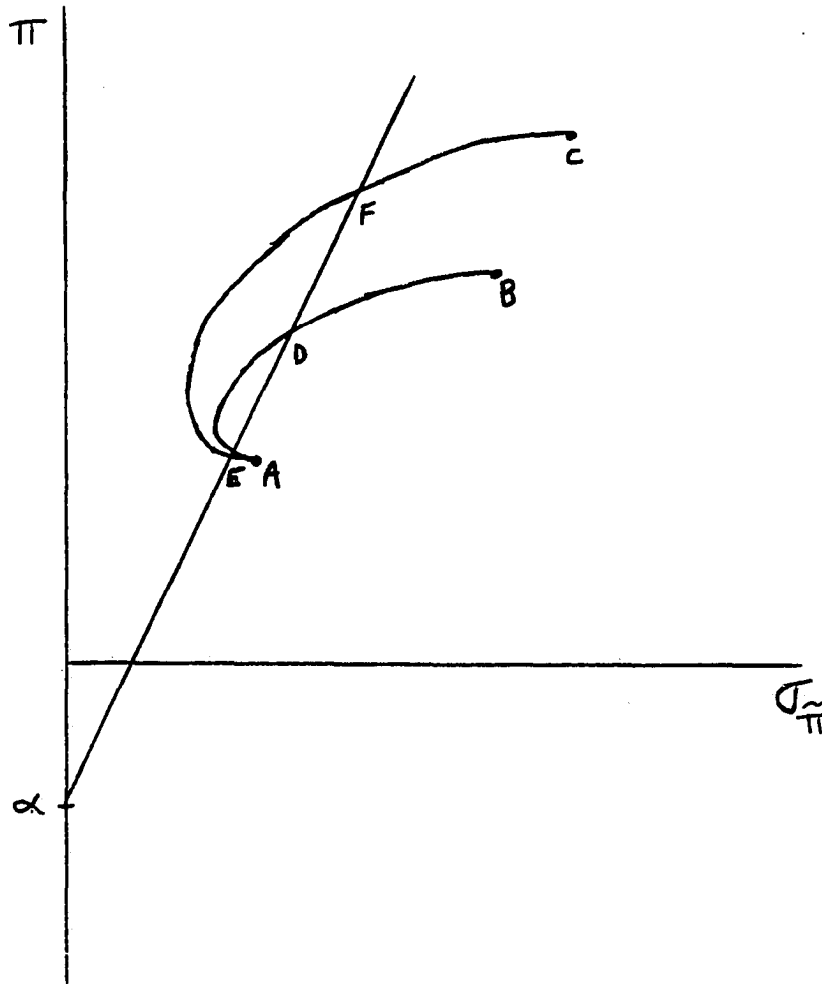


Diagram 2. Expanded Portfolio Locus

From Diagram 2, it is evident that what happens to the probability of failure partially depends on where the bank optimizes after asset restrictions have been eliminated. If the bank selects a portfolio between points E and F, the ray from α to the new portfolio will be

steeper. Recall, this implies a lower upper bound on the probability of failure. If instead, the bank selects a portfolio between F and C, the upper bound on the probability of failure will increase. Therefore, Blair and Heggstad suggest that whether portfolio restrictions are detrimental to the safety of individual banks is ambiguous.

Koehn and Santamero (21) extend the work of Blair and Heggstad. Rather than focusing on asset restrictions and individual bank safety, they attempt to analyze the affect of bank capital regulations and industry-wide risk. In so doing, they look at how a changing investment locus affects the probability of failure. Like Blair and Heggstad, Koehn and Santamero use a mean-variance framework. Following the work of Merton (28), they derive an efficient investment frontier subject to a capital constraint. Then, they demonstrate that the imposition of stricter capital constraints will affect the available efficient investment frontier. Notably, it will lead the available frontier to shift down, reducing the desirability of the choices. As with Blair and Heggstad, whether risk is increased or decreased will depend on the bank's re-optimization following the change in constraints. Koehn and Santamero demonstrate that this will depend on the relative risk aversion of the individual banks and therefore, aggregation is not feasible.

The value of the approach used in both of these studies is open to criticism. Specifically, Chebyshev's Inequality gives only the upper bound on the probability of failure. Thus, when making comparisons of the impact of asset expansion on risk, the results allow the researcher to compare only changes in the upper bounds. The actual probability of failure may have moved in the opposite direction. Furthermore, this approach gives no insights into the potential effect of relaxation of regulations on the solvency of the FDIC. This framework addresses only the probability of failure and not the expected value of payout by the FDIC.

3. The role of the FDIC

Various articles have expounded on the goals of the Federal Deposit Insurance Corporation (2,13,14,20,39,45,46). They suggest that the goals might include: the protection of the money supply, the protection of the payments mechanism, the protection of small depositors, and the protection of small institutions. While each of the studies emphasize different aspects of the role of the FDIC, all tend to agree with former FDIC chairman Frank Willie, that, "in the final analysis, the task is to assure confidence in the nation's banking system" (32, p. 374). The loss of this confidence potentially leads to bank runs and the undesirable social loss that results from widespread bank failure (11).

One method of maintaining this confidence is to guarantee that if a bank fails, deposits will be redeemed by the insuring agency.

Specifically, the public must be confident that there are adequate reserves to support such a guarantee (11). A variety of approaches to defining an adequate fund may be utilized. One possibility is for the agency to hold a fund equal to the total potential losses that could be incurred by the insuring agency. Another option is for them to hold a fund equal to some fraction of potential losses. An intermediate criteria would be to hold an actuarially sound fund. That is, a fund equal to the expected value of losses.

The current FDIC fund is maintained by an assessment levied on banks. The law requires that this assessment be based on the total deposits of the insured institution. While there is widespread debate over the appropriateness of such a fixed-rate pricing method, this is not a concern of this study. Rather, the issue is whether a relaxation of lending restrictions could potentially change the expected FDIC payout. Any change would imply a corresponding movement in the risk exposure of the banking system. Also, if it is possible to reduce the appropriate size of the fund while maintaining the safety of the system, then those resources that are saved could potentially be

diverted to more productive uses.² This desire for efforts to reduce the necessary size of the fund is strongly advocated by Scott and Mayer (37). In addition, Gibson notes, "the goal of having it (the FDIC) attain its goals with the fewest resources would be disputed by few" (14, p. 1576).

Sharpe (38) provides some insights into the nature of the FDIC's potential liability. Employing a complete market, state-preference approach, Sharpe indicates that the expected value of the FDIC liability is a function of the states of the world in which bankruptcy occurs and the loss in each of those states. This same notion can be applied to a probabilistic framework as will be shown in Chapter 2.

H. Summary

This chapter has argued that small banks seem to be constrained by the lending restrictions implied in the McFadden Act. Furthermore, it has suggested that removal of these barriers would provide these institutions with new opportunities which will affect their

²The FDIC currently invests most of its assets in short term government securities. If banks could retain a portion of those funds that they currently pay to the FDIC in the form of premiums, they could select the most productive use for these resources. While they may select an investment comparable to that of the FDIC, it is not obvious that this would be their choice. Rather, they would likely invest in assets with the greatest risk-adjusted rate of return. Thus, there is potential that these resources could be used more efficiently than they are now.

performance. It has argued that the usual notion of risk (i.e., variance) might not be appropriate when addressing issues of changes in risk from a societal perspective. Finally, it has shown that the current literature does not address the issue adequately.

Therefore, in Chapter 2, a framework will be developed within which to analyze the impact of risk changes that may result from relaxation of geographic lending restrictions. Chapter 3 will use this model in a simulation exercise. Finally, Chapter 4 will discuss the implications that follow from the exercise.

II. THE MODEL

A. Introduction

The move to interstate banking can be accomplished in various ways. Following the relaxation of restrictions, banks may more actively lend directly to other regions. That is, banks may find it advantageous to open new branches in various sections of the country in order to expand the geographical scope of their loan portfolio. However, the current lack of extensive utilization of loan production offices by medium- and small-sized banks might suggest this de novo method of geographic expansion is prohibitively costly. A more likely approach to portfolio diversification would be through the merger of already existing banks in different regions of the country. This could provide the immediate result of portfolio diversification without the cost of recruiting local expertise to manage the new branch.

Regardless of the method selected, the survey of the literature suggests that in order to determine the probability of bank failure and to compute the expected value of the FDIC payout, before and after deregulation, it is necessary to base the analysis on more than the traditional mean-variance approach. In fact, Lane and Golen (23) suggest that under certain circumstances, it may be appropriate to specify a joint probability distribution on all of the bank's activities, then to compute the desired values from an analysis of this distribution. However, with respect to an investigation of the risk

implications of interstate bank deregulation, a slightly less complicated procedure can be used.

B. Risk Identification

When considering a move to interstate banking, default loss is the primary type of bank risk that will be affected. Analysis of this will require a comparison of the default potential within a bank's portfolio before and after expansion across regional boundaries. Coupled with this default potential is the necessity to expend resources attempting to collect on these assets. These collection costs should be included in an analysis of the potential for bankruptcy.

The risk of fluctuating asset values due to interest rate changes should not be affected directly by this geographical deregulation. This risk, known as interest rate risk, results from the banks' mismatching of asset and liability maturity lengths. There is no a priori reason to believe that management's policies with respect to asset and liability mismatching will change simply because a new variety of assets is available. Therefore, while it is acknowledged that such mismatching can and does play an important role in the solvency of a bank, it should not be influenced by the relaxation of geographical restrictions.

Thus, when specifying a distribution for the study of bankruptcy potential and FDIC payout values, the analysis will focus on the potential that earnings on assets will be less than the contractual

return. Hence, the bank encounters difficulty if assets fall in value due to partial or complete default of interest and principle and/or if it expends too many resources attempting to collect on its assets.

C. Model Specification

1. Balance sheet identities

For purposes of the analysis, assume there exist two banks, H and T. These banks are located in different regions, 1 and 2. For simplicity, assume the only asset which either bank holds are loans.¹ These may be made to either region 1 or region 2. From these assumptions, the following relationships can be stated for a representative bank.

$$\sum_{i=1}^2 L_{it}^j = A_t^j \quad j=H,T \quad (2.1)$$

where: L_{it}^j is the dollar value of loans to region i by bank j at the beginning of period t and A_t^j is the total asset value of bank j at the beginning of period t .

In addition, due to the balance sheet identity, given an initial

¹In reality, banks hold other assets, including reserves and government securities. To the extent that these maintain their value, they would be available to payoff depositors before capital is eroded. This can be implicitly included in the model by having the capital buffer be larger than it is in reality.

stockholder investment, C_t , and a given initial deposit base, D_t , the bank is able to acquire assets such that,

$$A_t^j = D_t^j + C_t^j. \quad (2.2)$$

It is then possible to write capital at the end of the period, C_{t+1} , as a function of asset values at the end of the period, A_{t+1} .

$$C_{t+1}^j = A_{t+1}^j - D_{t+1}^j \quad j=H,T \quad (2.3)$$

where: C_{t+1}^j is capital at the end of the period for bank j ,
 A_{t+1}^j is the value of assets at the end of the period held by bank j , and
 D_{t+1}^j is the dollar value of deposits at the end of the period held by bank j .

