Int. Fin. Markets, Inst. and Money 24 (2013) 85–104

Contents lists available at SciVerse ScienceDirect

Journal of International Financial Markets, Institutions & Money

journal homepage: www.elsevier.com/locate/intfin

The impact of TARP on bank efficiency☆

Oneil Harris[a], Daniel Huerta[b], Thanh Ngo[b,*]

[a] East Carolina University, United States
[b] University of Texas – Pan American, United States

ARTICLE INFO

Article history:
Received 22 September 2011
Accepted 1 December 2012
Available online 20 December 2012

JEL classification:
G21
G28

Keywords:
Operating efficiency
TARP
Bank bailout

ABSTRACT

This paper examines the impact of the Troubled Asset Relief Program (TARP) capital injections on the operational efficiency of commercial banks. Using a nonparametric Data Envelopment Analysis to measure bank efficiency, we document a deteriorating pattern in the operating efficiency for banks that received the capital injection from TARP funds that is not evident in non-TARP banks. We test the impact of TARP on the change in bank efficiency as well as the abnormal change in bank efficiency; yet, our results continue to hold. We attribute the decrease in the operating efficiency of TARP funded banks to the abated incentives of bank managers to adopt best practices that improve asset quality, and the moral hazard associated with bailouts.

Published by Elsevier B.V.

1. Introduction

The latest financial crisis is often described as the worst economic downturn in the United States since the Great Depression. According to a report released by the U.S. Treasury's Office of Financial Stability, the financial system was on the verge of collapse for the first time in 80 years. Confidence in financial markets, and in the financial system as a whole, was quickly fading. Consequently, the Federal government enacted the Emergency Economic Stabilization Act (EESA) of 2008 that created the $700 billion Troubled Asset Relief Program (TARP). The purpose of TARP was to stabilize the financial

☆ We would like to thank G. Geoffrey Booth (the editor), two anonymous reviewers, and Omar Harris for valuable comments and suggestions.

* Corresponding author at: University of Texas – Pan American, 1201 W. University Drive, Edinburg, TX 78541, United States. Tel.: +1 956 665 3391.
E-mail address: ngotn@utpa.edu (T. Ngo).

1042-4431/$ – see front matter. Published by Elsevier B.V.
http://dx.doi.org/10.1016/j.intfin.2012.12.001

system by purchasing troubled assets[1] from banks, to inject liquidity into the financial system, and to reactivate the credit markets.

TARP represents the largest U.S. government bailout in history, and so its design and implementation inevitably provoked a flurry of criticisms (Harvey, 2008; Hoshi and Kashyap, 2010). The most notable and controversial provision within TARP was its Capital Purchase Program (CPP) that authorized the Treasury to candidly inject capital into troubled institutions by purchasing senior preferred shares. Under CPP, the Treasury acquired preferred equity and debt securities in excess of $205 billion in 707 banks from October 2008 to December 2009 (Office of Financial Stability, 2010).[2] This injection of capital was intended to restore the financial health of these institutions. TARP funded banks are scheduled to repay or redeem the preferred stock at an undetermined time, but the program requires them to pay an established dividend rate and interest rate to the Treasury as long as the securities are outstanding.

Empirical evidence indicates that TARP helped to mitigate the credit crisis and restored some confidence in the financial system. While lending activity in the U.S. decreased sharply during the crisis (Ivashina and Scharfstein, 2010), lending increased after the distribution of TARP funds (Li, 2011). TARP also created real economic value (Veronesi and Zingales, 2010; Bayazitova and Shivdasani, 2012) and reduced stock market volatility (Huerta et al., 2011). Policy makers also tout the program a success. The Treasury emphasizes that more than $204 billion of TARP funds have been repaid, that taxpayers have earned about $30 billion in income, and that the total estimated cost of TARP is now less than $50 billion (Office of Financial Stability, 2010).

Yet, Hoshi and Kashyap (2010) criticize the government for adopting policies in TARP that failed in Japan during its banking crisis in the 1990s. Bayazitova and Shivdasani (2012) underscore that the preferred equity acquired under TARP is senior to common equity, thereby reducing the upside potential for ordinary shareholders. In addition, while the government urged banks to lend the newly injected TARP capital, it also advised banks against risk taking (Cocheo, 2008). Black and Hazelwood (2010) argue that TARP had differing effects on risk-taking based on bank size due to these two opposing goals. The authors find that following the TARP capital injections, the risk rating of loan originations significantly increased at large TARP banks but significantly decreased at small TARP banks relative to non-TARP banks.

While much attention has been paid to the lending activities and the risk taking of TARP recipient banks, the impact of the capital injection on bank efficiency has been largely ignored. This study adds to the literature on TARP by documenting the effects of the TARP capital infusions on the operating efficiency of the recipient banks. TARP may impair bank efficiency because bailouts encourage moral hazard behavior (Cordella and Yeyati, 2003). To the extent that government assurances might lead to more risk taking (Flannery, 1998; Sironi, 2003), operational efficiency among TARP recipients may decline because managers will engage in aggressive banking practices that lower asset quality and profitability.

In addition, banks' efforts to comply with the TARP requirements may increase operating costs, thereby lowering banking efficiency. Thomson (1991) suggests that increased regulatory scrutiny reduces the flexibility of bank management. Consequently, the operational efficiency of TARP banks could also wane due to government involvement in bank management decisions. Banking efficiency may also debilitate subsequent to the distribution of TARP funds because the capital injections may allow some mismanaged banks to continue to operate without appropriate restructuring or management turnover. Furthermore, the political pressure imposed on banks to increase lending activities after receiving funds from TARP may have prompted some banks to issue low-quality loans.

For these reasons, we expect the operating efficiency at TARP banks to decline following the capital infusions. Our hypothesis is also buttressed by studies suggesting that government bailouts are wasteful. For instance, Faccio et al. (2006) study the bailouts of industrial firms in 35 countries and

[1] A troubled asset was defined in the EESA under Section 3 as "residential or commercial mortgages and any securities, obligations, or other instruments that are based on or related to such mortgages", as well as financial instruments deemed necessary by the Federal Reserve to promote financial market stability.

[2] http://www.treasury.gov/initiatives/financial-stability/briefing-room/reports/agency_reports/Documents/TARP%20Two%20Year%20Retrospective_10%2005%2010_transmittal%20letter.pdf.

find that bailed out firms tend to underperform non-bailed out firms. In accord, Weide and Kini (2000) suggest that political goals can make government bailouts inefficient.

In contrast to the expected decline in operating efficiency among TARP banks, we anticipate finding improved efficiency for non-TARP banks. Our rational is that, confronted with heighten uncertainty about borrower quality, non-TARP recipients reduced risk taking by tightening loan standards, thereby lowering credit risk and monitoring costs (Das and Ghosh, 2006). To avoid bankruptcy, non-TARP banks recapitalized through debt-for-equity swaps, negotiated workout arrangements with delinquent borrowers, increased the supervision of their performing loans, and expensed non-performing loans as bad debt. Although these strategic decisions induced mixed efficiency effects for non-TARP banks, we anticipate a net efficiency gain because these tactical measures will improve the overall asset quality of banks.

We posit that the capital injections under TARP reduced the incentives of managers at TARP banks to make strategic decisions to improve asset quality and encouraged moral hazard behavior, thereby decreasing operating efficiency. Alternatively, Veronesi and Zingales (2010) and Bayazitova and Shivdasani (2012) find that TARP-funded banks earned significant wealth gains when the capital injection program was publicized.[3] While these studies do not focus on bank efficiency, their results suggest that the market may anticipate performance improvements from TARP. Banks had large proportions of non-performing loans that negatively impact efficiency by decreasing profit margins (Das and Ghosh, 2006). To the degree that the capital infusions from TARP helped recipient banks to manage their non-performing loans, operational efficiency could improve for TARP banks.

In addition, the government imposed restrictions on executive compensation at TARP recipient banks which could lead to improved operating efficiency. Under TARP, policymakers limited cash salary to $500,000 and insisted on stock-based bonuses. These compensation guidelines are consistent with academic studies showing that firm performance is better when the equity portion of managerial compensation is higher (Jensen and Murphy, 1990; Mehran, 1995; Core et al., 1999). Hence, the increased scrutiny by officials over managerial compensation at TARP banks may better align the incentives of bank managers with that of shareholders, thereby leading to efficiency gains.

