FRBSF Working Paper 2002-14

Preliminary Draft
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The X-Efficiency of Commercial Banks in Hong Kong

Simon H. Kwan
Federal Reserve Bank of San Francisco
Hong Kong Institute for Monetary Research

December, 2001

Abstract

This paper uses the stochastic econometric cost frontier approach to investigate the cost efficiency of commercial banks in Hong Kong. On average, the X-efficiency of Hong Kong banks is found to be about 16 to 30 percent of observed total costs, which is comparable to the findings in the U.S. banking industry. X-efficiency is found to decline over time, indicating that banks in Hong Kong are now operating closer to the cost frontier than before. This is consistent with technological innovation that might have occurred in the Hong Kong banking industry. Furthermore, the average large bank in Hong Kong is found to be less efficient than the average small bank, particularly during the earlier time periods. Finally, X-efficiency is found to be related to certain bank characteristics. Specifically, X-efficiency is found to decline with bank size, deposit-to-asset ratio, loan-to-asset ratios, provision for loan loss, and loan growth, and to increase with off-balance sheet activities.

Please send correspondence to: Simon Kwan, Research Advisor, Federal Reserve Bank of San Francisco, 101 Market Street, San Francisco, CA 94105, U.S.A.
Telephone: 415-974-3485; Fax: 415-974-2168; E-mail: simon.kwan@sf.frb.org

Thanks are due to Irene Wang for excellent research assistance, and to Emily Cheng for assistance in data gathering. Special thanks are due to the Hong Kong Monetary Authority for providing the banking data for this study. This research was started when the author visited the Hong Kong Institute for Monetary Research. The views expressed are those of the author's and do not necessarily represent the views of the Hong Kong Monetary Authority, the Hong Kong Institute for Monetary Research, the Federal Reserve Bank of San Francisco, and the Federal Reserve System.

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I. Introduction

Following the deregulation of deposit interest rates in Hong Kong, commercial banks in this Asian financial capital have had to operate in an increasingly competitive environment. This trend is expected to continue as government policy is directed towards a competitive banking industry, and competition from foreign banks picks up, partly in response to the Asian financial crisis, but also in response to China entering the World Trade Organization. With heightened competition, whether and how banks may survive in the new environment depend in part on how efficiently Hong Kong banks operate. This paper uses the stochastic econometric cost frontier approach to study the cost inefficiency of commercial banks in Hong Kong.

The textbook definition of a cost function holds that it gives the minimum level of cost at which it is possible to produce some level of output, given input prices. The cost frontier means that the observed production cost must lie everywhere above the cost frontier but no points can lie below it. Thus, the amount by which a firm lies above its cost frontier can be regarded as a measure of inefficiency. This concept of measuring inefficiency dates back to the path-breaking work of Farrell (1957) who proposed specific measures of technical and allocative efficiency. Based on this concept, Leibenstein (1966) coined the term X-efficiency and noted that, for a variety of reasons, people and organizations normally work neither as hard nor as effectively as they could. The choice of focusing on X-efficiency in this study is partly because banking research to date suggests that X-efficiency appears to be large and tends to dominate scale and scope efficiencies.[1] More recently, researchers have linked X-efficiencies to organizational structure [Cebenoyan, Cooperman, Register, and Hudgins (1993) and Mester (1993)], executive compensation [Pi and Timme (1993)], market concentration [Berger and Hannan (1996)], risk-taking [Kwan and Eisenbeis (1996)], mergers and acquisitions [Peristiani (1997) and Berger (1997)], and common stock performance [Kwan and Eisenbeis (1996)], suggesting that X-efficiencies have potentially important implications for public policy and bank management.

We found that during our study period, cost inefficiency in Hong Kong banks was quite large, averaging 16 to 30 percent of observed total costs. Nevertheless, the range of the X-efficiency estimates is comparable to those reported in the U.S. banking industry. There is clear evidence that the level of inefficiency in Hong Kong banks was declining over time, indicating that banks in Hong Kong are now operating closer to the cost efficient frontier than before. Furthermore, as a whole, the average large bank in Hong Kong is found to be less efficient than the average small bank, but the gap seems to be narrowing over time. Finally, cost efficiency in Hong Kong banks are found to be associated with certain characteristics, including bank size, the ability to make loans and gather deposits, the quality of the loan portfolio, and loan growth.

The rest of the paper is organized as follows: Section II describes the methodology to measure X-efficiency. Model specification and data description are presented in Section III. Section IV reports the properties of the X-efficiency estimates, both over the time domain and cross-sectionally. The relation between X-efficiency and bank characteristics is investigated in

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[1] In their survey paper, Berger, Hunter, and Timme (1993) indicated that X-efficiency in the U.S. banking industry accounts 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 bank costs. Please also see Berger and Humphrey (1997) for the international survey.

Section V, and Section VI concludes this study.

II. Methodology

To measure the X-efficiency of individual banks in Hong Kong, the econometric technique that involves the estimation of the cost function and the derivation of X-efficiency estimates from the residuals is employed. This method, developed by Aigner, Lovell, and Schmidt [1977] has the virtue of allowing for "noise" in the measurement of efficiency, and has been shown to be more robust than the alternative method of data envelopment.[2] In this method, a bank's observed total cost is modeled to deviate from the cost efficient frontier due to random noise and X-efficiency. The stochastic cost frontier has the following general (log) form:

$$\ln C_n = f(\ln y_{i,n}, \ln w_{j,n}) + \epsilon_n , \qquad \textbf{(1)}$$

where C_n is the total cost for bank n, $y_{i,n}$ measures the i^{th} output of bank n, and $w_{j,n}$ is the price of the j^{th} input of bank n. The error term, ϵ_n , has two components:

$$\epsilon_n = \mu_n + \upsilon_n . \qquad \textbf{(2)}$$

The first component, μ_n, captures the effects of uncontrollable (random) factors while the second component, υ_n, represents controllable factors [Aigner, Lovell and Schmidt (1977)]. It is assumed that μ is distributed as a symmetric normal $N(0,\sigma_\mu^2)$ and that υ is independently distributed as a half-normal, $|N(0,\sigma_\upsilon^2)|$. Following Jondrow, Lovell, Materov, and Schmidt (1982), an estimate of the n^{th} bank's X-efficiency can be derived from the composite error term

[2] See, for example, Eisenbeis, Ferrier and Kwan (1998).

as follows:

$$XE_n = E[\nu_n | \epsilon_n] = \frac{\sigma\lambda}{(1+\lambda^2)} \left[\frac{\phi(\epsilon_n \lambda / \sigma)}{\Phi(\epsilon_n \lambda / \sigma)} - \frac{\epsilon_n \lambda}{\sigma} \right] \quad \textbf{(3)}$$

where XE_n is the X-efficiency of bank n, E(•) is the expectation operator, λ is the ratio of the standard deviation of υ to the standard deviation of μ (*i.e.*, $\sigma_\upsilon/\sigma_\mu$), $\sigma^2 = \sigma_\upsilon{}^2 + \sigma_\mu{}^2$, and ϕ and Φ are the standard and cumulative normal density functions, respectively. The X-efficiency estimate has the interpretation of the percent of total costs that could have been reduced were the bank operate at the cost efficient frontier.

