An Analysis of Inefficiencies in Banking: A Stochastic Cost Frontier Approach

Simon H. Kwan and Robert A. Eisenbeis

Economist, Federal Reserve Bank of San Francisco; and Senior Vice President and Director of Research, Federal Reserve Bank of Atlanta.

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This paper examines the properties of X-inefficiency and the relations of X-inefficiency with risk-taking and stock returns for U. S. banking firms. After controlling for scale differences, the average small size banking firm is found to be relatively less efficient than the average large firm. Smaller firms also exhibit higher variations in X-inefficiencies than their larger counterparts. While the average X-inefficiency appears to be declining over time, the rank orderings of X-inefficiency are found to be quite persistent. Furthermore, less efficient banking firms are found to be associated with higher risk-taking, and firm-specific X-inefficiencies are significantly correlated with individual stock returns for smaller banking firms.

The efficiency of banking organizations has been studied extensively in the banking literature. Earlier studies tended to focus on the issues of scale and scope efficiencies. Scale efficiency refers to the relationship between a firm's average cost and output. Detection of a U-shaped average cost curve suggests that there is an optimal scale of production, at which point the production cost would be minimized. Scope efficiency refers to the economies of joint production, where the costs of producing joint products are less than the sum of their stand-alone production costs. Though extensive, the studies of the scale and scope efficiencies of financial institutions to date do not seem to provide conclusive evidence on the economic significance of these types of inefficiencies in U.S. banking firms.

More recently, research on banking efficiency has devoted more attention to the issue of X-inefficiency. X-inefficiency refers to the deviations from the production-efficient frontier which depicts the maximum attainable output for a given level of input. The concept of X-inefficiency was introduced by Leibenstein (1966), who noted that, for a variety of reasons, people and organizations normally work neither as hard nor as effectively as they could. When applied to U.S. banking firms, research to date suggests that X-inefficiencies appear to be large and tend to dominate scale and scope inefficiencies.[1]

Because most of the studies of X-inefficiencies were based on cross-sectional analyses, the time-series properties of X-inefficiencies in U.S. banking firms have not been well-documented. There is little information on how X-inefficiencies in banking may evolve over time in response to market forces and on how the rankings of X-inefficiency of individual banking firms may change over time. These issues are especially interesting given the substantial changes in banking markets and banking regulations that have occurred during the past decade. For instance, if inefficient banking firms have a tendency to remain inefficient, it would be of interest to investigate how they can

1. In their summary of recent research, Berger, Hunter, and Timme (1993) indicated that X-inefficiencies in banking account for approximately 20 percent or more of banking costs, while scale and scope efficiencies—when they can be accurately estimated—are usually found to account for less than 5 percent of costs. See also Berger and Humphrey (1991).

remain economically viable and not be driven out of the banking market. Policymakers would be concerned about whether inefficient banking firms pose additional risks to the banking system and its safety net. Investors would be interested in the relationship between the firm-specific X-inefficiencies and the market valuation of bank stocks.

To examine these issues, we estimate a stochastic cost-efficient frontier à la Aigner, Lovell, and Schmidt (1977) based on a multiproduct translog cost function. Semiannual data for a sample of 254 bank holding companies from 1986 to 1991 are grouped into size-based quartiles to allow for different production technologies for each size class. Separate cost functions are estimated for each size quartile using the method of maximum likelihood. An estimate of X-inefficiency for each sample firm at each sample period is then derived following the method of Jondrow, Lovell, Materov, and Schmidt (1982).

As in the cross-section results reported in earlier studies, we find that X-inefficiencies are quite large. Furthermore, several interesting properties of X-inefficiencies also are detected. First, both the level of X-inefficiencies and their cross-sectional variations are, on average, noticeably smaller for large banking firms than for smaller firms. Second, regardless of firm size, X-inefficiencies appear to have declined gradually between 1986 and 1990, and then edged upward during 1991. Third, despite the decline in X-inefficiencies, the rank orderings of firm-specific X-inefficiencies are highly correlated over time. Specifically, the rank ordering persists for approximately three and one-half years for the sample firms that are in the three smaller size quartiles, and for about one year for the sample firms that are in the largest size quartile.

The finding that based on rank ordering, inefficient banking firms tend to stay inefficient leads us to investigate how these inefficient firms can be economically viable, if banking markets are truly contestable and efficient. This is especially puzzling given recent changes that suggest increased competition and substantial entry by non-banking firms in financial markets. We hypothesize that many banking markets may be effectively insulated, at least during the time period of this study, which enables inefficient firms to continue to survive by earning economic rents. Perhaps more importantly, with fixed premium deposit insurance during our sample period, inefficient firms may be induced to compensate for their inefficiencies by extracting subsidies from the FDIC through greater risk-taking.[2] Moreover, the managers of inefficient banking firms, who are more likely to be entrenched, may be inclined to take on more risk (Gorton and Rosen 1995). Finally, it is possible that bank regulators may exacerbate this risk-taking incentive by delaying much needed regulatory actions on problem institutions (see, for example, Kane 1992, Kane and Kaufman 1993). Taken together, the hypothesis that inefficient banking firms may be associated with higher risk-taking seems plausible.

