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The economic consequences of the TARP: The effectiveness of bank recapitalization policies in the U.S.

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ABSTRACT

This study empirically analyzes the impact of the United States' bank recapitalization program, the centerpiece of the United States' $700 billion Troubled Asset Relief Program (TARP), on bank portfolios. Through superior empirical analysis and correct model specification, our findings overturn much of the existing literature on the effectiveness of capital injections into the banking sector in Japan and the United States. We show that the TARP program did not achieve the stated policy objective of stimulating bank lending. On the contrary, we find evidence that recipient banks grew assets significantly slower, particularly heavily risk-weighted assets such as loans. These findings are robust to various empirical specifications, including two-stage least squares estimation using instrumental variables, difference-in-difference techniques and generalized method of moments. These techniques control for pre-existing trends in loan growth while addressing potential endogeneity bias.

You can't force banks to lend."

U.S. Treasury Secretary Tim Geithner[1]

1. Introduction

The Troubled Asset Relief Program (TARP), dubbed "the $700 billion bailout" in the popular press, was the largest government bailout in United States history. The bulk of the $700 billion in funds were earmarked for a series of capital injections in America's troubled financial sector. Representatives of the United States Treasury and the Federal Reserve have credited TARP with preventing a second great depression. But the effectiveness of the program remains a subject of heated debate among policymakers. The United States Treasury, which proposed the plan and oversaw its implementation, asserts that "thanks to TARP...credit is more available to consumers and small businesses" (Office of Financial Stability, 2013, page ii). However, the Congressional Oversight Panel for Economic Stabilization charged in its report on Accountability for the Troubled Asset Relief Program that "The Panel still does not know what the banks are doing with taxpayer money" (Congressional Oversight Panel, 2009). Public skepticism about the effectiveness of the program is evident in quotes such as this one from the New York Times:

"...*the dirty little secret of the banking industry is that it has no intention of using the money to make new loans.*"

The New York Times (October 25, 2008)

Academic research on this policy question is also divided. Theory suggests that shrinking assets is the preferred response for a bank manager facing a capital shortage (as an example of current research, see Hyun and Rhee (2011)). So, as Treasury Secretary Tim Geithner was trying to suggest in his comments to the Senate quoted above, although "you can't force banks to lend", boosting bank capital would be expected to stimulate lending by those banks. Policymakers in Japan implemented a similar program in the late 1990s and empirical research on that episode supports Geithner's thesis (Montgomery, 2005; Montgomery and Shimizutani, 2009; Peek and Rosengren, 1995; Watanabe, 2007; Woo, 2003). Policymakers in the U.K. are following suit with their "Funding for Lending" scheme.

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0922-1425/

[1] A comment by Treasury Secretary Timothy Geithner hearing of the Senate Committee on Small Business and Entrepreneurship. Secretary Geithner went on to add the important qualifier that "...for every bank that has capital in this program, they have more capacity to lend than they otherwise would have."

On the other hand, in a game theoretic approach to explaining how capital infusions may affect the banking sector, Diamond and Rajan (2000) point out that recapitalizations that are too small, or "only large enough to prevent bank runs from taking place may simply lead to the industrial sector being squeezed harder . . .[because] . . .the infusion helps banks just survive without selling loans, but forces them to be tough with borrowers." They conclude that "the industrial sector could be made worse off by such an infusion" (Diamond and Rajan, 2000, p. 2457). Empirical research by Iwatsubo (2007) has shown that in the case of Japan – where capital injections were perhaps inadequate to offset a credit crunch and were accompanied by more stringent regulation – government capital injections led banks to reduce certain kinds of loans. Using a novel approach to control for demand side effects, a recent study by Giannetti and Simonov (2013) finds that although Japan's capital injections increased bank lending on aggregate, they led undercapitalized banks to decrease lending.

Given the academic debate over the effectiveness of capital injections in Japan in the late 1990s, when the TARP program in the U.S. was announced commentators familiar with the experience of Japan worried that – despite the huge $700 billion headline figure – the TARP capital injections were not large enough to really be effective (Hoshi and Kashyap, 2008; Shimizutani and Montgomery, 2008). If the recapitalizations were not large enough and recipient banks themselves, or their regulators, were too draconian in their monitoring of capital adequacy ratios, incentives to shrink bank portfolios would have been strong.

Emerging research on the TARP bank recapitalization program suggests that some kind of regulatory arbitrage did indeed occur. Black and Hazelwood (2013) report that for large TARP-recipient banks, although aggregate business (C&I) loans outstanding did not increase the *risk* of loan originations did, which they find suggestive of "moral hazard due to government support".[2] Consistent with their findings, Duchin and Sosyura (2014) report that bailed-out banks initiated riskier loans and shifted assets toward riskier securities after receiving government support. However, the study most closely related to this one, Li (2013), finds that receipt of TARP substantially increased loan supply from poorly-capitalized banks, concluding that the TARP program positively stimulated credit supply during the 2008–2009 financial crisis.