Assuming the cost function to be stationary over time, pooled time-series cross-section observations are used to estimate the stochastic cost frontier. For robustness, in addition to estimating the cost frontier using the full sample of banks, the cost frontier is also estimated separately for the subsamples of large banks and small banks.

III. Model Specification and Data

To specify the functional form of the cost frontier in (1), the standard multi-product translog cost function is used:

$$\begin{aligned} \ln C = \alpha_0 + \Sigma_i\ \beta_i\ \ln y_i + \Sigma_j\ \beta_j\ \ln w_j + 1/2\ \Sigma_i\Sigma_k\gamma_{ik} \ln y_i \ln y_k \\ + 1/2\ \Sigma_j\Sigma_h\ \zeta_{jh} \ln w_j\ \ln w_h + \Sigma_i\Sigma_j\ \omega_{ij} \ln y_i \ln w_j\ , \end{aligned} \quad (4)$$

where C is total operating cost (including interest expenses), y_i, i = 1,...,m, are outputs, and w_j, j = 1,...,k, are input prices. The homogeneity restrictions,

$$\Sigma_j \beta_j = 1, \quad \Sigma_h \zeta_h = 0, \quad \Sigma_k \omega_k = 0, \tag{5}$$

are imposed by normalizing total costs and input prices by one of the input prices.

Micro banking data from 1992:Q1 through 1999:Q4 obtained from the Return of Assets and Liabilities, Return of Current Year's Profit and Loss Account, and Quarterly Analysis of Loans and Advances and Provisions that Authorized Institutions in Hong Kong must file with the Hong Kong Monetary Authority are used to estimate the model. For confidentiality, the names of the reporting institutions are not available. In addition, as a precaution that the identity of the largest bank and the smallest bank may be inferred from the data, both the largest bank and the smallest bank are not available for analysis.

Our method assumes that all banks have the same access to the underlying production technology and hence face the same cost frontier. Thus, to eliminate non-traditional banks, a bank must meet the following sampling criterion in order to be included in the final sample: (1) the amount of demand deposits, savings deposits, or time deposits must all be greater than zero; (2) the amount of total loans must be greater than zero; (3) both the labor cost and the physical capital cost must be positive; and (4) the number of branches must be greater than one. The last sampling criteria is imposed because multi-branch banks presumably have a different production technology than banks with no branch offices.[3] The final sample consists of 59 multi-branch banks that operate at some point in time between 1992 and 1999. Table 1 provides descriptive statistics for 51 sample banks as of 1999:Q4. The median asset size of the sample banks as of

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[3] As of 1999:Q4, total assets at all multi-branch banks were $4.6 trillion, accounting for over 70 percent of total assets in the entire banking system.

the end of 1999 was $42 billion, and the average asset size was $77 billion. For robustness, the X-efficiency is also estimated separately for large banks and small banks, on the ground that large banks may employ a somewhat different production technology than small banks. At each sampling period, banks whose total assets were above the median were classified as large, and those that were below the median were classified as small. For those banks that received dual classification over the entire sampling period, they were classified into the two size groups according to the majority of time they were classified.

There continues to be some debate about what constitutes the outputs and inputs in a banking firm. In this paper, the intermediation approach is used, which views the bank as employing labor, physical capital, and borrowed funds to produce earning assets [see for example, Sealey and Lindley (1977)]. This is the approach most commonly used in the conventional bank cost function literature. Three outputs are included in the model: y_1 = loans to finance imports, exports, re-exports, and merchandising trade, y_2 = loans for non-trade related financing, and y_3 = earning assets including negotiable certificate of deposits, all other negotiable debt instruments, and equity investments. The average volume of each of these three outputs at the sample banks as of the end of 1999 was about $1.9 billion, $29.3 billion, and $9.5 billion, respectively. Thus, about 5 percent of the average bank's output is in loans to finance trade, about 72 percent is in non-trade related lending, and the rest is in other earning assets.

The inputs (whose prices are used to estimate the cost frontier) include labor, physical capital, and borrowed money (including deposits and all other interest-bearing liabilities) used to fund the outputs. The price of labor, w_1 , is proxied by [staff expenses / number of employees]. The price of capital, w_2 , is constructed as [rental and other expenses / number of employees].

The borrowed money price, w_3 , is constructed as [interest expenses / total liabilities]. As of 1999:Q4, the average quarterly wage rate was about $82,000; the average quarterly price of capital was about $89,000; and the average quarterly interest rate on borrowed funds was 1.25%. Average total costs in 1999:Q4 was $1.07 billion, and the median total costs was $0.6 billion.

IV. Properties of X-Efficiencies

In using pooled time-series cross-section observations to estimate the cost efficient frontier, X-efficiency estimates for each sample bank at each sampling period are calculated. By aggregating the X-efficiency estimates cross-sectionally at each sampling period, time series properties of X-efficiency are obtained. In addition, the distributions of the X-efficiency estimates at each sampling period, and over the entire sampling period, provide useful information about the cross-sectional distribution of X-efficiency among sample banks.

A. Time-Series Properties

Table 2 shows the mean and the median X-efficiency estimates as of the end of the year between 1992 and 1999, for the full sample and the two sub-samples of large banks and small banks. For the full sample, the average X-efficiency was 45 percent in 1992 and declined to 29 percent in 1999. For large banks, average X-efficiency declined from 37 percent in 1992 to 26 percent in 1999; and for small banks, average X-efficiency fell from 31 percent in 1992 to 23 percent in 1999. A number of observations are evident from Table 1. First, X-efficiency was falling over time, suggesting that banks in Hong Kong on average are now operating closer to the cost efficient frontier than before. This is not surprising because in using pooled time-series cross-section data to estimate the efficient frontier, we are imposing the restriction that the production technology is constant throughout the estimation period. If technological innovation occurred in the Hong Kong banking industry during the estimation period, the X-efficiency estimates for the earlier time periods may be biased upward. This is because banking operation during the earlier time periods, even for the most efficient bank at that time, would be compared unfavorably to banking operation in more recent periods. Thus, the falling X-efficiency seems to be capturing the trend of banking technological improvements in Hong Kong. Second, the X-efficiency estimated separately for the large banks and the small banks are smaller than the X-efficiency estimated using the full sample. Again, by pooling large and small banks together in the full sample, we are imposing the restriction that large banks and small banks employ the same technology in bank production. To the extent that this restriction may not hold, separating the large banks from the small banks allows each size group to have its own production technology, resulting in a tighter fit of the data and a smaller X-efficiency estimate. Third, the range of the average X-efficiency estimate, between 16 to 30 percent of total costs in more recent time periods, is similar to the range documented in research based on U.S. banking data. In addition to providing some comfort to the X-efficiency estimates, it appears that the underlying forces contributing to X-efficiency may be quite similar across geographic boundaries.