Following studies by Das and Ghosh (2006), Hsiao et al. (2010), Park and Weber (2006), and Yeh (1996), we employ the nonparametric Data Envelopment Analysis (DEA) to measure bank operating efficiency. DEA uses a weighted sum of outputs to inputs to compute the relative efficiency of a bank in relation to all other banks. The method identifies the banks with the most proficient input–output combinations and develops a 'best practice' efficiency frontier against which banks are compared.

We test our predictions on a sample of 227 TARP funded banks and a matched portfolio of non-TARP banks. Specifically, we examine the operating efficiency of banks beginning six quarters preceding the TARP capital infusion and ending six quarters following the TARP capital infusion, while controlling for bank-level characteristics. As hypothesized, we document a significant deteriorating pattern in the operating efficiency of banks that received the capital injection from TARP funds that is not evident for non-TARP banks. For robustness, we examine the change in operating efficiency, as well as the abnormal change in efficiency. We also employ the Heckman (1976) two-step approach to address potential selection bias. Yet, our results continue to hold.

Consequently, although TARP recapitalized troubled banks, the operational efficiency of the banks weakened. We attribute the decrease in the operating efficiency of TARP funded banks to the abated incentives of bank managers to adopt best practices that improve asset quality, and the moral hazard associated with bailouts. Our analyses also reveal that when the likelihood of receiving the capital injection is higher, the change in bank efficiency is worse. This finding underscores the essential flaw inherent in the 'too big to fail' argument that generally underlie government bailouts. Consequently, our results have important implications for policymakers as it relates to future bailout schemes.

Our study not only makes a notable contribution to the growing literature on TARP, but it also contributes to the literature on bank operational efficiency around financial crises and regulatory reforms. The impact of financial crises and reforms on bank efficiency has been studied in Latin American, South

[3] This valuation gain contrasts with the typically price decline associated with bank announcements of stock issuance (Cornett and Tehranian, 1994; Krishnan et al., 2009).

East Asia, India, Switzerland, and Taiwan (Dietrich and Wanzenried, 2011; Hsiao et al., 2010; Williams and Nguyen, 2005; Yildimir and Philippatos, 2007; Zhao et al., 2010). To the best of our knowledge, this is the first study to examine the effect of TARP on the operational efficiency of commercial banks.

The remainder of this paper is organized as follows. Section 2 provides additional background on TARP and surveys the related literature. Section 3 describes the data and the sample selection criteria. We explain our methodology in Section 4 and discuss our main empirical findings in Section 5. We offer our conclusion in Section 6.

2. Background and related literature

The 2007–2009 economic meltdown is the major subject of our times. Researchers are investigating the reasons that triggered the crisis and the many ways the downturn has impacted the U.S. economy. The severity of the recession caused a crunch in the credit market and placed the soundness of the U.S. financial system at risk. In response to the crisis, TARP was introduced as a mechanism to create stability and to inject liquidity into the market. The design of TARP incited criticisms because the program embodies the largest U.S. government bailout in history (Harvey, 2008; Cocheo, 2008; Hoshi and Kashyap, 2010).

The centerpiece of TARP was the Capital Purchase Program (CPP) that injected capital into troubled banks. This program committed $250 billion[4] of the $700 billion authorized for TARP to allow financial institutions to sustain a normal flow of credit during the crisis (Office of Financial Stability, 2010). The Treasury purchased $125 billion in preferred equity and debt from the nine largest banks (Veronesi and Zingales, 2010). The preferred stocks pay a dividend rate of 5% per year for the first five years and will rise to 9% thereafter; the debt instruments pay a 7.7% interest rate that will increase to 13.8% after five years. The remaining $125 billion was made available to other banks that qualified for TARP funding.

Ivashina and Scharfstein (2010) examine bank lending during the crisis among large U.S. banks and document a substantial decline across all types of loans from August 2006 through November 2008. New loans fell by 47% in the fourth quarter of 2008 relative to the third quarter of 2008, and by 79% relative to the second quarter of 2007. While the decline in lending can be ascribed to the drop in the number of applications for loans, it is partly attributable to the non-performing loans on the balance sheets of banks and tightened lending standards given the increased uncertainty about borrower quality.

The official government response to the crisis was to directly inject TARP funds into troubled banks. Li (2011) finds that after the TARP capital injection, lending increased by an annualized rate of 6.41% in all major types of loans, which is equivalent to $2.66 more loans for every TARP dollar invested. Veronesi and Zingales (2010) estimate that the TARP intervention added between $84 billion and $107 billion in value, indicating that TARP produced valuation gains (Bayazitova and Shivdasani, 2012). However, they argue that a rescue plan that involved a debt-for-equity swap would have been less costly. Bayazitova and Shivdasani (2012) and Hoshi and Kashyap (2010) also criticize TARP for using preferred shares that are senior to common shares because this approach reduces the incentives of ordinary shareholders.

In related research, Huerta et al. (2011) find that the TARP capital injections resulted in a reduction in stock market volatility. They find that market volatility significantly decreased on TARP disbursement days, suggesting that the allocations helped to reduce investor fear as confidence was quickly fading. Fahlenbrach and Stulz (2011) examine whether bank performance during the crisis is related to chief executive officer (CEO) incentives and compensation prior to the crisis. They find no evidence that CEOs acted in their own interest. Further, CEO incentives had no impact on bank performance during the crisis, even while controlling for banks that receive TARP funds and those that do not.

On the other hand, the Office for Financial Stability (2010) posit that the crisis was caused by an unsustainable housing boom and by relaxed regulations that allowed firms to take on excessive risk

[4] This amount was determined on October 14, 2008, but the U.S. Treasury ultimately lowered this figure to $218 billion in March 2009 (Office of Financial Stability, 2010).

Table 1
Number of banks and observations of bank per quarter.

	TARP banks		Non-TARP banks	
	Mean	Median	Mean	Median
Market value of equity ($Million)	3204.91	135.67	2885.47	97.29
TARP injection ($Million)	470.65	36.00	–	–
TARP injection/market value of equity	40.97%	30.29%	–	–

This table reports descriptive summary statistics on TARP funding. The sample consists of 227 TARP recipient banks. Each TARP bank is matched to a portfolio of non-TARP banks. Our matching process is motivated by Lyon et al. (1999). We match banks on 4-digit SIC code, size, and book-to-market. To identify appropriate benchmark firms for each TARP bank, we restricted the pool of matching firms to the sample of non-TARP banks in the same 4-digit SIC code in a given quarter. We then identified all the potential matching firms with market capitalization between 70% and 130% of the market capitalization of the TARP bank. From this group, the ten non-TARP banks with the closest book-to-market ratio to that of the TARP bank were selected as the benchmark portfolio.

and to become highly leveraged. However, Black and Hazelwood (2010) find that TARP only helped to curtail risk at small TARP funded banks. They report that after the capital injections, the risk rating of loan originations significantly increased at large TARP banks but significantly decreased at small TARP banks relative to non-TARP banks.

3. Data

We obtain the full list of TARP recipients from the Treasury department that is hosted on its Financial Stability for the American Economy website.[5] This report discloses all firms that received TARP funds under CPP from October 2008 to December 2009 with the respective transaction dates and investment amounts. We focus our attention on the banking industry because this sector received the largest portion of funds. We only include publicly traded banks that we can identify on Compustat in our sample. Following Fahlenbrach and Stulz (2011), we keep only commercial banks by selecting firms with SIC codes between 6000 and 6300. We exclude firms with SIC code 6282 (Investment Advise) since they are not lending institutions and should not be classified as a bank.

This sample selection process yields an initial sample of 258 TARP banks. We obtain quarterly financial statement data from Compustat. We then require that for each TARP bank in each quarter, there should be an appropriate portfolio of non-TARP banks. Our matching process is motivated by Lyon et al. (1999). To identify appropriate benchmark firms, we restrict the pool of matching firms to the sample of non-TARP banks in the same 4-digit SIC code in a given quarter. We then identify all the potential matching firms with market capitalization between 70% and 130% of the market capitalization of the TARP bank. From this group of firms, we select the 10 non-TARP banks with the closest book-to-market ratio to that of the TARP bank as the benchmark portfolio. Hence, we match banks on 4-digit SIC code, size, and book-to-market.