In this study we overturn previous research on the effect of the TARP capital injections on bank lending, showing that those results are sensitive to the narrow time period examined and fundamentally misspecified due to a failure to control for pre-existing trends in loan growth. We base our empirical analysis in economic theory, which suggests the inclusion of lagged loan growth as an explanatory variable. Using dynamic panel data estimation techniques over a much longer time period than existing studies, we are able to control for pre-existing differences in loan growth and other characteristics across banks. Using instrumental variables and generalized method of moments estimation to address potential endogeneity, we examine the impact of receipt of TARP funds not only on total lending by recipient banks, but also on various asset risk-weight classes.

Our analysis presents no evidence that TARP stimulated bank lending. On the contrary, we find strong evidence that recipients of TARP actually *reduced* loan growth. This finding is robust to various empirical specifications. There is no evidence that poorly capitalized or small banks behave significantly differently from other banks. These findings are surprising given the predictions standard economic theory would provide on the effect of increased capital on bank behavior. However, as elaborated in the conclusions, our results may be consistent with the picture that is currently emerging from related studies.

The rest of this article is organized as follows. The next section provides some institutional detail on the Troubled Asset Relief Program that is most relevant to the analysis to follow. Section 3 lays out a model of bank behavior that can be used to analyze the effect of the TARP capital injections on the banks. Sections 4–6 then turn to an empirical evaluation of the effectiveness of the bank recapitalizations based on that model. Section 4 discusses our data, Section 5 details the different empirical methodologies employed and Section 6 discusses the empirical results. In the last section, we conclude with a discussion of our findings and how they may be interpreted and perhaps used to guide future policy interventions.

2. The Troubled Assets Relief Program (TARP)

The Troubled Assets Relief Program (TARP) was the centerpiece of the United States' Emergency Economic Stabilization Act[3] (EESA), signed into law by President Bush on October 3, 2008 in response to the economic meltdown that threatened the global economy in the autumn of 2008. As its name implies, the TARP was originally envisaged as a program to purchase troubled assets – in particular, mortgage backed assets – to stabilize the financial system. Treasury may have hoped not to have to actually use the allocated funds, the largest bailout in U.S. history. As then Secretary of the Treasury Hank Paulson famously quipped at a Senate Banking Committee hearing, "If you've got a bazooka and people know you've got it, you may not have to take it out." But immediately after passage of the TARP, attention shifted from troubled asset markets to the urgent need for bank capital. Eleven days later, on October 14, 2008, the Treasury announced that the bulk of the funds would be used toward recapitalization of the banking system.

Under the recapitalization programs – the Capital Purchase Program (CPP) – Treasury would recapitalize the U.S. banking system through purchases of up to $250 billion in senior preferred stock of U.S. controlled financial institutions. On the very day that the program was announced, Bank of America, Bank of New York Mellon, Citigroup, Goldman Sachs, JPMorgan Chase, Merrill Lynch, Morgan Stanley, State Street and Wells Fargo,[4] which had signed a merger agreement with Wachovia, were reportedly called into Treasury and told that they would receive a capital injection whether they wanted to or not. By the end of the day a total of $125 billion has been disbursed (see Appendix Table A1 for details).

Over the entire program, which spanned 2008–2009, more than 700 financial institutions received a TARP capital injection ranging between $301 thousand and $25 billion. As a ratio of risk-weighted assets, the amount ranged between 1% and 3%. However, as indicated in Fig. 1 (and noted by Duchin and Sosyura (2014)), the majority of banks received an amount of capital equal to the maximum allowed[5] 3% of their total risk-weighted assets.

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[2] Black and Hazelwood (2013) find the opposite result for small banks: the risk of loan originations decreased for small TARP recipients, and aggregate C&I lending remained fairly constant, while it fell for non-TARP recipients.

[3] The new law also allowed the Federal Reserve to begin paying interest on deposits of financial institutions and increased deposit insurance provided by the Federal Deposit Insurance Corporation (FDIC) from $100,000 to $250,000 per deposit account.

[4] Goldman Sachs and Morgan Stanley had recently transformed into bank holding companies. Merrill Lynch and Bank of America had agreed to merge, so although Merrill Lynch was present at the meeting, in the appendix the $10 billion allocated to Merrill Lynch is added to Bank of America's initial $15 billion for a total of $25 billion.