In Figure 1, the top panel depicts the cross-sectional mean and weighted average (weighted by total assets) of X-efficiency for each quarter between 1992 and 1999 for the full sample; the middle panel shows the 10^{th} percentile, the median, and the 90^{th} percentile of the X-efficiency estimate over time; and the bottom panel shows the cross-sectional standard deviation of X-efficiency over time. Both the mean and the median X-efficiency were declining from

1992 through 1997, then edged up in 1998 and 1999. The slight increase in X-efficiency in the last two sampling years may be related to the aftermath of the Asian financial crisis. Following the crisis, banks may have incurred additional operational costs to deal with the mounting bad loan problems when banking outputs declined simultaneously due to falling demand. These have the effects of lowering operating efficiency relative to the pre-crisis periods. Notice that the standard deviation of X-efficiency also rose in the recent sampling periods. This is consistent with the idiosyncratic nature of the bad loan problem faced by different banks. In the middle panel, it can be noted that X-efficiency is skewed to the left.

Figures 2 and 3 depict similar information as in Figure 1 for large banks and small banks, respectively. While the time-series patterns for large banks and small banks are broadly similar to the full sample, small banks on average were more efficient than large banks during the earlier time periods. Moreover, the cross-sectional standard deviation of X-efficiency for small banks is lower than for large banks, suggesting that small banks as a group are clustering closer to the cost frontier than large banks. Nevertheless, towards the end of the sampling period, X-efficiency appears to be quite similar between large banks and small banks.

The next time-series property of X-efficiency to be investigated is the issue of persistence. Specifically, we are interested in the question of how long an inefficient bank remains inefficient. To address this question, the temporal relationship of the cross-sectional rankings of X-efficiency is examined. Table 3 reports the Spearman rank correlations of the X-efficiency estimates between 1992:Q1 and subsequent sampling periods. Figure 4 charts the Spearman rank correlation through time. For the full sample, the rank of X-efficiency is found to be significantly correlated over time. While the Spearman rank correlation is significant up to the end of the sampling period, the correlation coefficient is declining over time and falls below 0.5 in four years. Thus, for the full sample, the evidence suggests that X-efficiency is highly persistence, indicating that an inefficient bank remains inefficient for a fairly long period of time.

From Table 3 and Figure 4, it is quite clear that the rank correlation for the small bank sub-sample is lower than the large bank sub-sample. For small banks, the X-efficiency rank correlation is insignificant after four years, and the correlation coefficient falls below 0.5 in less than two years. Thus, not only are small banks on average more efficient than large banks, X-efficiency seems to be much less persistent among small banks than large banks.

B. Cross-sectional Properties

Table 4 reports the cross-sectional properties of X-efficiencies. Panel A shows the cross-sectional distribution of the time-series average of X-efficiency computed for each bank using the quarterly estimates between 1992 and 1999. Averaging over the entire sampling period, the mean and the median X-efficiency based on the full sample were 32 percent and 29 percent, respectively. Thus, if the average bank were to use its inputs in the most efficient way during the eight-year period, it could reduce its production cost by roughly 30 percent, which seems economically large. By estimating X-efficiency separately for large banks and small banks and therefore allowing a tighter fit of the data to the respective frontiers, the mean and the median X-efficiency for large banks were 30 percent and 24 percent, respectively; the mean and the median X-efficiency for small banks were 22 percent and 19 percent, respectively.

Since not all banks are the ‘average’ banks, it would be interesting to see how the sample banks stack up against each other in terms of X-efficiency. Figure 5 shows the frequency distribution of the time-series average X-efficiencies that are estimated using the full sample, the large bank sub-sample, and the small bank sub-sample. For the full sample, a relatively large number of banks have average X-efficiency between 20 and 30 percent but the range of the X-efficiency estimates is wide. X-efficiency is left-skewed, indicating that there are relatively more banks at the low range of X-efficiency than at the high end. A very few banks have very large estimates of X-efficiency. Upon checking the data, these banks reported very low loan-to-asset ratio; and their input price of labor were well below average but the reported total costs were not. These outliers appear to have a very different product strategy and thus may have a somewhat different production function. For the two size sub-groups, the cross-sectional distribution of X-efficiency among large banks is similar to the full sample. For small banks, the distribution is more compact and no banks have X-efficiency greater than 50 percent.

Panels B & C of Table 4 report the cross-sectional distribution of X-efficiency at the end point and the starting point of the sampling period, respectively. In general, X-efficiency as of 1999:Q4 was lower than in 1992:Q1, perhaps due to technological innovations during the sampling period. The frequency distributions of X-efficiency as of 1999:Q4 are shown in Figure 6. Notice that in the large bank sub-sample, there were a number of banks that had fairly high X-efficiency estimates. Figure 7 shows the frequency distribution of X-efficiency in 1992:Q1. Of the 29 large banks, 21 had X-efficiency estimates over 20 percent, whereas only 12 of the 26 small banks' X-efficiency estimates were in that range.

V. X-Efficiency and Bank Characteristics

The final set of analysis is to examine the characteristics of inefficient banks. First, the simple correlation between the X-efficiency estimate and a set of bank characteristics is calculated. Second, X-efficiency estimates are regressed against the set of bank characteristics in a multiple regression framework. It should be noted that the statistical relationship needs not imply causality. That is, any uncovered relationship does not mean that those characteristics cause banks to be inefficient. Rather, these characteristics appear to be more prevalent among inefficient banks. In addition, inefficiency may be endogenous in bank characteristics so that the causality may run in either direction.

The set of bank characteristics examined includes: (1) bank size, measured by the log of total assets; (2) deposit-to-asset ratio; (3) ratio of trade related loans to total assets; (4) ratio of non-trade related loans to total assets; (5) ratio of loan loss provision to total loans; (6) ratio of off-balance sheet activities to total assets; and (7) loan growth, measured by the growth rate of total loans over the last four quarters. The size variable tests whether X-efficiency is related to bank size. The deposit and loan ratios capture the banks funding mix and loan portfolio composition. The loan loss provision captures the quality of the loan portfolio. Because our definition of bank outputs does not include any off-balance sheet activities, which are costly to produce, the off-balance sheet ratio is expected to be positively related to X-efficiency. Finally, the loan growth variable tests the relation between operating performance and growth.

The Pearson correlation coefficient between the X-efficiency estimate and bank characteristics are shown in Table 5, separately for the X-efficiencies that are estimated using the full sample, the large bank sub-sample, and the small bank sub-sample. The bivariate relation between X-efficiency and bank characteristics is similar across the three different samples. The correlation between X-efficiency and bank size is significantly positive, which is consistent with the cross-sectional properties of X-efficiency. Without controlling for other bank characteristics, large banks are associated with higher X-efficiency estimates. The correlation between X-efficiency and deposit-to-asset ratio is significantly negative, indicating that banks which gather more deposits to fund their assets tend to be more efficient. Both of the two loans-to-asset ratios are significantly negatively correlated with X-efficiency estimates, indicating that banks which make more loans are associated with higher level of efficiency. The provision for loan loss ratio is significantly negatively correlated with X-efficiency, suggesting that banks with more problem loans are more efficient. This may be due to the fact that banks that spend less resources on credit underwriting and loan monitoring are cost efficient but at the expense of more problem loans. Regarding off-balance sheet activities, X-efficiency is found to be significantly positively correlated with the off-balance sheet ratio, which seems to confirm that the omitted outputs in the cost function is contributing to higher X-efficiency estimates. We found the correlation between X-efficiency and loan growth is significantly negative only among small banks. The negative relation suggests that cost efficiency is associated with fast growing banks.

