THE EFFECT OF GLOBALIZATION ON EFFICIENCY CHANGE, TECHNOLOGICAL PROGRESS AND THE PRODUCTIVITY GROWTH OF U.S. SMALL AND LARGE BANKS

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ABSTRACT
A non-parametric approach is used to examine the effects of globalization and deregulation on the efficiency and productivity growth of small and large banks in the U.S. between 1990 and 2003. Using a representative sample of commercial banks, the study finds empirical evidence that both small and large banks made significant technological progress and productivity growth between 1990 and 2003. In addition, the statistical evidence shows that large banks are generally more efficient than small banks for most efficiency indices in both years. However, despite globalization, deregulation, and the gains in technology and productivity, there was a decrease in overall efficiency for both large and small banks in 2003 compared to 1990, caused exclusively by allocative inefficiency.

Key Words: Banking, technological change, efficiency, firm performance

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I. INTRODUCTION

The U.S. banking industry has gone through many dramatic transformations in the last two decades. The extensive regulatory changes, considerable advances in information and banking technologies, the widespread dominance and acceptance of the market economy by former "planned economies," and the increase and integration of international financial markets and institutions, have created new opportunities and challenges for both the U.S. and international banking industries. While these transformations have provided an expanded opportunity set for banks, they have intensified the completive pressure in the global banking arena as well. It follows that the continued and profitable existence of a banking firm in this post-deregulated, increasingly globally competitive environment is directly linked to its productive performance and efficient operation, which motivates this investigation of bank efficiency in the U.S. between 1990 and 2003.

In this paper, we first examine the performance of a sample of small and large U.S. commercial banks in 1990 and 2003: a) to measure bank efficiency before and after the passage of U.S. banking deregulatory legislative acts in 1994 (Riegle-Neal Interstate Banking and Branching Efficiency Act) and 1999 (Gramm-Leach-Bliley Financial Services Modernization Act), and an international banking deregulation accord (the Basel Proposal in 1999), and b) to evaluate changes in bank efficiency caused by the increasing globalization of financial institutions and the international integration of financial markets during this period. Second, we investigate whether there are any statistically significant efficiency differentials between small and large banks in both 1990 and 2003, and to identify the sources of any potential efficiency differentials between the two groups. Finally, we estimate Malmquist productivity growth indexes for both groups of banks in order to assess the efficiency changes and technological progress of small and large banks during an era of the deregulation and globalization of banking activities.

An examination of commercial bank efficiency and productivity growth differentials between large and small banks is important, since it is often suggested that global competition affects small banks and large banks asymmetrically, given that the markets in which small banks operate and the characteristics of consumers they serve are considerably different from those of large banks. For example, compared to large banks, small banks may have: a) less access to the expanded financial opportunities that globalization and deregulation have created, and b) less access to the financial resources necessary to take full advantage of technological advances. For example, the introduction of nationwide branch banking in 1994 and the removal of the separation between commercial and investment banking may have offered greater expanded opportunities to large banks than for small banks. In that case, we would expect

to find greater efficiency gains for large banks than for small banks in response to the recent domestic product and geographic deregulation and the globalization of financial markets.

We consider a representative sample of 131 small and 131 large U.S. banks in both 1990 and 2003 to investigate whether global competition and deregulation have had significant effects on bank efficiency and performance during this period, and whether or not these effects are symmetrical for small and large banks. The empirical results of this paper suggest that: a) overall efficiency declined on average for both small and large banks in 2003 compared to 1990, and allocative inefficiency was responsible for this decline, b) the overall technical efficiency of banks improved slightly in 2003 compared to 1990, c) large banks in 1990 were more efficient than small banks for all efficiency indices: overall, allocative, overall technical efficiency, pure technical efficiency and scale efficiency, d) large banks in 2003 again displayed higher efficiency than small banks for all efficiency measures expect scale efficiency, and e) the U.S. banking industry exhibited substantial technological progress and productivity growth between 1990 and 2003. This last result prevails when we partitioned our sample into small and large banks, as both groups illustrated considerable technological progress and productivity growth between 1990 and 2003 as measured by the Malmquist productivity index. Therefore, while the overall efficiency of U.S. commercial banks declined relative to the efficient frontier between 1990 and 2003 contrary to expectations, there were significant gains in technological progress and productivity during this period of increased globalization and deregulation, as might be anticipated.

The rest of the paper proceeds as follows. In the next section (II), the relevant literature is reviewed. Section III describes the data and methodology. Empirical results are presented in Section IV, which also contains a discussion of the implications of the findings, and summary remarks are offered in Section V.

