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US Bank Efficiency and FED Activity

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Abstract

We examine the relationship between cost efficiency of US banks and FED activity level. It turns out that FED actions have a positive effect on cost efficiencies of the US banks. In particular, as the number of FED actions increases, the cost efficiencies of the US banks increases. This illustrates the importance of FED's role in reaching a more cost efficient banking system.

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1. Introduction

One of the purposes of the Federal Reserve System (the Fed) is supervising and regulating the US banks and other important financial institutions to achieve a safe and sound banking and financial system. If the Fed is successful in its regulatory actions, this may help the banks to operate in a more stable and less problematic environment, which in turn enables the banks to use their inputs more effectively when producing the financial products. Not using the right level and mix of inputs or not producing the right output mix would lead to suboptimal cost levels. This affects the bank's profitability negatively and may increase the insolvency risk. Hence, the bank managers and policymakers should be concerned with the cost efficiency levels of banks.

The Fed plays a vital role in handling liquidity shortages of financial institutions. For example, Cecchetti and Disyatat (2010) have found that, in the inquietude of 2008 financial crisis, as a lender of last resort, the Fed has improved the banks' liquidity operations through intense interest implication. A healthy management of liquidity operations may help the banks to reduce their costs. Moreover, by resorting interest rate strategies, the Fed can eliminate the conflict between monetary policymakers and banks. This would help to assure that there are adequate financial activities and the banks reduce the amount of suboptimal risk taking actions. Some important duties of the Board of Governors are authorizing monetary and financial policy and approving regulations and policies. These actions may help the banks to operate in a more stable environment and also lift up or ease some of the operating difficulties of banks, which in turn can result in cost reductions. If these regulatory actions have effects that increase the competitiveness of the banking sector, then quiet life hypothesis of Hicks (1935) suggests that the efficiency of the banks are likely to increase. One of the roles of the Fed's delegated authority is making decisions on ownership structures such as considering the grant of merging and acquiring other companies, approving to purchase assets or shares, permitting or denying changing or extending the period for a change in bank control, etc. The ownership structure plays a serious role in shaping how a bank is managed and thus how effective the management is in achieving the desired optimal outcomes such as minimizing the costs. Hence, "right decisions" by the Fed's delegated authority may help the banking sector to reach outcomes that are more desirable. On the other hand, if the Fed is not successful in the actions mentioned, this may result in suboptimal outcomes for the banks.

In this study, we want to understand the effect of the Fed's involvement in the banking system on the cost efficiency of the US banks. For this purpose, we use the number of actions by the Fed as a proxy to measure the extent of the Fed's activity. A large number of actions taken by the Fed may lead to less cost efficiency if this increased work burden clouds the Fed's ability to make right decisions. On the other hand, a high involvement (i.e., larger number of actions) may improve the cost efficiency for the banking system if these actions help the banks to overcome the obstacles that are cost increasing. Hence, it is our interest to understand whether higher involvement of the Fed actually leads to higher cost efficiency levels for the US banking system. For this purpose, we examine the individual commercial US bank data that covers the years between 1997 and 2007. This is a period when the Fed decreased the amount of its actions over time. For example, in 1997 the total number of the Fed actions were 3462 whereas in 2007 it was only 1741. Therefore, over the years the Fed started to decrease its level of intervention, measured by the number of actions, to the banking sector. It turns out that the total number of actions by the Fed have a positive effect on cost efficiency. Hence, the Fed's efforts pay off and overall they improve the bank efficiency. This illustrates that besides its other objectives the Fed is also effective for achieving better cost efficiency in the banking sector.

In the next section, we provide the details of our dataset, empirical model, and estimation results. Then, we finalize our paper with concluding remarks.

2. Empirical Model and Estimation Results

2.1. Data

Our main dataset for the individual commercial bank data is constructed from the Reports of Condition and Income (or Call Reports) of the Federal Reserve System. Our data set for the cost function variables are obtained from the data set collected by Koetter, Kolari, and Spierdijk (2012) (KKS). Our annual year-end dataset covers the years between 1997 and 2007.[1] Our data set considers the period before 2008 crisis as post-crisis policies of the Fed is somewhat unconventional and aggressive, e.g., the zero interest policy of the Fed. We follow the intermediation approach when specifying inputs and outputs. The bank uses labor and capital to attract deposits, which are used to fund loans and other earning assets. Missing observations and observations with incorrect signs are dropped. All the monetary units are deflated to 2005 prices using the consumer price index obtained by Bureau of Economic Analysis. Among others, Almanidis, Karakaplan, and Kutlu (2016), Tsionas (2002), and Almanidis (2013) argue that the banking industry is characterized by heterogeneous technologies. A common frontier assumption for all banks may potentially lead to inconsistent parameter and distorted efficiency estimates. Hence, in order avoid this problem, in our benchmark scenario we only consider the banks with average asset size of more than $1 billion. In the final sample, we have 657 banks for the benchmark scenario.[2]