Table 6 reports the OLS results of regressing X-efficiency on bank characteristics using a fixed-effect model. The bank-specific dummies and the time-effect dummies are not reported. Overall, the data fit the model reasonably well, with the adjusted R-square ranges from 70 percent to 85 percent. While the multi-variate regression results are broadly similar to the bivariate correlation, several differences are noted. First, after controlling for other bank characteristics, X-efficiency estimates are found to decline with bank size. That is, after controlling for loan and deposit mixes, loan quality, off-balance sheet activities, and growth, larger banks are found to be associated with a higher level of operating efficiency. Second, the negative relation between X-efficiency and loan loss provision is not statistical significant for the full sample and the large bank sub-sample, and is only marginal significant for the small bank sub-sample. Third, the relation between X-efficiency and off-balance sheet activities is significantly positive across the three samples, providing stronger evidence that omitting the off-balance sheet outputs may account for some of the X-efficiency estimates. Fourth, we found loan-growth to have a significantly negative effect on X-efficiency estimates for both the large banks and small banks sub-samples, further indicating that high growth banks are associated with a higher level of cost efficiency.

VI. Conclusions

This paper uses the stochastic econometric cost frontier approach to investigate the cost efficiency of multi-branch banks operating in Hong Kong using quarterly data from 1992 through 1999. Based on pooled time-series cross-section estimation, the average X-efficiency of Hong Kong banks is about 16 to 30 percent, which is similar to the findings in the U.S. On the time-series dimension, X-efficiency is found to decline over the sampling period, indicating that banks in Hong Kong are now operating closer to the cost frontier than before. This is consistent with the existence of technological innovation in banking during the sampling period. X-efficiency is found to edge up following the Asian financial crisis, perhaps because banks were spending additional resources to deal with the mounting bad loan problem when outputs fell simultaneously. Cross-sectionally, X-efficiency is found to skew to the left, indicating that there are more banks that are relatively efficient than inefficient. As a whole, the average large bank is found to be less efficient than the average small bank, particularly during the earlier time periods.

X-efficiency is found to be related to certain bank characteristics. Ceteris paribus, X-efficiency is found to decline with bank size, deposit-to-asset ratio, loan-to-asset ratios, provision for loan loss, and loan growth; it is found to increase with off-balance sheet activities. The results suggest the followings. After controlling for on- and off-balance sheet ratios and growth, bigger banks tend to be more efficient than smaller banks. Banks that make more loans, and, banks that gather more deposits tend to be more efficient. Banks with higher loan loss provisions are found to be more cost efficient, perhaps at the expense of lower profits. Efficient banks tend to grow faster than inefficient banks. More off-balance sheet activities are associated with higher level of inefficiencies, in part because off-balance sheet products were not included in the output definition and therefore biased the output measure downward.

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Table 1: Data Summary for 51 Sample Banks as of 1999:Q4

All figures are in HK$ millions, unless otherwise specified.

	Mean	Median	Min	Max
Total Assets	77,058.06	41,973.57	639.17	820,138.50
Total Deposits	49,903.76	25,481.72	227.38	606,838.89
Demand Deposits	2,275.25	964.11	11.03	34,932.67
Saving Deposits	12,176.11	2,932.152	9.98	220,345.669
Time Deposits	35,452.39	21,114.76	127.539	351,560.55
Loans to Finance Trade	1,862.25	1,135.56	0.66	14,422.25
Non-Trade Related Loans	29,268.68	18,692.49	121.10	249,869.77
Other Earning Assets	9,488	3,904.58	24.09	1,425.14
Total Costs	1,070.34	597.02	5.88	9,857.55
Price of Labor ($000's)	81.64	78.93	37.93	166.93
Price of Capital ($000's)	89.45	64.87	24.56	432.75
Price of Funds	1.25 %	1.20 %	0.42 %	2.39 %

Table 2: Time-Series Properties of X-Efficiency Estimates

This table shows the mean (median) X-efficiency estimates of the sample banks as of the end of the year between 1992 and 1999.

	All Banks	Large Banks	Small Banks
1992: Q4	0.4555 (0.4355)	0.3667 (0.3144)	0.3073 (0.3109)
1993: Q4	0.4691 (0.4056)	0.3558 (0.3463)	0.2621 (0.2189)
1994: Q4	0.3889 (0.3451)	0.3753 (0.3340)	0.2507 (0.2253)
1995: Q4	0.3090 (0.2356)	0.3403 (0.2939)	0.1841 (0.1528)
1996: Q4	0.2707 (0.2067)	0.2762 (0.2124)	0.1875 (0.1380)
1997: Q4	0.2214 (0.1471)	0.2318 (0.1380)	0.1605 (0.1440)
1998: Q4	0.2735 (0.2059)	0.2573 (0.1866)	0.2037 (0.1738)
1999: Q4	0.2923 (0.2273)	0.2587 (0.2014)	0.2287 (0.1919)

Table 3: Spearman Rank Correlation of X-Efficiency Estimates at 1992: Q1 and Subsequent Time Periods

	All Banks	Large Banks	Small Banks
1993: Q1	0.8686 ***	0.7227 ***	0.7839 ***
1994: Q1	0.6105 ***	0.6370 ***	0.3305
1995: Q1	0.5103 ***	0.5877 ***	0.5277 ***
1996: Q1	0.4543 ***	0.4399 **	0.6265 ***
1997: Q1	0.3031 **	0.4138 **	0.1818
1998: Q1	0.2870 **	0.3847 **	0.3271
1999: Q1	0.4813 ***	0.4399 **	0.2253

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

Table 4: Cross-Sectional Properties of X-Efficiency Estimates

Panel A: Based on Averages from 1992: Q1 to 1999: Q4

	Mean	Median	Standard Deviation
All Banks	0.3208	0.2898	0.2195
Large Banks	0.2991	0.2377	0.2274
Small Banks	0.2168	0.1942	0.1177

Panel B: As of 1999: Q4

	Mean	Median	Standard Deviation
All Banks	0.2923	0.2273	0.2787
Large Banks	0.2587	0.2014	0.2304
Small Banks	0.2287	0.1919	0.1449

Panel C: As of 1992: Q1

	Mean	Median	Standard Deviation
All Banks	0.4166	0.3901	0.2801
Large Banks	0.4038	0.3717	0.3042
Small Banks	0.2425	0.1734	0.1759

Table 5: Relations between X-efficiency and Bank Characteristics

This table reports the Pearson correlation coefficients between the X-efficiency estimate and bank characteristics. P-values are in parentheses.