II. REVIEW OF LITERATURE

The efficiency and performance of commercial banks have been studied extensively over the last several decades. For instance, Ferrier and Lovell (1990), Elyasiani and Mehdian (1992), Grabowski et al. (1993) and Alam (2002), among others, use the Data Envelope Analysis (DEA) approach to assess the production performance of U.S. commercial banks relative to several best practiced frontiers. The empirical findings of these studies suggest that the overall efficiency of the U.S. banking industry ranged from 65% to 90% in the 1980s and 1990s. (For a comprehensive review of the banking industry efficiency literature, see Berger and Mester, 2003).

The efficiency of banks operating in countries outside the U.S. has also been studied extensively. For example, Berg et al. (1992) and Berger et al. (1993) evaluate the efficiency and productivity growth of banking industries in Nordic

countries, and conclude that Swedish banks are the most efficient, followed by Norwegian banks and then Finnish banks. Pastor et al. (1997) analyze and compare the efficiency of the banking industries in Europe and the U.S. These authors report that banks operating in France, Spain and Belgium are the most efficient banks in their samples, whereas banks operating in the U.K., Austria and Germany illustrate the lowest efficiency levels. Lozano-Vivas et al. (2002) examine the performance a sample of banks in 10 European countries, and conclude that country-specific environmental conditions exert a significant influence on the performance of each country's banking industry. Most recently, Casu et al. (2004) employ both parametric and non-parametric approaches to estimate productivity change in European banking systems from 1994 to 2000. They find that productivity growth was highest for Spanish and Italian banks, and more modest for French, German and British banks.

There are a limited number of papers in which the authors have studied the efficiency of banks in Asia (see for instance, Fukuyama (1995) for Japan, Yeh (1996) for Taiwan, Leightner and Lovell (1998) for Thailand, Gilbert and Wilson (1998) for Korea, and Lim and Chu (1998) and Rezvanian and Mehdian (2002) for Singapore). The results of most of these studies show that, in general, depository institutions have an average efficiency of approximately 77% (see Berger and Humphrey, 1997, for an international survey).

The efficiency of small and large banks has also been investigated by several researchers. For example, Elysiani and Mehdian (1995) examine the relative efficiency of U.S. small and large banks during the pre- and post-deregulation eras of the 1980s. They report that small banks were more efficient than large banks in the U.S. during the pre-deregulation era, while both groups of banks were equally efficient in the post-deregulation period. Alam (2001) employs a nonparametric technique to study the productivity growth and efficiency of large U.S. banks from 1980-1989, and he reports a statistically significant productivity progress for large U.S. banks mainly caused by technological change rather than changes in overall technical and scale efficiencies.

To date, however, there has been no research that specifically investigates the effects of the major deregulatory acts and globalization of the 1990s on the efficiency of small and large banks in the U.S., and this paper aims to fill that gap.

III. METHODOLOGY AND DATA

A. Methodology

In this study, we use a non-parametric frontier approach to calculate several efficiency and productivity indices to assess the efficiency of small and large banks in 1990 and 2003, and measure the technological and efficiency changes of both groups of U.S. commercial banks between 1990 and 2003. This is a period during which commercial banks experienced substantial deregulation and globalization, which could potentially impact bank efficiency and productivity. The non-parametric frontier approach involves the estimation of several efficiency indices relative to a set of "best practice" frontiers. One advantage of this approach is that the overall efficiency index
for each bank can be decomposed into a subset of efficiency measures in order to identify the possible sources of overall bank efficiency or inefficiency.

The overall efficiency (OE) index for each bank is computed as the ratio of the minimum cost of producing a given output bundle to the total actual (observed) cost incurred. The OE index is a composite index measure of allocative efficiency (AE), overall technical efficiency (OTE), pure technical efficiency (PTE) and scale efficiency (SE). If bank *i* is an observation in a sample of commercial banks operating in the U.S., the OE for this bank can be written as:

$$OE_i = OTE_i \times AE_i$$
$$OE_i = PTE_i \times SE_i \times AE_i$$

where (1)

$$AE_i = \frac{OE_i}{OTE_i} \quad and \quad SE_i = \frac{OTE_i}{PTE_i}$$

To calculate these efficiency indices for each bank included in our sample, several non-parametric linear programming problems are solved given panel data on prices, inputs and outputs. There is a large body of literature in which this non-parametric approach is discussed and applied, e.g. see Färe et al. (1985), Fukuyama (1993 and 1995), and Alam (2001).

Note that if $SE_i = 1$, bank *i* exhibits constant returns to scale (CRS) and is said to be scale efficient, indicating that the bank operates at the optimal size. If $0 < SE < 1$ the bank is said to be scale inefficient, suggesting that the bank is operating at a sub-optimal size. Scale inefficiency is caused by either decreasing returns to scale (DRS) when a bank is operating below the optimal size or increasing returns to scale (IRS) if a bank is operating above the optimal size. To identify the specific source of scale inefficiency, we follow a procedure discussed in Färe et al. (1985).