This matching process yields a revised sample of 227 TARP recipient commercial banks with appropriate non-TARP matching portfolios. The descriptive statistics in Table 1 show that on average, TARP recipient banks are larger than non-TARP recipient banks, as measured by market capitalization. The mean (median) market value of equity is $3204.91 ($135.67) million among TARP banks and $2885.47 ($97.29) million among non-TARP banks. The capital infusion from TARP for the average bank is about 471 million; the median is 36 million. The TARP capital infusion relative to the market value of equity is about 41% on average (median is 30%), which is comparable to that reported by Bayazitova and Shivdasani (2012).

We track each TARP bank over the period beginning six quarters preceding TARP fund disbursements and ending six quarters following TARP fund disbursements. We include a bank in our sample as long as it has information in Compustat for a given quarter. As a result, the sample of TARP banks is

[5] Available online at: http://financialstability.gov/. Accessed on October 22, 2010.

Table 2
Comparison of the financial soundness of TARP banks and non-TARP banks.

	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.
Tier 1 capital ratio			
Pre-TARP Q(−6,−1)	10.12%	9.69%	−4.16***
Post-TARP Q(+1,+6)	11.92%	9.29%	8.93***
Difference Q(+1,+6) – Q(−6,−1)	1.79%	−0.41%	7.64***
	19.34***	34.30***	
Loan loss provision ratio			
Pre-TARP Q(−6,−1)	0.19%	0.17%	1.19
Post-TARP Q(+1,+6)	0.54%	0.51%	1.35
Difference Q(+1,+6) – Q(−6,−1)	0.35%	0.34%	1.68*
	19.73***	37.14***	37.14***
Return on assets			
Pre-TARP Q(−6,−1)	0.10%	0.04%	6.57***
Post-TARP Q(+1,+6)	−0.10%	−0.30%	5.57***
Difference Q(+1,+6) – Q(−6,−1)	−0.20%	−0.26%	3.15**
	−6.55***	−71.16***	
Net interest margin			
Pre-TARP Q(−6,−1)	3.77%	3.10%	258.30***
Post-TARP Q(+1,+6)	3.50%	3.19%	235.64***
Difference Q(+1,+6) – Q(−6,−1)	−0.28%	0.09%	51.25***
	−1.19	32.67***	
Funding cost			
Pre-TARP Q(−6,−1)	0.94%	0.96%	−2.69***
Post-TARP Q(+1,+6)	0.51%	0.57%	−12.07***
Difference Q(+1,+6) – Q(−6,−1)	−0.43%	−0.39%	−1.72*
	−48.33***	−93.90***	
Operating revenue to total asset			
Pre-TARP Q(−6,−1)	1.74%	1.68%	8.28***
Post-TARP Q(+1,+6)	1.46%	1.45%	0.92
Difference Q(+1,+6) – Q(−6,−1)	2.83%	0.23%	4.98***
	28.00***	66.52***	

This table reports descriptive statistics on bank soundness and compare the financial soundness of TARP banks to non-TARP banks.

* Statistically significance at the 10% level.
** Statistically significance at the 5% level.
*** Statistically significance at the 1% level.

an unbalanced panel dataset of 2698 bank-quarter observations. The pre-TARP period: *Q*(−6,−1) and post-TARP period: *Q*(+1,+6) account for 1350 and 1348 observations, respectively. Since each TARP bank is matched to a corresponding value-weighted portfolio of non-TARP banks, the full sample consists of 5396 observations.

Pursuant to prior research, we analyze several measures of capital adequacy, liquidity, asset utilization, and profitability to assess the financial soundness of banks. We examine the following variables: tier 1 capital ratio, loan loss provision ratio, returns on assets, net interest margin, and funding cost. Appendix 1 describes how each of these measures is constructed.

In Table 2, we present sample descriptive statistics on the bank soundness variables and compare the financial soundness of TARP banks to non-TARP banks. Examining changes in indictors of bank soundness may provide insights into the immediate effects that the TARP capital infusions had on banks performance. The table shows results that compare the pre-TARP period and the post-TARP period bank soundness variables and results that compare TARP banks and non-TARP banks over the two periods.

Given the capital infusions from the government, TARP banks exhibit a significant increase in their capital base. The TIER 1 capital ratio is significantly higher in the 6 quarters after

TARP fund receipt (a mean of 11.92%) as compared to the previous 6 quarters (a mean of 10.12%); the mean difference is significant at the 1% level (*t*-statistic = 19.34). Although non-TARP banks also experience a significant increase in their TIER 1 capital ratio, on average, the magnitude of the changes is significantly larger for TARP banks than non-TARP banks. Thus, the economic downturn appeared to have a more pronounced impact of the viability of TARP banks, which in all likelihood, may explain their need for TARP funding.

To proxy credit risk, we use the loan loss provision relative to total loans. On average, TARP banks and non-TARP banks experience significantly higher loan loss provision ratio, but TARP banks exhibit a marginally larger increase than non-TARP banks. The mean change in the loan loss provision ratio is 0.3% higher for TARP banks but only 0.2% higher for non-TARP banks, and both changes are significant at the 1% level. These results suggest that relative to non-TARP banks, the asset quality for TARP banks is better before the capital infusions than after the capital infusions. Following the capital infusions, the mean change in the loan loss provision ratio is about 0.1% lower for TARP banks compared to non-TARP banks; this difference is statistically significant at the 10% level (*t*-statistic = 1.68). Thus, there is a notable decline in asset quality among TARP banks relative to non-TARP banks.

We also find that TARP banks and non-TARP banks experience a significant decrease in return on assets, implying lower profitability. Yet, while the mean change in the net interest margin is not significantly different from zero among TARP banks, net interest margin is notably higher among non-TARP banks (about a 0.1% change; *t*-statistic = 32.67). Accordingly, there is some evidence of lower profitability among TARP recipients following the capital injections compared to non-TARP recipients, as measured by relative interest-earning. The mean difference in the change in net interest margin is significant at the 1% level (*t*-statistic = 51.25). This result supports the view that the capital injections from TARP reduced the incentives of managers at TARP banks to make strategic decisions to improve asset quality and profitability.

As expected, the results show that both TARP banks and non-TARP banks experience significant decreases in funding cost, which may be attributed to the weak economy. We also observe a significant decrease in the operating revenue to total asset ratio of both TARP banks and non-TARP banks. However, the magnitude of decrease in the operating revenue to asset ratio is more pronounced for TARP banks compared to non-TARP banks; the mean difference is significant at the 1% level (*t*-statistic = 4.98).

4. Methodology

4.1. Data Envelopment Analysis and test statistics

To measure bank efficiency, we use a non-parametric Data Envelopment Analysis (DEA). The DEA technique evaluates the performance of decision-making units (DMUs) to success transform inputs into outputs relative to their peers (Hsiao et al., 2010; Park and Weber, 2006; Das and Ghosh, 2006). The DEA is especially effective when multiple performance measures are present since it provides the advantage to combine inputs and outputs simultaneously. Empirical studies using DEA to evaluate bank efficiency indicate that banks with higher efficiency scores have higher ratios in capital adequacy, asset utilization and profitability, as well as lower leverage and liquidity ratios compared to banks with lower efficiency scores (Yeh, 1996).

Following the method of Hsiao et al. (2010), we estimate bank efficiency using the Charnes et al. (1978) model of DEA that gauges efficiency as the minimal consumption of inputs for a given level of output. Although efficiency can also be measured by maximizing output given the inputs, it is potentially difficult for banks to increase their output levels given their input levels (Hsiao et al., 2010). Thus, the minimization of inputs consumed for a given output level is the typical approach employed by banks to increase performance.