	All Banks	Large Banks	Small Banks
Bank Size	0.1622*** (< 0.0001)	0.2207*** (<0.0001)	0.0651* (0.0667)
Deposit to Asset Ratio	-0.1421*** (<0.0001)	-0.1697*** (<0.0001)	-0.0043 (0.9045)
Trade Loans to Total Asset Ratio	-0.2595*** (<0.0001)	-0.2775*** (<0.0001)	-0.1603*** (<0.0001)
Non-Trade Loans to Total Asset Ratio	-0.6452*** (<0.0001)	-0.6035*** (<0.0001)	-0.5834*** (<0.0001)
Loan loss Provision to Total Loans	-0.0625*** (0.0089)	-0.0678** (0.0354)	-0.0655* (0.0654)
Off-balance Sheet Activities to Total Assets	0.1706*** (<0.0001)	-0.0007 (0.9836)	0.3643*** (<0.0001)
Four-quarter Loan Growth Rate	0.0381 (<0.1164)	-0.0048 (0.8849)	-0.1000*** (0.0056)

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

Table 6: Regression Results of X-Efficiency on Bank Characteristics

This table reports the OLS results of regressing the X-efficiency estimate on bank characteristics using a fixed effect model. Coefficients for the bank dummies and time effect dummies are not reported. Standard errors are in parentheses.

	All Banks	Large Banks	Small Banks
Bank Size	-0.0868 *** (-6.10)	0.0195 (1.06)	-0.0344 ** (-2.47)
Deposit to Asset Ratio	-0.1621 *** (-3.78)	0.0174 (0.24)	-0.1055 *** (-2.83)
Trade Loans to Total Asset Ratio	-2.0176 *** (-13.68)	-3.2795 *** (-14.34)	-0.5474 *** (-4.37)
Non-Trade Loans to Total Asset Ratio	-1.4363 *** (-35.62)	-1.2291 *** (-19.06)	-0.7567 *** (-19.93)
Loan loss Provision to Total Loans	-0.5744 (-0.90)	-0.9745 (-0.88)	-0.9867 * (-1.92)
Off-balance Sheet Activities to Total Assets	0.0072 *** (4.42)	0.0037 ** (2.33)	0.0157 *** (3.95)
Four-quarter Loan Growth Rate	-8.37E-7 (-0.00)	-0.0012 ** (-2.53)	-0.0320 *** (-2.92)
Adjusted R^2	0.81	0.85	0.71
N	1700	933	767

***, **, * indicates significance at the 1%, 5%, and 10% levels, respectively

Figure 1: Time-Series Properties of X-Efficiency for All Banks

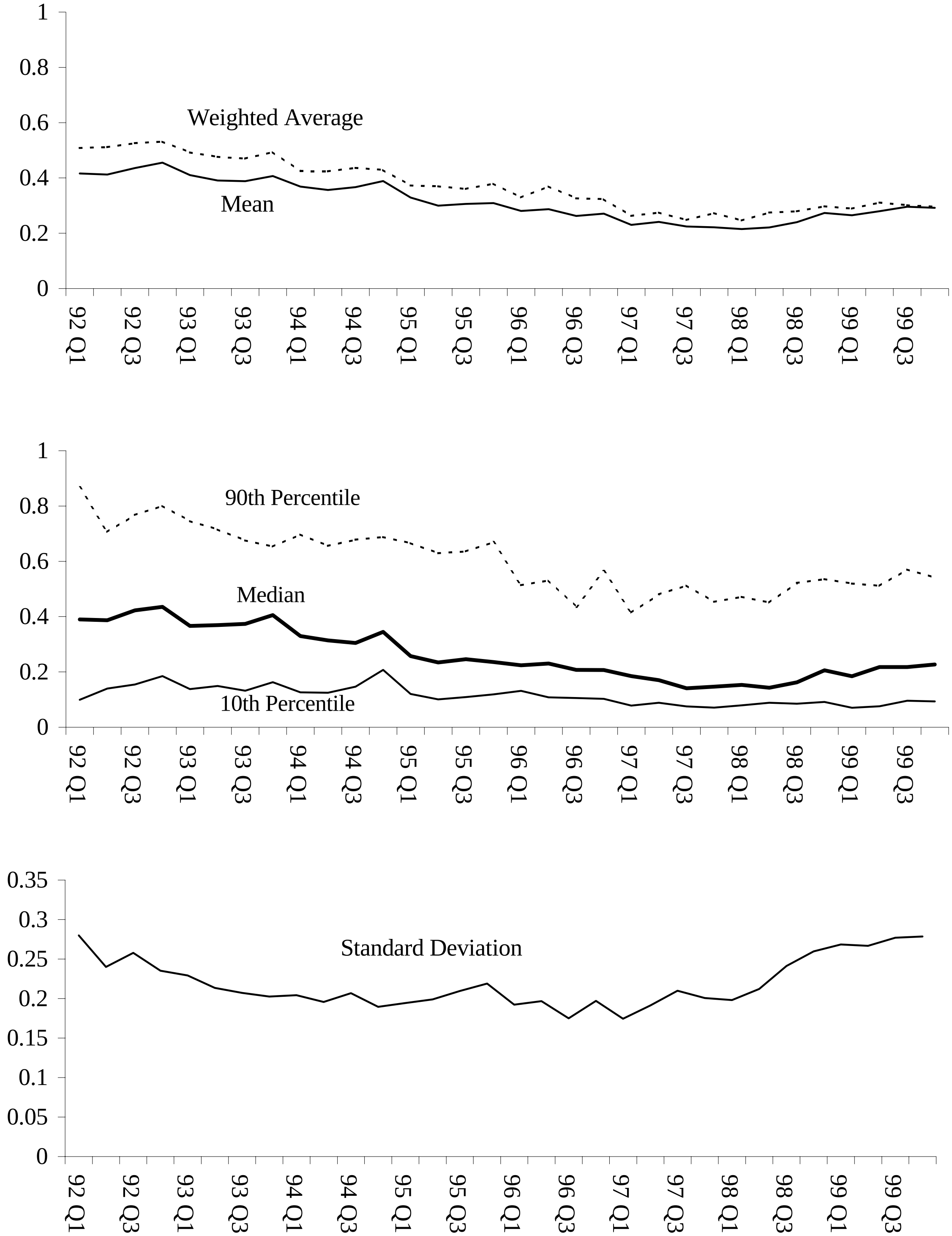
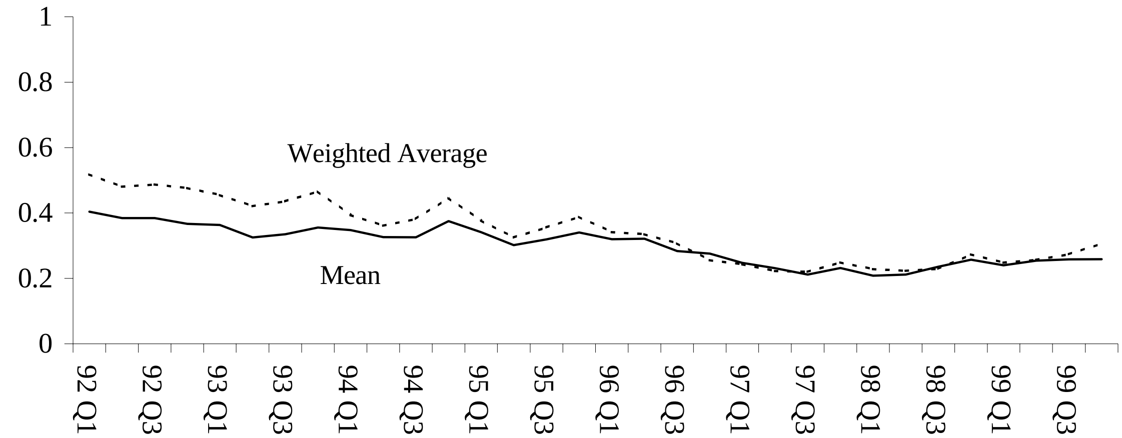
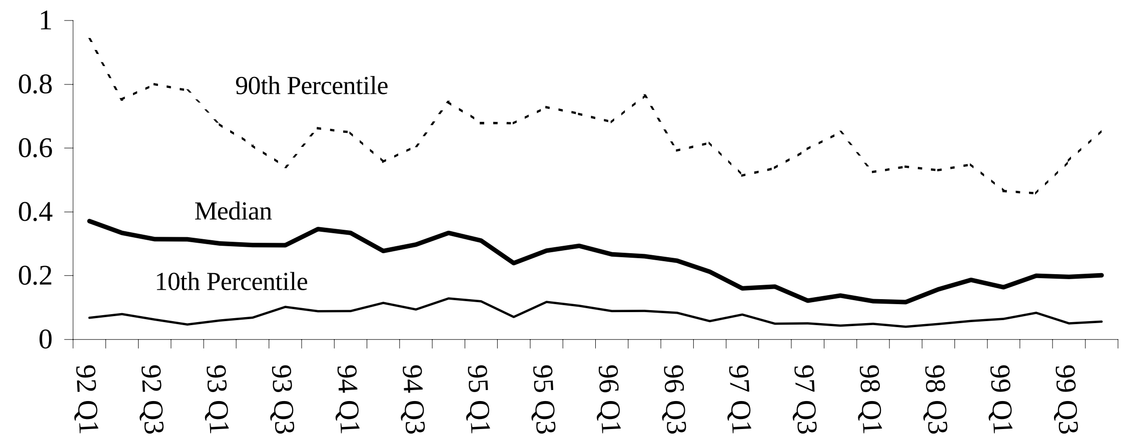