Our main variable of interest for examining efficiency is the number of actions by the Fed, we hand-collected this variable by counting the weekly actions of the Board of Governors, its staff, and the Federal Reserve Banks.[3] The actions that were taken by the Fed are either by the Board of Governors or by the Fed's delegated authority. The actions taken by the Board of Governors include deciding discount rates, publishing testimony and statements, authorizing monetary and financial policy, approving regulations and policies, approving applications of bank holding companies, etc. On the other hand, the delegated authority deals with the approval of establishing new branches, considering the grant of merging and acquiring other companies, approving to purchase assets or shares, permitting or denying changing or extending the period for a change in bank control etc. The delegated authority also oversees the approval of any new member of the Fed. The number of actions by the Fed include all of the aforementioned actions.

In Table 1, we provide the summary statistics and descriptions of the variables that we use in this study. The outputs are denoted by Y and the input prices are denoted by W. Gross total equity variable, E, is included in the cost frontier to reflect different risk attitudes of banks. The effect of size on bank efficiency is captured by the total assets, TA, variable. Since the number of banks may affect the number of actions by the Fed, we include the market and time specific number of banks as an additional explanatory variable for the inefficiency. This variable also serves as a proxy for competition in a market. Following Akins, Li, and Rusticus (2016), Berger and Bouwman (2013), and Berger, Imbierowicz, and Rauch (2016), we assume that states are the markets. Hence, the number of banks are year-state specific.

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[1] Koetter, Kolari, and Spierdijk (2012) use a dataset that covers years between 1976 and 2007. However, the additional variables that we use in our study only cover the years starting from 1997.

[2] At some time periods, a bank in our final data set may still have asset size smaller than $1 billion.

[3] The reports are announced in https://www.federalreserve.gov/releases/h2/. This variable is not included in the dataset of Koetter, Kolari, and Spierdijk (2012).

Table 1. Descriptive Statistics

	Variable	Mean	Standard Deviation	5th Percentile	95th Percentile
TC	Total costs	$ 0.674 B	$ 2.844 B	$ 0.039 B	$ 2.472 B
Y_1	Total securities	$ 2.100 B	$ 8.914 B	$ 0.075 B	$ 7.148 B
Y_2	Total loans	$ 7.503 B	$ 30.750 B	$ 0.392 B	$ 28.146 B
W_1	Cost of fixed assets	35.853	24.883	14.132	81.959
W_2	Cost of labor	48.976	12.162	31.759	71.672
W_3	Cost of borrowed funds	2.922	1.045	1.184	4.466
TA	Total assets	$ 11.913 B	$ 52.676 B	$ 0.715 B	$ 42.100 B
E	Gross total equity	$ 1.092 B	$ 4.570 B	$ 0.057 B	$ 3.825 B
N	Number of banks	233.284	197.228	23	736
ACT	Number of Fed actions	2650.207	578.342	1741	3488
Number of observations = 4332					

Note: B stands for billions.

2.2. Empirical Model and Stochastic Frontier Models

In order to estimate the bank efficiency, we utilize stochastic frontier analysis. This approach assumes that the error term is composed of two components. One component is the usual two-sided error term and the other component is a non-negative error term that captures inefficiency. The panel stochastic frontier model that we estimate is given as follows:[4]

$$\begin{aligned}\ln\left(\frac{TC}{W_3}\right) = \alpha + \sum_{j=1}^{2} \beta_j lnY_j + \sum_{j=1}^{2} \gamma_i ln\left(\frac{W_j}{W_3}\right) + \frac{1}{2}\sum_{j=1}^{2} \delta_j lnY_j^{\,2} \\ + \frac{1}{2}\sum_{j=1}^{2} \theta_i ln\left(\frac{W_j}{W_3}\right)^2 + \xi ln(Y_1)ln(Y_2) + \varphi ln\left(\frac{W_1}{W_3}\right) ln\left(\frac{W_2}{W_3}\right) \\ + \sum_{j=1}^{2}\sum_{k=1}^{2} \varpi_{jk} lnY_j ln\left(\frac{W_k}{W_3}\right) + \tau_1 t + \frac{1}{2}\tau_2 t^2 + \sum_{j=1}^{2} \kappa_j t lnY_k \\ + \sum_{j=1}^{2} \lambda_j t ln\left(\frac{W_j}{W_3}\right) + \psi lnE \\ + u(constant, ln(TA), ln(N), \ln(ACT)\,, t) + v,\end{aligned}$$

where t is the time trend, $u \geq 0$ is the one-sided term that captures cost inefficiency, and v is the usual two-sided error term. Since the cost function must be homogenous of degree one in input prices, we normalize the total cost and other input prices by W_3. This ensures that the homogeneity