We find a strong association between our X-inefficiency estimates and various proxies for bank risk-taking in all four size classes. Specifically, inefficient firms tend to have higher common stock return variance, higher idiosyncratic risk in stock returns, lower capitalization, and higher loan charge-offs. Furthermore, firm-specific X-inefficiencies are found to have explanatory power for banking firms' stock returns, after controlling for the stock market return and changes in the riskless interest rate.

The remainder of this paper is organized as follows: Section I describes the approach we use to estimate firm-specific X-inefficiency. Section II outlines the data used in this study. The properties of the estimated X-inefficiency for our sample banking firms are discussed in Section III. Section IV examines the relationship between X-inefficiency and bank risk-taking. Section V investigates the relationship between X-inefficiency and bank stock returns. Section VI summarizes and concludes this paper.

I. MEASURING X-INEFFICIENCY IN BANKING

To measure the X-inefficiency of individual banking firms, we use the stochastic efficient frontier methodology of Aigner, Lovell, and Schmidt (1977). In this method, a banking firm's observed total cost is modeled to deviate from the cost-efficient frontier due to random noise and possibly X-inefficiency. For the nth firm,

$$\ln TC_n = f(\ln Q_i, \ln P_j) + \varepsilon_n \quad (1)$$

where TC_n is the total cost for firm n, Q_i are measures of banking output, and P_j are input prices. In equation (1), ε_n is a two-component disturbance term of the form:

$$\varepsilon_n = \mu_n + \delta_n , \quad (2)$$

where μ_n represents a random uncontrollable factor and δ_n is the controllable component of ε_n. In equation (2), μ_n is independently and identically distributed normal with zero mean and σ_μ standard deviation, i.e., $N(0,\sigma_\mu^2)$. The term δ_n is distributed independently of μ_n and has a half-normal

2. The moral hazard of fixed-premium deposit insurance has long been recognized in the banking literature (see for example Merton 1977, Marcus 1984, and Keeley 1990). Furthermore, Marcus and Shaked (1984), Ronn and Verma (1986), and Pennacchi (1987) provide evidence on the mispricing of deposit insurance.

distribution, i.e., δ_n is the absolute value of a variable that is normally distributed with zero mean and standard deviation σ_δ, $N(0,\sigma_\delta^2)$.

The X-inefficiency of firm n, defined as c_n, can be expressed as the expected value of δ_n conditional on ε_n (Jondrow, Lovell, Materov, and Schmidt 1982):

$$(3)\quad c_n = E(\delta_n|\varepsilon_n) = [\sigma\lambda/(1+\lambda^2)][\phi(\varepsilon_n\lambda/\sigma)/\Phi(\varepsilon_n\lambda/\sigma) + \varepsilon_n\lambda/\sigma]\,,$$

where λ is the ratio of the standard deviation of δ_n to the standard deviation of μ_n (i.e., σ_δ/σ_μ), $\sigma^2 = \sigma^2_\delta + \sigma^2_\mu$, Φ is the cumulative standard normal density function, and ϕ is the standard normal density function. Estimates of c_n are obtained by evaluating equation (3) at the estimates of σ^2_δ and σ^2_μ.

To specify the cost function in equation (1), we employ the following multiproduct translog cost function:

$$(4)\ \ln TC = \alpha_0 + \Sigma_i\alpha_i\ln Q_i + \Sigma_j\beta_j\ln P_j + {}^1\!/_2\Sigma_i\Sigma_k\gamma_{ik}\ln Q_i\ln Q_k + {}^1\!/_2\Sigma_j\Sigma_h\zeta_{jh}\ln P_j\ln P_h + \Sigma_i\Sigma_j\omega_{ij}\ln Q_i\ln P_j\,,$$

where TC is total operating costs (including interest costs), Q_i are outputs, and P_j are input prices. Five measures of banking outputs are included: book value of investment securities ($Q1$), book value of real estate loans ($Q2$), book value of commercial and industrial loans ($Q3$), book value of consumer loans ($Q4$), and off-balance sheet commitments and contingencies ($Q5$) which include loan commitments, letters of credit (both commercial and standby), futures and forward contracts, and notional value of outstanding interest rate swaps. Three input prices are utilized: the unit price of capital ($P1$) measured as total occupancy expenses divided by fixed plant and equipment, the unit cost of funds ($P2$) defined as total interest expenses divided by total deposits, borrowed funds, and subordinated notes and debentures, and the unit price of labor ($P3$), defined as total wages and salaries divided by the number of full-time equivalent employees. The linear homogeneity restrictions,

$$\Sigma_j\beta_j = 1,\quad \Sigma_h\zeta_{jh} = 0, \forall j,\quad \Sigma_j\omega_{ij} = 0, \forall i,$$

are imposed by normalizing the total cost and the input prices by the price of labor. To allow the cost function to vary across size classes, the sample banking firms are first sorted into size-based quartiles according to average total assets between 1986 and 1991. Assuming the cost function to be stationary over time, pooled time-series cross-section observations are used to estimate the stochastic cost frontier separately for each size-based quartile by the method of maximum likelihood. Estimates of c_n, which represent the measure of firm-specific X-inefficiency, are then computed for each sample firm in each sample period.

