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AGRICULTURAL LENDING AND BANK CLOSURES IN THE FIRST HALF OF 1986: A LOGIT REGRESSION MODEL

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Introduction

Less than four commercial banks a year were declared insolvent and closed on average, over the 1946-74 period. Now, bank closures are becoming almost a daily event. Since 1982, 303 commercial banks have been closed by their regulators; almost 60 percent were rural and over 40 percent agricultural.[2] These closures and their determinants have important implications for the stability of the banking system, the availability of credit in farm and rural areas, as well as the future role of commercial banks in financing farm production.

This paper examines the determinants of bank closure during the first half of 1986 using a relatively new approach. The focus is on institutions declared insolvent and closed by regulators rather than failure, which is not as well defined for banks. A probability-of-bank-closure model is developed where the closure outcome is a reaction of bank regulators to a bank's deteriorating financial condition and systemic risk factors. Measures of bank capital, profitability, loan quality, management strategy, local economic characteristics, and variables reflecting regulator concerns not directly pertaining to the bank's solvency are hypothesized to be key determinants of closure probability. Bank specialization in agricultural lending is viewed as a component of management strategy in this framework.

The logit estimation method is used to produce parameter estimates for this probability-of-closure model. Several specifications are estimated to illustrate the robustness of the results. Different specifications of three models found in the literature are estimated for comparison. The models are then rated on the basis of their bank closure classification power and Akaike Information Criterion (AIC) statistics.

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2 Bank closures are FDIC-insured commercial banks that were closed due to financial difficulties. Banks receiving open-bank assistance, merged to prevent closure, or located in U.S. possessions and territories are excluded. Rural banks are those headquartered in nonmetropolitan counties. Agricultural banks have farm loan to total loan ratios exceeding the unweighted average of such ratios at all insured commercial banks.

Institutional Considerations

An unregulated business fails when it is not able to meet its current obligations. Usually, a firm's creditors will then force it into bankruptcy if the market value of its liabilities exceeds the market value of its assets. Such a firm is market-value insolvent and has negative net worth. Otherwise, if some true net worth remains, the firm will voluntarily seek bankruptcy. Bankruptcy affords the opportunity to either restructure the firm or liquidate its assets in an orderly manner.

Banks cease operation under a different set of rules.[3] The decision to "fail" a bank rests with its chartering authority: the Comptroller of the Currency for national banks or the relevant state banking agency for state banks. While the chartering authorities may close a bank if certain banking statutes have been violated, almost all are closed due to insolvency (Avery and Hanweck, 1984). When a bank is determined to be insolvent by its chartering authority, the Federal Deposit Insurance Corporation (FDIC), as receiver, is notified that the bank is "in imminent danger of failing." The FDIC has the option to liquidate the bank, arrange its acquisition by a healthy bank, or provide "open bank assistance."

Several aspects of this process may result in market-value insolvent banks remaining open. If the chartering authorities believe that a merger without public assistance or other private recapitalization scheme is likely to occur in the near future, notification of the FDIC is delayed. Alternatively, the FDIC may request the chartering agency not to close the bank until a subsidized acquisition (known as a purchase and assumption transaction) is negotiated. The FDIC will make this request if a purchase and assumption is judged to be the preferred resolution technique but more time is needed to attract and negotiate with a satisfactory acquiring bank. After the purchase and assumption transaction's terms have been agreed upon, the insolvent institution is closed and immediately reopened by the acquiring bank.

Open bank assistance, as its name implies, does not result in the bank's closure. Rather, it is returned to solvency with financial assistance from the FDIC. Negotiations between the bank's owners and the FDIC over the terms of such assistance, however, may lengthen the amount of time that the market-value insolvent bank remains open.[4] Of course, the chartering authority's approval is needed to permit the bank's continued operation during this time.

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[3] For a more complete discussion of the bank closure process see Benston, Eisenbeis, Horvitz, Kane, and Kaufman (1986).

[4] The "rescue" of Continental Illinois in 1984 is an example of this type of transaction. As of September 10, 1986 three banks received such assistance in 1986.

Finally, a bank that is market-value insolvent will remain open if its regulators are not aware of its true condition. Lack of accounting data on a market-value basis makes it impossible to identify precisely how many banks are market-value insolvent without on-site examinations. While most analysts believe that fewer market-value insolvent banks than savings and loans remain open, some believe the number to be nontrivial (Benston, et.al., 1986). In addition, the number of such banks is likely to have risen in recent years, considering the growth in financial stress exhibited by the industry and the limited examiner resources of the regulatory agencies.

Federal deposit insurance and the Federal Reserve System's (FRS) role as lender of last resort enable market-value insolvent banks to remain going concerns in spite of market pressures. Deposit insurance substantially reduces the incentive for depositors to withdraw funds from such banks, while emergency borrowings through the FRS discount window allow the bank to meet its current obligations.

From a research perspective, the distinction between failure (market-value insolvency) and closure is important for two reasons. First, the determinants are somewhat different, because regulators close only a subset of insolvent banks at any point in time. Considerations such as regulator-incurred costs and banking system stability do not influence the probability of market-value insolvency, yet they are pivotal to the probability of closure. [5] Defining failure as closure may thus lead to poorly specified models.

Second, results may be interpreted incorrectly if the failure-closure distinction is ignored and events affecting the probability of closure are all attributed to the actions of the individual bank or the general economy. As Barth, Brumbaugh, Sauerhaft and Wang (1986) point out, most bank failure studies are actually bank closure studies, where these errors are common. [6] The probability of closure is jointly determined by individual banks, their regulators, and economic events outside the industry. Available data and models do not allow for accurate separation of bank from regulator behavior.

To illustrate the possible size of the failure-closure distinction, semiannual data on closures, potentially vulnerable banks, and the ratio of bank closures to potentially vulnerable banks at the end of the previous six month period are presented in table 1 for the

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[5] See Short, O'Driscoll, Jr., and Berger (1985) as an example of this problem. Using five bank-level financial ratios as the only independent variables in a probit bank failure model, they conclude ". . . that management decisions to incur portfolio risk have played a significant role in the determination of bank failure." Regulator actions were ignored.