[4] We drop time and individual-specific indices, i.e., i and t, for the sake of notational simplicity.

assumption is satisfied. We assume that:

$$u_{it} = \sqrt{exp(x'_{uit}\varphi_u)}u_i^*,$$

where $u_i^* \sim \mathbf{N}^+(0, \sigma_u^2)$ and x'_{uit} are variables that explain inefficiency. Here, u_i^* gives an individual specific dependence to the efficiency component, u_{it}. The efficiency is predicted by:

$$eff_{it} = exp(-\hat{u}_{it}),$$

where $\hat{u}_{it}$ is the prediction of u_{it}. Hence, when $u = 0$, the bank is fully efficient; and as u increases, the efficiency of the bank decreases. A positive coefficient for a variable in x'_u indicates that this variable is positively related with inefficiency.

The standard stochastic frontier models do not allow endogeneity, which maybe a problem in our case because there can be a feedback effect between the Fed's actions and cost inefficiency of the banks. Similarly, a feedback effect maybe present between the extent of competition and inefficiency. Therefore, the standard stochastic frontier models may not be suitable for our model. When there are endogenous variables, our model can be estimated by using the limited information maximum likelihood method such as Kutlu (2010) and Karakaplan and Kutlu (2017a, 2017b). In particular, when any one of the regressors or u is correlated with the two-sided error term, v, the parameter and efficiency estimates would be inconsistent. They overcome this difficulty by allowing the variables in the frontier or/and x'_u to be correlated with v. One advantage of their method is that the estimations are done in a single stage. The case with exogenous variables is a special case of this model. Kutlu and Karakaplan (2017b) and Amsler, Prokhorov, and Schmidt (2016) recommend testing the endogeneity by testing the significance of a bias correction term included in the model.[5]

Guan et al. (2009) propose a two-stage the generalized method of moments (GMM) method that solves the endogeneity problem for stochastic frontier models when the endogenous variables are in the frontier.[6] However, if there are endogenous variables in the distribution of u term, their method gives inconsistent efficiency estimates. Tran and Tsionas (2013) propose a GMM based solution by utilizing moment conditions derived from the log-likelihood function of Kutlu (2010). Karakaplan and Kutlu (2017b) propose a cross-sectional counterpart of Karakaplan and Kutlu (2017a). Kutlu and Karakaplan (2017a, 2017b) assume that u^* term is independent of v. Amsler, Prokhorov, and Schmidt (2016, 2017) relax this assumption utilizing a copula approach, which requires specifying a copula such as Gausian copula. This copula is convenient but it imposes some restrictions in the correlation structure. Also, the application of copula may be computationally demanding depending on the application. Hence, since it is a convenient and effective way to handle endogeneity in the stochastic frontier setting, we use the panel data stochastic frontier model of Kutlu (2010) and Karakaplan and Kutlu (2017a) in order to get the estimates that allow endogeneity. Therefore, we assume that the prediction equations for the endogenous variables are given by:

$$x = Z\delta + \varepsilon$$

$$\begin{bmatrix} \tilde{\varepsilon} \\ v \end{bmatrix} \equiv \begin{bmatrix} \Omega^{-1/2}\varepsilon \\ v \end{bmatrix} \sim \mathbf{N}\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} I & \sigma_v\rho \\ \sigma_v\rho' & \sigma_v^2 \end{bmatrix}\right)$$

where x is a vector of all endogenous variables (in our case $x = (ln(N), \ln(\text{ACT}))'$); $Z = I \otimes \Omega^{-1/2}z'$ where z is a vector of all exogenous variables; ε are two-sided error terms; and u^* is so

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[5] An earlier version of Kutlu and Karakaplan (2017b) is the first study proposing such a test.