To investigate the inter-temporal productivity growth of the large and small banks between 1990 and 2003, we employ the Malmquist index, which decomposes productivity growth into two components: technological change and changes in technical efficiency. Following Berg et al. (1992) and Färe et al. (1994), the Malmquist index of productivity growth is written as:

$$M_i = \Delta OTE_i \times \Delta T_i \qquad (2)$$

where
M_i = the Malmquist index of productive growth of bank *i* between 1990 and 2003.
ΔOTE_i = the change in overall technical efficiency gain (loss) of bank *i* between 1990 and 2003.
ΔT_i = the change in technological progress (regress) change of bank *i* between 1990 and 2003.
Note that $M_i > 1$ in Equation (2) implies productivity growth between 1990 and 2003, and $M_i < 1$ indicates a productivity decline during the period.

If $\Delta OTE_i > 1$ in Equation (2), the relative OTE of bank *i* has increased, and if $\Delta OTE_i < 1$, the relative OTE of this bank has declined between the two periods. And if $\Delta T_i > 1$, bank *i* exhibits technological progress, and if $\Delta T_i < 1$ this bank demonstrates technological regress between the two periods. As discussed previously, we expect to find technological progress due to globalization for both small and large banks from 1990 to 2003.

Equation (1), ΔOTE can be further decomposed into ΔPTE and ΔSE, and therefore Equation (2) can be expressed as:

$$M_i = \Delta OTE_i \times \Delta T_i = \Delta PTE_i \times \Delta SE \times \Delta T_i$$

where:
ΔPTE_i = the pure technical efficiency gain (loss) of bank *i* between 1990 and 2003.
ΔSE_i = the scale efficiency gain (loss) of bank *i* between 1990 and 2003.
This decomposition is useful in order to identify the specific sources of changes in productivity growth over the sample period studied.

To the extent that increased globalization and the integration of financial markets result in more efficient dissemination of information combined with advances in banking technology, we would expect to find an increase in productivity growth for commercial banks between 1990 and 2003. Furthermore, we expect large banks to progress technologically more than their smaller counterparts, since they are in a better position to take advantage of international exchanges of new technologies and emerging innovations.

B. Data

The commercial banking data for this study were obtained from the 1990 and 2003 "Report of Condition and Income" files posted on the Federal Reserve Bank of Chicago's website, which contain data on approximately 15,000 individual U.S. banks in 1990 and 10,000 banks in 2003. The decline in the number of U.S. commercial banks was due to a certain extent to bank failures, but mostly because of bank merger and acquisition activities during this period. Only those banks that existed in 1990 and 2003, with complete data in both years, were considered for this study. From this subset, there were 131 commercial banks with total assets greater than $500 million in 2003 and this group was classified as "large banks." Those banks with total assets less than $50 million in 2003 were classified as "small banks," which generated a much larger sample than 131 banks. In order to match the sample sizes between large and small banks, and to eliminate any regulatory differentials by state, we selected 131 small banks from the same states as the large banks, in approximately equivalent proportions. In states where the number of small banks was greater than the number necessary to match the number of large banks, the appropriate number of small banks was selected at random. This procedure produced an equal number of small (131) and large (131) banks in 1990 and 2003.

For each bank in the sample, outputs, inputs, and input prices were then collected for both 1990 and 2003. Bank outputs consist of: a) commercial and industrial loans, b) real estate loans, c) other loans, and d) securities (denoted by Y1, Y2, Y3 and Y4 respectively). Bank inputs are: a) the number of full-time employees, b) capital, and c) borrowed funds (denoted by X1, X2 and X3), and the prices of bank inputs are defined as the: a) unit price of labor, b) the unit price of capital and c) the price of borrowed funds (denoted by P1, P2 and P3 respectively).

Table 1 contains summary statistics of outputs, inputs, and input prices for the sample of small banks, the sample of large banks, and the pooled sample of all banks, in both years. As can be seen, the average size of the large banks, measured by their total assets, was about 100 times greater than the average size of small banks in the sample. Additionally, the average loan portfolio of large banks was almost 200 times the size of the average loan portfolio of small banks in both years, illustrating the significant size differential between small and large banks.

The figures in Table 1 also show that the average number of bank employees in the small bank sample was 21 in 1990 and 42 in 2003, generating $1.46 million and $2.67 million of earning assets respectively per employee in nominal terms. At the same time, the average number of bank employees at the large banks was 1,200 in 1990 and 3,193 in 2003, generating earning assets per employee of $1.82 million and $3.56 million respectively. As expected, the higher productivity per employee of the large banks is accompanied by a higher salary expense per employee in both 1990 and 2003. In terms of the cost of borrowing,

the average interest paid on borrowed funds by both small and large banks was the same (5.8%) in 1990, but by 2003 the large banks were able to borrow at lower cost than the small banks (1.40% for large banks vs. 1.80% for small banks).