II. Data

Semiannual bank holding company data from 1986 through 1991 are obtained from the Federal Reserve FR Y-9C Bank Holding Company Reports. Since only bank holding companies with total consolidated assets of $150 million or more or with more than one subsidiary bank are required to file the FR Y-9C Report, our sample consists mainly of larger banking organizations. Daily stock price data for our sample bank holding companies are obtained from the Center for Research in Security Prices (CRSP) at the University of Chicago.

Our sample consists of 254 bank holding companies, of which 174 had complete time-series data from 1986 through 1991. The average total assets of the 174 sample firms with a complete time series of observations are used to sort these firms into size-based quartiles. The remaining 80 sample firms with an incomplete time series of observations are then classified into respective size classes using the quartile break points established by the 174 firms at matching time periods. This classification method ensures that the sample firms stay in the same size class throughout the study period, which is necessary to study the time-series properties of X-inefficiency.[3]

Table 1 reports the summary statistics of banking outputs, input prices, total assets, and total costs for the 254 sample banking firms. Both firm size and the cost function variables are highly skewed, indicating the desirability of grouping firms into size classes. In addition, off-balance sheet activities tend to be concentrated in the larger firms in the sample, further suggesting that the cost functions of large banking firms may be different from those of smaller firms.

III. Properties of X-Inefficiency in Banking

Table 2 reports summary statistics of the estimates of c_n in equation (3). These firm-specific X-inefficiency estimates are derived from the stochastic cost frontier estimated separately for banking firms in each size-based quartile. Consistent with earlier studies, we find that substantial inefficiencies exist in banking, averaging between 10 to 20 percent of total costs. However, after controlling for scale

3. Potential misclassification due to intertemporal size changes of individual firms does not seem to be a major concern. If the sample firms had been permitted to move freely from size class to size class intertemporally, there would have been 69 instances of firms moving up to the next size class (of which 51 are within 10 percent of the quartile break points), and 77 instances of firms moving down to the next size class (of which 72 are within 10 percent of the quartile break points).

differences, both the mean and the median estimates of inefficiency decrease monotonically from Quartile 1 to Quartile 4. This suggests that, on average, smaller bank holding companies deviate more from their respective cost-efficient frontier than do larger bank holding companies. Relatively speaking, smaller banking firms appear to be less efficient than their larger counterparts. Moreover, both the intra-quartile range and the standard deviation of inefficiency decrease with firm size. Hence, not only are smaller firms relatively less efficient than larger firms, but their variations in X-inefficiencies also seem to be higher than their larger counterparts. Interestingly, Table 2 also

TABLE 1

DATA SUMMARY FOR 254 BANK HOLDING COMPANIES, BASED ON SEMIANNUAL DATA FROM 1986 TO 1991

	25TH PERCENTILE	MEDIAN	MEAN	75TH PERCENTILE
Total assets[a]	1,198,481	2,779,545	9,814,536	8,110,207
Commercial and industrial loans[a]	164,143	434,074	1,657,808	1,435,509
Real estate loans[a]	306,258	689,684	2,136,602	1,857,829
Consumer loans[a]	139,356	345,852	1,178,900	957,541
Investment securities[a]	266,438	613,962	1,407,576	1,480,544
Commitments & contingencies[a,e]	71,486	307,048	17,684,563	1,984,561
Total costs[a]	50,644	121,354	462,233	346,316
Price of labor[b]	12.41	14.02	14.85	16.08
Price of physical capital[c]	0.126	0.166	0.180	0.219
Price of funds[d]	0.025	0.027	0.028	0.030
Number of observations		2,733		

[a] in thousands of dollars.
[b] in thousands of dollars per full-time equivalent employee.
[c] in thousands of dollars per thousands of dollars of fixed assets.
[d] in thousands of dollars per thousands of dollars of deposits and borrowed funds.
[e] includes loan commitments, letters of credit, futures and forward contracts, and notional value of outstanding interest rate swaps.