[6] These authors distinguish their savings and loan closure study from previous failure studies by including a measure of the Federal Savings and Loan Insurance Corporation's (FSLIC) ability to absorb losses from thrift-closures in their probability-of-closure model.

1983-1986 period. Potentially vulnerable banks are those which reported past-due and nonaccrual loans exceeding their primary capital (equity capital plus loan loss reserves) at the end of the quarter. Melichar (1986) found that over two-thirds of the banks closed in 1985 were in this potentially vulnerable grouping based on data from the December preceding closure. Over a longer time-frame, Marino (1984) found the ratio of primary capital less past due and nonaccrual loans to total assets to be a powerful leading indicator of closure.

Equating the potentially vulnerable condition with economic insolvency, however, has serious drawbacks. Most past-due and nonperforming loans do not result in total loss, so these banks do not necessarily have negative market values. On the other hand, adjustments are not made for market-value losses caused by interest-rate risk exposure or other potential losses not reflected in bank accounting data, which would weaken many banks' positions.[7] Moreover, banks have strong incentives to under report their past-due and nonperforming loans. With these caveats in mind, the data suggest that bank regulators have not drastically changed their closure rules over the past three years, with the ratio of closures per half-year to vulnerable banks at the end of the previous period rising only slightly.

A Model of Closure

A bank's financial condition deteriorates because it is overexposed to at least one of five risk factors when adverse or unexpected events occur in the nonbanking economy. These are: credit (loan default) risk, fraud risk, liquidity risk, interest-rate risk, and operating environment risk.[8] Overexposure then becomes losses, which first absorb the bank's profit, followed by its loan loss reserve and equity capital. When equity capital is exhausted, the bank is market-value insolvent; it becomes a candidate for closure by regulators. The regulators' decision to close the institution is based on their estimates of: expected cost to the deposit insurance fund, expected damage to the banking system's stability, and the expected effects on the local economy.

Credit risk refers to the probability that customers will not repay loans. Credit risk increases when banks do not diversify their loan portfolios across both individuals and industries. The performance of banks that concentrated their lending in agriculture, oil and gas, commercial real estate, or to less developed nations, show the drawbacks to this strategy (Martin, 1986; Seidman, 1986; Clarke, 1986). Many analysts believe that the loan quality problems

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[7] Bank accounting data is based on Generally Accepted Accounting Principles (GAAP), which uses historical costs, not current market values.

[8] Benston et.al. (1986) develops a more comprehensive and somewhat different set of risk factors. Those which appear to have been most influencial for closures in the past several years are discussed here.

resulting from credit-risk overexposure can explain most bank closures in the 1980's.

Fraud risk is difficult to detect and quantify ex ante. Fraud and insider abuse have been identified as the primary cause of closure in nearly half of the bank closures over the 1982-84 period (Peterson and Scott, 1985).[9] Fraud and insider abuse range from making unsound loans to bank officers or their cronies who engage in wild speculation with the borrowed funds to "loans" to nonexistent borrowers. When it takes this form, fraud that threatens bank solvency should be revealed through declines in the bank's loan quality and performance (Meyer and Pifer, 1970).

Historically, more savings and loans than banks have suffered insolvency from overexposure to interest-rate risk. Financial institutions assume interest-rate risk when the maturities (repricing opportunities) of their assets and liabilities are not matched. For example, an institution suffers losses from this type of risk if it has a low-rate, long-term loan portfolio but rate-sensitive, short-term deposits when market interest rates go up. Then the institution pays more for deposits than it earns from loans.

Liquidity risk is substantially reduced in the presence of relatively efficient credit markets, FRS willingness to act as the lender of last resort, and credible deposit insurance. It refers to the risk of being unable to meet high, unexpected deposit withdrawals without suffering losses by selling illiquid assets at "fire-sale" prices. Depositor runs can quickly push market-value solvent banks into insolvency. This type of risk can be reduced by holding higher percentages of bank assets in the form of cash, or readily marketable government securities.

The term operating environment risk refers to those factors over which the individual bank has little control, at least in the short-run. Such factors as branching restrictions, capital requirements, location, activities prohibitions, and holding company regulations are grouped in this category. For example, banks in rural areas may face higher costs for information and access to national money markets. Banks in unit-banking farm states have less opportunity to develop diversified loan portfolios. Other regulations also increase the cost or limit the ability of banks to diversify their portfolios.

These types of risk are neither mutually exclusive nor independent. Management strategies reflect operating environment risk together with the risk-preferences of owners/managers and the bank's current financial condition. Many assert that flat-rate deposit insurance coupled with partial deregulation have increased incentives for banks, especially those with weak capital positions, to pursue

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[9] This statistic is subject to dispute. Because the division between poor judgement in making low-quality loans and fraud or insider abuse is not well defined, the proportion could be much lower.

high-risk management strategies (Simmons, 1986). These strategies are characterized by rapid loan-led asset growth, often supported by brokered and/or large, rate-sensitive, volatile deposits. Banks adopting such strategies will be exposed to greater credit risk as a higher loan volume is often achieved by lowering customer quality standards. Additionally, the higher loan-asset ratios associated with this approach result in less protection against liquidity risk while a greater reliance on rate-sensitive and (technically) uninsured deposits increases liquidity risk.

Formalizing the concepts and processes presented thus far, for the k^{th} bank:

$$(1) \qquad P_c(Y_{t,k}=1) = f(E_{t-1}(NW_{t,k}), E_{t-1}(RC_{t,k}))$$

where:

P_c = probability of closure

$Y_{t,k}$ = binary variable, $Y_{t,k} = 1$ indicates closure of the k^{th} bank at time t, $Y_{t,k} = 0$ otherwise.

$E_{t-1}(NW_{t,k})$ = regulators' expectation at t-1 of the k^{th} bank's market-value net worth at t.

$E_{t-1}(RC_{t,k})$ = regulators' expectation at t-1 of explicit and implicit costs to regulatory agencies of closing the k^{th} bank at t.