Pursuant to Hsiao et al. (2010), the input-oriented efficiency measure is the reciprocal of the inefficiency measure θ_j, which is given as:

$$\begin{aligned} &\theta_j = Max\theta \\ &\quad \text{s.t.} \quad \frac{X_{ij}}{\theta} \geq \sum_{j=1}^{N} \lambda_j X_{ij}, \quad i = 1, \ldots, I, \\ &Y_{rj} \leq \sum_{j=1}^{N} \lambda_j Y_{rj}, \quad r = 1, \ldots, R, \\ &\lambda_j \geq 0, \end{aligned} \tag{1}$$

where θ_j is the estimated inefficiency for bank j, X_{ij} is input i for bank j, Y_{rj} is output r for bank j, and λ_j is the weight placed on banks. Following the method of Hsiao et al. (2010), Kao and Liu (2004), Yeh (1996) and others, we choose three outputs and three inputs for estimating bank efficiency. The input variables are the interest expense to total asset ratio, the non-interest expense to assets ratio, and the total deposits to assets ratio. We use the interest income to total asset ratio, the non-interest income to assets ratio, and the total loan to assets ratio as the output variables.

Two DEA-based test statistics are available. Under the assumption that θ_j is exponentially distributed, the test statistic is given as:

$$T_{exp} = \left[\sum_{j \in N1} \frac{\theta_j - 1}{N1} \right] \div \left[\sum_{j \in N2} \frac{\theta_j - 1}{N2} \right] \tag{2}$$

which is evaluated by the F-distribution with $(N1, N2)$ degrees of freedom. $N1$ and $N2$ are the periods before and after the TARP disbursement of funds, respectively. Similarly, under the assumption that θ_j is half-normally distributed, the test statistic is:

$$T_{hn} = \frac{\sum_{j \in N1} (\theta_j - 1)^2 / N1}{\sum_{j \in N2} (\theta_j - 1)^2 / N2} \tag{3}$$

In addition to the DEA-based test statistics, we also report two conventional tests: (1) the Welch test and (2) the Kolmogorov–Smirnov test.

Table 3 presents descriptive statistics on the inputs and outputs used to estimate bank efficiency and compares the inputs and outputs of TARP banks to non-TARP banks. TARP banks exhibit a lower interest expense ratio in the post-TARP period compared to non-TARP banks (t-statistic = −2.10), but the interest income ratio is higher among non-TARP banks in the post-TARP period compared to TARP banks (t-statistic = −16.94). However, compared to TARP banks, non-TARP banks exhibit a significantly higher non-interest expense ratio in both the pre-TARP and post-TARP periods, and a significantly lower non-interest income ratio in the post-TARP period. In addition, we find no notable difference in the deposit to asset ratio of TARP banks and non-TARP banks in the pre-TARP and post-TARP periods. Yet, non-TARP banks exhibit a significantly larger loan to asset ratio than TARP banks in the post-TARP period (t-statistic = −2.05).

4.2. *Tobit regression*

Following the method of Hsiao et al. (2010) and others, we use Tobit regression analyses to examine the impact of TARP on banking efficiency. The Tobit model is two-side censored because the efficiency score (i.e., the dependent variable) is bounded between 0 and 1. We create two dichotomous variables: (1) *POST TARP PERIOD* and (2) *TARP BANK*. The indicator variable denoted *POST TARP PERIOD* takes the value 1 if the quarter in question is in the post-TARP period; otherwise it takes the value of 0. The variable denoted *TARP BANK* takes the value 1 if the bank in question is a TARP recipient; otherwise it takes the value of 0. We then create a third variable of primary interest that captures the interaction between *TARP BANK* and *POST TARP PERIOD* (see Table 4).

Table 3
Comparison of TARP banks vs. value-weighted portfolio of non-TARP banks matched on assets and market-to-book.

Quarters	Interest expense to assets			Non-interest expense to assets			Deposit to assets		
	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.
Panel A – Efficiency score input variables									
−6	0.83%	0.79%	2.79***	0.72%	0.88%	−12.27***	74.62%	73.41%	2.16**
−5	0.85%	0.85%	−0.40	0.72%	0.88%	−12.06***	73.43%	71.39%	3.62***
−4	0.83%	0.89%	−4.07***	0.73%	0.91%	−11.34***	72.91%	71.20%	3.11***
−3	0.78%	0.74%	2.23**	0.71%	0.84%	−9.76***	72.59%	73.11%	−0.93
−2	0.76%	0.79%	−1.80*	0.71%	0.88%	−9.50***	72.46%	72.80%	−0.63
−1	0.83%	0.76%	2.71***	0.80%	1.00%	−5.85***	72.93%	72.58%	0.62
0	0.82%	0.79%	1.45	0.87%	1.07%	−3.89***	72.82%	72.65%	0.34
1	0.81%	0.70%	3.46***	0.79%	0.89%	−2.90***	73.91%	73.94%	−0.05
2	0.83%	0.81%	0.53	0.89%	0.87%	0.34	74.87%	73.32%	3.04***
3	0.81%	1.03%	−5.60***	0.81%	1.00%	−5.44***	75.80%	75.76%	0.07
4	0.75%	0.87%	−3.82***	0.79%	1.18%	−12.42***	76.52%	77.08%	−1.12
5	0.65%	0.62%	0.84	0.76%	0.88%	−6.87***	76.92%	78.28%	−2.66***
6	0.63%	0.73%	−3.20***	0.80%	0.92%	−5.54***	76.84%	77.57%	−1.41
Q(−6,−1)	0.81%	0.81%	0.59	0.73%	0.90%	−12.41***	73.16%	72.41%	1.41
Q(+1,+6)	0.75%	0.79%	−2.10**	0.81%	0.96%	−8.78***	75.81%	75.99%	0.39
Mean difference *Q*(1,6) – *Q*(−6,−1)	−2.61***	−3.90***		3.52***	20.02***		3.69***	21.73***	

Quarters	Interest income to assets			Non-interest income to assets			Loan to assets		
	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.
Panel B – Efficiency score output variables									
−6	1.58%	1.56%	1.83*	0.29%	0.22%	5.31***	70.66%	70.56%	0.13
−5	1.57%	1.54%	2.77***	0.28%	0.22%	4.32***	70.97%	70.79%	0.24
−4	1.51%	1.50%	0.98	0.28%	0.21%	4.53***	70.96%	71.01%	−0.07
−3	1.47%	1.43%	0.76	0.24%	0.20%	0.85	71.18%	71.25%	−0.08
−2	1.43%	1.43%	−0.29	0.21%	0.20%	0.37	71.68%	70.76%	1.21
−1	1.45%	1.43%	0.70	0.13%	0.20%	−2.06**	71.63%	71.38%	0.332
0	1.30%	1.42%	−7.08***	0.21%	0.20%	0.71	69.92%	71.51%	−2.23**
1	1.23%	1.32%	−5.10***	0.27%	0.23%	1.45	68.82%	70.55%	−2.28**

Table 3 (*Continued*)

Quarters	Interest expense to assets			Non-interest expense to assets			Deposit to assets		
	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.	TARP banks (1)	Non-TARP banks (2)	Difference (1) – (2) *t*-stat.
2	1.23%	1.87%	−14.33***	0.26%	0.07%	5.89***	68.53%	68.76%	−0.31
3	1.19%	1.29%	−6.12***	0.29%	0.24%	1.76*	67.55%	69.08%	−2.03**
4	1.14%	1.32%	−12.03***	0.32%	0.21%	4.75***	66.56%	68.70%	−2.84***
5	1.12%	1.24%	−10.02***	0.29%	0.21%	5.31***	65.83%	67.63%	−2.42**
6	1.10%	1.61%	−21.19***	0.32%	0.23%	5.51***	65.16%	66.54%	−1.87*
Q(−6,−1)	1.50%	1.48%	1.35	0.24%	0.21%	1.80*	71.18%	70.96%	0.29
Q(+1,+6)	1.22%	1.45%	−16.94***	0.29%	0.20%	−5.54***	67.07%	68.54%	−2.05**
Mean difference *Q*(1,6) – *Q*(−6,−1)	−18.86***	−4.94***		2.15**	−5.14***		−3.99***	−21.53***	

This table reports report descriptive statistics on the three inputs and three outputs used to measure bank efficiency. We compare the inputs and outputs of TARP banks to the matched portfolio of non-TARP banks. Panel A report the results for the three inputs. The input variables are the interest expense to total asset ratio, the non-interest expense to assets ratio, and the total deposits to assets ratio. Panel B report the results for the three outputs. The output variables are the interest income to total asset ratio, the non-interest income to assets ratio, and the total loan to assets ratio.