TABLE 2

SUMMARY STATISTICS OF X-INEFFICIENCY

	QUARTILE 1	QUARTILE 2	QUARTILE 3	QUARTILE 4
Mean	0.1855	0.1446	0.1211	0.0808
Median	0.1483	0.1166	0.1003	0.0704
Minimum	0.0146	0.0197	0.0159	0.0208
Maximum	0.9460	0.6144	0.4708	0.3212
Std. Deviation	0.1454	0.0977	0.0819	0.0417
Skewness	1.6447	1.4156	1.2244	1.4741
Kurtosis	3.1797	2.4199	1.4317	3.0111
N	774	657	643	659

Note: Quartile 1 (4) contains the smallest (largest) firms.

shows that the X-inefficiency estimates are positively skewed and that they are more fat-tailed for firms in Quartiles 1 and 4.

Figure 1 depicts the 10th and 90th percentile of the X-inefficiency estimates at each semiannual subperiod for the 174 firms that have complete time-series of inefficiency estimates. In addition to confirming that controllable firm-specific inefficiency tends to be relatively larger and to have higher variation among smaller banking firms, Figure 1 indicates that the median X-inefficiency estimate exhibits a gradual decline from 1986 to mid-1990, and then turns up slightly during the last three quarters of the sampling period. The decline in inefficiency from 1986 through 1990 suggests that the market and regulatory changes in banking during the 1980s may have forced banking firms to respond to increased competition in banking by operating more efficiently. While the slight increase in inefficiency since 1990 is somewhat puzzling, the observed pattern may be related to regulatory developments that occurred during this period. First, the increase in inefficiency may be partially driven by the steep rise in deposit insurance premiums, from 8.33 cents per $100 of domestic deposits in 1989 to 23 cents per $100 of domestic deposits in 1992. This structural change in banking costs may not be fully reflected by μ_n in equation (2) and may spill over into δ_n, resulting in higher estimated inefficiencies. Second, the increase in capital requirements as a result of the 1988 Basle Capital Accord may lead to spurious estimates of X-inefficiency.[4] It is possible that banking firms may have responded to the risk-weighted capital requirement by rebalancing their product mix, for example, by shifting from loans to investment securities.[5] While the shift in product mix may be an efficient way to address the new capital constraint, this shift can result in higher observed inefficiency if, for example, the factors of loan production cannot be quickly adjusted to the new product mix.

The final property of X-inefficiency to be investigated in this section is the issue of persistence. Specifically, we are interested in examining the temporal relationship of the cross-sectional rankings of individual firms' inefficiency estimates. Table 3 reports the Spearman rank correlations of the estimated inefficiencies for firms which have a complete time series of data between June 1986 and eleven subsequent time periods. In Quartiles 1, 2, and 3, the rank orderings of X-inefficiency are significantly correlated over time at the 1 percent level for seven subperiods, suggest-

FIGURE 1A

QUARTILE 1 FIRMS

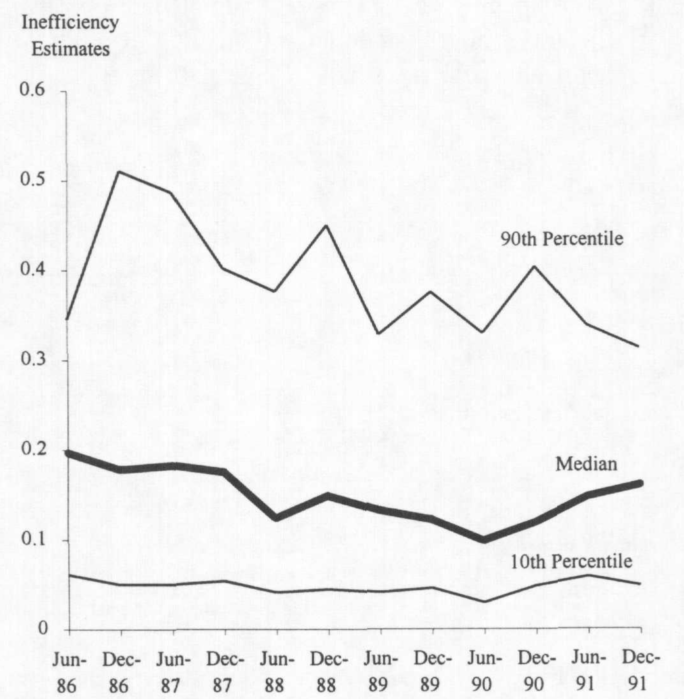
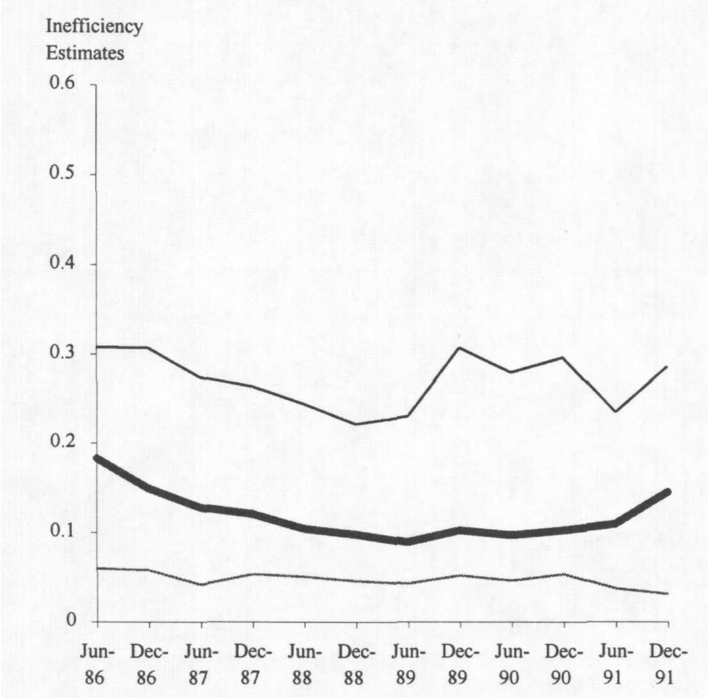