Observe, that since loans to a region are considered risky, (i.e., they have default potential), the sum of loan values at the end of the period, A_{t+1} , is a random variable. Also, deposits at the end of the period, D_{t+1} , may fluctuate. The model assumes that deposits do not fall but can increase.² Specifically, it is important to realize that any collection expense in excess of revenue from assets must be financed by either attraction of new deposits or new capital. A stock

²This allows attention to be focused on default problems and not on problems caused by asset liquidation in imperfect secondary markets brought on by a bank run.

offering would expose the bank to careful scrutiny by both investors and regulatory agencies. Since this is likely to be undesirable from the bank's standpoint, deposit expansion seems a more desirable source of funds. Note, that since depositors are insured, they have little incentive to assess the risk exposure of the bank. Thus, the bank acquires deposits, a liability, and also cash, an asset. However, the model assumes the cash is immediately expended in attempts to collect on the loans. This highlights the possibility that FDIC-redeemable liabilities could grow rapidly in the final days of the bank as it attempts to collect on its assets. Recent experience with banks' use of brokered funds just prior to collapse confirms this possibility. Therefore, since equation 2.3 indicates that capital at the end of the period is a function of two random variables, it too is a random variable.

2. Utilizing a distribution on capital

The FDIC becomes financially involved if the value of capital at the end of the period is negative. That is, only if the bank's assets fall sufficiently in value and/or the bank expends excessive amounts of resources attempting to collect on its assets does it become necessary for the FDIC to redeem part or all of the bank's liabilities. Specifically, the FDIC will have to redeem all insured liabilities in excess of asset values at the end of the period. For purposes of the

analysis, assume that all liabilities are insured.³ Hence, it is possible to find the probability that the FDIC will have to payoff depositors at a representative bank by evaluating the probability that C_{t+1} is negative. This is given by the definite integral

$$\int_{-\infty}^0 h(C_{t+1}^j) dC_{t+1}^j \quad j=H,T. \quad (2.4)$$

Therefore, by specifying a distribution on end-of-the-period capital, the probability of capital being negative (i.e., the firm is bankrupt) can be found. Note, the integral allows capital to go to $-\infty$ because, as previously suggested, D_{t+1}^j may grow rapidly as the bank attempts to remain solvent.

3. Utilizing a distribution on losses

Suppose, however, that instead of specifying a distribution on capital, a distribution on loan losses were characterized. This may be advantageous because it is loan losses that lead to capital erosion. Furthermore, this method of specification will allow explicit analysis of the relationship of losses between regions.

³In reality, only \$100,000 per account is insured. While this assumption will affect the size of the payout, it should not affect the qualitative results of the model. Also note, the study is looking primarily at small- and medium-sized banks which have fewer uninsured deposits.

Loan losses should be defined in a very broad sense in order to incorporate all of the variability reflected in terminal capital. Specifically, loan losses include not only defaults but also collection expenses. Thus, losses can exceed the original value of the loan.

Recall from equation 2.3, that it is possible to write capital at the end of the period as

$$C_{t+1}^j = A_{t+1}^j - D_{t+1}^j \quad (2.3)$$

Furthermore, it is possible to specify that asset values at the end of the period as

$$A_{t+1}^j = \sum_{i=1}^2 L_{it}^j (1+r_i) - \sum_{i=1}^2 D1_i \quad (2.5)$$

where: A_{t+1}^j and L_{it}^j are as previously defined,
 r_i is the contractual return on L_i , and
 $D1_i$ is the default loss on loans to region i .

Note, the maximum value assets can take is A^* , where

$$A^* = \sum_{i=1}^2 L_{it} (1+r_i). \quad (2.6)$$

Likewise, the value of deposits at the end of the period, D_{t+1}^j , is assumed to be equal to

$$D_{t+1}^j = D_t^j + \sum_{i=1}^2 C1_i \quad (2.7)$$

where $C1_i$ are the collection costs for loans to region i .

Finally, loan losses, l_i , can be specified to equal

$$l_i = Dl_i + Cl_i. \quad (2.8)$$

Then, substituting 2.6 into 2.5, and 2.5 and 2.7 into 2.3 yields

$$C_{t+1}^j = A^* - \sum Dl_i - (D_t^j + \sum Cl_i). \quad (2.9)$$

Rearranging terms,

$$C_{t+1}^j = A^* - D_t^j - (\sum Dl_i + \sum Cl_i). \quad (2.10)$$

Substituting 2.8 into 2.10 gives,

$$C_{t+1}^j = A^* - D_t^j - l_1 - l_2. \quad (2.11)$$

Thus, by utilizing this relationship, it will be possible to find from a distribution on loan losses the probability of a representative bank failing and the expected FDIC payout.

Given the lack of accurate data on individual bank loan losses and collection expenses with which to determine the actual distribution, the analysis requires that an assumption be made about the nature of the distribution. There are certain characteristics that are desirable for an assumed probability distribution on loan losses. Among these are a minimum value of zero for the distribution and a heavy weighting of probability on low values of losses, yet a possibility of high loss values. Furthermore, in order to utilize the distribution, it should be reasonably easy to manipulate. One such distribution is a truncated normal. Besides having a minimum value of zero and a high probability of low values, the truncated normal is fully defined by a few

parameters. Thus, by specifying that loan losses between regions are distributed as a truncated joint normal, the necessary analysis should be both realistic and tractable.

In order to find the probability of a payout by the FDIC, the distribution needs to be integrated over the region where capital is negative. From equation 2.11, this results when the sum of loan losses is greater than $A^* - D_t$. $A^* - D_t$ represents the maximum value capital can take at the end of the period. Note, if losses are zero, equation 2.11 indicates that C_{t+1} would equal $A^* - D_t$. C_{t+1} remains positive as long as losses are less than this maximum capital value.

Graphically, in l_1, l_2 space, negative capital is represented by the area outside the buffer zone (see Diagram 3). This zone is bounded by a line that represents combinations of losses, $l_1 + l_2$, which just equal the maximum value capital can take at the end of the period. That is, this line represents loss combinations such that C_{t+1} is equal to zero.

With losses defined to be distributed as a truncated bivariate normal, the probability of failure, and hence a payout, for a representative bank, is found by evaluating the definite integral

$$\int_0^{\infty} \int_0^{\infty} g(l_1, l_2) dl_1 dl_2 \quad l_1, l_2 > 0 \quad (2.12)$$

$$\circ (A^* - D_t - l_2)$$

where $g(l_1, l_2)$ is a density function for a truncated bivariate normal distribution.

It is possible to compute the expected value of the FDIC payout by

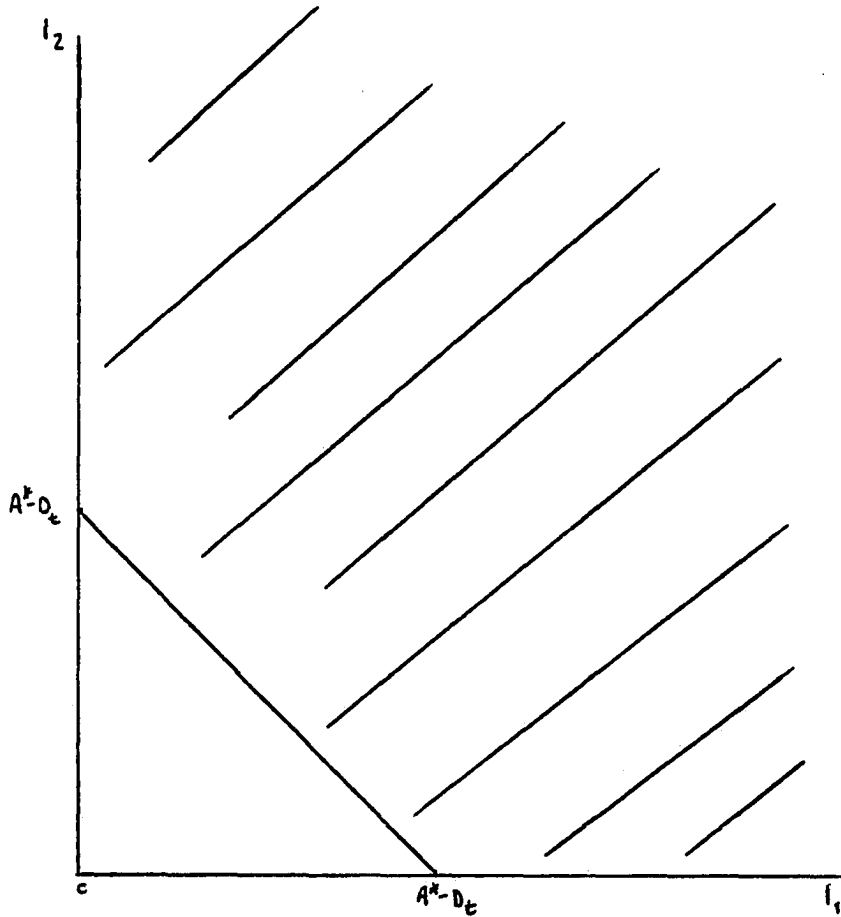


Diagram 3. Loan Loss Space

evaluating the definite integral

$$\int_0^{(A^*-D_t)} \int_0^{(A^*-D_t-l_2)} (0)g(l_1, l_2)dl_1 dl_2 + \int_0^\infty \int_{(A^*-D_t-l_2)}^\infty (l_1+l_2-A^*+D_t^*)g(l_1, l_2)dl_1 dl_2. \quad (2.13)$$

Note, since the FDIC redeems liabilities only if they are in excess of those redeemable by asset liquidation, the payout is zero when the sum of losses is less than or equal to the buffer, and $D_{t+1} - A_{t+1}$ when losses exceed the buffer. From equation 2.3, this non-zero payment is simply $-C_{t+1}$. However, from equation 2.11, this can be represented by

the term $l_1 + l_2 - A^* + D_t$. Thus, the procedure integrates over the entire outcome space and multiplies each probability by the payout for that outcome.

4. Deriving the truncated bivariate normal distribution

It is possible to derive the desired truncated distribution from a full bivariate normal distribution in the following manner. Let x_1 and x_2 be variables with a bivariate normal distribution. Let l_1 and l_2 be variables distributed as a truncated bivariate normal, where the truncation results in l_1 and l_2 having positive probability only in the positive quadrant. To obtain the distribution for l_1 and l_2 from the distribution on x_1 and x_2 , it is necessary to multiply the probability in the positive quadrant of x_1 and x_2 by a scalar. This scalar is equal to the reciprocal of the probability in the positive quadrant. This will allow the total probability of $l_1 l_2$ combinations to equal 1. Symbolically, this procedure can be shown in the following manner.