Figure 2: Time-Series Properties of X-Efficiency for Large Banks





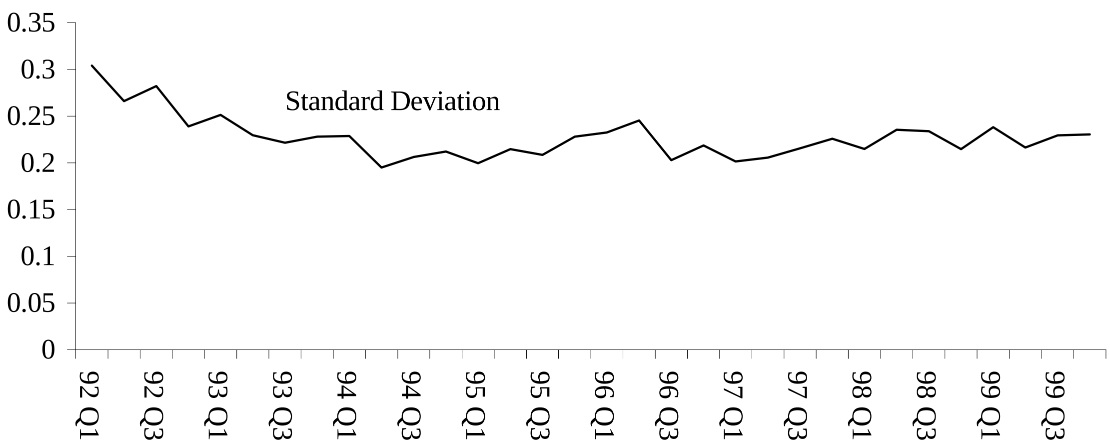
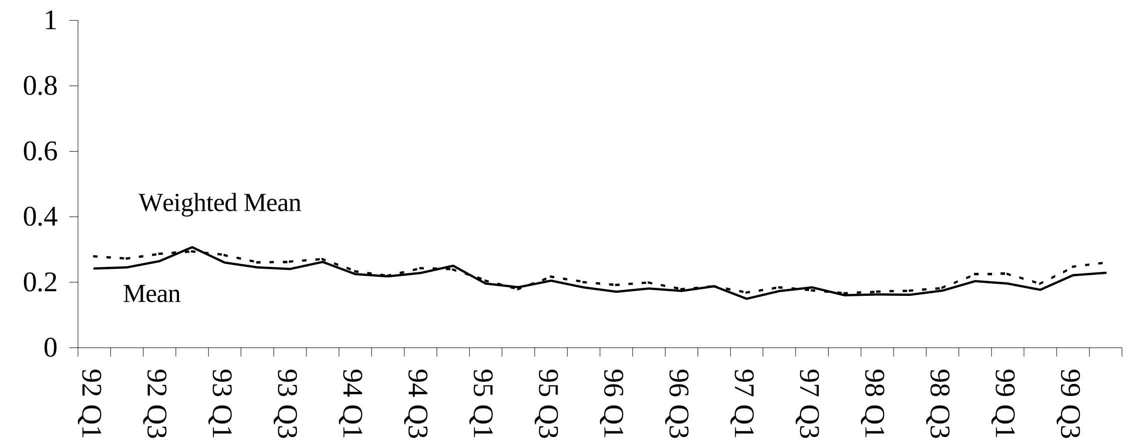
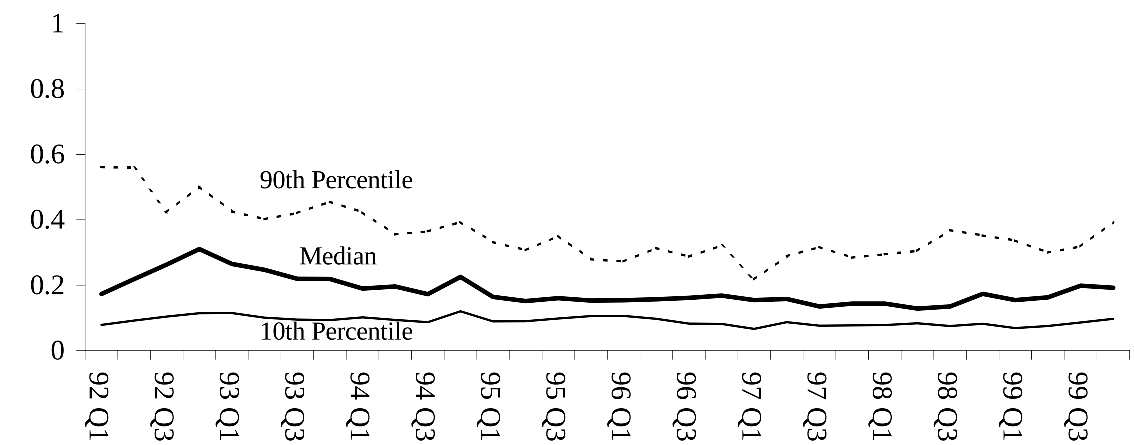