Furthermore, the data suggest that small banks typically operate in a single, small community with relatively few employees, and this could prevent these banks from having access to the same financial markets and global advances in banking technology as larger banks. Therefore, it follows that large banks might have enjoyed a higher level of technological progress relative to small banks during the 1990-2003 period, by taking advantage of the significant banking deregulation and internationalization of financial markets.

Table 1: Summary Statistics of the Inputs, Outputs, and Price of Inputs, for Years 1990 and 2003.

Panel a. 1990				
	Y1	**Y2**	**Y3**	**Y4**
POOLED				
Mean	$242,542	$353,707	$237,758	$272,928
Std. Dev.	628,988	714,931	620,886	559,226
Minimum	127	1,200	605	176
Maximum	4,862,232	5,524,981	6,744,349	5,953,556
LARGE BANKS				
Mean	$481,275	$695,860	$469,942	$536,240
Std. Dev.	824,272	888,939	815,663	698,650
Minimum	8,726	21,538	10,077	45,537
Maximum	4,862,232	5,524,981	6,744,349	5,953,556
SMALL BANKS				
Mean	$3,809	$11,554	$5,575	$9,616
Std. Dev.	3,085	5,923	3,377	5,405
Minimum	127	1,200	605	176
Maximum	14,525	30,096	20,041	24,003

	X1 (P1)	**X2 (P2)**	**X3 (P3)**
POOLED			
Mean	611 (29.65)	$18,624 (1.42)	$1,251,353 (.058)
Std. Dev.	1,194 (6.69)	38,616 (1.01)	2,545,108 (.008)
Minimum	9 (16.65)	42 (.18)	23,927 (.026)
Maximum	10,142 (51.40)	281,351 (4.29)	18,520,221 (.084)
LARGE BANKS			
Mean	1,200 (30.81)	$36,612 (1.35)	$2,469,490 (.058)
Std. Dev.	1,470 (6.72)	48,388 (.72)	3,164,556 (.009)
Minimum	134 (18.96)	2,815 (.41)	422,129 (.040)
Maximum	10,142 (51.40)	281,351 (7.51)	18,520,221 (.084)
SMALL BANKS			
Mean	21 (21.48)	$635 (1.50)	$33,216 (.058)
Std. Dev.	7 (7.1)	482 (1.23)	4,380 (.007)
Minimum	9 (16.56)	42 (.18)	23,927 (.026)
Maximum	46 (49.35)	2,653 (7.5)	42,404 (.073)

Y1: Commercial and Industrial Loans ($ thousands)
Y2: Real Estate Loans ($ thousands)
Y3: Other Loans ($ thousands)
Y4: Securities ($ thousands)
X1: # Full-Time Employees
X2: Capital ($ thousands)
X3: Borrowed Funds ($ thousands)
P1: Unit price of labor input
P2: Unit price of capital input
P3: Unit price of borrowed funds

Table 1. (continued): Summary Statistics of the Inputs, Outputs, and Price of Inputs, 2003.

Panel b. 2003				
	Y1	**Y2**	**Y3**	**Y4**
POOLED				
Mean	$953,657	$2,512,521	$858,966	$1,408,461
Std. Dev	2,737,906	6,123,545	2,444,816	3,144,588
Minimum	201	7,373	360	1,853
Maximum	22,399,882	42,833,515	21,338,970	23,084,151
LARGE BANKS				
Mean	$1,896,208	$4,966,327	$1,707,959	$2,784,800
Std. Dev.	3,641,327	7,946,437	3,247,682	4,004,254
Minimum	33,508	69,787	5,376	75,943
Maximum	22,399,882	42,833,515	21,338,970	23,084,151
SMALL BANKS				
Mean	$11,105	$58,716	$9,974	$32,122
Std. Dev	13,724	56,878	11,161	33,486
Minimum	201	7,373	360	1,853
Maximum	73,440	308,045	85,917	186,727

	X1 (P1)	**X2 (P2)**	**X3 (P3)**
POOLED			
Mean	1,617 (53.64)	$78,605 (1.37)	$6,138,838 (.016)
Std. Dev	3,521 (15.67)	179,453 (1.10)	14,270,264 (.005)
Minimum	12 (20.17)	58 (.29)	32,418 (.003)
Maximum	26,061 (121.2)	1,350,698 (8.10)	113,583,496 (.030)
LARGE BANKS			
Mean	3,193 (60.88)	$155,133 (1.49)	$12,163,925 (.014)
Std. Dev.	4,460 (16.52)	229,888 (1.09)	18,321,478 (.004)
Minimum	169 (20.17)	6,339 (.41)	435,386 (.005)
Maximum	26,061 (121.2)	1,350,698 (7.81)	113,583,496 (.024)
SMALL BANKS			
Mean	42 (46.40)	$2,076 (1.24)	$113,750 (.018)
Std. Dev.	28.8 (10.68)	1,774 (1.11)	94,520 (.005)
Minimum	12 (28.67)	58 (.29)	32,418 (.003)
Maximum	161 (80.87)	8,649 (8.10)	587,031 (.030)