Let the probability density function on x_1 and x_2 be equal to $f(x_1, x_2)$, such that,

$$f(x_1, x_2) = \omega e^{-T} \quad (2.14)$$

where:

$$\omega = \frac{1}{2\pi\sigma_{x_1}\sigma_{x_2}(1-\rho^2)^{-1/2}}$$

and,

$$\tau = \frac{1}{2(1-p^2)} \left[\left[\frac{x_1 - u_{x_1}}{\sigma_{x_1}} \right]^2 - 2p \left[\frac{x_1 - u_{x_1}}{\sigma_{x_1}} \right] \left[\frac{x_2 - u_{x_2}}{\sigma_{x_2}} \right] + \left[\frac{x_2 - u_{x_2}}{\sigma_{x_2}} \right]^2 \right]$$

Then, the probability in the positive quadrant is equal to the definite integral

$$\int_0^{\infty} \int_0^{\infty} f(x_1, x_2) dx_1 dx_2. \quad (2.15)$$

The scalar needed to obtain the density function on l_1 and l_2 is equal to the reciprocal of 2.15. Let this scalar be gamma (γ). Then, the density function on l_1 and l_2 is

$$g(l_1, l_2) = (\gamma) f(x_1, x_2) \quad (2.16)$$

where: $g(l_1, l_2)$ is the density function for l_1 & l_2 ,
 $l_1, l_2 > 0$, and
 $l_i = x_i$.

5. Parameter specification

Recall, equation 2.1 defined the total portfolio in terms of the sum of the various assets.

$$\sum_{j=1}^2 L^j_{it} = A^j_t. \quad (2.1)$$

It is also possible to define variables which allow discussion of the banks' portfolio in terms of the proportion of each asset in the

portfolio. Let Q^j be the proportion of assets invested in loans to region 2 by bank j , such that,

$$Q^j = L_2^j \div A^j. \quad (2.17)$$

Solving for L_2^j yields

$$L_2^j = Q^j A^j. \quad (2.18)$$

Furthermore, let $(1-Q^j)$ be the proportion of loans by bank j to region 1.

$$(1-Q^j) = L_1^j \div A^j, \quad (2.19)$$

so that,

$$L_1^j = (1-Q^j)A^j. \quad (2.20)$$

Then, for purposes of analysis if it is specified that the mean of losses is proportional to the amount of loans to the region, and the standard deviation of losses is proportional to the amount of that type of loans, it is possible to define the following relationships.

$$u_{1_1} = \theta_1 L_1 = \theta_1 (1-Q)A \quad (2.21)$$

where θ is the expected value of losses per dollar of loans to region 1, and

$$\sigma_{1_1} = \theta_1 L_1 = \theta_1 (1-Q)A \quad (2.22)$$

where θ is the standard deviation of losses per dollar of loans to region 1.

Similarly,

$$u_{1_2} = \theta_2 L_2 = \theta_2 QA \quad (2.23)$$

and,

$$\sigma_{1_2} = \theta_2 L_2 = \theta_2 QA. \quad (2.24)$$

Thus, once θ and Θ are given and the volume of loans to a region specified, the determination of the mean and standard deviation of losses on the assets in the portfolio can be completed. Theoretically, these can then be used in the density function for losses in equation 2.12 and 2.13 to compute the desired probabilities and payouts.

However, note from equation 2.16 that the density function on losses is derived from the truncation of a bivariate normal distribution on x_1 and x_2 . This truncation occurs such that all probability rests in the positive quadrant. Thus, it is possible to write the mean and standard deviation of losses as

$$u_{1_i} = \int_0^{\infty} \int_0^{\infty} (x_1) (\gamma) f(x_1, x_2) dx_1 dx_2 \quad (2.25)$$

and,

$$\sigma_{1_i} = \left[\int_0^{\infty} \int_0^{\infty} (x_1 - u_{1_i})^2 (\gamma) f(x_1, x_2) dx_1 dx_2 \right]^{1/2}. \quad (2.26)$$

Also, the correlation of losses between regions can be written as

$$P_{1_1 1_2} = \frac{\int_0^{\infty} \int_0^{\infty} (x_1 - u_{1_1})(x_2 - u_{1_2})(\gamma) f(x_1, x_2) dx_1 dx_2}{\sigma_{1_1} \sigma_{1_2}} \quad (2.27)$$

Observe that equations 2.25 thru 2.27 explicitly describe the mean and standard deviation of losses in each region and the correlation between regions as functions of the underlying means, standard deviations and correlation of the x 's which characterize the density function $f(x_1, x_2)$. Thus, once equations 2.21 thru 2.24 are used to specify the means and standard deviations of losses, and a correlation of losses is established, they implicitly suggest the underlying means, standard deviations, and correlation of the x 's which would be necessary to generate the appropriate truncated distribution. Since substitution of 2.16 into 2.12 implies that calculation of the desired probabilities requires knowledge of the means, standard deviations, and correlation of the x 's, 2.25 thru 2.27 would need to be simultaneously solved to reveal these values. However, given the complexity of the functions, explicit equations for the mean and standard deviation of each x and their correlation as functions of the mean and standard deviation of losses and their correlation are not readily discernible. Therefore, a comparable procedure needs to be employed. Namely, rather than specifying $p_{1_1 1_2}$ and using ϕ and θ to compute u_1 and σ_1 respectively, suppose that the mean and standard deviation of x were first characterized.

As previously defined, x is a variable with a full normal distribution which can be truncated to derive the distribution on loan losses to a region. Given this, it is possible to scale the x variable such that it represents a distribution from which a distribution on

losses per dollar of loans could be derived. Specifically, since \bar{x} is the expected value of losses per dollar of loans, let λ be the mean of the scaled distribution needed to generate \bar{x} . Furthermore, just as σ is the standard deviation of losses per dollar of loans, let k be the standard deviation of the scaled distribution needed to generate \bar{x} . This λ, k combination will then characterize a distribution which can be truncated to derive the distribution on losses per dollar of loans. Furthermore, given these definitions, it is possible to specify that the mean of x is equal to λ times the amount of loans to the region and the standard deviation of x is equal to k times the amount of loans to a region. Symbolically,

$$\mu_{x_i} = \lambda_i L_i \quad (2.28)$$

and,

$$\sigma_{x_i} = k_i L_i \quad (2.29)$$

Therefore, once the λ 's and k 's have been specified, and the correlation of the x 's given, it is possible to determine the probability density function for $l_1 l_2$ combinations (i.e., losses on the actual portfolio) from a distribution on x_1 and x_2 . These can then be used to compute the post-deregulation probability of failure and expected payout by the FDIC for a representative bank.

6. Complete model specification

Equations 2.18 and 2.20 describing loans to a region as a proportion of total portfolio size can now be substituted into equations 2.28 and 2.29. The resulting equations for the means and standard deviations of the x 's can then be used in the truncated bivariate normal density function in equation 2.16. If this density function is then substituted into equations 2.12 and 2.13 it is possible to obtain expressions for the post-deregulation probability of failure and expected payout which depend on λ_1 , k_1 , $\rho_{x_1x_2}$, A, B, and Q. That is, functions which depend on: the riskiness of the assets as represented by λ_1 and k_1 , the correlation of the losses as approximated by $\rho_{x_1x_2}$, the original size of the portfolio, A, the buffer, B, which gives the maximum capital value at the end of the period, (i.e., $A^* - D_t$), and the proportion of each asset in the portfolio, Q.

D. Analysis of Risk Changes

Given parameter values, the model allows a calculation of the probability of failure and expected FDIC payout after geographical deregulation for a representative bank. However, as previously indicated, in order to analyze the impact such deregulation has on the riskiness of banks, a comparison is needed between pre- and post-deregulation results. This is accomplished by assuming that before deregulation banks lend to only one geographic region. This results in the analysis being conducted on losses on loans to that

region. Specifically, the model will continue to assume that these losses are distributed as a truncated normal. However, now the losses are distributed as a univariate truncated normal.

Following the transformation procedures and method of parameter specification from the previous section, the probability of failure for a representative bank before deregulation is

$$\int_{A^*-D_t}^{\infty} j(l_1) dl_1 \quad l_1 > 0 \quad (2.30)$$

where $j(l_1)$ is the density function for a truncated normal distribution.

Also, the expected payout by the FDIC is

$$\int_0^{A^*-D_t} (0) j(l_1) dl_1 + \int_{A^*-D_t}^{\infty} (l_1 - A^* + D_t) j(l_1) dl_1. \quad (2.31)$$

Comparison of the results from equations 2.30 and 2.31 with the results obtained from 2.12 and 2.13 will allow an understanding of how interstate bank deregulation will affect the riskiness of a representative bank. Note, this riskiness is being approximated by the bank's probability of failure and the expected payout by the FDIC. Furthermore, examination of the sensitivity of these results to the correlation of the loan losses in different regions, the underlying riskiness of the loans, and the bank's capitalization rate can provide insights into potential policy decisions to be discussed in the final chapter.

In addition to these findings, certain assumptions can be made which will allow the results to indicate the potential changes in systemic risk that result from a modification in the regulation framework. Systemic risk can be measured in various ways. One possibility is to look at the probability of a bank failure in the banking system. Another option is to determine the probability of more than one bank failing at a given time. This is the problem of multiple bank failures. Finally, systemic risk could be measured as the total expected FDIC payout.

The present model allows the probability of a bank failure and the probability of multiple failures to be analyzed if the assumption is made that losses on loans to different regions are independent. This assumption allows the conditional probability function to be specified. Also, if the assumption that after deregulation banks are identical to one another is made, an extreme case can be analyzed.

From these assumptions, the pre-interstate deregulation probability of multiple failures in the system is given by the probability that banks H and T fail. That is,

$$\Pr(H_f \cap T_f) = \Pr(H_f | T_f) \Pr(T_f) \quad (2.32)$$

where the subscript f indicates failure.

Recall, that if loan losses are independent, then the probability that H fails given T fails is simply the probability of H failing. Thus,

$$\Pr(H_f \cap T_f) = \Pr(H_f) \Pr(T_f). \quad (2.33)$$

The probability that a bank fails is given by the probability that H or

T fails. That is,

$$\Pr(H_f \cup T_f) = \Pr(H_f) + \Pr(T_f) - \Pr(H_f \cap T_f). \quad (2.34)$$

From equation 2.33, this becomes,

$$\Pr(H_f \cup T_f) = \Pr(H_f) + \Pr(T_f) - \Pr(H_f)\Pr(T_f). \quad (2.35)$$

Finally, the total expected FDIC payout is simply the sum of random variables. Specifically, it is

$$E(\text{Payout}_{(\text{system})}) = E(\text{Payout}_H) + E(\text{Payout}_T). \quad (2.36)$$

For the special case when banks are identical after deregulation, the probability of multiple failures is equal to the probability that any one bank fails. Thus, the probability of multiple failures is equal to the probability of a failure, both of which are equal to the probability of a representative bank failing. Symbolically, this is

$$\Pr(H_f \cap T_f) = \Pr(H_f \cup T_f) = \Pr(H_f) = \Pr(T_f). \quad (2.37)$$

Calculation of the expected FDIC payout is still given by equation 2.36.