[6] Guan et al. (2009) (GMM based) and Kutlu (2010) (MLE based) are the earliest papers that address the endogeneity problem in the SFA context.

that it is independent from v and ε. Here, Ω is the variance-covariance matrix of ε, σ_v^2 is the variance of v, and ρ is the vector representing correlation between $\tilde{\varepsilon}$ and v. By a Cholesky decomposition of the variance-covariance matrix of $(\tilde{\varepsilon}', v)'$ is represented as follows:

$$\begin{bmatrix} \tilde{\varepsilon} \\ v \end{bmatrix} = \begin{bmatrix} I & 0 \\ \sigma_v \rho' & \sigma_v\sqrt{1-\rho'\rho} \end{bmatrix} \begin{bmatrix} \tilde{\varepsilon} \\ \widetilde{w} \end{bmatrix},$$

where $\tilde{\varepsilon}$ and $\widetilde{w} \sim \mathbf{N}(0,1)$ are independent. So, the frontier equation can be written as:

$$y = x_{\mathrm{y}}'\beta + (x - \mathrm{Z}\delta)'\eta + \mathrm{e},$$

where $\mathrm{y} = \ln\left(\frac{TC}{W_3}\right)$; x_{y}' is a vetor of regressors included in the frontier; $e = w + u$, $w = \sigma_v\sqrt{1-\rho'\rho}\widetilde{w} = \sigma_w\widetilde{w}$, and $\eta = \sigma_w\Omega^{-1/2}\,\rho/\sqrt{1-\rho'\rho}$. Here, the term $(x - \mathrm{Z}\delta)'\eta$ serves as a bias correction term. If this bias correction term is statistically significant, then we would concluded that there is endogeneity in the model.

2.3. Estimation Results

We consider two models. Model EN assumes that $ln(N)$ and $ln(ACT)$ are endogenous and the rest of the variables are exogenous. Model EX assumes that all variables are exogenous. In our benchmark model, we use the one year lagged values of the endogenous variables as instruments. The estimation results for our benchmark models are given in Table 2.[7] In the prediction equations for endogenous variables, the t-values for the corresponding lagged instruments are large. In particular, for $ln(N)$ and $ln(ACT)$ the t-values are 452.8 and -17.4, respectively. This provides some evidence that the instruments are likely to be not weak. The endogeneity test rejects exogeneity at any conventional significance level. Hence, when interpreting the results, we use the Model EN. In any case, the coefficients for the variables that model inefficiency have the same sign for both models. Both models satisfy the regularity conditions (concavity and monotonicity) when the variables are evaluated at their medians. The median of ray scale economies for Model EX and Model EN are 1.47 and 1.43, respectively, which agrees with recent findings of Wheelock and Wilson (2012).

The positive sign for the total assets variable indicates that as the total asset of a bank increases, the inefficiency would increase. This may be because of the increased complexity that larger banks face when they grow larger. The negative coefficient for the number of banks in a state variable indicates that as the competition increases the inefficiency decrease, which agrees with the quiet life hypothesis of Hicks (1935). According to this hypothesis, those firms with high market power enjoy their quiet life and act relaxed when optimizing their decisions, which in turn leads to more inefficiency. However, as the competition increases the banks would be compelled to perform more efficiently to overcome the negative effects of competitive pressure. Moreover, our main variable of interest, the total number of actions by the Fed, has a negative effect on inefficiency. Hence, the Fed's effort pays off and improves the banking system in terms of cost efficiency. While efficiency improvement for banks is not the Fed's only purpose, it is still important to understand whether the actions of the Fed lead to a better performing banking system in terms of cost management. Therefore, the Fed is a positive and relevant factor for achieving

[7] Our estimation results are qualitatively and quantitatively similar if we include 2001 crisis dummy (equals one for 2001 and zero otherwise) and post-crisis dummy (equals one for all years after 2001 and zero otherwise) along with time trend and its square. In particular, the mean efficiencies were 64.97 and 64.72 for Model EX and Model EN, respectively. Moreover, the signs of environmental variables (i.e., explanatory variables for cost efficiency) were the same as the benchmark scenario.

better cost efficiency in the banking sector. Since the efficiency has a skewed distribution, the mean of this variable is not as informative as it would be for a variable with symmetric distribution. Hence, in Figure 1 we present the empirical distribution for our efficiency estimates. Even when