* Statistically significance at the 10% level.

** Statistically significance at the 5% level.

*** Statistically significance at the 1% level.

Table 4
Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1)	1.000									
(2)	−0.398***	1.000								
	(0.000)									
(3)	0.056***	−0.000	1.000							
	(0.000)	(1.000)								
(4)	−0.285***	0.578***	0.575***	1.000						
	(0.000)	(0.000)	(0.000)							
(5)	0.044***	−0.013	0.114***	0.081***	1.000					
	(0.001)	(0.331)	(0.000)	(0.000)						
(6)	−0.118***	0.354***	0.064***	0.310***	−0.062***	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
(7)	−0.582***	0.430***	0.030***	0.266***	0.096***	0.031**	1.000			
	(0.000)	(0.000)	(0.030)	(0.000)	(0.000)	(0.026)				
(8)	−0.266***	0.257***	−0.024	0.140***	−0.377***	0.188***	0.080***	1.000		
	(0.000)	(0.000)	(0.082)	(0.000)	(0.000)	(0.000)	(0.000)			
(9)	0.257***	−0.745***	−0.085***	−0.507***	−0.019	−0.426***	−0.327***	−0.487***	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.169)	(0.000)	(0.000)	(0.000)		
(10)	0.458***	−0.423***	0.052***	−0.304***	0.036**	−0.110***	−0.291***	−0.317***	0.308***	1.000
	(0.000)	(0.000)	(0.001)	(0.000)	(0.016)	(0.000)	(0.000)	(0.000)	(0.000)	

This table reports the correlation coefficients and their corresponding *p*-values. The variables are (1) bank efficiency score, (2) the post TARP period variable, (3) the TARP BANK variable, (4) the interaction between the post TARP period variable and the TARP BANK variable, (5) bank size, (6) the tier 1 capital ratio, (7) the loan loss provision ratio, (8) the deposits to equity ratio, (9) funding cost, (10) and lagged bank efficiency score.
* Statistically significance at the 0.1 level.
** Statistically significance at the 0.05 level.
*** Statistically significance at the 0.01 level.

We control for several bank level variables. Das and Ghosh (2006) find that bank efficiency is related to bank size. Therefore, we control for the natural logarithm of total bank assets (denoted *BANK SIZE*). Larger banks were more likely to receive TARP funding than smaller banks because they posed more systematic risk (Bayazitova and Shivdasani, 2012). In addition, banks with higher capital adequacy ratios tend to have higher efficiency; whereas, banks with higher non-performing loan ratios tend to have lower efficiency (Das and Ghosh, 2006; Hsiao et al., 2010). As a result, we control for the bank's Tier 1 capital ratio (*TIER 1 CAPITAL RATIO)* and its loan loss provision ratio (denoted *LOAN LOSS PROVISION*).

Das and Ghosh (2006) also relate efficiency to bank management quality. We use several bank soundness measures to proxy management quality. For instance, we control for the bank's deposits to equity ratio (*DEPOSIT TO EQUITY*), and its funding cost (*FUND COST*). Berger et al. (2000) point out that bank profits tend to persist over time. Accordingly, we include the lag of the efficiency score in the model as a control variable. Table 3 presents the correlation matrix for the variables in the model. Our baseline model is of the general form:

$$\begin{aligned} ESCORE \; &= \alpha + \beta_1 TARP\;\; BANK_{jt} + \beta_2 POST\;\; TARP\;\; PERIOD_{jt} + \beta_3 TARP\;\; BANK * POST\;\; TARP\;\; PERIOD_{jt} \\ &\quad + \beta_4 BANK\;\; SIZE_{jt} + \beta_5 TIER1\;\; CAPITAL\;\; RATIO_{jt} + \beta_6 LOAN\;\; LOSS\;\; PROVISION_{jt} \\ &\quad + \beta_7 DEPOSIT\;\; TO\;\; EQUITY_{jt} + \beta_8 FUNDING\;\; COST_{jt} + \beta_9 ESCORE_{jt-1} \end{aligned} \tag{4}$$

Provided that the sample is an unbalanced panel dataset, we also include bank and quarter fixed effects to mitigate potential omitted variables bias as well as to control for the effect of unobserved variables that are constant across banks and that are constant over time.

The generalized method of moments (GMM) technique is a rigorous treatment for dealing with potential endogeneity problems. Given that endogeneity may be a problem when estimating bank profitability (Garcia-Herrero et al., 2009), we use the system GMM technique as suggested by Arellano and Bover (1995) for robustness. The Arellano–Bover (1995)/Blundell–Bond (1998) dynamic panel

Table 5
Descriptive statistics of bank efficiency.

Quarters	TARP banks (1)			Non-TARP banks (2)			Difference (1) – (2)	
	Mean	Median	Std. dev.	Mean	Median	Std. dev.	Mean	t-stat.
Panel A – Efficiency score								
−6	0.734	0.734	0.090	0.736	0.728	0.038	−0.002	−6.763***
−5	0.775	0.772	0.090	0.731	0.760	0.041	0.044	2.322**
−4	0.763	0.762	0.093	0.711	0.683	0.054	0.053	0.806
−3	0.769	0.767	0.102	0.713	0.749	0.051	0.056	7.280***
−2	0.758	0.755	0.113	0.701	0.657	0.062	0.057	2.209**
−1	0.764	0.777	0.125	0.722	0.762	0.053	0.042	4.580***
0	0.702	0.699	0.108	0.706	0.690	0.027	−0.004	−8.626***
1	0.683	0.682	0.118	0.684	0.715	0.042	−0.001	−2.174**
2	0.645	0.632	0.118	0.684	0.723	0.057	−0.039	−4.099***
3	0.596	0.577	0.119	0.589	0.621	0.050	0.007	0.789
4	0.610	0.576	0.134	0.653	0.623	0.073	−0.043	−10.576***
5	0.679	0.672	0.120	0.708	0.702	0.037	−0.029	−5.225***
6	0.684	0.686	0.126	0.694	0.723	0.040	−0.010	−6.189***
Q(−6,−1)	0.761	0.761	0.102	0.719	0.723	0.050	0.042	4.260***
Q(+1,+6)	0.649	0.637	0.122	0.669	0.684	0.050	−0.019	−11.340***

	Mean difference Q(+1,+6) – Q(−6,−1)	Exponentially distributed t-stat. (T_{exp})	Half-normally distributed t-stat. (T_{hn})	t-Test stat.	Wilcoxon t-stat.
Panel B – Statistical test results of equality of the efficiency score after TARP vs. before TARP					
TARP banks (1)	−0.111	−1.47***	−2.12***	−28.91***	−29.01***
Non-TARP banks (2)	−0.050	−1.18***	−1.38***	−22.38***	−22.95***
(1) – (2)	−0.061	−1.15***	−1.58***	−3.79***	−5.48***

This table reports summary statistics on bank efficiency and provides statistical test results of equality of the efficiency score after the TARP capital infusion compared to before the TARP capital infusion. Bank efficiency is calculated based on a nonparametric Data Envelopment Analysis (DEA). We report the two DEA statistical tests: based on (i) the exponentially distributed assumption (T_{exp}) and (ii) the half-normally distributed assumption (T_{hn}). For robustness, we also report the *t*-test and the Wilcoxon test statistics.
* Statistically significance at the 0.1 level.
** Statistically significance at the 0.05 level.
*** Statistically significance at the 0.01 level.

estimators are popular in the literature. We report the Hansen test for over-identifying restrictions in GMM dynamic model estimation and the Arellano–Bond test for autocorrelation in the residuals.

5. Results

5.1. Univariate analysis

Table 5 provides summary statistics on bank operating efficiency and univariate results that compare the efficiency of TARP banks to non-TARP banks. As expected, the results show that the efficiency of TARP recipients declined following the capital infusion. The mean (median) efficiency score for TARP banks decreased from 0.761 (0.761) before the capital injection to 0.649 (0.637) after the capital injection (Panel A). As shown in Panel B, the four statistical tests for equality all indicate that the difference in the mean efficiency score across the two periods (−0.111) is significant at the 1% level. We attribute this result to bailout related moral hazards.