In the next chapter, a simulation exercise will be conducted. Using various parameter values, the issues suggested in this chapter can be addressed. The results of these simulations can then be used in the policy implications to be discussed in the final chapter.

III. SIMULATION EXERCISES

A. Introduction

The model developed in Chapter 2 provides a framework within which to analyze the impact of geographical deregulation. Specifically, it allows an investigation of how bank riskiness might be affected by such deregulation. Recall that riskiness is being approximated by the probability of a representative bank failing and the expected payout by the FDIC in the event of a failure.

As was suggested in section D of the previous chapter, in order to use the model, certain parameter values need to be specified. These parameters will allow a characterization of the environment in which the bank operates and the decisions made by the bank. A more general discussion of these parameters will be developed in the next section.

Before proceeding, however, it is important to clarify why a simulation exercise was conducted in place of a purely analytic solution. Note that the questions being asked could be addressed analytically by differentiating the equations for the probability of failure and expected FDIC payout, equations 2.12 and 2.13 respectively, with respect to the various parameters. However, this would entail differentiating an integral for which there is no apparent closed form solution. Thus, analytic solutions seem intractable if a realistic distribution is employed.

Faced with this predicament, a comparable approach can be used. That is, rather than differentiating the functions, equations 2.12 and 2.13 can be evaluated at different values of the parameters. The results of these exercises can then be compared. This will provide information as to how the functions behave under different conditions. Effectively, it allows an understanding of how the results change as parameters change. This, in essence, is the information a derivative provides.

In order to derive the desired values, at various parameter settings, an algorithm needed to be used which could approximate the appropriate volume under the functions. The procedure employed was a modified version of the Romberg Algorithm (9, p. 206). This algorithm uses a trapezoidal rule (33) to estimate the value of the integral. When the width of the trapezoid is set sufficiently small, the sum of the trapezoidal areas will approximate the integral. The algorithm needed to be modified in order to account for the fact that the current analysis involves a double integral. This was accomplished by dividing the l_2 axis into subintervals. The estimation procedure was then applied for each value of l_2 to approximate the area under the function for each individual l_2 . Each incremental result was multiplied by the interval width. When the interval width is small, this value will approximate the volume of the function for the given interval. These incremental volumes were then summed to determine the total volume outside the buffer.

B. The Parameter Selection

The parameters necessary to use the framework developed in Chapter 2 can be grouped into two categories, environmental parameters and choice parameters. Environmental parameters characterize the world in which the bank operates. In this model, these include the lambdas, kappas, and rho. The lambdas and the kappas give the mean and standard deviation of x per dollar of loans, where x is a variable with a full normal distribution. Given that the distribution on loan losses is derived from the truncation of this distribution then λ and k also influence the mean and standard deviation of losses. Thus, they characterize the potential losses on the assets available to the bank. Similarly, the correlation of the x 's influences the correlation of losses and hence the potential interaction of portfolio choices.

Two criteria seemed appropriate in selecting the environmental parameters. First, the parameters needed to generate loan loss characteristics which were consistent with observed phenomena. However, as noted before, individual bank loan default data have only been publically available for a relatively short time period. In addition, no data were available on loan collection expenses for individual banks. Thus, data on loan losses as defined in the model were not accessible, and this criterion was impossible to satisfy. The second criterion appropriate for determining environmental parameters was that the parameters should have a wide enough range such that the results would be robust. This allows the results to be relevant for

analyzing most bank loan loss experiences.

Choice parameters are those factors that are influenced by the decisions of the bank. These include: the portfolio size, A, the buffer, B, and the proportions of asset 1 and 2 in the portfolio, 1-Q and Q respectively. While the portfolio size could take on any positive value selected by the bank, subject to balance sheet and market constraints, all of the simulations were conducted with a portfolio size equal to 1. Thus, the results for the expected payout can be scaled up to the desired representative bank size. Conversely, the results presented in the tables indicate the expected payout per dollar of assets.

The buffer represents the maximum value that capital at the end of the period can achieve. It reflects the combination of capital at the beginning of the period and the contractual return on assets. The choice of the appropriate buffer was guided by historical bank capitalization rates (43). However, as with the environmental parameters, the buffer was allowed to vary to enhance the robustness of the results.

The proportions of the two assets in the portfolio, 1-Q and Q respectively, are determined by the bank's optimization procedure. In the simulation exercises, these parameters were allowed to take on a wide range of values. This facilitated the analysis of the impact of various portfolio combinations on bank riskiness.

C. Results

1. Risk changes for a representative bank

The results of the simulation exercises are reported in Tables 3.1 through 3.8. The discussion that follows will analyze these results.

Table 3.1 gives the results of the simulation exercise conducted within the pre-deregulation framework. Recall that in this environment, banks lend to only one region. The results reported here can be used for comparisons with the results from the exercises carried out within the post-deregulation model. In a post-deregulation world, banks can hold loans made to both regions.

The numbers from the regulated environment produce some intuitively pleasing results. First, one would expect that the larger the buffer, all else held constant, the lower the probability of failure and the lower the expected payout by the FDIC. Note that the buffer represents the bank's first line of defense against loan losses. A comparison of columns 1 and 2 in the first set of rows in Table 3.1 substantiates this expectation. In both columns, the mean of loan losses is 2.78 cents per dollar of loans, and the standard deviation is .0213. However, in column 1 where the buffer is 8 cents per dollar of assets, the probability of a bank failing is .0226, but in column 2 where the buffer is 9 cents per dollar of assets, this probability falls to .0131. Similarly, the expected payout by the FDIC falls from .0262 cents per dollar of assets to .0101 cents per dollar. A

comparable result can be obtained by comparing columns 3 and 4 in the top half of the table. Again, as the buffer rises from 8 cents per dollar to 9 cents per dollar of assets, the probability of a failure and the expected payout by the FDIC decline.

Second, one might expect that riskier assets would generate a higher probability of failure and a higher expected payout. A riskier asset is usually considered to be one with either a higher mean loss value or a larger standard deviation of losses or both.¹ For simulation purposes, these larger means and standard deviations can be generated by a larger k , a larger λ , or a combination of the two. A comparison within columns 1 through 4 supports the expectation. Observe that in column 1, as the mean of loan losses rises from 2.78 cents per dollar of assets to 3.97 cents per dollar, and the standard deviation goes from .0213 to .0304, the probability of failure rises from .0226 to .111. A corresponding increase is found in the expected FDIC payout. It rises from .0262 cents per dollar to .229 cents per dollar. Similar results can be noted in columns 2, 3, and 4. Furthermore, observe from column 3 in the bottom half of the table that among the values considered the largest probability of failure and expected payout is obtained when the mean and standard deviation of

¹However, as can be seen in the Appendix, this classification is not always appropriate. Its applicability depends on the distributional assumption made.

Table 3.1. Simulation results for a representative bank in a regulated environment under different assumptions about the mean and standard deviation of loan losses, and the bank's capital buffer

<u>A=1</u>				
	<u>lambda=0.0</u>		<u>lambda=0.01</u>	
	<u>B=.08</u>	<u>B=.09</u>	<u>B=.08</u>	<u>B=.09</u>
<u>k=.035</u>				
mean of l	.0278	.0278	.0318	.0318
std. dev. l	.0213	.0213	.0231	.0231
Prob. Failure	.0226	.0131	.0377.	.0185
E(Payout)	.000262	.000109	.0004775	.000214
<u>k=.05</u>				
mean of l	.0397	.0397	.0436	.0436
std. dev. l	.0304	.0304	.0322	.0322
Prob. Failure	.111	.07275	.14	.0956
E(Payout)	.00229	.0014	.00312	.002

losses are both at their maximum values, and the buffer is at its smallest value.

For the first set of simulations on the deregulated environment (those with results presented in Tables 3.2 through 3.4), the characteristics of the loan losses in the two regions are assumed to be the same. That is, the mean of losses per dollar of loans in region 1 will be assumed to be the same as the mean of losses per dollar of loans in region 2. Similarly, the standard deviation of losses per dollar of loans in region 1 will be assumed to be the same as the standard deviation of losses per dollar of loans in region 2.² Making such an assumption will allow our attention to focus on how changes in asset proportions and correlations affect the riskiness of banks, without having the results be influenced by differences in the means and standard deviations of losses in the two regions.

Note that in Tables 3.2 through 3.4 the results of the simulations are only presented for Q equal to .3, .4, and .5. However, when the mean and standard deviation of losses per dollar of loans are the same

²This would suggest that when Q is equal to .5 (i.e., equal proportions invested in the two assets), the mean of losses in region 1 should be the same as the mean of losses in region 2. Also, the standard deviation of losses in the two regions should be the same. However, note from Table 3.2 that these figures are not precisely the same. Since these values were computed by the simulation program, any difference in the reported numbers is due to rounding error. This error is generated by the necessity of the simulation program to approximate the area under the integral.

in the two regions, the probability of failure and the expected payout by the FDIC for Q equal to .3 is the same as for Q equal to .7. Similarly, the results for Q equal to .4 correspond to Q equal to .6. Thus, a broader range of results are implicitly presented.³

Table 3.2 shows how the riskiness of a representative bank in a deregulated world changes as the buffer and portfolio proportions change. The environment is characterized by losses in the two regions being independent. Also, as stated above, the mean and the standard deviation of losses per dollar of loans are assumed equal in the two regions. Consistent with the results in the pre-deregulated world, a comparison of the values for the probability of failure and the expected FDIC payout for each Q in column 1 with those in column 2, shows that a larger buffer reduces each of these risk measures. Similar results can be observed by comparing these two measures of risk for each portfolio in column 3 with the corresponding one in column 4. Furthermore, comparing the values for the probability of failure and the expected FDIC payout in column 1 with those in column 3, demonstrates that the combination of a larger mean and standard

³ This section investigates hypothetical portfolio combinations for an individual bank. The next section will introduce the systemic constraint that when there are 2 or more banks in the system, and the total pool of loans are fixed, one bank's portfolio decision implies the other bank's portfolio proportions. Thus, the term representative bank does not necessarily mean the average bank, and Q is allowed to take on values other than .5.