Figure 3: Time-Series Properties of X-Efficiency for Small Banks





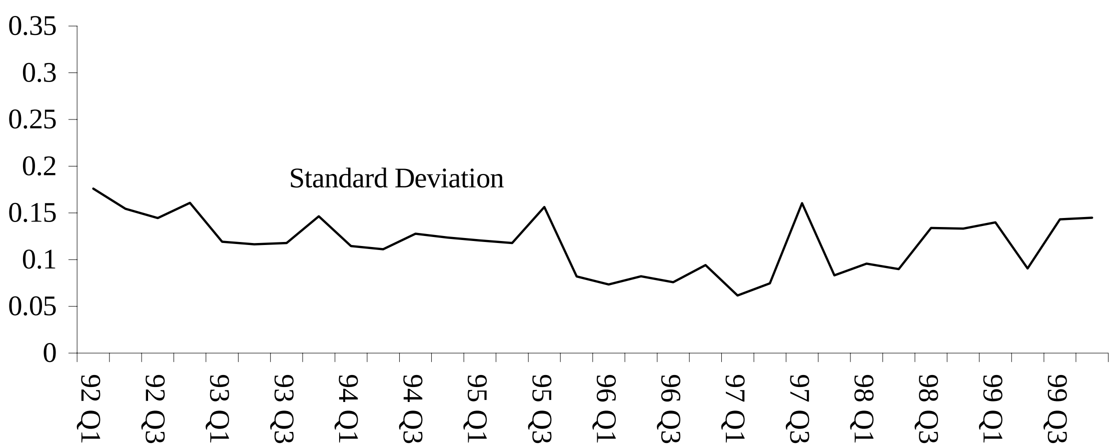


Figure 4: Spearman Rank Correlation of 1992: Q1 X-Efficiency Estimates Through Time