The mean (median) efficiency score for non-TARP banks decreased from 0.719 (0.723) in the pre-TARP period to 0.669 (0.684) in the post-TARP period (Panel A). The statistical tests for equality show that the difference in the mean efficiency score across the two periods is only −0.050, which is less than half the magnitude of the decline among TARP recipient banks. This finding supports the view that confronted with uncertainty about borrower quality in the recession, non-TARP banks adopted better credit risk management practices that improve asset quality relative to TARP funded banks.

We also analyze the difference in the operating efficiency of TARP banks vs. non-TARP banks over the two sub-periods. Panel A shows that prior to the capital infusions, TARP banks exhibit significantly higher quarterly efficiency scores than non-TARP banks, except in quarter 4. However, following the capital injection, the quarterly efficiency scores among TARP banks are significantly lower than those of non-TARP banks (except in quarter 3). The mean quarterly differences are statistically significant at the 5% level or better.

Overall, the mean efficiency measure in the pre-TARP period is about 0.042 higher for TARP banks compared to for non-TARP banks, which is highly significant (t-statistic = 4.26). Yet, the mean efficiency score in the post-TARP period is about 0.019 lower for TARP banks compared to non-TARP banks, which is significant at the 1% level (t-statistic = −11.34). The collective drop in operating efficiency among TARP banks after the capital infusion relative to non-TARP banks (−0.061) is also statistically significant at the 1% level in all four of the statistical tests for equality (see Panel B). This finding also supports the hypothesis that the TARP bailout encouraged moral hazard behavior among fund recipient banks.

Since our analysis may be sensitive to when operational efficiency is assessed, we consider an alternative time period. We also compute operating efficiency beginning 4 quarters preceding the TARP capital infusion and ending 4 quarters following the TARP capital infusion. We find similar results. In addition, we assess the cost-to-income ratio, net interest margin, and return on assets as alternative measures of operational efficiency. Using these alternative measures, we find very similar results to those reported in Table 5. For brevity, we do not report the sensitivity tests in a table.

Interestingly, some of the results in Tables 2 and 5 suggest that before the injection, TARP banks were better capitalized, more profitable, and more efficient than non-TARP banks. Thus, it seems counter-intuitive that these banks received TARP funding. However, Dunchin and Sosyura (2010) suggest that a bank's political connection was a major determinant in the distribution of TARP funds. Indeed, Bayazitova and Shivdasani (2012) find that the TARP infusions were provided to those banks that posed systemic risk, faced high expected financial distress costs, but had strong asset quality and were politically well connected. Banks with large portfolios of commercial and industrial loans were also more likely to receive TARP capital, implying that the government targeted banks heavily involved in providing credit to corporations (Bayazitova and Shivdasani, 2012). According to Bloomberg, Neel Kashkari acknowledged on Monday, October 13th 2008, that TARP funds were geared toward "healthy" banks.[6]

Furthermore, regulatory scrutiny over executive compensation led many banks to reject TARP funds despite their capital needs. As Bayazitova and Shivdasani (2012) note, some weakly capitalized banks that would have benefited from TARP rejected the capital infusion due to concerns over compensation requirements. However, there is evidence that political ties were used to coerce some reluctant banks to participate in TARP as strong political connections lower the probability that banks refused TARP funds (Bayazitova and Shivdasani, 2012).

5.2. Regression analysis

In Table 6, we present Tobit regression results that control for bank fixed-effects and quarter (or time) fixed-effects. Panel A reports the results for the two sub-samples of TARP banks and non-TARP banks separately. In these results, the variable *POST TARP PERIOD* is the variable of primary interest. For the sub-sample of TARP banks, *POST TARP PERIOD* (−0.117) is significantly negative at the 1% level (t-statistic = −15.07) signifying that operating efficiency declined following the TARP capital injection. This confirms the univariate results in Table 5. However, while the corresponding coefficient for that non-TARP banks is positive (0.008), it is not significantly different from zero. Several of the control variables are also significant, and their signs are consistent with prior studies on bank efficiency.

We then analyze the full dataset for the whole sample and report the results in Panel B. As indicated the coefficient of *POST TARP PERIOD* is still negative and highly significant, reflecting a drop in banking efficiency in the post-TARP period. The *TARP BANK* variable is positive, but insignificant. However, more interestingly, the interaction variable between *TARP BANK* and *POST TARP PERIOD* is negative

[6] Treasury to invest in "healthy" banks, Kashkari says, Bloomberg News, October 13, 2008.

Table 6
Tobit model results on banking efficiency score.

	Panel A		Panel B
	TARP BANKS	*NON-TARP BANKS*	*WHOLE SAMPLE*
INTERCEPT	1.382	2.244***	1.412***
	(0.137)	(10.04)	(14.68)
POST TARP PERIOD	−0.117***	0.008	−0.023***
	(−15.07)	(1.25)	(−4.71)
TARP BANK	–	–	0.067
	–	–	(1.33)
*TARP BANK*POST TARP PERIOD*	–	–	−0.091***
	–	–	(−22.14)
BANK SIZE	−0.014	−0.201***	−0.028**
	(−0.81)	(−5.81)	(−2.04)
TIER 1 CAPITAL RATIO	−0.002**	0.008***	−0.004***
	(−2.01)	(3.17)	(−4.23)
LOAN LOSS PROVISION	−11.419***	−15.400***	−13.091***
	(−24.85)	(−38.77)	(−42.47)
DEPOSIT TO EQUITY	−0.445**	−0.261***	−0.437***
	(−6.87)	(−2.53)	(−9.09)
FUNDING COST	−11.764***	−4.377***	−11.261***
	(−8.11)	(−2.45)	(−11.27)
LAG EFFICIENCY SCORE	0.019	−0.257***	−0.057***
	(0.93)	(−12.12)	(−4.21)
LR Chi-squared	2386.30***	1899.38***	4528.36***
Number of Obs.	2145	2235	4363
Bank fixed effects	Yes	Yes	Yes

This table reports Tobit regression results. The Tobit model is two-side censored because the efficiency score (i.e., the dependent variable) is bounded between 0 and 1. The sample is an unbalanced panel dataset. Panel A reports the results for the subsamples of TARP banks and non-TARP banks separately. Panel B reports the joint results for the whole sample. The variable denoted *POST TARP PERIOD* equals 1 if the quarter in question is in the post-TARP period; otherwise it takes the value of 0. The variable denoted *TARP BANK* equals 1 if the bank in question is a TARP recipient; otherwise it takes the value of 0. *TARP BANK*POST TARP PERIOD* is the interaction between *TARP BANK* and *POST TARP PERIOD*. We control for several bank level variables. *BANK SIZE* is the natural logarithm of total bank assets. We also control for the bank's Tier 1 capital ratio (*TIER 1 CAPITAL RATIO*) and its loan loss provision ratio (*LOAN LOSS PROVISION*). We use several bank management quality measures: deposits to equity ratio (*DEPOSIT TO EQUITY*) and funding cost (*FUNDING COST*). Berger et al. (2000) point out that bank profits tend to persist over time. Accordingly, we include the lag of the efficiency score (*LAG EFFICIENCY SCORE*) to control for auto-correlation. We also control for bank fixed-effects.

* Statistically significance at the 10% level.

** Statistically significance at the 5% level.

*** Statistically significance at the 1% level.

and highly significant. The coefficient of the interaction term denoted *TARP BANK*POST TARP PERIOD* is −0.091, which is significant at the 1% level (*t*-statistic = −22.14).

Overall, the results in Table 6 support our hypothesis that the operating efficiency at TARP banks declined after the capital infusion because government interventions reduce the incentives of bank managers to adopt best practices that improve asset quality. Yet, we replicate our analysis using the GMM estimation to dispel concerns about potential endogeneity problems.

Table 7 presents the Arrellano–Bover/Blundell–Bond dynamic GMM regression results. As shown in Panel A, the variable *POST TARP PERIOD* is negative and significant for the sub-sample of TARP banks (*coeff.* = −0.134; *t*-statistic = −9.35), but positive and significant for the matched portfolios of non-TARP banks (*coeff.* = 0.023; *t*-statistic = 3.75). Furthermore, when we analyze the full sample, the interaction variable between *TARP BANK* and *POST TARP PERIOD* remains negative and highly significant (*coeff.* = −0.083; *t*-statistic = −4.06). These findings are consistent with the results in Table 6 and provide further support for the hypothesis that the operating efficiency declined among TARP recipient banks.