Table 3.2. Simulation results for a representative bank in a deregulated environment where losses between regions are uncorrelated, and the buffer, the portfolio proportions, and the mean of x are allowed to vary

A=1 $k(1)=.035$ $p[x(1), x(2)]=0$ $p[l(1), l(2)]=0$

	lambda=0		lambda=.01	
	B=.08	B=.09	B=.08	B=.09
<u>Q=.3</u>				
mean of $l(1)$	.019136	.019136	.0221	.0221
std. dev. $l(1)$	.0153	.0153	.0165	.0165
mean of $l(2)$	.00835	.00835	.0095	.0095
std. dev. $l(2)$	.00634	.00634	.0069	.0069
Prob. Failure	.00528	.00148	.0115	.00365
E(payout)	.000034	.0000087	.000085	.000024
<u>Q=.4</u>				
mean of $l(1)$	.0164	.0164	.0191	.0191
std. dev. $l(1)$	.01311	.01311	.0138	.0138
mean of $l(2)$	.0111	.0111	.0126	.0126
std. dev. $l(2)$	.00845	.00845	.00942	.00942
Prob. Failure	.00321	.00077	.00773	.0021
E(Payout)	.000019	.0000041	.000052	.000013
<u>Q=.5</u>				
mean of $l(1)$	.01366	.01366	.01578	.01578
std. dev. $l(1)$	.0109	.0109	.01178	.01178
mean of $l(2)$	.01391	.01391	.0159	.0159
std. dev. $l(2)$	.0106	.0106	.01149	.01149
Prob. Failure	.00258	.000586	.0065	.0017
E(Payout)	.000015	.0000031	.000043	.000010

deviation of losses per dollar of loans, all else held constant, generates a higher probability of failure and a higher expected payout. This finding is also supported by a similar comparison between columns 2 and 4.

Within each column of Table 3.2 it can be seen that there is an optimal portfolio from the regulators perspective. That is, there is a portfolio which generates a minimum probability of failure and expected payout. Among the alternatives evaluated in this example, it is the portfolio of Q equal to .5 which is optimal. This suggests that the regulators would prefer to have the banks in this environment hold an equal amount of each type of loan in their portfolios.

However, regardless of the portfolio chosen, comparing the results in Table 3.2 for each λ and buffer with corresponding ones from the top half of Table 3.1 shows that geographic deregulation will reduce the probability of failure and the expected payout by the FDIC for a representative bank. For example, if under deregulation the bank is in an environment where λ is equal to 0, it has a buffer of .08, and it selects a portfolio of 70% in asset 1 and 30% in asset 2 (i.e., $Q=.3$), the bank has a probability of failure equal to .00528. This can be contrasted to a probability of failure in the regulated environment equal to .0226. Also, the expected payout per dollar of loans falls from .000262 to .000034. Using the respective value from the regulated environment as the base, these translate into a 76% reduction in the probability of failure and an 87% reduction in the

expected payout by the FDIC.

Table 3.3 continues the results from a simulation where the mean and standard deviation of losses per dollar of loans are assumed to be equal in the two regions. The changing parameters reflected in this table are the correlation of the losses and the composition of the portfolio. The correlation of the x 's are allowed to take values $-.7$, 0 , and $+.7$. These correspond to correlations for losses of $-.177$, 0 , and $+.466$ respectively.

Results in this table suggest that a lower probability of failure and expected FDIC payout can be obtained as the correlation of losses to the regions gets algebraically smaller. This can be seen by comparing the results among columns 1, 2, and 3 for any given Q . In addition, the lowest value for the probability of failure and the expected payout by the FDIC is achieved when the losses are negatively correlated and a portfolio of equal proportions of the two assets is held by the bank.

Table 3.4 differs from Table 3.3 in that λ is now equal to $.01$ which generates a mean and standard deviation of losses per dollar of loans that are greater in Table 3.4 than in Table 3.3. Also, while the correlation of the x 's are still $-.7$, 0 , and $+.7$, the corresponding correlation of losses are now $-.233$, 0 , and $+.5$ respectively. Comparing Table 3.3 with 3.4 suggests that regardless of the correlation of losses or the proportions of the assets held in the portfolio, the probability of bank failure and the expected FDIC payout

Table 3.3. Simulation results for a representative bank in a deregulated environment where lambda equals 0, the regions have the same mean and standard deviation of losses per dollar of loans, and the portfolio proportions and correlation of loan losses are allowed to vary

A=1 B=.08 lambda=0 k(i)=.035

p[x(1), x(2)]	-.7	0	.7
p[l(1), l(2)]	-.177	0	.466

Q=.3

mean of l(1)	.011	.019136	.02215
std. dev. l(1)	.0092	.0153	.0156
mean of l(2)	.0055	.00835	.0095
std. dev. l(2)	.0045	.00634	.0066
Prob. Failure	1.2×10^{-7}	.00528	.02025
E(Payout)	2.05×10^{-10}	.000034	.0002

Q=.4

mean of l(1)	.0098	.0164	.019
std. dev. l(1)	.008	.01311	.0134
mean of l(2)	.0066	.0111	.0127
std. dev. l(2)	.0054	.00845	.00875
Prob. Failure	2×10^{-8}	.00321	.0187
E(Payout)	3.7×10^{-11}	.000019	.000184

Q=.5

mean of l(1)	.00816	.01366	.0158
std. dev. l(1)	.0068	.0109	.0114
mean of l(2)	.00817	.01391	.0158
std. dev. l(2)	.0068	.0106	.0113
Prob. Failure	1.09×10^{-8}	.00258	.0181
E(Payout)	2.17×10^{-11}	.000015	.000181

Table 3.4. Simulation results for a representative bank in a deregulated environment, where lambda equals .01, the regions have the same mean and standard deviation of losses per dollar of loans, and the portfolio proportions and correlation of loan losses are allowed to vary

A=1 B=.08 lambda=0.01 k(i)=.035

p[x(1), x(2)]	-.7	0	.7
p[1(1), 1(2)]	-.233	0	.5

Q=.3

mean of 1(1)	.0148	.0221	.02477
std. dev. 1(1)	.0114	.0165	.0166
mean of 1(2)	.0064	.0095	.0106
std. dev. 1(2)	.0049	.0069	.0071
Prob. Failure	.0000055	.0115	.0342
E(Payout)	1.05×10^{-8}	.000085	.00037

Q=.4

mean of 1(1)	.0127	.0191	.0212
std. dev. 1(1)	.0098	.0138	.01422
mean of 1(2)	.0085	.0126	.0142
std. dev. 1(2)	.0065	.00942	.00947
Prob. Failure	5.24×10^{-7}	.00773	.0321
E(Payout)	1.1×10^{-9}	.000052	.00035

Q=.5

mean of 1(1)	.0106	.01578	.0177
std. dev. 1(1)	.00815	.01178	.0119
mean of 1(2)	.0106	.0159	.0177
std. dev. 1(2)	.0081	.01149	.0117
Prob. Failure	3.44×10^{-7}	.0065	.0313
E(Payout)	7.8×10^{-10}	.000043	.00034

is always less in Table 3.3 than in the comparable cell of Table 3.4. This implies that the greater the mean and standard deviation of losses, the riskier the bank.

Both Table 3.3 and 3.4 can be used to support the notion that geographic deregulation reduces the riskiness of banks. This can be seen if the results of these tables are contrasted with those from the top half of columns 1 and 3 in Table 3.1. Observe that, even when assets are positively correlated, as long as the correlation is less than 1, a reduction in the probability of failure and expected FDIC payout can be achieved by geographic deregulation. For example, the third column of Table 3.4 shows that when losses are positively correlated and the bank selects a portfolio of equal proportion in the two assets (i.e., $Q=.5$), the probability of a bank failing is .0313. The corresponding probability of failure for the bank in a regulated environment where it lends to only one region is .0377. Thus, deregulation could generate up to a 17% reduction in the probability of failure. Similarly, the expected payout by the FDIC would fall from .048 cents per dollar of assets to .034 cents per dollar, a decrease of 29%.

The distinguishing feature of Tables 3.5 and 3.6 is that the mean and the standard deviation of losses per dollar of loans are now assumed to be different in the two regions. Table 3.5 differs from 3.6 in that in Table 3.5 λ is 0, and the correlation of loan losses are $-.177$, 0 , and $.466$, but in Table 3.6 λ is $.01$, and the

Table 3.5. Simulation results for a representative bank in a deregulated environment where lambda equals 0, the mean and standard deviation of loan losses are different in the two regions, and the portfolio proportions and the correlation of losses are allowed to vary

A=1 B=.08 lambda=0 k(1)=.05 k(2)=.035

p[x(1), x(2)]	-.7	0	.7
p[l(1), l(2)]	-.177	0	.466

Q=.3

mean of l(1)	.0156	.0273	.0316
std. dev. l(1)	.013	.0219	.0223
mean of l(2)	.00546	.00835	.0095
std. dev. l(2)	.00446	.0063	.0066
Prob. Failure	.00057	.0467	.0874
E(Payout)	.0000032	.00055	.00135

Q=.5

mean of l(1)	.01166	.0195	.0226
std. dev. l(1)	.00977	.0156	.0159
mean of l(2)	.0083	.014	.01586
std. dev. l(2)	.00676	.0106	.0109
Prob. Failure	.0000092	.0180	.0575
E(Payout)	2.7×10^{-8}	.00015	.00079

Q=.7

mean of l(1)	.007	.0117	.0136
std. dev. l(1)	.0059	.0094	.0096
mean of l(2)	.0116	.0195	.0222
std. dev. l(2)	.0095	.0148	.0153
Prob. Failure	.000005	.0106	.03925
E(Payout)	1.7×10^{-8}	.000086	.0005

Q=.8

mean of l(1)	.0046	.0078	.009
std. dev. l(1)	.0039	.0062	.0064
mean of l(2)	.0132	.0223	.025
std. dev. l(2)	.0108	.017	.0175
Prob. Failure	.000033	.0125	.0341
E(Payout)	8.32×10^{-8}	.00011	.00025

Table 3.6. Simulation results for a representative bank in a deregulated environment where lambda equals .01, the mean and standard deviation of loan losses are different in the two regions, and the portfolio proportions and the correlation of losses are allowed to vary

A=1 B=.08 lambda=.01 k(1)=.05 k(2)=.035

p[x(1), x(2)]	-.7	0	.7
p[l(1), l(2)]	-.233	0	.5

Q=.3

mean of l(1)	.0193	.0302	.0336
std. dev. l(1)	.0151	.023	.0233
mean of l(2)	.0068	.00954	.0107
std. dev. l(2)	.00524	.0069	.00705
Prob. Failure	.0023	.06835	.113
E(Payout)	.000014	.000882	.0019

Q=.5

mean of l(1)	.0144	.0216	.024
std. dev. l(1)	.0113	.0165	.0166
mean of l(2)	.0104	.016	.018
std. dev. l(2)	.008	.0115	.012
Prob. Failure	.000075	.0316	.0811
E(Payout)	2.45×10^{-7}	.00030	.00122

Q=.7

mean of l(1)	.0086	.013	.0144
std. dev. l(1)	.00676	.0099	.01
mean of l(2)	.0145	.022	.0251
std. dev. l(2)	.011	.0161	.01645
Prob. Failure	.000044	.0208	.060
E(Payout)	1.2×10^{-7}	.000187	.000826

Q=.8

mean of l(1)	.00575	.0086	.0096
std. dev. l(1)	.00451	.0066	.0068
mean of l(2)	.01656	.0254	.0287
std. dev. l(2)	.0127	.0184	.0188
Prob. Failure	.0002	.0234	.0536
E(Payout)	5.7×10^{-7}	.0002314	.000719

correlation of loan losses are $-.233$, 0 , and $.5$. Note that in both tables Q now ranges from $.3$ to $.8$. In the previous tables, the results were only given for Q equal to $.3$, $.4$, and $.5$. However, as previously mentioned, when the mean and standard deviation of losses per dollar of loans are the same in the two regions, the probability of failure and the expected payout for Q equal to $.3$ is the same as for Q equal to $.7$. Thus, a broader range of results was implicitly presented. In the following tables, where the means and standard deviations are not the same in the two regions, this parallel relationship does not hold. Instead, it is necessary to explicitly allow Q to take the full range of values.