Regulators' expectation of an institution's market-value net worth next period, an unobservable variable, is determined by their evaluation of the bank's financial condition this period. Information obtained from the most recent on-site examination and call report data are used. The evaluation method is assumed to rely on the CAMEL rating system. CAMEL is a mnemonic developed by bank examiners that represents key attributes of a bank's condition for examination: capital adequacy, asset quality, management, earnings power, and liquidity.

Because problems in the agricultural and the oil and gas sectors have hurt the quality of many banks' loan portfolios, it is hypothesized that regulators take into account the characteristics of the bank's local economy and the proportion of local loans when determining expected net worth. Further, it is expected that local economic characteristics will be useful proxy measures of confidential information from on-site examinations, which could not be used in this study. Such information on the local economy is seen as useful in predicting changes in asset (loan) quality. This may be written as:

$$(2) \qquad E_{t-1}(NW_{t,k}) = g\left(\sum_{i=1}^{N} X_{t-1,k,i}, \sum_{j=1}^{M} COND_{t-1,k,j}\right)$$

where:

$\sum X_{t-1,k,i}$ = financial conditions variables for the k^{th} bank at t-1

$\sum_{j=1}^{M} COND_{t-1,k,j}$ = structural characteristics variables for the local economy of the k^{th} bank at t-1 (i.e. county economic dependence on the agriculture and mining sectors).

Minimizing the explicit costs of bank insolvencies to the deposit insurance fund is one of the FDIC's stated objectives.[10] This goal is somewhat at variance with the main purpose of deposit insurance: protection of the safety and soundness of the banking system. But, if keeping a market-value insolvent bank open is seen as preventing deposit-runs (and insolvencies) at other banks, then safety and soundness issues can be viewed as minimizing implicit costs.

In this context, factors influencing the decisions of whether and when to close an insolvent institution include the value of the bank in receivership, its size, and corporate structure. Receivership value equals the value of the bank charter to potential acquiring banks plus any remaining economic net worth or less losses if net worth is negative. Because the bank's charter value depends upon the attractiveness of the local market, characteristics of the local economy are important. Asset size reflects the bank's importance to the system; large bank closures are more likely to trigger runs and financial market instability. On a regional or state level, closing a bank which is a member of a multibank- holding company (MBHC) risks runs on other subsidiary banks of the same MBHC. Regulators' expectations of all costs to them of closing the k^{th} bank, also an unobservable variable, is thus:

$$(3)\quad E_{t-1}(RC_{t,k}) = h\left(\sum_{j=1}^{M} COND_{t-1,k,j},\ LTA_{t-1,k,},\ BHC_{t-1,k}\right)$$

where:

$LTA_{t-1,k,j}$ = natural log of total assets of the k^{th} bank at t-1.

$BHC_{t-1,k}$ = discrete variable which is equal to zero if the bank is independent or a one-bank holding company, otherwise equal to the number of subsidiary banks in the MBHC owning the k^{th} bank at t-1.

Method and Data

The application of least-squares estimation techniques to models with a discrete and bounded dependent variable results in heteroskedastic residuals and biased predictions (Maddala, 1983). Use of

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[10] Although the FDIC does not have closure authority, it can threaten to revoke a bank's deposit insurance coverage, thus pressuring the chartering agency into declaring the bank legally insolvent (Kane, 1985).

the logistic multiple regression technique, however, results in all predicted probabilities of closure falling inside the zero-one range. It also ameliorates heteroskedasticity problems. Following other studies (Barth et. al, 1986, 1985; Avery and Hanweck, 1984; Martin, 1977) of financial institution failures and closures, the logistic method is used here.

Substituting equations 2 and 3 into 1 and using the logistic specification:

$$(4) \quad P_c(Y_{t,k} = 1 | Z_{t-1}) = 1/(1 + \exp^{-[Z_{t-1}]})$$

where:

$$Z_{t-1} = \sum_{i=1}^{N} a_i X_{t-1,k,i} + \sum_{j=1}^{M} b_j COND_{t-1,K,j} + c_1 LTA_{t-1,k} + c_2 BHC_{t-1,k}$$

All models presented here take the form of equation (4) and are estimated by the LOGIST procedure in the Statistical Analysis System (SAS). This procedure computes maximum likelihood estimates using the Newton-Raphson algorithm.

All bank-level financial and structure data used in this study are from the June 30, 1984 and June 30, 1985 Reports of Income and Condition. Data on local economic characteristics are from the Bureau of Economic Analysis (BEA), Department of Commerce. County-level employment and income estimates for 1978, 1982, and 1983 were used to construct variables measuring dependence on the agricultural, mining, and oil and gas sectors. Measures of county economic growth were also computed. County-level estimates of 1978 and 1982 farm land prices from the Census of Agriculture were also examined.

Because bank closure is a comparatively rare event (recently about one percent a year), closures and nonclosures were sampled at different rates. All FDIC-insured commercial banks that were closed due to financial difficulties between January 1 and June 30, 1986 were placed in the sample. Banks receiving open bank assistance or merged to prevent closure were treated as nonclosed banks for the purposes of sample construction. A 10 percent random sample of banks operating on June 30, 1985 that did not close in the following 12 months was drawn for the nonclosed portion of the sample. To be selected, banks must have reported less than $800 million in assets as of June 30, 1985, and nonzero deposits, assets, and loans.[11] Banks not in existence

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[11] When this study was initially designed, large banks were excluded for several reasons. In the 52 year history of the FDIC, only three banks with assets above this threshold were closed. This combined with the "too big to fail" doctrine suggested that such banks should be treated as belonging to a different population. The closure of First Oklahoma on July 14, with $1.6 billion in assets, suggest otherwise. The size restriction will be eased or removed in future research.

before June 30, 1984, or for which required data were not available, were dropped from the sample. The final sample included 62 closed and 1348 nonclosed banks.