FIGURE 1B

QUARTILE 2 FIRMS



4. The Accord requires that the minimum standard ratio of capital to weighted risk assets be 8 percent, of which the core capital element must be at least 4 percent to be effective at the end of 1992.

5. Some banking observers further attribute this portfolio shift to the so-called credit crunch in 1990.

FIGURE 1C

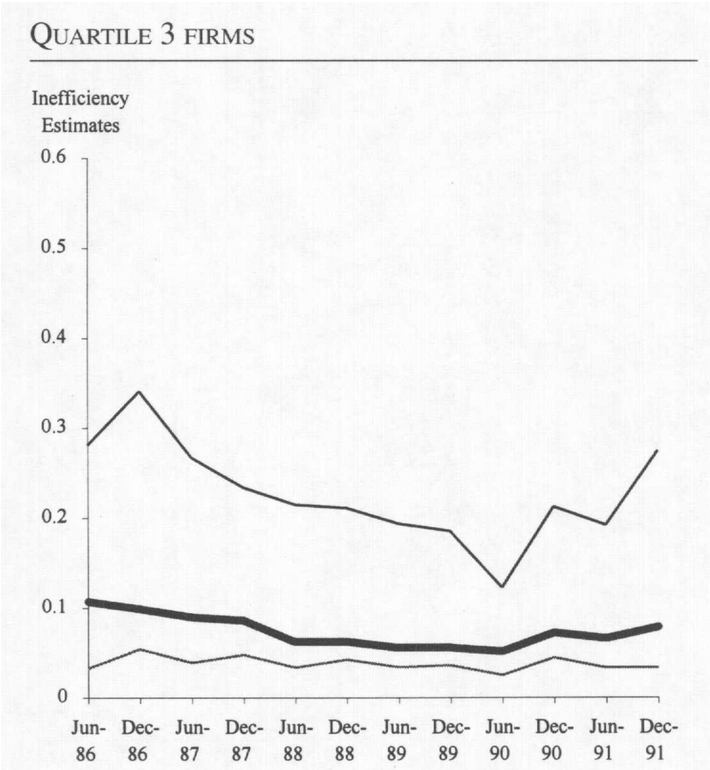
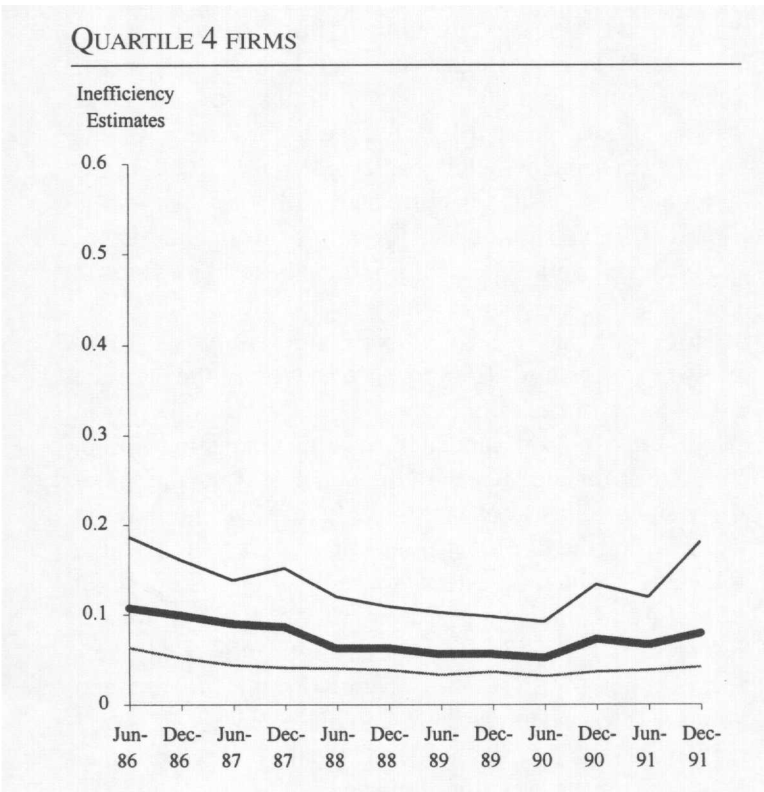