Y1: Commercial and Industrial Loans ($ thousands)
Y2: Real Estate Loans ($ thousands)
Y3: Other Loans ($ thousands)
Y4: Securities ($ thousands)
X1: # Full-Time Employees
X2: Capital ($ thousands)
X3: Borrowed Funds ($ thousands)
P1: Unit price of labor input
P2: Unit price of capital input
P3: Unit price of borrowed funds

IV. EMPIRICAL RESULTS

Using the non-parametric approach outlined in Section III, we calculated several efficiency indices, described earlier, for each of the 262 banks in the dataset. The summary statistics of these efficiency indices, computed relative to the pooled sample-year specific frontiers constructed for years 1990 and 2003, are presented in Table 2 (Panels a and b). As can be seen in Table 2 (Panel a), all five efficiency indices (OE, AE, OTE, PTE, SE) for large banks in 1990 were higher than those for small banks. For example, the average OE computed for large banks in 1990 is 0.748, which indicates that the large banks in 1990 could have produced the same level of outputs (commercial and industrial loans, real estate loans, other loans, and securities) at about 25% lower production costs if they had all been operating with 100% overall efficiency. On the other hand, small banks could have produced the same level of outputs at almost 72% of their actual cost had they all been 100% overall efficient in 1990. The results in Panel b of Table 2 reveal that in 2003 large banks could have produced the same level of outputs with 64% of their actual costs, and small banks with 60% of their actual production costs.

In order to test whether the differences between efficiency indices of large banks and small banks are statically significant, we use both parametric (ANOVA) and non-parametric (Kruskall-Wallis, and Median Chi-Square) tests and report the calculated test-statistics in Table 3. We have included non-parametric tests since it is argued that efficiency indices are not normally distributed, and therefore the parametric ANOVA test may have certain limitations because it assumes that the underlying variables are normally distributed. The test statistics for 1990 presented in Table 3a provide evidence that the higher efficiency measures for large banks compared to small banks are statistically significant in the case of the OE, AE and OTE for both non-parametric tests and statistically significant for OE and AE using the ANOVA test.

The results displayed in Panel b of Table 3, show that again in 2003 large banks had superior efficiency compared to small banks in the case of OE, AE, and PTE. However, for the SE index, small banks were found to be significantly more efficient than large banks. This result suggests that small banks operated at a more appropriate scale of operation compared to large banks in 2003. The nonparametric tests presented in Table 3b demonstrate that these differences in efficiency measures between large and small banks in 2003 are all statistically significant except for OTE. These tests suggest that in both 1990 and 2003, large banks were generally more efficient than small banks at a statistically significant level for overall efficiency. This result implies that larger banks in both years operated closer to their potential cost savings compared to small banks. Furthermore, since the large banks were found to be significantly more allocatively efficient than small banks in both years, the optimal utilization of input-mix seems to play an important role in the cost savings of large banks.

Table 2: Summary Statistics for the Efficiency Indices Relative to the Common Frontier, 1990 and 2003.

Panel a. 1990

POOLED	**OE**	**AE**	**OTE**	**PTE**	**SE**
Mean	0.733	0.825	0.886	0.933	0.950
Std. Dev.	0.129	0.100	0.082	0.066	0.055
Minimum	0.357	0.432	0.579	0.621	0.672
Maximum	1.000	1.000	1.000	1.000	1.000
LARGE BANKS					
Mean	0.748	0.835	0.893	0.938	0.953
Std. Dev.	0.120	0.097	0.077	0.068	0.043
Minimum	0.432	0.432	0.590	0.621	0.827
Maximum	1.000	1.000	1.000	1.000	1.000
SMALL BANKS					
Mean	0.719	0.814	0.879	0.928	0.946
Std. Dev.	0.136	0.102	0.086	0.064	0.065
Minimum	0.357	0.510	0.579	0.686	0.672
Maximum	1.000	1.000	1.000	1.000	1.000

Panel b. 2003

POOLED	**OE**	**AE**	**OTE**	**PTE**	**SE**
Mean	0.622	0.687	0.897	0.938	0.957
Std. Dev.	0.176	0.157	0.084	0.079	0.049
Minimum	0.216	0.275	0.450	0.476	0.754
Maximum	1.000	1.000	1.000	1.000	1.000
LARGE BANKS					
Mean	0.644	0.709	0.898	0.944	0.952
Std. Dev.	0.191	0.165	0.099	0.092	0.049
Minimum	0.237	0.275	0.450	0.476	0.754
Maximum	1.000	1.000	1.000	1.000	1.000
SMALL BANKS					
Mean	0.600	0.665	0.897	0.933	0.962
Std. Dev.	0.158	0.146	0.066	0.064	0.048
Minimum	0.216	0.278	0.634	0.713	0.792
Maximum	1.000	1.000	1.000	1.000	1.000

OE: Overall Efficiency
AE: Allocative Efficiency
OTE: Overall Technical Efficiency
PTE: Pure Technical Efficiency
SE: Scale Efficiency

Table 3a. Tests of the Difference between Efficiency Indices of U.S. Large and Small Banks, 1990.