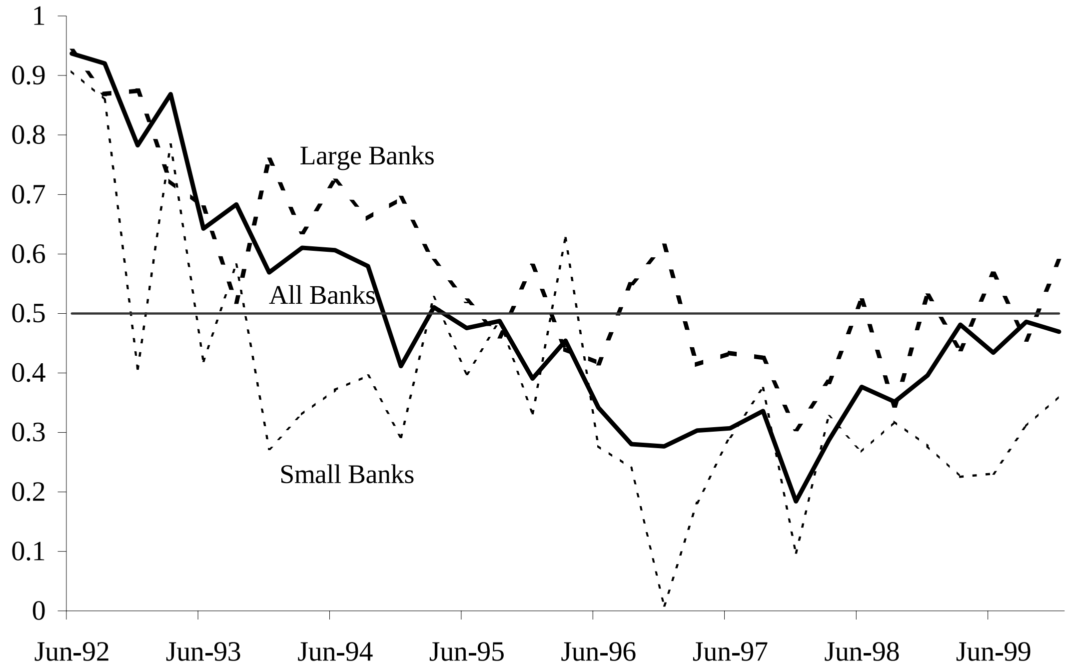


Figure 5: Frequency Distribution of Average X-Efficiency from 1992 to 1999

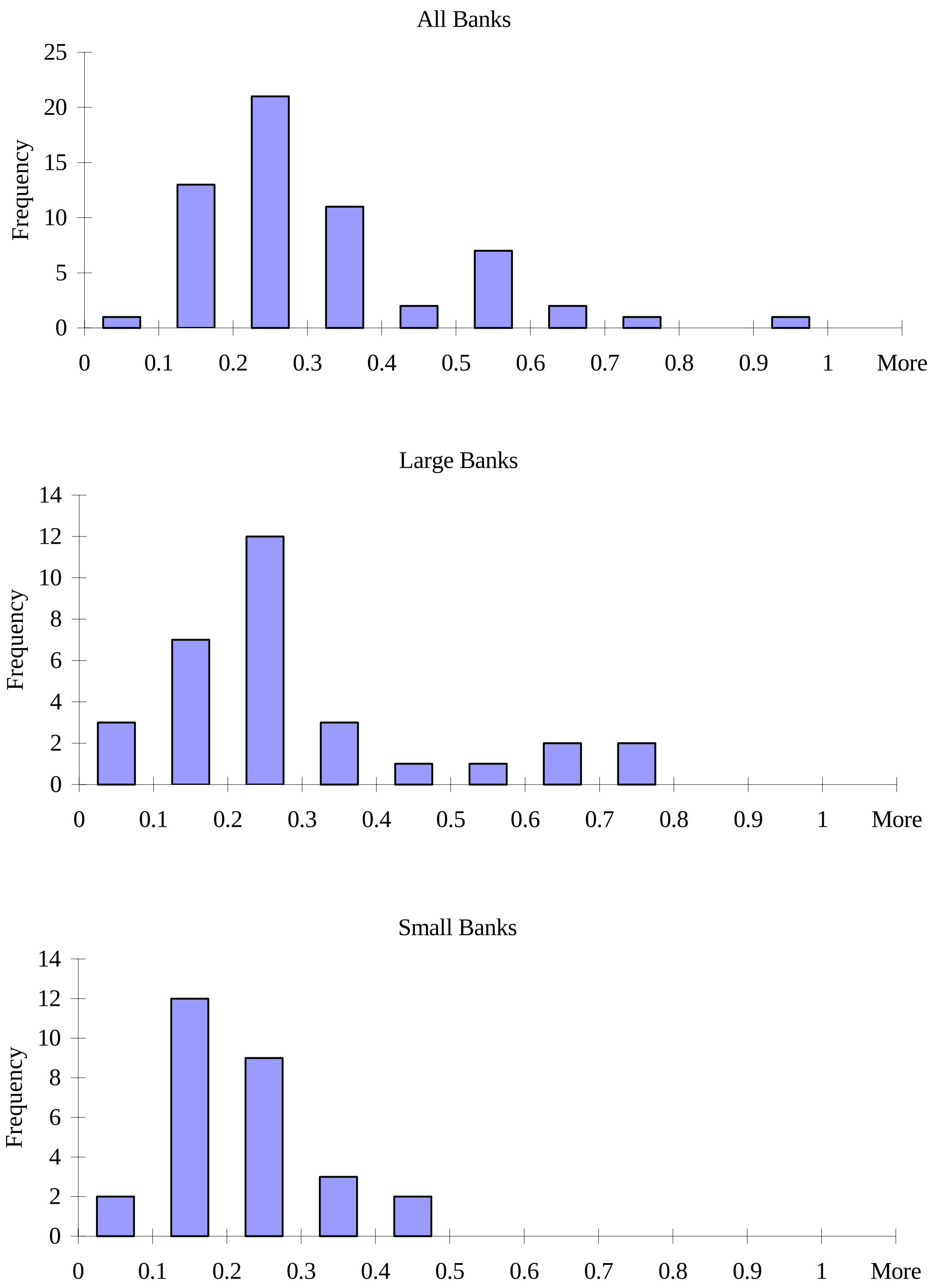
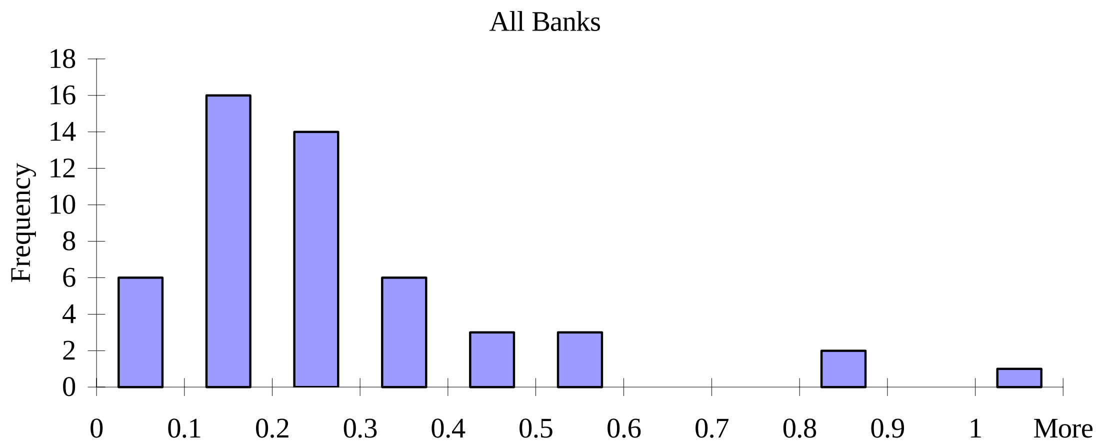
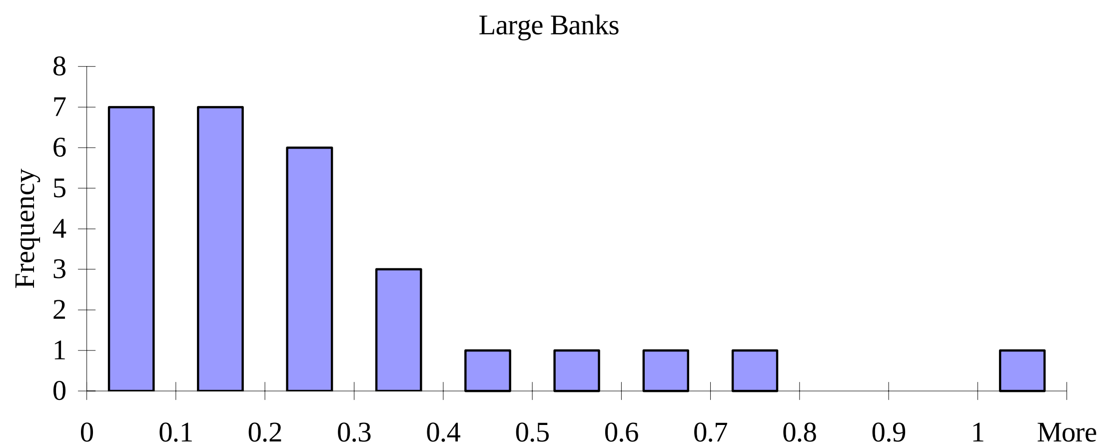


Figure 6: Frequency Distribution of X-Efficiency as of 1999: Q4





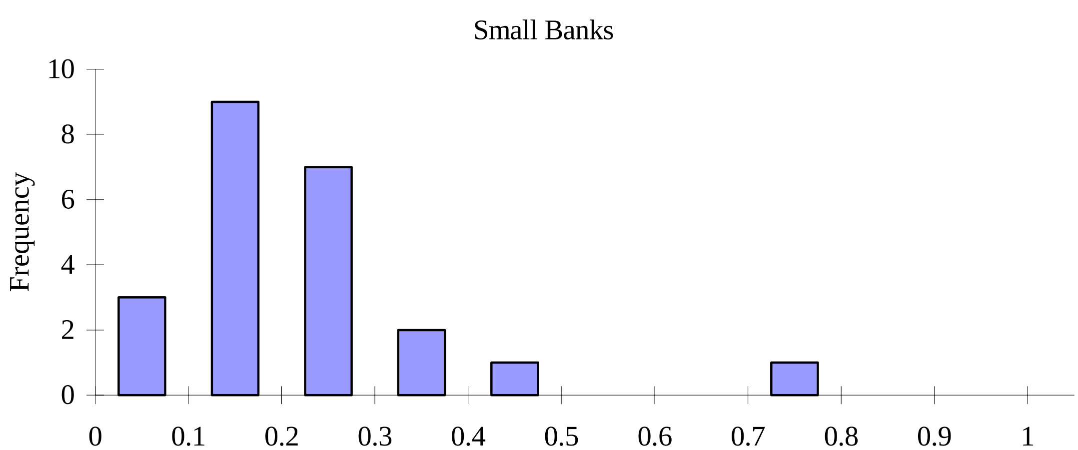


Figure 7: Frequency Distribution of X-Efficiency as of 1992: Q1