FIGURE 1D



ing that the ranking of firm-specific inefficiency persists for up to three and one-half years. For the largest firms in Quartile 4, the rank orderings of X-inefficiency are significantly correlated at the 1 percent level for only two subperiods, indicating that the ranking of X-inefficiency is relatively short-lived for large banking firms. Qualitatively similar results are obtained when different reference periods are used.

The findings in Table 3 again imply that the properties of the controllable firm-specific X-inefficiency for the very large banking firms are quite different from those of the smaller ones. The very large banking firms, on average, seem to operate closer to their respective efficient frontiers, and their firm-specific X-inefficiency appears to be transitory. In contrast, the smaller firms, on average, tend to operate further away from their respective frontiers, and their firm-specific X-inefficiency appears to be more permanent.

IV. X-INEFFICIENCY AND BANK RISK-TAKING

The apparent persistence of X-inefficiency, at least among the smaller banking firms, prompts us to investigate how inefficient firms can remain economically viable, especially if financial markets are efficient. Specifically, do inefficient firms do anything differently to compensate for being off the efficient frontier? In this paper, we investigate one plausible linkage between controllable X-inefficiency and firm behavior, namely, bank risk-taking. With fixed premium deposit insurance, the moral hazard hypothesis postulates that a bank insured by the FDIC may be able to increase the option value of deposit insurance by increasing bank risk. Theoretically, deposit insurance can be modeled as a put option written by the FDIC to the bank (Merton 1977). For simplicity, assuming all bank debts are insured at face value, in the event of insolvency, an insured bank can put the bank's assets to the FDIC at the face value of its debts, and the value of this put option increases with the bank's asset risk. However, not all banks engage in risk-maximizing behavior. The valuable bank charter, which will be lost upon failure, limits bank risk-taking (Marcus 1984 and Keeley 1990). To the extent that an inefficient banking organization may have a lower charter value to be preserved, it may be more prone to risk-taking than an efficient banking firm. Thus, it would be interesting to find out whether inefficient firms are associated with a higher level of risk.

We use five measures of bank risk, of which three are market-based and two are accounting-based. The three market measures of risk are: (i) standard deviation of daily stock returns, which reflects the total systematic and nonsystematic risks of the banking firm's common stock; (ii)

TABLE 3

Spearman Rank Correlation Coefficients of Inefficiency Estimates at June 1986 and Subsequent Time Periods

Time Period	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Dec. 86	0.7809***	0.7862***	0.8003***	0.6951***
June 87	0.7792***	0.7171***	0.6727***	0.4737***
Dec. 87	0.7377***	0.6192***	0.4665***	0.2987*
June 88	0.6070***	0.5326***	0.4684***	0.3580**
Dec. 88	0.6077***	0.4769***	0.4644***	0.3082**
June 89	0.6226***	0.5240***	0.3959***	0.2971*
Dec. 89	0.4276***	0.6890***	0.4186***	0.5158***
June 90	0.3582**	0.5353***	0.1356	0.3703**
Dec. 90	0.2576*	0.3882***	0.2486	0.2153
June 91	0.3248**	0.2530*	0.1750	0.1871
Dec. 91	0.2611*	0.2547*	0.1128	0.1718
N	43	44	44	43

***, **, * indicate significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

standard deviation of the residuals from the Market Model,[6] which captures the non-systematic, idiosyncratic risk of the firm's stock; and (iii) the ratio of market value of equities to book value of total assets, which measures the banking firm's capitalization. The two accounting measures of risk are (i) the ratio of book value equity to total assets and (ii) the ratio of loan charge-offs to total loans, which measure respectively the firm's book value capitalization and exposure to credit risk.[7] The moral hazard hypothesis predicts that inefficiency is positively related to the total risks and the idiosyncratic risk of stock returns, negatively related to capitalization, and positively related to loan charge-offs.

Panels A and B of Table 4 report the Pearson correlation coefficients between the estimated X-inefficiency and the five risk measures. Regarding stock returns, X-inefficiency is found to be positively correlated with both the total risks and the idiosyncratic risk of the banking firm's stock at the 1% significance level, regardless of firm size. On the association between inefficiency and capitalization, X-inefficiency is found to be negatively correlated with market value capitalization for firms in Quartiles 1, 2, and 3 at the 1 percent significance level and negatively correlated with book value capitalization for firms in all size classes at the 1 percent significance level. Finally, on the relation between inefficiency and credit risk, X-inefficiency is found to be positively correlated with loan charge-offs at the 1 percent significance level for firms in Quartiles 1, 2, and 3, and at the 5 percent significance level for firms in Quartile 4.