The results in Tables 3.5 and 3.6 support the hypothesis that the lower the correlation coefficient of the losses, the lower is the probability of failure and the expected FDIC payout. In addition, comparing cells of 3.5 with corresponding ones in 3.6 supports the claim that the greater is λ , the riskier is the bank.

The optimal portfolio from society's perspective is no longer the one of equal proportions. Recall society would prefer the bank to hold the portfolio which generates the lowest probability of failure. Thus, the optimum portfolio is one where a larger proportion is held in the asset with the smaller mean and standard deviation of losses per dollar of loans. However, observe that the optimal portfolio is one with Q less than 1. Specifically, in this example, when losses are uncorrelated or negatively correlated, the optimum portfolio lies

between Q equal to .5 and .8. When losses are positively correlated, the optimum is with a Q greater than .7. However, comparing these results with those presented in Table 3.1 shows that the optimum portfolio is one with Q less than 1. This conclusion results from the fact that for each correlation coefficient, a lower probability of default and expected FDIC payout can be obtained by holding certain portfolios of loans to both regions. Thus, geographical deregulation provides the opportunity to reduce the riskiness of banks.

It follows then that a comparison of Tables 3.5 and 3.6 with their respective counterparts in Table 3.1 strengthens a claim made by Blair and Heggstad (4). They argue that whether an individual bank becomes more or less risky after deregulation of asset restrictions depends on how the bank reoptimizes its portfolio. Note, in the current example, if the bank before deregulation had a buffer of .08, and was in a region where k was equal to .035 and λ was equal to 0, its probability of failure was .0226 and the expected payout by the FDIC was .000262. After deregulation, if the losses between regions are independent and the bank selects a portfolio with Q equal to .3, the probability of failure rises to .0467 and the expected payout goes up to .00055. If it selects a portfolio with Q equal to .7, the probability of failure declines to .0106 and the expected payout declines to .000086. Thus, when the mean and standard deviation of losses per dollar of loans in the two regions are different, the effect of deregulation on the riskiness of a representative bank depends on

how the bank reoptimizes its portfolio. However, as suggested above, there do exist portfolios where the probability of failure and expected FDIC payout will decline. These results are stronger than those of Blair and Heggstad in that they show actual probability movements instead of upper bound movements.

Tables 3.7 and 3.8 allow explicit analysis of how changing the standard deviation of x per dollar of loans to a region affects the riskiness of the bank. Table 3.8 differs from 3.7 only in that the mean of x per dollar of loans is greater in Table 3.8. As might be expected, for any portfolio combination, the lower the standard deviation of losses per dollar of loans, the lower is the probability of failure and the expected FDIC payout. Also, all risk measures in Table 3.8 are greater than the risk measures for corresponding cells in Table 3.7. This implies that greater mean loss values increase the riskiness of banks. Finally, comparing the results of columns 1 and 2 of Table 3.7 and Table 3.8 with the corresponding ones from Table 3.1 indicates that when the mean and standard deviation of losses per dollar of loans are the same in the two regions, then geographical deregulation reduces the probability of failure and expected FDIC payout. However, as was previously suggested, a comparison of column 3 in Tables 3.7 and 3.8 with Table 3.1 indicates that when the means and the standard deviations of losses per dollar of loans to a region differ, the impact of deregulation on bank riskiness depends on the bank's reoptimization decision.

Table 3.7. Simulation results for a representative bank in a deregulated environment, where lambda equals 0, loan losses are uncorrelated, and the portfolio proportions and the standard deviation of x per dollar of loans are allowed to vary

A=1 B=.08 lambda=0.0 p[x(1), x(2)]=0 p[l(1), l(2)]=0			
	k(i)=.035	k(i)=.05	k(1)=.05 k(2)=.035
<u>Q=.3</u>			
mean of l(1)	.019136	.0273	.0273
std. dev. l(1)	.0153	.0219	.0219
mean of l(2)	.00835	.0119	.00835
std. dev. l(2)	.00634	.0091	.0063
Prob. Failure	.00528	.0635	.0467
E(Payout)	.000034	.00080	.00055
<u>Q=.4</u>			
mean of l(1)	.0164	.0234	.0236
std. dev. l(1)	.01311	.0187	.01823
mean of l(2)	.0111	.016	.01115
std. dev. l(2)	.00845	.0121	.00844
Prob. Failure	.00321	.0526	.02821
E(Payout)	.000019	.00061	.00031
<u>Q=.5</u>			
mean of l(1)	.01366	.0195	.0195
std. dev. l(1)	.0109	.0156	.0156
mean of l(2)	.01391	.0198	.014
std. dev. l(2)	.0106	.0151	.0106
Prob. Failure	.00258	.0483	.0180
E(Payout)	.000015	.00054	.00015
<u>Q=.7</u>			
mean of l(1)	.00835	.0119	.0117
std. dev. l(1)	.00634	.0091	.0094
mean of l(2)	.019136	.0273	.0195
std. dev. l(2)	.0153	.0219	.0148
Prob. Failure	.00528	.0635	.0106
E(Payout)	.000034	.0008	.000086

Table 3.8. Simulation results for a representative bank in a deregulated environment, where lambda equals .01, loan losses are uncorrelated, and the standard deviation of x per dollar of loans and the portfolio proportions are allowed to vary

A=1 B=.08 lambda=0.01 $p[x(1), x(2)]=0$ $p[l(1), l(2)]=0$

k(i)=.035 k(i)=.05 k(1)=.05
k(2)=.035

Q=.3

mean of l(1)	.0221	.0302	.0302
std. dev. l(1)	.0165	.023	.023
mean of l(2)	.0095	.0131	.0095
std. dev. l(2)	.0069	.0096	.0069
Prob. Failure	.0115	.0897	.06835
E(Payout)	.000085	.00125	.000882

Q=.4

mean of l(1).	.0191	.0259	.026
std. dev. l(1)	.0138	.01975	.0197
mean of l(2)	.0126	.0175	.0127
std. dev. l(2)	.00942	.0128	.0093
Prob. Failure	.00773	.0773	.0452
E(Payout)	.000052	.00098	.00054

Q=.5

mean of l(1)	.01578	.0216	.0216
std. dev. l(1)	.01178	.01645	.0165
mean of l(2)	.0159	.0218	.016
std. dev. l(2)	.01149	.01601	.0115
Prob. Failure	.0065	.0723	.0316
E(Payout)	.000043	.00090	.00030

Q=.7

mean of l(1)	.0095	.0131	.013
std. dev. l(1)	.0069	.0096	.0099
mean of l(2)	.0221	.0302	.022
std. dev. l(2)	.0165	.023	.0161
Prob. Failure	.0115	.0897	.0208
E(Payout)	.000085	.00125	.000187

2. Systemic risk changes

The analysis in the previous section suggests that geographic deregulation can potentially reduce the probability of failure and the expected payout by the FDIC for a representative bank. As was suggested in Chapter 2, however, the question still remains as to how geographic deregulation will affect the riskiness of the banking system. Recall, it was stated that the notion of systemic risk could be approximated in three ways: the probability of a bank failure, the probability of multiple bank failures, or the total expected payout by the insuring agency. The question of systemic risk from the insuring agency's perspective is interesting because it might be argued that the agency already pools the risk of losses in the banking system. If so, geographic deregulation would have no affect on this measure of systemic risk.

The model developed in Chapter 2 can be used to analyze the effect of geographic deregulation on the probability of a bank failure and the probability of multiple bank failures if two assumptions are made. First, loan losses in different regions are assumed to be independent. This will allow a characterization of the conditional probability function. Second, post-deregulation banks are assumed to be identical to one another. This allows the results for a representative bank to reflect the condition of any bank in the system. While this is an extreme assumption, it does allow the analysis to be tractable.

The necessary formulas to compute the effect of geographic deregulation on these system-wide risk measures are given by equations 2.32 and 2.34 from Chapter 2. These state that prior to deregulation, given the two assumptions stated above, the probability of a bank failure is equal to,

$$\Pr(H_f) + \Pr(T_f) - \Pr(H_f)\Pr(T_f) \quad (2.34)$$

and the probability of multiple bank failures is equal to,

$$\Pr(H_f)\Pr(T_f). \quad (2.32)$$

Furthermore, after deregulation, the assumption that the banks are identical implies that the probability of a bank failure is equal to the probability of multiple bank failures. That is, if conditions lead one bank to fail, they lead all the banks to fail. Using the results from the simulation exercises, it is possible to determine the values for these systemic risk measures. The results of these computations are presented in Table 3.9.

Observe that the table compares these risk measures under a wide spectrum of parameter settings. The last two columns show that for any set of lambdas, kappas, and buffer, deregulation can potentially reduce the probability of a bank failing in the system. Note, that each number under the column marked post (i.e., values for the deregulated environment), is smaller than its respective counterpart under the column marked pre. However, as was suggested in the previous section,

this result rests on the banks holding a certain portfolio. It is possible that the banks could select portfolios where the probability of a bank failing rises. From equation 2.34, it can be seen that this condition could result if the banks select portfolios such that the sum of the probabilities of the two banks failing individually increased sufficiently to offset any increase in the joint probability of the banks failing. This condition could occur only if the two regions have different means and standard deviations of losses per dollar of loans. If these parameters are the same in the two regions, section 1 of this chapter demonstrated that any diversified portfolio would reduce the probability of a representative bank failing. Hence, it is only when the means and standard deviations of loan losses per dollar of loans are different between regions that the banks portfolio selection could adversely influence the probability of a bank failing in the system.