Differential sampling rates allow the use of all available information on closed institutions, but may introduce consistency problems. Some contend that weighting schemes are necessary to produce consistent parameter estimates (Avery and Hanweck, 1984). More recently, however, others have found that this problem is avoided in logit models (Barth et.al., 1986). Consequently, weighting schemes were not used in this study.

Empirical Results

The model presented in equations 1-3 does not identify a unique set of independent variables. As an aid to the final specification, a one-way analysis of variance was used to pinpoint variables most useful in distinguishing between closures and nonclosures. Conforming to the time dimension of the model, all variables were constructed with data on conditions at least six months prior to closure.

Those variables showing the most statistically significant differences in mean values between banks that were and were not closed, among others, are in table 2. Measures of capital adequacy, loan quality, management strategy, local characteristics, and variables of concern to regulators were all significantly different for the two groups of banks. Variables reflecting interest-rate risk (ISAL84), local bank market concentration (HERF85), and banks' rural location (SMSA), were not.[12]

Results from estimating three specifications of the model (referred to hereafter as the new model) are given in table 3. The specification preferred in terms of overall fit and predictive power is shown along with two alternative specifications to indicate the robust nature of the estimates. Tables 4, 5, and 6 present several specifications of different models adapted from the literature and re-estimated using this study's sample. The first specification in each of these tables represents the basic model put forth in earlier work. Variables reflecting regulators' concerns and local economic characteristics are added in the second specification. Finally, the farm loan ratio is added in the third specification.

Because it is regulators' expectation of future net worth that is important, financial condition variables deemed critical by them are most appropriate. Six financial ratios have been identified by the FDIC for classifying banks into two risk groups (Hirschhorn, 1986). Five of these six ratios are included in the new model: primary capital to assets, net income to assets, loans past due 90 days or more but still accruing interest to total loans, nonaccrual loans to total loans, and renegotiated "troubled" loans to total loans.

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[12] See the glossary for definitions of variables.

The dependent variable is the probability of closure; it is equal to one if the bank was closed between January 1, 1986 and June 30, 1986, zero otherwise. Independent variables are those hypothesized to jointly determine regulators' expectation of a bank's net worth and their expectation of its closure costs. These expectations are based on conditions existing at least six months prior to the closure decision period. The variables are grouped by bank characteristics. A negative (positive) sign indicates that an increase in the variable decreases (increases) the probability of closure. The model chi-square statistics (reflecting the overall fit of the model), are significant above the one percent level for all three specifications of the new model (table 3). Moreover, the first specification is superior to the others based on the AIC statistics.[13]

Capitalization and profitability both measure a bank's ability to sustain future losses as well as creditworthiness for interbank lending in case of liquidity problems. A lower capital ratio is likely to increase the risk-preferences of the bank's management. The ratio of primary capital to assets coefficient has the expected sign and is significant at the one percent level in all three specifications. The net income to assets coefficient is only significant if loan quality variables are omitted, as in the second specification, where it has the expected sign. Multicollinearity between loan quality measures and profitability is expected, making the size and significance of the parameters suspect.

Loan quality variables are useful in adjusting book-value capital to market-value net worth by reflecting unrealized and possible future loan losses. They also indicate the bank's preference, ex post, for credit risk. The three variables are mutually exclusive ratios of problem to total loans. Coefficients of all three are statistically significant and have the expected signs in all specifications tested.

Measures of liquidity, volatile deposits, and the farm loan ratio were selected to reflect management strategy and overall risk preferences in an ex ante sense. These strategy variables, measuring credit-, liquidity-, and to some extent, potential interest-rate risk, appear useful in detecting loan quality problems not reported as past-due or nonaccruing loans. Hence, they help determine expected net worth and the expected value of the bank in receivership. All coefficients are significant at the five percent level or better, have the expected signs, and are robust across specifications.

Both variables hypothesized as critical to regulators, but not

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[13] Akaike's Information Criterion (AIC) is defined as:

$$AIC = -2\ln(lkhd) + 2k$$

where

lkhd = model maximum likelihood ratio

k = number of independent variables.

The specification with the lowest AIC value is superior to others.

directly relevant as determinants of market-value insolvency, have significant coefficients and the expected signs in all specifications. While it could be argued that large size and membership in a MBHC with many subsidiary banks results in cost advantages that lower the probability of closure, evidence of such advantages in the literature is weak. On the contrary, recent research suggests that the non-bank activities of MBHC's significantly increase the banks' risk-exposure (Cornyn, Hanweck, Rhoades and Rose, 1986). Flannery (1986) has found some evidence of contagion among bank subsidiaries in a MBHC when one subsidiary is closed, which supports the contention here that regulators are reluctant to close MBHC-affiliated banks.

Local economic characteristics variables, while improving the fit and predictive power of the model, are not as robust as anticipated. Two indicators describing the structure of the local economy were selected: the ratio of county employment in the mining sector to total county employment in 1982, and the ratio of 1978 county agricultural income to total county income. These indicators are meant to show the local economic dependence on the mining and farm sectors prior to the contractions in those sectors. If the loan quality variables and the agricultural loan ratio are omitted, coefficients of these proxies for operating environment risk are significant and have the expected signs. When the loan quality variables are added, the mining employment ratio coefficient became insignificant. However, this ratio still noticeably improved the overall fit. Adding the agricultural loan ratio resulted in the insignificance of the county farm income ratio coefficient (specification not shown in table 3). While an agricultural or mining-dependent county location increases the probability of closure, this operating risk factor appears less important for banks not specializing in agricultural finance and maintaining high customer creditworthiness standards.

Measures of other operating environment risk factors were also tested. Restrictive branching laws, few branch offices and having the headquarters office located in a rural county, other things being equal, did not materially increase the probability of closure. These variables were independently added to the preferred model; none of the coefficients were significant at the 10 percent level and overall model performance was not improved.