However, since the volatility of stock returns is positively related to capitalization, *ceteris paribus*, the bivariate relations between inefficiency and stock return volatility in panel A may be confounded by the effect of capitalization. To control for the leverage effect, standard deviations of daily stock returns are regressed against the inefficiency estimate and the ratio of market value equity to book value total assets. The OLS estimation results, reported in panel C of Table 4, indicate that even after controlling for the leverage effect, inefficiency has a significantly positive effect on stock return volatility. Similar results are obtained when the dependent variable is replaced by the standard deviation of the Market Model residual, reported in panel D of Table 4. The relations between inefficiency and risks embedded in stock returns seem robust.

6. In the Market Model, daily individual stock returns are regressed against the CRSP value-weighted market portfolio returns and an intercept term.

7. A caveat with respect to the ratio of loan charge-offs to total loans is that it also may capture managerial quality, which is correlated with inefficiency.

TABLE 4

RELATIONS BETWEEN X-INEFFICIENCY AND FIRM RISK FOR 254 BANK HOLDING COMPANIES FROM 1986 TO 1991

PANEL A: PEARSON CORRELATION COEFFICIENT BETWEEN INEFFICIENCY AND MARKET MEASURE OF RISK

	Standard Deviation of Daily Stock Returns	Standard Deviation of Residuals from Market Model	Market Value Equity to Book Value Assets	*N*
Quartile 1	0.3605***	0.3637***	–0.3333***	636
Quartile 2	0.2906***	0.2961***	–0.3636***	596
Quartile 3	0.1786***	0.1791***	–0.2589***	550
Quartile 4	0.1493***	0.1462***	–0.0676	554

PANEL B: PEARSON CORRELATION COEFFICIENT BETWEEN INEFFICIENCY AND ACCOUNTING MEASURE OF RISK

	Ratio of Loan Charge-offs to Total Loans	Book Value Equity to Asset Ratio	*N*
Quartile 1	0.5288***	–0.5355***	774
Quartile 2	0.4708***	–0.3469***	657
Quartile 3	0.3162***	–0.3388***	643
Quartile 4	0.0782**	–0.2531***	659

PANEL C: OLS REGRESSION OF STANDARD DEVIATION OF STOCK RETURNS ON INEFFICIENCY AND CAPITALIZATION

	Inefficiency	Market Value Equity to Total Assets	*N*
Quartile 1	0.058***	–0.130***	636
	(0.008)	(0.022)	
Quartile 2	0.026***	–0.118***	596
	(0.006)	(0.013)	
Quartile 3	0.013**	–0.107***	550
	(0.006)	(0.012)	
Quartile 4	0.033***	–0.125***	554
	(0.010)	(0.013)	

PANEL D: OLS REGRESSION OF STANDARD DEVIATION OF MARKET MODEL RESIDUALS ON INEFFICIENCY AND CAPITALIZATION

	Inefficiency	Market Value Equity to Total Assets	*N*
Quartile 1	0.059***	–0.130***	636
	(0.008)	(0.022)	
Quartile 2	0.025***	–0.117***	596
	(0.006)	(0.013)	
Quartile 3	0.012**	–0.101***	550
	(0.006)	(0.012)	
Quartile 4	0.026***	–0.105***	554
	(0.008)	(0.011)	

***, ** indicate significance at the 1 percent and 5 percent levels, respectively. Standard errors are in parentheses.

Taken together, the findings provide strong evidence that X-inefficiency is associated with bank risk-taking and thus are consistent with the moral hazard hypothesis. Inefficient banking firms tend to have higher stock return variances, higher idiosyncratic risk in stock returns, lower capitalization, and higher loan losses. While the results in Table 4 reflect association, and not necessary causation, X-inefficiency seems to have important implications for risk management and bank safety, which should concern bank management as well as bank regulators.

V. X-INEFFICIENCY AND STOCK MARKET VALUATION

This section further explores the relationship between X-inefficiency and bank stock returns. Previous research has shown that bank stock returns are sensitive to changes in interest rates, in addition to the market return, based on the two-index model (see, for example, Flannery and James (1984), Kane and Unal (1990), and Kwan (1991)). Both Flannery and James (1984) and Kwan (1991) also found that the sensitivity of bank stock returns to interest rate changes is related to the individual bank's assets and liabilities maturity profile, indicating that certain firm-specific factors have explanatory power for bank stock returns. In a similar spirit, it would be interesting to test whether another firm-specific factor, namely, operating efficiency, also provides explanatory power for bank stock returns.