Efficiency Indices	ANOVA F-Value	Kruskall-Wallis (Chi-Square Value)	Median Chi-Square Value
Overall (OE)	3.30*	4.08**	5.51**
Allocative (AE)	2.84*	3.54*	4.41**
Overall Technical (OTE)	2.20	2.32*	3.43*
Pure Technical (PTE)	1.24	2.18	2.58
Scale (SE)	0.89	1.30	1.23

Note: The statistical tests are of the null hypothesis that the efficiency measures of small banks and large banks are equal. ** indicates that large bank are more efficient than small banks at the 5% level of significance, and * indicates significance at the 10% level.

Table 3b. Tests of the Difference between Efficiency Indices of U.S. Large and Small Banks, 2003.

Efficiency Indices	ANOVA F-Value	Kruskall-Wallis (Chi-Square Value)	Median Chi-Square Value
Overall (OE)	4.19*	5.21**	6.73***
Allocative (AE)	5.41**	6.29***	8.07***
Overall Technical (OTE)	1.03	1.95	0.38
Pure Technical (PTE)	1.25	5.98**	5.51**
Scale (SE)	2.87*	5.03*	8.07***

Note: The statistical tests are of the null hypothesis that the efficiency measures of small banks and the efficiency measures of large banks are equal. *** indicates statistical significance at the 1 percent level, ** indicates significance at the 5 percent level, and * indicates significance at the 10% level.

To investigate whether the relative efficiency of large and small banks has improved over time, we next contrast the efficiency of each group of banks in 1990 with their efficiency in 2003. We hypothesize that the deregulatory banking acts, combined with increased globalization and the integration of financial institutions and markets, created a more intensely competitive environment that would increase the efficiency of banking operations in general. It follows that a higher level of banking efficiency for both small and large banks would be predicted in 2003 compared to 1990.

In addition, we observe in Table 5 that from 1990 to 2003 both groups of banks, large and small, changed the composition of their loan portfolios considerably. More specifically, in 1990 the share of real estate loans in the four asset categories considered (commercial loans, real estate loans, other loans, and securities) was 32% for large banks and 38% for small banks, and by 2003 large banks increased real estate loans to 44% and small banks to 52%. On the other hand, both groups of banks decreased their shares of commercial loans and "other loans" in their asset portfolios noticeably from 1990 to 2003, large banks from 22% to 17% for commercial loans, and 22% to 15% for other loans; and small banks from 12% to 10% for commercial loans and 18% to 9% for other loans.

In order to determine the possible effects of the shift in portfolio-mix described above, banking deregulation, increased globalization, and the integration of financial institutions and markets on bank efficiency between 1990 and 2003, we reconsider the summary statistics of all five efficiency indices reported in Table 2. These efficiency indices are calculated relative to a frontier constructed using pooled samples of both large and small banks in 1990 and 2003, and they can therefore help to identify efficiency changes over time. The data in Table 2 suggest that overall efficiency (OE) has declined for the pooled bank sample (large and small banks combined) from 0.733 in 1990 to 0.622 in 2003, a decline of 11.10% in OE. The loss of overall bank efficiency was totally due to a significant decline in AE from 0.825 to 0.687 (-13.8%) during the period between 1990 and 2003. We observe, however, that OTE showed a small gain of 1.10% during the same period for the pooled sample. These results suggest that all banks - the pooled sample of both small and large banks – employed a noticeably "suboptimal mix" of inputs in the production process in 2003, but produced a given of set of outputs utilizing a smaller amount of inputs in 2003 relative to 1990.

The results presented in Table 2 also provide evidence to indicate that the OE of the large banks dropped by 10.40% between 1990 and 2003. This drop is described by a substantial decline in AE while the OTE demonstrated a 0.50% increase. The findings are generally the same in the case of small banks, since their OE declined by almost 12% as a result of a drop of 14.9% in their AE. However, the OTE of small banks improved by 1.80% between 1990 and 2003. Three alternative statistical tests of the difference in efficiency for large and small banks between 1990 and 2003 are presented in Tables 4a and 4b. The test statistics displayed in this table reveal that the decreases in overall efficiency for both groups of banks are statistically significant at the 1% level.