Table 2. Cost Stochastic Frontier Estimation Results: Benchmark

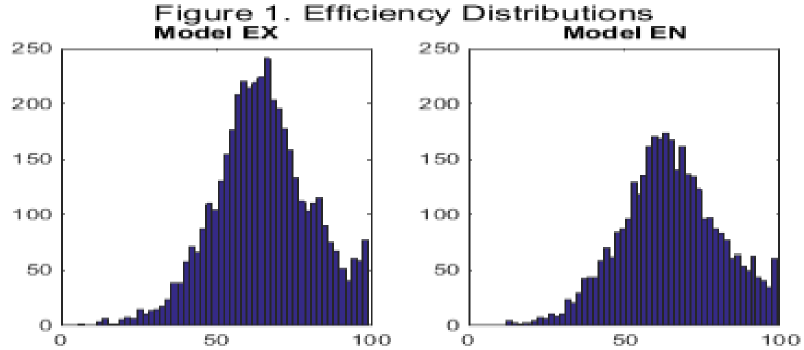
Dependent variable: $\ln(TC/W_3)$	Model EX		Model EN	
Constant	-1.3528***	(0.331)	-2.1767***	(0.422)
$\ln(W_1/W_3)$	-0.0260	(0.075)	-0.2111**	(0.083)
$\ln(W_2/W_3)$	0.2640***	(0.100)	0.4464***	(0.106)
$\ln(Y_1)$	0.1752***	(0.039)	0.1682***	(0.044)
$\ln(Y_2)$	0.2850***	(0.054)	0.4359***	(0.066)
$\ln(E)$	0.2060***	(0.010)	0.1803***	(0.011)
$0.5 \times \ln(W_1/W_3)^2$	-0.0567***	0.014)	-0.0666***	(0.016)
$\ln(W_1/W_3) \times \ln(W_2/W_3)$	0.0720***	(0.017)	0.0756 ***	(0.018)
$0.5 \times \ln(W_2/W_3)^2$	0.1016***	(0.028)	0.1282***	(0.030)
$0.5 \times \ln(Y_1)^2$	0.0427***	(0.002)	0.0558***	(0.003)
$\ln(Y_1) \times \ln(Y_2)$	-0.0406***	(0.003)	-0.0503***	(0.003)
$0.5 \times \ln(Y_2)^2$	0.0582***	(0.005)	0.0572***	(0.006)
$\ln(Y_1) \times \ln(W_1/W_3)$	-0.0174***	(0.005)	-0.0013	(0.006)
$\ln(Y_1) \times \ln(W_2/W_3)$	0.0134*	(0.007)	-0.0101	(0.008)
$\ln(Y_2) \times \ln(W_1/W_3)$	0.0209***	(0.006)	0.0197***	(0.007)
$\ln(Y_2) \times \ln(W_2/W_3)$	-0.0272***	(0.009)	-0.0234**	(0.010)
t	0.0933***	(0.014)	0.0691***	(0.017)
t^2	-0.0020***	(0.001)	0.0015	(0.001)
$\ln(W_1/W_3) \times t$	-0.0070***	(0.002)	-0.0059***	(0.002)
$\ln(W_2/W_3) \times t$	-0.0095***	(0.003)	-0.0109***	(0.004)
$\ln(Y_1) \times t$	-0.0035***	(0.001)	-0.0013	(0.001)
$\ln(Y_2) \times t$	-0.00238**	(0.001)	-0.0041***	(0.001)
Dependent variable: : $\ln(\sigma_v^2)$				
Constant	-4.3128***	(0.024)	-4.4655***	(0.027)
Dependent variable: $\ln(\sigma_u^2)$				
Constant	-2.3636**	(1.004)	1.3765	(1.685)
$\ln(TA)$	0.1835***	(0.032)	0.2560***	(0.036)
t	0.0494***	(0.010)	0.0102	(0.012)
$\ln(N)$	-0.0934***	(0.035)	-0.0653*	(0.037)
$\ln(ACT)$	-0.1697	(0.104)	-0.7948***	(0.181)
Average efficiency		65.04		64.71
Median efficiency		64.79		64.31
Log-likelihood		2043.73		9798.06
Number of observations		4332		3570

Notes: Standard errors are in parentheses. Asterisks indicate significance at the 1% (***), 5% (**), and 10% (*) levels.

the averages of efficiency estimates are close for different estimation methods; this does not necessarily imply that the estimates are similar. Indeed, for Model EX and Model EN efficiency estimates, the Kolmogorov-Smirnov test rejects the equality of the distributions at any conventional significance level (p-value = 0.0000). This is also verified by looking at the distributions. Hence, it is essential to handle endogeneity to be able to get proper estimates for efficiency.

As a robustness check, we also estimated the same models for relatively smaller banks. This dataset includes banks with average asset sizes between $100 million and $1 billion. Again, both models satisfy the regularity conditions when the variables are evaluated at their medians. The qualitative results for efficiency variables are the same and presented in Table 3. The median of ray scale economies for Model EX and Model EN are 1.40 and 1.47, respectively.