Five variables in the new model's preferred specification are also in the model considered by the FDIC in their risk-adjusted deposit insurance premium proposal (Hirschhorn, 1986). In this proposal, six financial ratios would be used to identify high-risk banks. If these banks also had a less than satisfactory CAMEL rating (i.e. three, four or five) from their most recent examination, then they would be assessed a higher deposit insurance premium. The FDIC model, however, used the bank's problem list status as the dependent variable (one equals problem, zero otherwise), not closure, and was estimated with a probit, not logit, model specification. The six ratios performed well as a closure model (table 4); the model chi-square is significant over the one percent level and five of the six ratios' coefficients are significant at the five percent level or better with the expected

signs.

The net loan charge-off ratio reported for the first-half 1985 was not significant in explaining first-half 1986 closure probabilities, which conflicts with the FDIC's results and prior expectations. It is possible that seasonality in charge-offs accounts for this anomaly, because the FDIC model was originally estimated with December, not June, data. Further, a smaller sample was used in fitting the closure model, which may have worsened any multicollinearity problems.

All performance measures were improved when local economic characteristics and regulatory concern variables were added. Yet, the new model's preferred specification outperformed even the modified FDIC model in terms of the AIC and pseudo-R^2 statistics.[14] The asset size, agricultural loan ratio, and farm employment ratio coefficients were not significant at the 10 percent level, however, suggesting collinearity between these and loan quality variables, especially the net loan charge-off ratio.

Avery and Hanweck (1984) were among the first to discuss the importance of regulator behavior in the "failure" decision. Using a pooled time-series cross-section approach, they built and estimated a logit model where the probability of failure in a six month period is determined by current and lagged values of selected financial ratios and other variables. Because they found lagged variables to be insignificant, a version of their model without lagged terms was estimated (table 5).[15]

The new model and the FDIC model both outperformed the modified Avery-Hanweck (1984) model. Their alternative proxies of management strategy were not significant at the 10 percent level. A measure of local banking market concentration added little explanatory power and was not significant. When variables reflecting local economic characteristics, regulators' concerns, and the farm loan ratio were added, overall fit was improved. Except for the bank size coefficient, which became insignificant, these were statistically significant and had the expected signs.

Barth et.al. (1986) found that five independent variables were sufficient to accurately model savings and loan closures over the

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[14] Conventional R^2 statistics do not accurately reflect goodness-of-fit in regression models with binary dependent variables. Judge et.al. (1980) suggest an alternative measure, a pseudo-R^2, defined as:

$$\text{pseudo-}R^2 = 1-(L(\hat{B})/L(\hat{B}_0))$$

Where:

$L(\hat{B})$ = log of likelihood function where all explanatory variables are included

$L(\hat{B}_0)$= log of likelihood function with the constant term only.

[15] A variable they included, percentage change in the local banking market's deposits, was not used here as the data were not available.

1981-84 period.[16] Using a similar specification for bank closures resulted in less success, however (table 6). The model chi-square from this specification is significant at over the one percent level as are all coefficients. Estimated signs are also as hypothesized. Local condition and regulatory concern variables, and the farm loan ratio substantially improved the overall fit as measured by both the AIC and pseudo-R^2 statistics. As was the case with adding these variables to the Avery-Hanweck model, their coefficients are significant and have the expected signs. The bank size coefficient, however, again becomes insignificant at the 10 percent level in the presence of these other variables.

A farm loan concentration strategy, local economic characteristics, and regulatory concerns are fairly important in determining a bank's probability of closure. Modifying three models from the literature to include these factors resulted in improved performance. Moreover, most coefficients of variables reflecting these factors remained statistically significant over the different models and specifications. The main exception to this is the bank size variable, which is not surprising because the larger nonclosed banks were excluded from the sample.

Classification Power

Different models can also be compared by examining their relative forecasting abilities. The comparisons here are all based on within-sample forecasts. Forecast or bank classification accuracy is subject to both type I error, when the model classifies a closure as a nonclosure, and type II error, when the model classifies a nonclosure as a closure. Type I errors can be reduced at the cost of more type II errors by choosing a lower probability of closure defining the boundary between predicted closure and predicted nonclosure.

Using the model's forecast to improve bank supervision would require choosing an optimal boundary probability. Such an optimal boundary would have to balance the costs of misclassifying a potential closure (higher closure costs and more closures) against the cost of misclassifying a nonclosure (unnecessarily high supervision costs). Somewhat arbitrarily, the percentage of closures correctly classified by each specification is presented (tables 3,4,5, and 6) with a boundary probability of 0.3. Thus, if a specification predicts a bank's probability of closure equal to or greater than 0.3, it is counted as a predicted closure.

Different models' and specifications' classification powers vary inversely with their AIC values, for the most part. The preferred specification of the new model is able to classify 58.1 percent of the closures correctly, compared to 48.4 percent correct closure

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16 The variable measuring FSLIC's loss-absorbing capacity used in the Barth et.al. (1986) model was omitted here. Because it only varies over time and is the same for all banks at a point in time, an analog FDIC measure is not appropriate for this study.

classification for the basic FDIC model. Consistent with their AIC values, the basic Avery-Hanweck model correctly classifies only 30.6 percent of the closures while the basic Barth et.al. model correctly indentifies 24.2 percent. Modifying these basic models to include local economic conditions and regulatory concern variables as well as the farm loan ratio markedly improves their classification power, although the new model outperforms them all.

Tables 7 and 8 compare the classification powers of the basic FDIC model relative to the new model in more detail. The trade-off between type I and II errors is illustrated by varying the cut-off probability between 0.5 and 0.1. At the lowest cut-off shown, the new model correctly classifies 80.6 percent of the closures, relative to 64.5 percent identified by the FDIC model. This results in predicting 5.6 percent of the nonclosures as closures in the new model, somewhat higher than the 4.1 percent of nonclosures misclassified by the FDIC model.

Although an out-of-sample forecast based on the new model's best specification has not been generated, its within-sample classification power portends good results. It compares favorably to models presented in the literature, both those reviewed here and others. Of course, any closure model's forecast accuracy is predicated on a stable regulator policy rule.