Table 4a. Tests of the Difference between Efficiency Indices of U.S. Small Banks, 1990 vs. 2003

Efficiency Measures	ANOVA F-Value	Kruskall-Wallis (Chi-Square Value)	Median Chi-Square Value
Overall (OE)	42.76***	42.50***	33.70***
Alloacative (AE)	92.25***	70.12***	56.80***
Overall Technical (OTE)	3.61*	2.52	2.58
Pure Technical (PTE)	0.29	0.47	0.38
Scale (SE)	5.07*	2.54	1.23

Note: The statistical tests are of the null hypothesis that the efficiency measures of small banks in 1990 and 2003 are equal. *** indicates that small banks were significantly more efficient in 1990 than 2003 at the1 percent level, ** indicates significance at the 5 percent level, and * indicates significance at the 10 percent level.

Table 4b. Tests of the Difference between Efficiency Indices of U.S. Large Banks, 1990 vs. 2003.

Efficiency Measures	ANOVA F-Value	Kruskall-Wallis (Chi-Square Value)	Median Chi-Square Value
Overall	42.76***	42.50***	33.70***
Alloacative	92.25***	70.12***	56.80***
Overall Technical	3.61*	2.52	2.58
Pure Technical	0.29	0.47	0.38
Scale	5.07*	2.54	1.23

Note: The statistical tests are of the null hypothesis that the efficiency measures of small banks in 1990 and 2003 are equal. *** indicates that small banks were significantly more efficient in 1990 than 2003 at the1 percent level, ** indicates significance at the 5 percent level, and * indicates significance at the 10 percent level.

Table 5. Composition of Bank Portfolios, 1990 and 2003.

Assets / Bank Size	Commercial Loans		Real Estate Loans		Other Loans		Securities	
	YEARS 1990	2003	1990	2003	1990	2003	1990	2003
Large	22%	17%	32%	44%	22%	15%	24%	24%
Small	12%	10%	38%	52%	18%	9%	32%	29%

Consequently, contrary to our expectations that the efficiency of commercial banks would increase between 1990 and 2003, the empirical findings suggest a significant decline in overall bank efficiency for both small and large banks in the era of deregulation and globalization. Furthermore, the results provide no empirical support that the observed shift in the portfolio-mix of both small and large banks improves bank efficiency.

In sum, the empirical findings presented here provide evidence that the decline in the overall efficiency of the U.S. banking industry was caused entirely by allocative inefficiency, i.e. a deviation from the "optimal mix of inputs." This decline in allocative efficiency between 1990 and 2003 – a period characterized by significant globalization, deregulation and integration of financial markets and institutions – suggests that the banks in the U.S. allocated input resources (labor, capital and borrowed funds) inefficiently in the process of producing loans and securities.

Table 6 displays the distributions of banks in different classes of scale economies (decreasing, constant and increasing returns) identified by using a procedure outlined in Färe et al. (1985). As can be seen from this table, in 1990 46% of the small and large banks in the pooled sample were operating at decreasing returns to scale (DRS), 13% at constant returns to scale (CRS), and 41% at increasing returns to scale (IRS). Among large banks in 1990, 85% operated at DRS, 14% at CRS, and 1% at IRS, while these percentages for small banks were 6%, 13%, and 81%, respectively. The results presented in Table 6 also reveal that in 2003 for the pooled sample, 56% of the banks included in the sample operated at DRS, 12% at CRS, and 32% at IRS. In the case of large banks in 2003, 84% operated at DRS, 16% at CRS, and 0% at IRS whereas these percentages for small banks are 27%, 8%, and 64% correspondingly.

Table 6: Number of Banks in Different Categories of Scale Economies: 1990 and 2003.

1990	**DRS**	**CRS**	**IRS**	**TOTAL**
Pooled	120(46%)	35 (13%)	107 (41%)	262
Large	112 (85%)	18 (14%)	1 (1%)	131
Small	8 (6%)	17 (13%)	106 (81%)	131
2003	**DRS**	**CRS**	**IRS**	**TOTAL**
Pooled	146 (56%)	32 (12%)	84 (32%)	262
Large	110 (84%)	21 (16%)	0	131
Small	36 (27%)	11 (8%)	84 (64%)	131
DRS: Decreasing Return to Scale				
CRS: Constant Return to Scale				
IRS: Increasing Return to Scale				

These findings on scale economies show that the large and small bank mostly experienced either DRS or IRS in both years 1990 and 2003. However, one important point is that in both years large banks did not operate at IRS (1% in 1990 and none in 2003), which may imply that mergers and acquisitions among large banks had a limited effect on improving the scale efficiency of large banks. Therefore, the potential positive effect of mergers and acquisitions among large banks on scale efficiency, argued for by supporters of bank mergers and acquisitions, is not confirmed by the empirical findings presented here. On the other hand, the conclusion is different for small banks, since a substantial portion of that group operated at IRS (81% in 1990 and 64% in 2003). This finding may suggest that small banks could have reduced their cost of operation by increasing their size through mergers and acquisitions.