Figure 1. Efficiency Distributions



One may argue that the lagged Fed activity may be the relevant determinant of current cost efficiency. That is, the actions taken by the Fed current year may not show its effects on cost efficiency instantly. Hence, as a robustness check we use the one year lagged activity of the Fed as a determinant for efficiency, which we assume to be predetermined. Therefore, Model EN has only one endogenous variable, $ln(N)$. Both Model EX and Model EN satisfy the regularity conditions when the variables are evaluated at their medians. The estimation results for this case is presented in Table 4. The exogeneity of $ln(N)$ is rejected only at 10% significance level. Although the coefficient of $ln(N)$ is not significant, it is negative, which is in line with our findings. The lagged Fed activity is significant and has a negative sign. This verifies our conclusion that the Fed activities have a positive effect on bank cost efficiency. The median of ray scale economies for Model EX and Model EN are 1.42 and 1.41, respectively. This is also in line with our other estimates.

Finally, we examine whether different kinds of the Fed actions have different effects on cost efficiency. For this purpose, we use the number of actions that were taken by the Board of Governors (BGACT) and by the delegated authority (DAACT) separately. As mentioned earlier Board of Governors actions include deciding discount rates, publishing testimony and statements, authorizing monetary and financial policy, approving regulations and policies, approving application of bank holding companies, etc. Hence, broadly speaking, these are policy-oriented actions that are relatively more general. The delegated authority actions include the approval of establishing new branches, considering the grant of merging and acquiring other companies, approving to purchase assets or shares, permitting or denying changing or extending the period for a change in bank control etc. Hence, these are more related to the ownership structures of banks. We assume that $ln(N)$, $ln(BCACT)$, and $ln(DAACT)$ are endogenous and we use their one year lagged values as instruments. The estimates are presented in Table 5. Both Model EX and Model EN satisfy the regularity conditions when the variables are evaluated at their medians. In both Model EX and Model EN, the coefficients of all these three variables are negative. Hence, both policy oriented and ownership structure related actions have led to improved cost efficiency for the banking sector in general. The median of ray scale economies for Model EX and Model EN are 1.46 and 1.41, respectively. These results are in line with what we found in our earlier estimates. The qualitative results for efficiency estimates are the same when we rather use the lagged values of $ln(BCACT)$ and $ln(DAACT)$ as predetermined explanatory variables for efficiency. Hence, we conclude that our result regarding the effect of Fed actions on cost efficiency are reasonably robust to a variety of different specifications.

Table 3. Cost Stochastic Frontier Estimation Results: Total Asset Between 100M-1B

Dependent variable: $\ln(TC/W_3)$	Model EX		Model EN	
Constant	1.9477***	(0.180)	-2.0925***	(0.249)
$\ln(W_1/W_3)$	-0.0055	(0.024)	-0.0612**	(0.027)
$\ln(W_2/W_3)$	0.3869***	(0.034)	0.4213***	(0.038)
$\ln(Y_1)$	0.1364***	(0.015)	0.2251***	(0.018)
$\ln(Y_2)$	-0.2348***	(0.028)	0.4722***	(0.042)
$\ln(E)$	0.0951***	(0.003)	0.0735***	(0.004)
$0.5 \times \ln(W_1/W_3)^2$	-0.0505***	(0.003)	-0.0453***	(0.003)
$\ln(W_1/W_3) \times \ln(W_2/W_3)$	0.0720***	(0.004)	0.0663***	(0.004)
$0.5 \times \ln(W_2/W_3)^2$	0.0849***	(0.007)	0.0814***	(0.007)
$0.5 \times \ln(Y_1)^2$	0.0380***	(0.001)	0.0346***	(0.001)
$\ln(Y_1) \times \ln(Y_2)$	-0.0323***	(0.001)	-0.0379***	(0.002)
$0.5 \times \ln(Y_2)^2$	0.1053***	(0.003)	0.0459***	(0.004)
$\ln(Y_1) \times \ln(W_1/W_3)$	0.0114 ***	(0.001)	- 0.0094***	(0.001)
$\ln(Y_1) \times \ln(W_2/W_3)$	-0.0101***	(0.002)	-0.0095***	(0.002)
$\ln(Y_2) \times \ln(W_1/W_3)$	-0.0112***	(0.002)	-0.0039	(0.002)
$\ln(Y_2) \times \ln(W_2/W_3)$	-0.0114***	(0.003)	-0.0142**	(0.003)
t	0.1070***	(0.006)	0.0383***	(0.006)
t^2	-0.0009***	(0.000)	0.0016***	(0.000)
$\ln(W_1/W_3) \times t$	-0.0079***	(0.000)	-0.0075***	(0.000)
$\ln(W_2/W_3) \times t$	-0.0044***	(0.001)	-0.0012	(0.001)
$\ln(Y_1) \times t$	-0.0009***	(0.000)	-0.0002	(0.000)
$\ln(Y_2) \times t$	-0.0071***	(0.000)	-0.0038***	(0.000)
Dependent variable: : $\ln(\sigma_v^2)$				
Constant	-4.6163***	(0.008)	-4.8105***	(0.009)
Dependent variable: $\ln(\sigma_u^2)$				
Constant	-2.6437***	(0.340)	-0.7930	(0.590)
$\ln(TA)$	0.1775***	(0.015)	0.4678***	(0.020)
t	0.0181***	(0.003)	-0.0417***	(0.004)
$\ln(N)$	-0.1413***	(0.016)	-0.1228***	(0.060)
$\ln(ACT)$	-0.0393	(0.033)	-0.6948***	(0.018)
Average efficiency		66.93		64.87
Median efficiency		66.021		64.14
Log-likelihood		25964.01		122085.78
Number of observations		39768		34261