To test the effect of operating efficiency on bank stock performance, the two-index model is modified to include the X-inefficiency estimate, in addition to the market return and changes in long-term interest rates:[8]

$$R_{jt} = \beta_0 + \beta_1 R_{mt} + \beta_2 R_{it} + \beta_3 Inefficiency_{jt} + \varepsilon_{jt} \quad (5)$$

where

R_{jt} = return on firm j's stocks for the semiannual period ending at time t,

R_{mt} = return on the CRSP value-weighted market portfolio for the semiannual period ending at time t,

R_{it} = relative change in 30-years constant maturity Treasury yield (y) from time t–1 to time t, i.e., $(y_t - y_{t-1})/y_{t-1}$,

$Inefficiency_{jt}$ = firm j's estimated X-inefficiency for the semiannual period ending at time t, β's are regression coefficients, and ε_{jt} is the disturbance term.

Equation (5) is estimated by OLS using pooled time-series cross-section observations separately for each size class and the results are reported in Table 5. Consistent with prior studies, the coefficients of the CRSP market portfolio return are significantly positive and are close to unity. Moreover, the coefficients of the relative change in

8. Using short-term interest rates provides qualitatively similar results.

TABLE 5

OLS REGRESSION RESULTS OF BANK STOCK RETURNS ON THE CRSP MARKET RETURN, RELATIVE CHANGE IN THE LONG-TERM TREASURY YIELD, AND X-INEFFICIENCY

	Coefficient Estimate				
	Market Return	Treasury Yield Change	$Inefficiency_{jt}$	N	Adj. R^2
Quartile 1	1.0233 (12.597)***	–0.5684 (–5.115)***	–0.3718 (–5.034)***	569	0.30
Quartile 2	1.0706 (13.368)***	–0.6259 (–5.672)***	–0.4349 (–4.311)***	543	0.33
Quartile 3	1.1278 (16.136)***	–0.6608 (–7.024)***	–0.1337 (–1.280)	505	0.43
Quartile 4	1.3554 (17.433)***	–0.4728 (–4.437)***	–0.3148 (–1.365)	512	0.42

*** indicates significance at the 1 percent level; t-statistics are in parentheses.

long-term bond yield are significantly negative, indicating that increases in interest rates have a negative effect on bank stock returns. The level of firm-specific X-inefficiency is significantly negatively related to bank stock returns for firms in Quartiles 1 and 2, suggesting that inefficiency has a negative effect on stock returns. Although it has the expected negative sign, the coefficient of X-inefficiency is insignificant for the larger firm quartiles. However, the fact that the X-inefficiency is both smaller and has less cross-sectional variation among larger firms may make it more difficult to detect a statistically significant relationship between X-inefficiency and stock returns for these firms. On balance, inefficient banking firms seem to be associated with poor stock return performance, *ex post.*

VI. Summary and Conclusion

Our findings provide further empirical evidence that substantial X-inefficiencies seem to exist in banking. In addition, several interesting properties of X-inefficiency are detected. After controlling for scale differences, smaller banking firms on average are found to be relatively less efficient than larger banking firms. Moreover, smaller banking firms tend to exhibit larger variations in X-inefficiencies than larger firms. While the findings suggest that the average large banking firm operates closer to its respective efficient frontier than the average small banking firm, the sources of these cross-sectional variations in X-inefficiencies can be answered only by future research.

Furthermore, the average X-inefficiency appears to decline over the period 1986 to mid-1990, apparently responding to the increased competition in banking wrought by market and regulatory changes. Although the average X-inefficiency seems to be falling, the rank orderings of firm-specific X-inefficiency are strongly correlated over time. The persistence of X-inefficiency rankings suggests that relatively efficient (inefficient) banking firms tend to stay relatively efficient (inefficient) over a fairly long period.

The persistence of firm-specific X-inefficiency leads us to investigate how the inefficient firms compensate for their inefficiency in the banking industry in order to avoid being driven out of the banking market. A strong correlation between firm-specific X-inefficiency and bank risk-taking is detected. Specifically, inefficient banking firms exhibit higher stock return variances, greater idiosyncratic risk in stock returns, lower capitalization, and higher loan charge-offs. The findings are consistent with the moral hazard hypothesis that inefficient banking firms may be able to extract larger deposit insurance subsidies from the FDIC to offset part of their operating inefficiencies. Hence, operating inefficiencies should concern not only bank management but also bank regulators.

Finally, for the smaller banking firms which exhibit large cross-sectional variations in X-inefficiencies, bank stock returns are found to be significantly negatively related to firm-specific X-inefficiency, after controlling for the market return and changes in risk-free interest rates. However, X-inefficiency appears to provide little explanatory power for the stock returns of larger banking firms, which tend to be more clustered together inside their respective efficient frontiers. The detection of a significant statistical relationship between X-inefficiency and *ex post* bank stock returns lays the groundwork for a more important research question: whether and how operating risk is priced in bank stocks.

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