The effect of geographic deregulation on the probability of multiple bank failures is not as easily predicted. Note from equation 2.31 that this probability depends on the interaction of two variables.

$$\Pr(H_f \cap T_f) = \Pr(H_f | T_f) \Pr(T_f) \quad (2.31)$$

One is the conditional probability of bank H failing given that bank T fails. The other is the unconditional probability that bank T fails. The assumption that post-deregulation banks are identical clearly increases the conditional probability of H failing given T fails. However, it was just reported that the probability of T failing

Table 3.9. A comparison of the systemic risk changes, as measured by the probability of single and multiple bank failures, that result from interstate deregulation

A=1 Q=.5 p[1(1), 1(2)]=0

PARAMETERS			PROB. OF MULTIPLE FAILURES		PROB. OF FAILURE	
B	k(1)	λ	Pre	Post	Pre	Post
.08	.035	0	.00051	.00258	.04469	.00258
.09	.035	0	.00017	.00059	.02603	.00059
.08	.05	0	.01232	.0483	.2097	.0483
.08	.05	.01	.0196	.0723	.2604	.0723
.08	.035	.01	.00142	.0065	.074	.0065
.09	.035	.01	.00034	.0115	.0336	.0115
.08	.035 .05	0	.00025	.0180	.1311	.0180
.08	.035 .05	.01	.00528	.0316	.1724	.0316

potentially declines. Thus, the product of these two components is not obvious.

Contrasting columns 4 and 5 of Table 3.9, it can be seen that under the present scenario, the probability of multiple failures increases. However, this result hinges critically on the conditional probability rising sufficiently to offset the decline in the probability of bank T failing. Had a less stringent assumption about the similarity of post-deregulation banks been made, this outcome might be reversed.

Finally, there arises the question of how geographic deregulation influences the total expected payout by the FDIC. Recall, it had been suggested earlier that one might argue that the FDIC already pools bank risk and therefore a re-structuring of portfolios would have no effect on the total expected payout. However, from Table 3.10 it can be seen that this is not the case.

The column in Table 3.10 labeled pre gives the total expected payout by the FDIC under a regulated environment for various assumptions about the mean and standard deviation of losses per dollar of loans in each region. Recall that in a regulated environment, each bank lends to only one region, and thus Q is equal to one for bank H and is equal to zero to bank T. The last three columns of the table give the total expected payout by the FDIC in a deregulated environment for various assumptions about the correlation of loan losses and the portfolios selected by the banks. The current analysis assumes that

Table 3.10. A comparison of the systemic risk changes, as measured by the total expected payout by the FDIC, that result from interstate deregulation

$A^j=1$ $B^j=.08$		<u>lambda=0</u>		
$p[x(1), x(2)]$	<u>pre</u>	<u>post</u>		
		<u>-.7</u>	<u>0</u>	<u>.7</u>
<u>k(1)=.035</u>				
$Q_H=1$ $Q_T=0$	.000524			
$Q_H=$ $Q_T=.5$		4.34×10^{-11}	.00003	.000362
$Q_H=.7$ $Q_T=.3$		4.1×10^{-10}	.000068	.0004
<u>k(1)=.05 k(2)=.035</u>				
$Q_H=1$ $Q_T=0$	.002552			
$Q_H=$ $Q_T=.5$		5.4×10^{-8}	.0003	.00158
$Q_H=.7$ $Q_T=.3$		3.37×10^{-6}	.000636	.00185
<u>lambda=.01</u>				
<u>k(i)=.035</u>				
$Q_H=1$ $Q_T=0$	.000955			
$Q_H=$ $Q_T=.5$		1.5×10^{-9}	.000086	.00068
$Q_H=.7$ $Q_T=.3$		2.1×10^{-8}	.00017	.00074
<u>k(1)=.05 k(2)=.035</u>				
$Q_H=1$ $Q_T=0$	.0036			
$Q_H=$ $Q_T=.5$		4.9×10^{-7}	.0006	.00244
$Q_H=.7$ $Q_T=.3$		.0000141	.0011	.0027

the banks are of equal size and that the total pool of loans is fixed. It then addresses the issue of how a redistribution of this fixed pool influences the total expected payout. These assumptions necessitate that the sum of the Q 's be equal to one.

A comparison of any of the values in the last three columns of this table with their respective counterparts in the column marked pre (i.e., the regulated environment), suggests that deregulation will reduce the total expected payout by the FDIC. This result holds for each set of assumptions about the lambdas, kappas, rho, and the portfolio proportion, Q .

In addition, the results highlight another interesting observation. Recall from section 1 of this chapter that when the mean and standard deviation of losses per dollar of loans were different between regions, the optimal portfolio for a representative bank from the regulators perspective was not one with an equal proportion in the two assets. Rather, it was one where the bank held a larger proportions in the less risky asset. However, under the current restriction that the total pool of loans is fixed and the banks are of equal size, a lower total expected payout can be achieved with each bank holding portfolios of equal proportion.

Observe that when λ is .01, k_1 is .05 and k_2 is .035, the total expected payout by the FDIC when banks lend to only one region is equal to .0036. However, in a deregulated environment where losses on loans between regions are uncorrelated, and bank H holds 70% of its portfolio

in loans to region 2 (i.e., $Q_H=.7$), while bank T holds 30% of its portfolio in these loans (i.e., $Q_T=.3$), the total expected payout falls to .0011. Thus, the actuarially sound fund would decline.

In fact, from Table 3.6, it can be seen that the move to a deregulated environment, where Q_H is equal to .7, results in the expected payout by the FDIC to this bank becoming .000187. This is a decline from the expected payout of .0004775 to this bank in a regulated environment (see Table 3.1). Similarly, for bank T in the deregulated environment where Q_T is equal to .3, the expected payout by the FDIC is .000882. In the regulated environment, the expected payout to this bank was .00312. So, deregulation leads the FDIC to have a lower expected payout to each bank.

However, an even larger decline in the total expected payout is possible if both banks hold an equal proportion of loans to each region. In the current example, the total expected payout falls to .0006. Hence, while the expected payout to bank H does not decline by as much (.0003 versus .000187), the expected payout to bank T falls sufficiently (.0003 versus .000882) to lead to an overall decline in the FDIC total payout.

Thus, while it is optimal (i.e., minimizes the probability of failure and expected FDIC payout for an individual bank) to have a representative bank hold a portfolio of unequal proportions in the two loans, the constraints that the total pool of loans is fixed and the banks are of equal size precludes each bank from achieving this

individual optimal position. Hence, from a system-wide perspective, if the goal is to minimize the total expected payout, it is advantageous to have each bank hold a less-than-optimal individual portfolio, in order to achieve an optimal systemic position.

Careful interpretation of this observation is required. Realize that this conclusion is the direct result of holding the pool of loans fixed and the bank's sizes equal. In fact, over time, the pool of loans could change. This would allow each bank to achieve a position such that the portfolio generated the minimum expected payout by the FDIC for the individual bank, and also the minimum total expected payout. This could happen if the amount of loans to the less risky region increases while the amount to the riskier region declines. Thus, while in the short run, the optimal portfolio for a representative bank differs from the optimal for the system, in the longer run, these two portfolios are completely compatible.

Further analysis can highlight the rationale for the initial finding that geographic deregulation reduces the necessary size of the insurance fund if the current fund is actuarially sound. Specifically, note that there are two conditions under which the pre- and post-deregulation total expected FDIC payout would be the same. One case is when banks have an infinite amount of capital. In this scenario, the probability of failure both before and after deregulation would be zero. Hence, the expected payout by the FDIC would be zero.

The second case is when banks have no capital. In this situation, the reshuffling of assets would not affect the expected FDIC payout. This results from the fact that portfolio changes cannot reduce the probability of bank failure because in this case it is essentially equal to 1. Put differently, there is no private capital over which to spread the losses. Thus, all losses must be absorbed by the FDIC. When there is private capital, portfolio reoptimization allows the loan losses to be more effectively spread over the existing capital before it is necessary for the FDIC to absorb losses.

This section has demonstrated that geographic deregulation will affect system-wide risk measures differently. If the appropriate measure of risk is the probability of multiple failures, then deregulation will likely increase systemic risk. If the appropriate measure of systemic risk is the probability of a bank failing or the total expected payout by the FDIC, then deregulation will potentially reduce systemic risk. The next chapter will evaluate some of the policy implications that follow from these systemic results and the results in section 1 on the risk changes for a representative bank.

IV. POLICY IMPLICATIONS AND CONCLUSIONS

A. Introduction

The results presented in Chapter 3 provide valuable information on the affect of geographical deregulation on the social riskiness of banks. The next section of this chapter will interpret the policy implications of these results. The third section will discuss the limitations of the model and the results. The fourth section will suggest some possible extensions to the research. Finally, the last section will summarize the research project.

B. Policy Implications

The implications of the results derived in Chapter 3 can be grouped into three categories: scope issues, efficiency issues, and stability issues. The scope implications deal with the issue of the appropriate range of geographical deregulation. This concern focuses on whether policy makers should allow regional pacts among contiguous states as are being advocated by various banking groups or instead should promote a complete breakdown of geographic barriers.

The results in Chapter 3 suggest that the greatest reduction in the probability of a representative bank failing and in the expected payout by the FDIC could be achieved when losses on the loans in the portfolio are negatively correlated. It would seem probable that the greater the geographical distance between states, the less correlated

the losses will likely be. As an example, consider the losses on a portfolio of loans made to Iowa farmers and Florida citrus growers. It would seem that the losses on these two types of loans would be less correlated than those on loans made to Iowa farmers and Illinois farmers. Thus, from a social perspective, where society is concerned about the probability of a bank failure, it would be more advantageous to have Iowa and Florida banks merge rather than allow the merger between Iowa and Illinois banks. In a more general sense, this would tend to argue against regional compacts and argue in favor of a complete breakdown of geographical barriers.

Coupled with this implication is the suggestion for an appropriate FDIC guideline when selecting a merger partner for a failing bank. Rather than simply accepting the highest bid, the FDIC might give preferential treatment to banks from regions that are more negatively correlated with the region of the failing bank. This would offer the greatest potential for a reduction in the probability of failure and the expected payout by the FDIC for the newly-merged bank.

The second implication that follows from the results of the simulations concerns the efficiency gains from geographical deregulation. Efficiency gains refer to the ability of the insuring agency to protect the safety of the banking system with a lower per-bank premium. Recall that the results in Table 3.10 suggested that the total expected payout by the FDIC will decline as geographic barriers are removed. This would imply that the necessary premiums to

maintain an actuarially sound fund would also decline. Thus, banks could divert those resources previously expended on premiums to more productive uses.¹

The third policy implication that can be derived from the simulation results concerns overall banking stability. Note that the removal of geographic barriers will provide opportunities for banks to reduce their probability of failure. However, as banks begin holding portfolios of loans to various regions, the similarity of individual banks will grow. This implies that events which trigger one bank to fail will likely set off many bank failures. Thus, as was argued in Chapter 3, while the probability of an individual bank failure declines, the probability of multiple bank failures will likely increase. If in fact regulators are concerned with the public's perception of bank safety, they may wish to allow more individual bank failures and avoid the potential for multiple failures. The argument is that the public might accept isolated failures as simply the competitive market place at work. However, the observation of many simultaneous failures may invoke public concern and encourage panics. Obviously, policy makers must weigh the benefits of an increase in individual bank safety against the potential harm that results from

¹This argument holds if the comparison is made between two actuarially sound funds. If the fund prior to deregulation is not actuarially sound, then the actuarially sound fund after deregulation might not be smaller than the actual fund before deregulation.

widespread failures.