In unreported tests, we check for multicollinearity by examining the variance inflation factor (VIF) for each variable in the model. The VIF indicate that multicollinearity is not a problem in our model. The tolerance values (defined as 1/VIF) also show that none of the variables are problematic. Furthermore,

Table 7
GMM regression results on the efficiency score.

	Panel A		Panel B
	TARP BANKS	*NON-TARP BANKS*	*WHOLE SAMPLE*
INTERCEPT	0.574***	1.583***	0.776***
	(4.99)	(8.84)	(10.61)
POST TARP PERIOD	−0.134***	0.023***	−0.013
	(−9.35)	(3.75)	(−0.90)
TARP BANK	–	–	−0.006
	–	–	(−0.21)
*TARP BANK*POST TARP PERIOD*	–	–	−0.083***
	–	–	(−4.06)
BANK SIZE	0.027***	−0.096***	0.020***
	(5.71)	(−3.50)	(3.97)
TIER 1 CAPITAL RATIO	0.005*	0.013***	−0.002
	(1.92)	(6.87)	(−1.04)
LOAN LOSS PROVISION	−11.458***	−16.178***	−14.441***
	(−18.65)	(−39.91)	(−36.37)
DEPOSIT TO EQUITY	0.112***	−0.315***	−0.011
	(1.01)	(−4.10)	(−0.15)
FUNDING COST	−11.565***	0.060	−7.527***
	(−7.13)	(0.04)	(−6.54)
LAG EFFICIENCY SCORE	−0.038*	−0.276***	−0.073***
	(−1.76)	(−15.43)	(−4.74)
Wald X^2 statistic	2135.87***	2394.52***	1752.38***
Sargan test statistics	1471.52***	2678.43***	1976.75***
Number of Obs.	2145	2235	4363

This table reports regression results based on the Arellano–Bover/Blundell–Bond dynamic GMM. The dependent variable is the efficiency score of TARP banks and non-TARP banks. The sample is an unbalanced panel dataset. Panel A reports the results for the subsamples of TARP banks and non-TARP banks separately. Panel B reports the joint results for the whole sample. The variable denoted *POST TARP PERIOD* equals 1 if the quarter in question is in the post-TARP period; otherwise it takes the value of 0. The variable denoted *TARP BANK* equals 1 if the bank in question is a TARP recipient; otherwise it takes the value of 0. *TARP BANK*POST TARP PERIOD* is the interaction between *TARP BANK* and *POST TARP PERIOD*. We control for several bank level variables. *BANK SIZE* is the natural logarithm of total bank assets. We also control for the bank's Tier 1 capital ratio (*TIER 1 CAPITAL RATIO*) and its loan loss provision ratio (*LOAN LOSS PROVISION*). We use several bank management quality measures: deposits to equity ratio (*DEPOSIT TO EQUITY*) and funding cost (*FUND COST*). Berger et al. (2000) point out that bank profits tend to persist over time. Accordingly, we include the lag of the efficiency score (*LAG EFFICIENCY SCORE*) to control for auto-correlation.

* Statistically significance at the 10% level.
**Statistically significance at the 5% level.
*** Statistically significance at the 1% level.

our findings continue to hold even when we replicate our analysis using an alternative definition for the sample period, given as *Q*(−4,+4) and when we use alternative measures of operational efficiency. For brevity, we do not discuss these results.

5.3. Additional results

5.3.1. Change in bank efficiency and TARP amount

In this section, we investigate the relation between the change in bank efficiency and the amount of the TARP capital infusion for the subsample of recipient banks. By directly relating the change in the efficiency of TARP banks to the amount of the TARP capital infusion, we can ascertain whether TARP had an unequivocally negative impact on the operating efficiency of the recipient banks. For this analysis, we first compound the quarterly efficiency scores of the TARP recipient banks in each sub-period as:

$$CBE_{-4,-1} = (1 + BE_{-6})(1 + BE_{-5})(1 + BE_{-4})(1 + BE_{-3})(1 + BE_{-2})(1 + BE_{-1}) - 1 \quad (5)$$

$$CBE_{+4,+1} = (1 + BE_{+1})(1 + BE_{+2})(1 + BE_{+3})(1 + BE_{+4})(1 + BE_{+5})(1 + BE_{+5}) - 1 \quad (6)$$

The change in bank efficiency is then computed as:

$$\Delta BE = CBE_{+1,+6} - CBE_{-6,-1} \tag{7}$$

We regress the estimated change in efficiency score of TARP recipient banks (ΔBE) on the *TARP AMOUNT* variable (defined as the natural logarithm of to the amount of the TARP capital infusion) and the change in the control variables from the model in Eq. (4). However, we estimate two model specifications because the *TARP AMOUNT* variable and the *BANK SIZE* variable may be highly correlated.

Considering that some banks elected not to participate in TARP (Bayazitova and Shivdasani, 2012), a potential concern is selection bias. For instance, there may be a self-selection bias because banks that were in major problems (and thus less efficient) were more likely to seek funding from TARP. Furthermore, to some extent, TARP recipient banks were not randomly selected in part because of the 'too big to fail' argument. Larger banks were more likely to receive funding from TARP than smaller banks because they posted greater systematic risk to the financial system.

To address the potential selection bias, we employ the Heckman (1976) two-step approach. The likelihood that a bank in the pre-TARP period may receive capital injection from TARP is first estimated using a probit regression. The inverse Mill's ratio from the probit regression is then included in our model as an explanatory variable to control for potential selection bias (denoted *INVERSE MILLS RATIO*).

In the first step of the Heckman technique, the dependent variable takes the value of 1 if the bank in question is a TARP recipient; otherwise it takes the value of 0. We estimate the probability that a bank in the pre-TARP period may receive the capital injection from TARP at the end of the quarter before the TARP distribution. The likelihood of receiving TARP funding is determined as a function of the bank's market share (the ratio of a bank market value to the total market values of all banks in the same corresponding 4-digit SIC codes), bank size, return on asset (net income to assets), and the loan to asset ratio. Panel A of Table 8 report the results from the first step of the Heckman technique.

The regression results from the second step of the Heckman technique are reported in Panel B of Table 8. We find a strong negative relationship between the amount of TARP capital infusion and the change in the efficiency of recipient banks (as shown in Model 1). The marginal effect of the *TARP AMOUNT* variable on the change in bank efficiency is −0.005, and this estimate is significant at the 5% level (t-statistic = −2.07). This implies that for every dollar of TARP injected into the banks, the efficacy of the average bank decreased by approximately 0.005 units. The confidence interval indicates that for 95% of the banks, the estimated decline in efficiency is between 0.001 and 0.01 units, which is economically significant.

The coefficient of the *INVERSE MILLS RATIO* variable is also negative and significant, signifying that the probability of receiving capital injections from TARP adversely affects bank efficiency. When the likelihood of receiving the capital injection is higher, the change in efficiency is worse. This finding highlights the fundamental flaw inherent in the 'too big to fail' argument. Several of the other control variables are also significant and have expected signs. Moreover, multi-collinearity is not a problem in the model and the model explains about 40% of the variability in the change in TARP bank efficiency.

We perform robustness check by estimating the Heckman model for the full sample. Provided that we include the non-TARP banks in this analysis, we cannot require the *TARP AMOUNT* variable. As a result, we replace *TARP AMOUNT* with the *TARP BANK* dummy variable and the change in the *BANK SIZE* variable. The regression results from the Heckman model for the whole sample are presented in Model 2. As expected, the *TARP BANK* variable is negative and highly significant. The marginal effect of *TARP BANK* on the change in efficiency is −0.634 (t-statistic = −6.35), suggesting that the change in operating efficiency is significantly worse for TARP banks at the 1% level compared to non-TARP banks after controlling for potential selection bias.

Table 8
Heckman correction analyses on the change in bank efficiency.