Notes: Standard errors are in parentheses. Asterisks indicate significance at the 1% (***), 5% (**), and 10% (*) levels.

Table 4. Cost Stochastic Frontier Estimation Results: Lagged ACT

Dependent variable: $\ln(TC/W_3)$	Model EX		Model EN	
Constant	-2.2394***	(0.416)	-2.2316***	(0.417)
$\ln(W_1/W_3)$	-0.2325***	(0.081)	-0.2294***	(0.081)
$\ln(W_2/W_3)$	0.5889***	(0.106)	0.5825***	(0.106)
$\ln(Y_1)$	0.1718***	(0.044)	0.1729***	(0.044)
$\ln(Y_2)$	0.4216***	(0.064)	0.4203***	(0.064)
$\ln(E)$	0.1775***	(0.010)	0.1767***	(0.010)
$0.5 \times \ln(W_1/W_3)^2$	-0.0581***	(0.015)	-0.0583***	(0.015)
$\ln(W_1/W_3) \times \ln(W_2/W_3)$	0.0686***	(0.018)	0.0690***	(0.018)
$0.5 \times \ln(W_2/W_3)^2$	0.1206***	(0.029)	0.1207***	(0.029)
$0.5 \times \ln(Y_1)^2$	0.0549***	(0.003)	0.0549***	(0.003)
$\ln(Y_1) \times \ln(Y_2)$	-0.0503***	(0.003)	-0.0503***	(0.003)
$0.5 \times \ln(Y_2)^2$	0.0601***	(0.006)	0.0602***	(0.006)
$\ln(Y_1) \times \ln(W_1/W_3)$	-0.0020	(0.006)	-0.0021	(0.006)
$\ln(Y_1) \times \ln(W_2/W_3)$	-0.0072	(0.008)	-0.0072	(0.008)
$\ln(Y_2) \times \ln(W_1/W_3)$	0.0221***	(0.007)	0.0219***	(0.007)
$\ln(Y_2) \times \ln(W_2/W_3)$	-0.0339***	(0.009)	-0.0335**	(0.009)
t	0.0648***	(0.015)	0.0665***	(0.015)
t^2	0.0026***	(0.001)	0.0026***	(0.001)
$\ln(W_1/W_3) \times t$	-0.0068***	(0.002)	-0.0069***	(0.002)
$\ln(W_2/W_3) \times t$	-0.0141***	(0.004)	-0.0142***	(0.004)
$\ln(Y_1) \times t$	-0.0012	(0.001)	-0.0012	(0.001)
$\ln(Y_2) \times t$	-0.0035***	(0.001)	-0.0035***	(0.001)
Dependent variable: : $\ln(\sigma_v^2)$				
Constant	-4.4868***	(0.026)	-4.4867***	(0.026)
Dependent variable: $\ln(\sigma_u^2)$				
Constant	6.6475**	(1.388)	6.7057***	(1.391)
ln(TA)	0.2341***	(0.035)	0.2358***	(0.035)
t	-0.0228**	(0.011)	-0.0234**	(0.011)
ln(N)	-0.0392	(0.037)	-0.0576	(0.038)
ln(ACT1)	-1.4079***	(0.145)	-1.4067***	(0.145)
Average efficiency		65.12		65.12
Median efficiency		64.90		64.88
Log-likelihood		1905.80		4444.90
Number of observations		3570		3570

Notes: Standard errors are in parentheses. Asterisks indicate significance at the 1% (***), 5% (**), and 10% (*) levels.