Conclusions

In this paper, a model of bank closure has been developed, estimated, and compared to others in the literature. A bank's closure probability is jointly determined by regulators' expectations of the bank's net worth and closure costs in this new model. Empirically, it performs well, both relative to others and in an absolute sense. Measures of bank capital, profitability, loan quality, management strategy, local economic characteristics, and variables reflecting regulator concerns not directly pertaining to the bank's solvency were all found to be important determinants of closure probability. Coefficients of almost all variables were statistically significant at the 10 percent level or better and were robust across different specifications and models. The new model is able to correctly classify 80.6 percent of first-half 1986 closures with only a 5.6 percent type II error rate, outperforming other models found in the literature.

Those variables reflecting regulators' concern about contagion markedly improved the model's performance. Banks belonging to MBHC's that have many other bank subsidiaries have a lower probability of closure, other things equal. This is consistent with regulator reluctance to close MBHC-affiliated institutions, which could trigger runs on the other affiliates. It may also reflect the low charter value of such banks in receivership, because banks wishing to purchase these closed MBHC subsidiaries are often legally prohibited from acquiring other portions of the MBHC. Larger bank size also results in a lower closure probability, other things equal, consistent with regulators' stated unwillingness to close larger banks. While the

corporate structure coefficient is highly significant and robust, the size variable was not found to be robust across different models. This likely reflects the exclusion of the largest banks from the sample.

While banks located in farm- or mining-dependent counties face an elevated probability of closure, this operating environment risk factor appears less important for banks not specializing in farm lending and who limit their exposure to credit risk in other ways. State branching law, number of branch offices, and rural location are other indicators of operating environment risk that were tested. None of these appear to be significant or improve model performance.

Banks choosing to specialize in financing agriculture have a higher probability of closure, other things equal, according to the empirical results presented here. The agricultural loan ratio coefficient is statistically significant at the one percent level in all but one of the estimated models. While a high agricultural loan ratio clearly indicates increased credit-risk exposure, its significance in the presence of loan quality and local economic conditions is somewhat surprising. It is possible that farm loans deteriorate at a faster rate than others, passing quickly through the various problem loan categories and resulting in larger losses. Also, banks dominated by farm loans that are nearly insolvent may have reduced receivership charter values; potential acquiring banks are likely wary of such portfolios regardless of current quality. Thus, regulators may close such banks as soon as is practicable to minimize deposit insurance losses.

Glossary of Variables[1]

RPKTA	Regulator-defined primary capital/assets: (equity capital + allowance for possible loan losses + minority interest in consolidated subsidiaries - intangible assets + mortgage servicing rights + allowable mandatory convertable debt)/ (total assets + allowance for possible loan losses + mortgage servicing rights - intangible assets).
NITA	Net income / total assets.
LPDR85	Loans past-due 90 days or more, still accruing interest / total loans.
NALR85	Nonaccrual loans / total loans.
RLR85	Renegotiated loans / total loans.
NLCHTL	Net loan charge-offs / total loans.
LIQUID	Liquid assets / total assets. Liquid assets include: book value of U.S. securities not in trading account, interest-bearing cash items, and vault cash.
SENSDTD	Sensitive or volatile deposits / total deposits. Sensitive deposits are defined as time deposits greater than $100,000.
AGTOTTL	total agricultural (both production and real estate) loans / total loans.
LTA	Natural log of total assets.
HCN	Corporate structure variable, equal to zero if the bank was independent or a one bank holding company; equal to the number of banks in the multibank holding company if a subsidiary.
NLTA	Net loans / total assets. Net loans equals gross loans less allowance for possible loan losses.
CILTL	Commercial and industrial loans / total loans.
HERF85	Herfindahl index for the bank's SMSA or county, if not urban.

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[1] All ratios were multiplied by 100 to convert to percentages. Data as of June 30, 1985 unless otherwise noted.

BROKDTD	Total brokered deposits / total deposits.
INSIDE84	Unsecured loans to bank managers and directors / total loans, as reported for June 30, 1984.
SMSA	Binary variable, equal to 1 if the county is part of an MSA, equal to zero otherwise.
BB85	Number of branch offices.
ISAL84	The absolute difference between interest-sensitive assets and interest-sensitive liabilities (maximum remaining maturity or repricing opportunity for both assets and liabilities is one year) / total assets, as reported for June 30, 1984.
NIM	Net interest margin, defined as total interest income less total interest expense / total assets.
MINIR78	County-level mining income / total income, 1978.
MINIR82	County-level mining income / total income, 1982.
AGIN78	County-level agricultural income / total income, 1978.
AGIN82	County-level agricultural income / total income, 1982.
LEMT82	County-level employment growth rate 1978-82 (computed by natural log differences).
AGER78	County-level agricultural employment / total employment, 1978.
AGER82	County-level agricultural employment / total employment, 1982.
MINER78	County-level mining employment / total employment, 1978.
MINER82	County-level mining employment / total employment, 1982.
OGINR82	County-level oil and gas sector income / total income ratio, 1982.

Table 1

Bank Vulnerability and Closures[a/]

	Banks Closed During Previous 6 months			Banks Vulnerable		Ratio[b/]
	Total	Agricultural	Rural	Total	Agricultural	Closed/Vulnerable
June 30, 1983	26	2	8	419	96	———
Dec. 31, 1983	18	5	7	453	133	0.043
June 30, 1984	43	9	17	471	195	0.095
Dec. 31, 1984	34	22	24	614	239	0.072
June 30, 1985	52	34	34	689	302	0.085
Dec. 31, 1985	66	35	47	806	332	0.096
June 30, 1986	64	27	37	n.a.	n.a.	0.079

a/ Bank closures are FDIC-insured commercial banks that were closed due to financial difficulties. Banks receiving "open-bank assistance" or located in U.S. possessions and territories are excluded. Vulnerable banks are those which had past-due and nonperforming loans greater than primary capital at the end of the quarter.

b/ This is the ratio of banks closed in the given period to banks vulnerable at the end of the previous period.