Panel A: Heckman Step 1		Panel B: Heckman Step 2		
	Probit		Model 1	Model 2
INTERCEPT	1.930***	*INTERCEPT*	−0.091***	0.030*
	(2.84)		(−4.98)	(1.90)
BANK MARKET SHARE PRIOR TO TARP	0.641*	*TARP AMOUNT*	−0.005**	–
	(1.71)		(−2.07)	–
BANK SIZE PRIOR TO TARP	0.000**	*TARP BANK*	–	−0.634***
	(−2.16)		–	(−6.35)
DEPOSIT TO EQUITY PRIOR TO TARP	−0.401	Δ*BANK SIZE*	–	0.000
	(−0.52)		–	(−0.02)
LOANS TO ASSET PRIOR TO TARP	−1.332**	Δ*TIER 1 CAPITAL RATIO*	−0.004*	−0.004***
	(−2.03)		(−1.68)	(−5.08)
		Δ*LOAN LOSS PROVISION*	−16.941***	−10.080***
			(−10.49)	(−11.35)
		Δ*DEPOSIT TO EQUITY*	−0.548***	−0.587***
			(−4.50)	(−6.54)
		Δ*FUNDING COST*	−23.009***	−7.951***
			(−5.39)	(−5.49)
		INVERSE MILLS RATIO	−0.393***	−0.225***
			(−3.14)	(−5.97)
Wald X^2 statistic	73.29	*F*-Statistic	7.053***	7.144***
Pseudo-R^2	0.0300	Adjusted R^2	0.4986	0.4022
Number of Obs.	528	Number of Obs.	227	528

This table reports Heckman regression results. In the first step, the dependent variable equals 1 if the bank is a TARP recipient; zero otherwise. The likelihood of receiving TARP funding is determined the prior quarter as a function of the bank's market share, bank size, return on asset, and the loan to asset ratio. The dependent variable in the second step is the change in bank efficiency score. *TARP AMOUNT* is the natural logarithm of the amount of the TARP capital infusion. *TARP BANK* equals 1 if the bank in question is a TARP recipient; otherwise it takes the value of 0. We control for the change in several bank level variables. *BANK SIZE* is the natural logarithm of total bank assets. We control for the bank's Tier 1 capital ratio (*TIER 1 CAPITAL RATIO*) and its loan loss provision ratio (*LOAN LOSS PROVISION*). We use several bank management quality measures: deposits to equity ratio (*DEPOSIT TO EQUITY*), and funding cost (*FUND COST*). We control for bank fixed-effects and time fixed-effects.

* Statistically significance at the 10% level.
** Statistically significance at the 5% level.
*** Statistically significance at the 1% level.

5.3.2. Abnormal change in bank efficiency and TARP amount

In a final robustness check, we now examine the impact of the TARP capital infusion (*TARP AMOUNT*) on the abnormal change in the efficiency of recipient banks. We define abnormal efficiency as the efficiency score of the TARP bank minus that of the value-weighted portfolio of non-TARP banks. We then compound the quarterly abnormal efficiency score of each TARP bank in both the pre-TARP period and the post-TARP period. The change in abnormal efficiency following the receipt of TARP funds is computed as the difference between the compounded abnormal efficiency score in the post-TARP period minus the compounded abnormal efficiency score in the pre-TARP period.

We expect the change in abnormal bank efficiency to be negatively related to the amount of the capital infusion (*TARP AMOUNT*) into the TARP recipient banks. We test this prediction in our model and report the results in Table 9. As theorized, we find a significantly negative relation between the change in abnormal bank efficiency and the amount of the TARP capital infusion. An increase in the amount of the TARP capital infusion of $1 (expressed in natural logarithm) decreases the change in abnormal efficiency for TARP bank by 0.0004 units on average (see Model 1). This marginal impact of the amount of the TARP capital infusion on the change in abnormal bank efficiency is higher (−0.008) in the model that account for the potential sample selection bias.

In addition, the variable *INVERSE MILLS RATIO* is significantly negative, implying that when the probability of receiving the capital injection from TARP is higher, the change in abnormal bank

Table 9
Heckman correction analyses on the abnormal change in bank efficiency.

	Model 1	Model 2
INTERCEPT	−0.066***	−0.036
	(−4.47)	(−1.48)
TARP AMOUNT	−0.0004***	−0.008**
	(−3.14)	(−2.18)
Δ*TIER 1 CAPITAL RATIO*	−0.007***	−0.005*
	(−3.04)	(−1.94)
Δ*LOAN LOSS PROVISION*	−13.446***	−15.473***
	(−12.38)	(−10.62)
Δ*DEPOSIT TO EQUITY*	−0.604***	−0.568***
	(−4.25)	(−3.80)
Δ*FUNDING COST*	−19.131***	−22.651***
	(−4.89)	(−4.57)
INVERSE MILLS RATIO		−0.241*
		(−1.79)
F-Statistic	25.37***	46.65***
Adjusted R^2	0.5005	0.4905
Number of Obs.	225	225

This table reports regression results. The dependent variable is the abnormal change in the efficiency score of TARP banks. The variable *TARP AMOUNT* is the natural logarithm of the amount of the TARP capital infusion. We control for the change in several bank level variables. *BANK SIZE* is the natural logarithm of total bank assets. We also control for the bank's Tier 1 capital ratio (*TIER 1 CAPITAL RATIO*) and its loan loss provision ratio (*LOAN LOSS PROVISION*). We use several bank management quality measures: deposits to equity ratio (*DEPOSIT TO EQUITY*), net interest income share (*INTEREST INCOME SHARE*), funding cost (*FUND COST*), and cost to income ratio (*COST TO INCOME*).

* Statistically significance at the 10% level.
** Statistically significance at the 5% level.
*** Statistically significance at the 1% level.

efficiency is worse. This is consistent with the results reported in Table 8 and provides further support against the 'too big to fail' argument. A number of the other control variables are also significant.[7]

6. Conclusion

In response to the recent 2007–2009 economic crisis, the U.S. government introduced the Troubled Asset Relief Program through the Emergency Economic Stabilization Act of 2008. The purpose of this program was to inject liquidity into the financial system in order to reactivate the credit markets and restore the quickly fading confidence in the financial system. In this paper, we examine the impact of the TARP bailout on bank efficiency. We employ a nonparametric Data Envelopment Analysis to measure bank efficiency, and test the impact of TARP on efficiency, the change in efficiency, and the abnormal change in efficiency in a sample of U.S. commercial banks.

Overall, our results indicate that the operating efficiency of banks declined as a result of the crisis. However, the mean change in operating efficiency is significantly worse for TARP banks (i.e., −0.111) compared to non-TARP banks (i.e., −0.050). We attribute this finding to bailout related moral hazards. Specifically, although TARP recapitalized troubled banks, the operating efficiency of the banks weakened because the government intervention reduces the incentives of bank managers to adopt best practices that improve asset quality.

Our results also reveal that when the likelihood of receiving the capital injection is higher, the change in bank efficiency is worse. Our study makes a notably contribution to the growing literature on TARP, as well as the literature on bank efficiency around financial crises and regulatory reforms. In addition, our results have important implications for policymakers. The results suggest that future bailout schemes should have efficiency requirements as bailouts diminish healthy market discipline.

[7] These findings continue to hold even when we replicate our analysis using an alternative definition for the sample period, given as Q(−4,+4) and when we use alternative measures of operational efficiency.

Appendix 1. Definition of measures

Variables	Definition
Interest expenses ratio	Ratio of total interest expense to total assets
Non-interest expense ratio	Ratio of total non-interest expense to total assets
Deposits to asset ratio	Ratio of total deposits to total assets
Interest revenue ratio	Ratio of total interest revenues to total assets
Non-interest revenue ratio	Ratio of total non-interest revenues to total assets
Loans to assets ratio	Ratio of net loans to total assets
Funding cost	Ratio of total interest expenses to total deposits
Tier 1 capital ratio	Risk-adjusted Tier 1 capital ratio: ratio of the bank's core equity capital to its total risk-weighted assets
Net interest margin	Ratio of net interest income to total assets
Return on assets	Ratio of net income to average assets for the period
Loan loss provision ratio	Ratio loan loss provision to total loan amount
Deposits to equity ratio	Ratio of total deposits to total equity
Bank's market share	Ratio of a bank's market value to the total market values of all banks in the same 4-digit SIC code

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