Table 7 summarizes the comprehensive decomposition of the Malmquist productivity growth index for banks in 1990 compared to 2003, both for the pooled bank sample, and for large and small banks separately. The Malmquist index contains two primary components: a measure of the change in overall technical efficiency, and a measure of technological change (a shift in the efficiency frontier). As can be seen in the last column of Table 7, between 1990 and 2003 all banks (both pooled and separately: small and large) experienced productivity growth of about 6% given that the Malmquist productivity index is 1.065, 1.065, and 1.064, for the pooled sample, large banks, and small banks respectively.

The decomposition of this productivity growth shows that in the case of large banks, approximately the entire productivity growth from 1990 to 2003 was due to technological progress (ΔT = 1.055). This finding is consistent with Alam (2001), who provides evidence that the productivity growth of large U.S. banks from 1980 to 1989 was caused mostly by technological progress and not by changes in overall technical efficiency.

In the case of small banks, however, the productivity growth was equally caused by increases in overall technical efficiency (ΔOTE = 1.030), and technological progress (ΔT = 1.032). In addition, the decomposition of the change in overall technical efficiency presented in Table 7 suggests that an increase in scale efficiency for small banks was mainly responsible for the improvement in the overall technical efficiency between 1990 and 2003. The same decomposition discloses that the increase in overall technical efficiency for large banks was primarily caused by an increase in pure technical efficiency during this period.

Table 7: Malmquist Index and Descriptive Statistics of Efficiency Change, Technological Progress and Productivity Growth: 1990 vs. 2003.

POOLED	**ΔOTE**	**ΔPTE**	**ΔSE**	**ΔT**	**M**
Mean	1.019	1.010	1.011	1.043	1.065
Std. Dev.	0.118	0.106	0.074	0.100	0.166
Minimum	0.523	0.532	0.792	0.698	0.470
Maximum	1.477	1.560	1.420	1.797	1.819
LARGE BANKS					
Mean	1.009	1.010	1.000	1.055	1.065
Std. Dev.	0.113	0.113	0.051	0.124	0.175
Minimum	0.523	0.532	0.792	0.698	0.470
Maximum	1.477	1.560	1.145	1.797	1.797
SMALL BANKS					
Mean	1.030	1.009	1.022	1.032	1.064
Std. Dev.	0.121	0.099	0.091	0.068	0.156
Minimum	0.634	0.713	0.830	0.921	0.673
Maximum	1.433	1.457	1.420	1.467	1.819

ΔOTE: Overall Technical Efficiency Change
ΔPTE: Pure Technical Efficiency Change
ΔSE: Scale Efficiency Change
ΔT: Technological Change
M: Malmquist Index of Productivity Change

V. SUMMARY AND CONCLUSIONS

This paper employs a non-parametric approach to study the effects of increased globalization and bank deregulation on the efficiency and productivity growth of U.S. banks between 1990 and 2003. The study further investigates efficiency and productivity growth differentials between small and large banks, and attempts to identify the factors responsible for any differentials, if they exist. This examination of bank efficiency and productivity growth differentials between large and small banks during this period is important, since it is perceived that increased competition due to globalization and deregulation should have affected small banks and large banks asymmetrically.

The empirical results of this paper indicate that both large and small banks performed less efficiently overall in 2003 compared to 1990. Therefore, contrary to expectations that domestic product and geographic deregulation,
along with globalization would have a positive effect on bank overall efficiency, especially for large banks, the empirical results of this study indicate that the
overall efficiency of U.S. commercial banks declined between 1990 and 2003. Further analyses show that the drop in overall efficiency of the U.S. banking industry (small, large and pooled samples) was entirely caused by a deviation from the "optimal mix of inputs" that led to an allocative inefficiency. However, a marginal increase in overall technical efficiency was found for all banks together, and for each sub-sample.

As might be expected, large banks in 1990 were found to be more efficient compared to small banks for all efficiency indices. These findings remain the same in 2003 expect for scale efficiency, in which small banks were found to be more efficient than large banks, suggesting that small banks operated at a more optimal scale of operation than large banks.

Additionally, the estimated Malmquist index of productivity growth provides empirical support that the aggregate sample of all U.S. banks, and sub-samples of small and large banks separately, displayed significant technological progress and productivity growth during the period between 1990 and 2003. Over this period, both the pooled sample of banks, and separate sub-samples of small and large banks enjoyed an annual average of 6% growth in productivity. The decomposition of the productivity growth index suggests that in the case of large banks, almost all of the productivity growth was due to technological progress. In the case of small banks, the productivity growth was equally caused by increases in both overall technical efficiency (reflecting a rise in scale efficiency) and technological progress. In summary, our findings suggest that, despite the decline in allocative efficiency, the U.S. banking industry nevertheless made significant positive gains in the area of technological progress and productivity growth during this period of increased globalization and deregulation. We speculate that the dynamic changes of globalization that improved bank productivity from 1990 to 2003, will possibly also lead to increases in bank efficiency over the long run, given enough time for adjustment of the optimal mix of inputs to the dynamic nature of the new global environment.

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