Table 5. Cost Stochastic Frontier Estimation Results: The Fed Actions by Type

Dependent variable: ln(TC/W_3)	Model EX		Model EN	
Constant	-1.3163***	(0.334)	-2.1135***	(0.421)
ln(W_1/W_3)	-0.0156	(0.075)	-0.1940**	(0.082)
ln(W_2/W_3)	0.2736***	(0.010)	0.4950***	(0.106)
ln(Y_1)	0.1884***	(0.039)	0.1859***	(0.044)
ln(Y_2)	0.2654***	(0.055)	0.4012***	(0.065)
ln(E)	0.2051***	(0.009)	0.1802***	(0.010)
0.5 × ln(W_1/W_3)^2	-0.0540***	(0.014)	-0.0586***	(0.016)
ln(W_1/W_3) × ln(W_2/W_3)	0.0697***	(0.017)	0.0684***	(0.018)
0.5 × ln(W_2/W_3)^2	0.1081***	(0.028)	0.1339***	(0.030)
0.5 × ln(Y_1)^2	0.0428***	(0.002)	0.0563***	(0.003)
ln(Y_1) × ln(Y_2)	-0.0415***	(0.003)	-0.0518***	(0.003)
0.5 × ln(Y_2)^2	0.0611***	(0.005)	0.0622***	(0.006)
ln(Y_1) × ln(W_1/W_3)	-0.0169***	(0.005)	0.0002	(0.006)
ln(Y_1) × ln(W_2/W_3)	0.0124*	(0.007)	-0.0115	(0.008)
ln(Y_2) × ln(W_1/W_3)	0.0197***	(0.006)	0.0173**	(0.007)
ln(Y_2) × ln(W_2/W_3)	-0.0283***	(0.009)	-0.0258***	(0.009)
t	0.0830***	(0.014)	0.0415**	(0.017)
t^2	-0.0006	(0.001)	0.0046***	(0.001)
ln(W_1/W_3) × t	-0.0071***	(0.002)	-0.0058***	(0.002)
ln(W_2/W_3) × t	-0.0092***	(0.003)	-0.0109***	(0.004)
ln(Y_1) × t	-0.0033***	(0.001)	-0.0010	(0.001)
ln(Y_2) × t	-0.0024**	(0.001)	-0.0039***	(0.001)
Dependent variable: : $\ln(\sigma_v^2)$				
Constant	-4.3147***	(0.024)	-4.4807***	(0.026)
Dependent variable: $\ln(\sigma_u^2)$				
Constant	-0.3920	(1.087)	4.9002***	(1.670)
ln(TA)	0.1640***	(0.033)	0.2263***	(0.036)
t	0.0269***	(0.010)	-0.0257**	(0.013)
ln(N)	-0.0997***	(0.036)	-0.0655*	(0.039)
ln(GBACT)	-0.4688***	(0.106)	-0.7380***	(0.121)
ln(DAACT)	-0.0378	(0.097)	-0.6543***	(0.153)
Average efficiency	65.40		64.73	
Median efficiency	65.07		64.16	
Log-likelihood	2053.21		16714.16	
Number of observations	4332		3570	

Notes: Standard errors are in parentheses. Asterisks indicate significance at the 1% (***), 5% (**), and 10% (*) levels.

3. Concluding Remarks

In this study, we wanted to understand the effect of Fed's involvement in the banking system on the cost efficiency of US banks for the years between 1997 and 2007. We use the annual number of actions reported by the Fed as a proxy measure for the Fed's involvement (i.e., activity). Prior to our estimations, it was not clear whether there would be a positive or negative relationship between the Fed activity and efficiency. If the Fed's actions are not constructive, then this may have negative effects on the bank cost efficiency. In addition, the labor force in the Fed may be relatively slow to adjust for changing workloads in extreme market conditions. Hence, when the work burden reaches extreme levels, it can be difficult for the Fed to make right decisions. Because of these reasons, the Fed may not always provide the most desirable environment that could help the banks to use their resources more effectively. However, if the Fed were relatively successful in the actions it takes, there would be some room for improved cost efficiency and productivity. We examined the former, i.e., cost efficiency, by using the recent developments in the stochastic frontier analysis. We found that the overall Fed actions had a positive impact on cost efficiency of US banks in our sample period. In particular, the Fed was successful in both policy-oriented and ownership structure related actions. While this does not enable us to claim that the Fed was successful in this period, these results indicate that at least in one dimension this was the case.

Note that the years between 1997 and 2007 is an interesting period as it includes the minor recession of 2001 and some regulations in the financial sector. Hence, although as a robustness check we included crisis and post-crisis dummies in our estimations, which lead to qualitatively and quantitatively similar results, it would be interesting to implement a similar analysis for other time periods to see whether our qualitative results extrapolate to other time periods. Finally, note also that, the actions of the Fed are diverse, and it is difficult to measure the corresponding individual "activity level" for each Fed-action. Hence, using the total number of actions may not necessarily reflect the "overall activity level" of the Fed. Therefore, it may be interesting to see whether our results are robust to alternative measures of Fed's activity level. We leave these problems as future research questions.

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