Table 2
Banks Closed and the Nonclosed Bank Sample:
An Analysis of the Differences Between Mean Values[a/]

Variable[b/]	Closed Banks Mean Values	Nonclosed Bank Sample-mean Values	Difference Between means	t-Statistics[c/]
REKTA	6.92	9.47	2.55	8.52+
NITA	-1.39	0.41	1.80	7.69+
LPDR85	2.20	0.75	-1.45	-4.23+
NALR85	4.68	0.93	-3.75	-8.58+
RLR85	0.47	0.09	-0.38	-2.88+
NLCHIL	2.59	0.47	-2.12	-5.37+
LIQUID	20.23	28.59	8.36	6.70+
SENSDID	22.06	12.52	-9.54	-4.55**
AGIOITL	24.19	16.78	-7.41	-2.12*
LITA	10.25	10.49	0.24	1.91
HCN	0.306	4.45	4.14	10.56+
CILIL	29.85	23.64	-6.21	-3.20+
NLTA	64.63	55.14	-9.49	-7.40+
HERF85	0.226	0.224	-0.002	-0.12
BROKDID	0.740	0.166	-0.574	2.51**
INSIDE84	1.93	1.20	-0.73	-2.13**
SMSA	0.419	0.458	0.039	0.60
BB85	0.839	1.50	0.661	3.02+
ISAL84	14.85	16.42	1.57	0.93
NIM	1.88	2.13	0.25	2.91+
MINIR78	3.46	2.37	-1.09	-1.18
MINIR82	4.75	3.01	-1.74	-1.67**
AGIN78	8.98	6.23	-2.75	-2.52*
AGIN82	4.76	3.73	-1.03	-1.25
LEMI82	0.072	0.028	-0.044	-3.03+
AGER78	3.10	2.74	-0.36	-0.81
AGER82	3.16	2.72	-0.44	-0.92**
MINER82	3.59	2.22	-1.37	-2.07*
MINER78	2.38	1.79	-0.59	-1.09**
OGINR82	3.68	1.89	-1.79	-2.13*

a/ Includes the 62 banks closed between January 1, 1986 and June 30, 1986 for which data are available and thus in the sample as well as the 1348 nonclosed banks in the sample.
b/ See the glossary for variable definitions.
c/ +Significant at the 1 percent level; *Significant at the 5 percent level; **Significant at the 10 percent level.

Table 3
Logit Analysis of Bank Closure; New Model[a]

Variables	Preferred Specification		Loan quality variables omitted		County agricultural income ratio added	
Capital Adequacy						
RFKTA[b]	-0.490	(5.01)+	-0.512	(5.77)+	-0.438	(4.68)+
Profitability						
NITA	-0.134	(1.51)	-0.317	(3.35)+	-0.124	(1.43)
Loan Quality						
LFDR85	0.187	(1.77)*			0.195	(1.85)*
NALR85	0.336	(5.51)+			0.349	(5.75)+
RLR85	0.385	(1.95)*			0.419	(2.09)**
Mgt. Strategy						
LIQUID	-0.039	(2.10)**	-0.065	(3.91)+	-0.037	(2.03)**
SENSDID	0.074	(5.18)+	0.052	(4.36)+	0.063	(4.78)+
AGIOTIL	0.029	(3.25)+				
Reg. Concern						
LTA	-0.406	(1.99)**	-0.372	(1.94)*	-0.441	(2.16)**
HCN	-0.261	(1.99)**	-0.229	(1.87)*	-0.269	(1.98)**
Local Conditions						
MINER82	0.045	(1.47)	0.064	(2.55)**	0.041	(1.35)*
AGIN78			0.078	(4.66)+	0.037	(1.77)*
intercept	3.113	(1.26)	5.031	(2.17)**	3.523	(1.42)
% closures correctly classified[c]	58.1%		43.5%		54.8%	
AIC	276.17		329.70		283.68	
Pseudo-R^2	0.500		0.383		0.485	
-2 ln(lkhd)	254.17		313.70		261.68	
Model Chi-square	254.46+		194.93+		246.96+	

a. The dependent variable is the probability of closure; it is equal to 1 if the bank was closed between January 1 and June 30, 1986, zero otherwise. Asymptotic t-statistics are in parentheses.
b. +Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level.
c. Where the probability of closure is greater than or equal to 0.3.

Table 4
Logit Analysis of Bank Closure: Based on FDIC risk-adjusted deposit-insurance premium proposal[a/]

Variables	Basic Model		Local conditions & regulatory concern variables added		Agricultural loan ratio added	
Capital Adequacy						
RPKIA[b/]	-0.424	(4.79)$^{+}$	-0.470	(4.97)$^{+}$	-0.500	(5.11)$^{+}$
Profitability						
NITA	-0.265	(2.05)**	-0.240	(1.75)*	-0.249	(1.82)*
Loan Quality						
LPDR85	0.275	(2.73)$^{+}$	0.267	(2.67)$^{+}$	0.266	(2.67)$^{+}$
NALR85	0.386	(6.96)$^{+}$	0.360	(6.13)$^{+}$	0.353	(6.03)$^{+}$
RLR85	0.518	(2.71)$^{+}$	0.471	(2.44)**	0.453	(2.38)**
NLCHIL	-0.094	(1.07)	-0.099	(1.08)	-0.107	(1.17)
Mgt. Strategy						
LIQUID						
SENSDID						
AGIOTIL					0.014	(1.61)
Reg. Concern						
LTA			-0.188	(0.98)**	-0.146	(0.76)**
HCN			-0.236	(2.04)**	-0.229	(2.02)**
Local Conditions						
MINER82			0.051	(1.89)*	0.053	(1.97)**
AGIN78			0.021	(0.93)		
intercept	-0.930	(1.33)	1.431	(0.63)	1.132	(0.51)
% closures correctly classified[c/]	48.4%		51.6%		50%	
AIC	323.96		312.66		310.91	
Pseudo-R^2	0.387		0.425		0.428	
-2 ln(likhd)	311.96		292.66		290.91	
Model Chi-square	196.67^{+}		215.98^{+}		217.72^{+}	

a. The dependent variable is the probability of closure; it is equal to 1 if the bank was closed between January 1 and June 30, 1986, zero otherwise. Asymptotic t-statistics are in parenthesis.
b. $^{+}$Significant at the 1 percent level; **Significant at the 5 percent level *Significant at the 10 percent level.
c. Where the probability of closure is a greater than or equal to 0.3.