C. Limitations

There are three factors which can be identified as limiting the robustness of the conclusions derived from this research. First, the necessity to assume the joint probability distribution on loan losses, rather than being able to determine the actual distribution, has important implications. While, as was suggested in Chapter 2, the selection of the truncated normal distribution should have made the analysis both realistic and tractable, it also influenced the final outcome. Had a different distribution been selected (e.g., the log normal), the results might have been different.² Therefore, since lack of appropriate data limited my ability to determine the actual distributional properties of loan losses, any application of these results must be conditional on the acceptance of the assumed distribution.

A second factor which needs to be considered in interpreting the results concerns the competitive changes that may occur with deregulation. Some would argue that the current restrictions on geographic expansion have created pockets of monopoly power for local

²In fact, simulations that were run with the assumption that loan losses were distributed as a bivariate lognormal led to conflicting results. The analysis in the Appendix helps to explain those findings.

institutions (16, 17). Once the geographic barriers are removed, competition will alter the decisions made by the local institutions. Namely, if an institution formerly selected safe assets in order to protect itself, it might now be forced to pursue more risky endeavors in an attempt to maintain its profitability. Thus, the characteristics of the assets which the bank holds may change from those in the regulated environment. Whether the benefits from geographic expansion will outweigh the detrimental effect of selecting riskier assets is an empirical question. Insights into this possibility however can be gained by comparing the results from a simulation in a safe environment (e.g., $\lambda=0$ $k=.035$) with those from simulations on portfolios with more risky assets (e.g., $\lambda=.01$ $k=.05$). The final outcome will still depend on the portfolio selected. However, it is possible that under these circumstances deregulation might not reduce the probability of failure or the expected payout by the FDIC.

A third limiting factor which needs to be mentioned is that this research is static. That is, it compares the social riskiness of banks before and after deregulation. It does not trace out the time paths over which the change occurs. Drawing from the previous paragraph, the nature of the institutions might be radically different during the transition period as opposed to the end result. This model limits the comparison to only the beginning and end results.

D. Extensions

Careful reflection suggests a few extensions which might be carried out on the current research. First, as more data become available, it would be advantageous to try to determine the actual distribution that loan losses follow. This would then make it possible to carry out comparable analysis on this distribution and eliminate the necessity of assuming the distributional properties for loan losses. Second, with these data it might also be beneficial to determine the actual correlation of loan losses between regions. This would provide valuable information to the regulatory agency charged with making decisions on mergers and geographic expansion. It may in fact influence the decision as to the appropriateness of deregulation since the correlation of the losses has an important influence on the amount of benefits that can be derived from deregulation.

A third possible extension to this research is to apply a Roy's Safety First type model to the solvency of the FDIC. Note that the current research argues that the expected FDIC payout will potentially decline. If one were to compute the variance of the FDIC payout it would be possible to compare the upper bound on the probability of the FDIC fund going bankrupt before deregulation with the upper bound after deregulation. While the previous criticism that this approach only tells movements in the upper bound of the probability still applies, it might provide some interesting insights into possible future problems with the solvency of the fund.

E. Summary

This research project investigated the question of how geographic deregulation might affect the riskiness of the banking system. In Chapter 1, it was argued that the geographical constraints imposed by the McFadden Act are binding on small and medium size banks. Furthermore, it was noted that states or groups of states in this country have unique economic cycles and that these cycles influence bank loan performance. Finally, it was suggested that the variance of asset returns might not be the appropriate measure of risk from a social perspective. Rather, the probability of a bank failing and the necessary size of an insurance fund were offered as alternative measures of risk from society's viewpoint. Thus, it was found that portfolio theory in a mean-variance context would not provide the relevant answers and an alternative approach needed to be developed.

Chapter 2 developed a simplified two bank, two asset model within which to analyze the risk changes that result from geographic deregulation. The probabilistic framework that was suggested required specification of a distribution on loan losses and a characterization of the portfolios which banks hold. Furthermore, it specified the appropriate approach to investigate risk changes at an individual bank, and the necessary assumptions to analyze systemic risk changes.

Since no closed-form solution was available for the derivatives of the integral of the truncated bivariate normal density function assumed on loan losses, Chapter 3 documents the simulation exercises that were

conducted to determine the implications of deregulation. Using various specifications about the characteristics of the loan losses in the regions, the correlation of the losses, and the portfolio selected by the bank, the questions of changes in the probability of bank failure and the expected FDIC payouts were addressed. In addition, following the required assumptions stated in Chapter 2, systemic risk changes were analyzed.

Chapter 4 then draws on the results of these simulations to suggest possible policy implications that follow from the research. Specifically, this chapter argues against regional pacts and in favor of a full breakdown of geographic barriers. However, it also raises the issue of a tradeoff between an increase in individual bank safety and the potential increase in the probability of multiple bank failures. Finally, it suggests that geographic deregulation should be beneficial to society since it can reduce the necessary size of the insurance fund. Recall, the size of the fund was suggested as an alternative measure of risk from a social perspective. Chapter 4 concludes by identifying the limitations of the model and suggesting some possible extensions to this research.

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VII. APPENDIX: THE RELATIONSHIP BETWEEN CHANGES IN THE VARIANCE AND THE PROBABILITY OF DEFAULT WITH A LOG NORMAL DISTRIBUTION

Movements in the variance of a distribution and the probability of default are not always consistent with each other. An example of a distribution where this compatibility does not always hold is the log normal distribution.

Borrowing from the framework developed in Chapter 2, define capital at the end of the period as

$$C_{t+1} = A^* - D_t - l. \quad (A.1)$$

Assume that losses, l , are distributed log normally. Failure occurs when capital at the end of the period, C_{t+1} , is less than or equal to zero. This event happens when losses, l , are greater than the buffer, $A^* - D_t$. To provide an intuitive explanation for why an increase in the variance of losses does not imply a decrease in the probability of default when losses are log normally distributed, it is advantageous to convert the problem into one that can be analyzed in normal space.

Observe, that a variable with a log normal distribution can be transformed into a variable with a normal distribution in the following manner. If,

$$l = e^x \quad (A.2)$$

and l is log normally distributed, then x is normally distributed.

Thus, if failure occurs when losses are greater than the buffer,

$$l > A^* - D_t, \quad (\text{A.3})$$

then equation A.3 can now be written as,

$$e^x > A^* - D_t. \quad (\text{A.4})$$

However, this is equivalent to writing that failure occurs when,

$$x > \ln(A^* - D_t), \quad (\text{A.5})$$

where x is a normally distributed variable. The probability of failure is found by determining the probability that x is greater than the log of the buffer. Graphically, this probability is given by the shaded area under the normal probability distribution function in Diagram A.1.

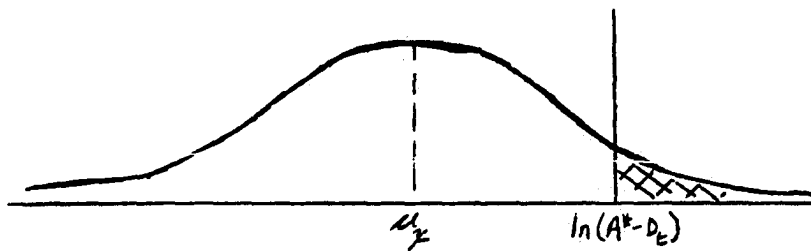


Diagram A.1. The Probability of Default in Normal Space

Aitchison and Brown (1) have shown that the mean and variance of a log normally distributed variable, l , are related to the mean and variance of a normally distributed variable, x , in the following way.

$$u_1 = e^{(u_x + (1/2)\sigma_x^2)} \quad (\text{A.6})$$

and,

$$\sigma_1^2 = (e^{(2u_x + \sigma_x^2)})(e^{(\sigma_x^2)} - 1). \quad (\text{A.7})$$

Solving these for the mean and variance of x as functions of the mean and variance of l yields

$$u_x = 2\ln(u_1) - (1/2)\ln(\sigma_1^2 + e^{(2\ln(u_1))}) \quad (\text{A.8})$$

$$\sigma_x^2 = \ln(\sigma_1^2 + e^{(2\ln(u_1))}) - 2\ln(u_1). \quad (\text{A.9})$$

Note from equations A.8 and A.9 that a change in the variance of losses, σ_1^2 , while holding the mean of losses constant, will result in a change in both the mean and variance of x . Mathematically, this is expressed by taking the derivatives of equations A.8 and A.9 with respect to the variance of losses. These derivatives are given in equations A.10 and A.11.

$$\frac{du_x}{d\sigma_1^2} = -\frac{1}{2} \left[\frac{1}{\sigma_1^2 + e^{2\ln(u_1)}} \right] < 0 \quad (\text{A.10})$$

$$\frac{d\sigma_x^2}{d\sigma_1^2} = \frac{1}{(\sigma_1^2 + e^{2\ln(u_1)})} > 0 \quad (\text{A.11})$$

From equations A.10 and A.11, it can be seen that a change in the variance of losses results in the mean and variance of x moving in opposite directions. Specifically, a decrease in the variance of losses will increase the mean of x but will decrease the variance of x . The increase in the mean of x will raise the probability of failure (i.e., increase the area outside $\ln(A^*-D_t)$), but the decrease in the variance of x will reduce this probability (i.e., reduce the area outside $\ln(A^*-D_t)$). This can be seen graphically in Diagram A.2 which presents the former distribution on x with a mean of u_x and a variance of σ_x^2 , and the new distribution on x that results from a reduction in the variance of losses. This new distribution has a mean equal to u_x' which is greater than u_x , and a variance of $\sigma_x'^2$ which is less than σ_x^2 .

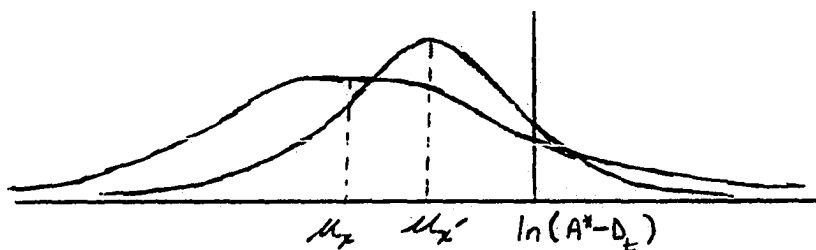


Diagram A.2. The affect on the probability of default of a change in the variance of losses.

The two conflicting movements in the parameters of the distribution on x lead to ambiguity as to what happens to the probability of failure. The final outcome will hinge on the size of

the buffer, $A^* - D_t$. Thus, to assume that a reduction in variance reduces risk might be in error if risk is approximated by the probability of failure, and the appropriate distribution is the log normal.