Table 5
Logit Analysis of Bank Closure: Based on the Avery-Hanweck (1984) model[a]

Variables	Basic Model		Local conditions & regulatory concern variables added		Agricultural loan ratio added	
Capital Adequacy						
RPKTA[b]	-0.451	(5.23)$^{+}$	-0.530	(5.64)$^{+}$	-0.573	(5.87)$^{+}$
Profitability						
NITA	-0.289	(2.25)**	-0.343	(2.45)**	-0.324	(2.31)**
Loan Quality						
NLCHTL	0.086	(1.08)	-0.012	(0.14)	-0.007	(0.10)
Mgt. Strategy						
LIQUID	-0.049	(1.91)*	-0.045	(1.62)	-0.048	(1.73)*
NLTA	0.024	(1.05)	0.036	(1.43)	0.033	(1.26)
CILTL	0.009	(0.91)	0.013	(1.23)	0.021	(1.88)*
AGIOTTL					0.039	(4.64)$^{+}$
Reg. Concern						
LTA	-0.514	(2.95)$^{+}$	-0.212	(1.13)	-0.155	(0.82)
HCN			-0.217	(1.98)**	-0.204	(1.96)*
Local Conditions						
MINER82			0.083	(3.28)$^{+}$	0.077	(3.04)$^{+}$
AGIN78			0.082	(4.11)$^{+}$		
HERF85	0.808	(0.93)	-0.822	(0.76)	-0.268	(0.24)
intercept	5.087	(1.64)	1.449	(0.42)	1.006	(0.30)
% closures correctly classified[c]	30.6%		43.5%		43.5%	
AIC	382.46		349.69		342.75	
Pseudo-R^2	0.280		0.356		0.369	
-2 ln(lkhd)	366.46		327.69		320.75	
Model Chi-square	142.17^{+}		180.95^{+}		187.89^{+}	

a. The dependent variable is the probability of closure; it is equal to 1 if the bank was closed between January 1 and June 30, 1986, zero otherwise. Asymptotic t-statistics are in parentheses.
b. $^{+}$Significant at the 1 percent level; **Significant at the 5 percent level; *Significant at the 10 percent level.
c. Where the probability of closure is greater than or equal to 0.3.

Table 6
Logit Analysis of Bank Closure: Based on the Barth et.al. (1986) model[a/]

Variables	Basic Model		Local conditions & regulatory concern variables added		Agricultural loan ratio added	
Capital Adequacy						
RPKTA[b/]	-0.453	(5.41)+	-0.545	(5.91)+	-0.588	(6.10)+
Profitability						
NITA	-0.388	(4.08)+	-0.337	(3.37)+	-0.329	(2.27)+
Loan Quality						
LPDR85						
NALR85						
RLR85						
Mgt. Strategy						
LIQUID	-0.070	(4.40)+	-0.081	(4.82)+	-0.082	(4.88)+
SENSDID						
AGTOTIL					0.032	(4.54)+
Reg. Concern						
LTA	-0.547	(3.23)+	-0.232	(1.28)**	-0.172	(0.93)**
HCN			-0.206	(1.98)**	-0.196	(1.97)**
Local Conditions						
MINER82			0.078	(3.30)+	0.078	(3.25)+
AGIN78			0.069	(4.01)+		
intercept	7.903	(3.66)+	5.121	(2.25)**	4.711	(2.07)**
% closures correctly classified[c/]	24.2%		40.3%		38.7%	
AIC	378.13		346.13		340.18	
Pseudo-R^2	0.272		0.347		0.358	
-2 ln(lkhd)	370.13		332.13		326.18	
Model Chi-square	138.51+		176.51+		182.46+	

a. The dependent variable is the probability of closure; it is equal to 1 if the bank was closed between January 1 and June 30, 1986, zero otherwise. Asymptotic t-statistics are in parentheses.
b. +Significant at the 1 percent level; **Significant at the 5 percent level; Significant at the 10 percent level.
c. Where the probability of closure is greater than or equal to 0.3.

Table 7
Classification Accuracy of the FDIC Model[a/]

	Probability of Closure				
	Pc ≥ 0.5	Pc ≥ 0.4	Pc ≥ 0.3	Pc ≥ 0.2	Pc ≥ 0.1
Type I Error[b/]	0.677	0.548	0.516	0.452	0.355
Closure Accuracy	0.323	0.452	0.484	0.548	0.645
Type II Error[c/]	0.008	0.013	0.016	0.026	0.041
Nonclosure Accuracy	0.992	0.987	0.984	0.974	0.959
Overall Accuracy	0.962	0.963	0.962	0.955	0.945
	Number				
Predicted Closures	31	46	51	69	95
Actual Closures	62	62	62	62	62
Predicted Nonclosures	1379	1364	1359	1341	1315
Actual Nonclosures	1348	1348	1348	1348	1348

a/ Computed from the specification in the first colum of table 4.
b/ Type I Error: classification of a closure as a nonclosure.
c/ Type II Error: classification of a nonclosure as a closure.

Table 8
Classification Accuracy of the New Model[a/]

	Probability of Closure				
	Pc ≥ 0.5	Pc ≥ 0.4	Pc ≥ 0.3	Pc ≥ 0.2	Pc ≥ 0.1
Type I Error[b/]	0.597	0.532	0.419	0.339	0.194
Closure Accuracy	0.403	0.468	0.581	0.661	0.806
Type II Error[c/]	0.010	0.013	0.018	0.023	0.056
Nonclosure Accuracy	0.990	0.987	0.982	0.977	0.944
Overall Accuracy	0.964	0.964	0.965	0.963	0.938
	Number				
Predicted Closures	39	47	60	72	126
Actual Closures	62	62	62	62	62
Predicted Nonclosures	1371	1363	1350	1338	1284
Actual Nonclosures	1348	1348	1348	1348	1348

a/ Computed from the specification in the first colum table 3.

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