[5] The maximum allowed TARP capital injection was the larger of $25 billion *or* 3% of risk-weighted assets.

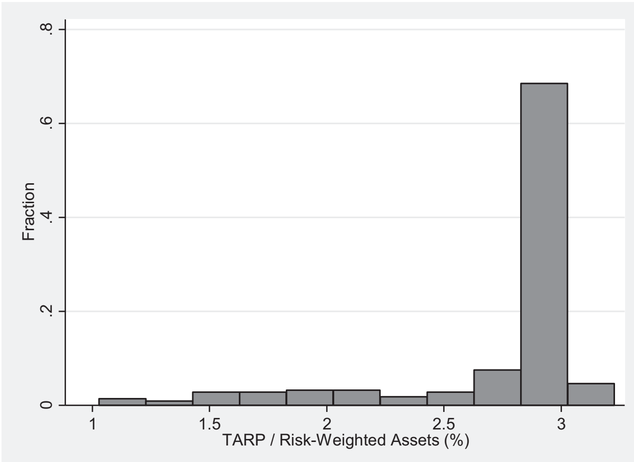

Fig. 1. Distribution of TARP funds.

This program was started under the Bush administration and continued under President Obama. One difference between the handling of the program under the two administrations was that in 2009 under President Obama's administration, the new Secretary of the Treasury Tim Geithner implemented "stress tests" (called the Supervisory Capital Assessment Program, or SCAP) of the largest 19 financial institutions (see Appendix Table A2 for details). Each of these 19 financial institutions owned total assets of over $100 billion and collectively comprised "two-thirds of the assets and more than one-half of the loans" of the banking sector as a whole (BGFRS, 2009, p. 3). Readers are referred to Bayazitova and Shivdasani (2012) for more interesting details on the implementation of the TARP, the CPP and the SCAP.

The overarching goal of the TARP was "to stabilize the financial system by providing capital to viable financial institutions of all sizes throughout the nation" (U.S. Department of the Treasury, n.d.). This was to be achieved through the following objectives of the program, as we interpret them from statements by the Department of the Treasury: (1) boosting bank capital, both directly and indirectly by increasing "confidence in our banks. . .in a way that attracts private capital as well", (2) increasing lending by encouraging banks to "deploy, not hoard, their capital" and (3) in particular, increasing mortgage roll-overs in order to "avoid foreclosures" (U.S. Department of the Treasury, 2008a).

Although banks were encouraged to meet these objectives, there were no explicit targets or incentives for doing so and no guidance on how to balance the conflicting demands on their limited capital. Policymakers have bemoaned the lack of clear targets for recipients of TARP funds.[6] Some economists, however, have praised Treasury for this approach as having for avoiding the dangers of linking explicit lending targets with bank recapitalization programs that were seen in Japan in the late 1990s (Hoshi and Kashyap, 2010). Although Japan's bank recapitalization program was found by some researchers to have been successful in achieving policy objectives such as stimulating loan growth (Allen et al., 2011; Ito and Harada, 2005; Montgomery and Shimizutani, 2009; Watanabe, 2007), bank restructuring (Onji et al., 2012) and firm investment (Kasahara et al., 2011), other researchers uncovered the fact that much of the increased lending went to unhealthy "zombie firms" (Peek and Rosengren, 2005; Watanabe, 2010).

At the time of this writing, the overarching goal of stabilizing financial markets appears to have been achieved. Bayazitova and Shivdasani (2012) report valuation gains for all banks when the TARP was first announced and Veronesi and Zingales (2010), in an analysis of the costs and benefits of the TARP, conclude that there was a net benefit from TARP thanks to the reduced probability of bankruptcy. But despite exhortations from Treasury officials to the financial industry to "meet their responsibility to lend" (U.S. Department of the Treasury, 2008b), a sharp drop in aggregate bank lending has been clearly documented (Cornett et al., 2011; Ivashina and Scharfstein, 2010). This study builds on these findings, examining the impact of the TARP on individual bank lending using micro-level panel data.

3. Model of representative bank behavior

Our empirical analysis is based on a rational expectations model of bank behavior. Consider a simplified balance sheet in which we have loans on the assets side and deposits and capital (shareholder's equity) on the liability side:

Assets	Liabilities
L	D
	K

where L is loans, D is deposits and K is capital. Under perfect competition, each bank is in principle a price taker, so the interest rate on loans, r^L, and deposits, r^D, are assumed to be exogenously given in each time period t.

In the short run, capital, K, is also assumed to be exogenous, so the revenue of an individual bank at time t is determined by the interest income on loans minus the interest expense on deposits[7]:

$$R_{i,t} = r_t^L L_{i,t} - r_t^D D_{i,t} \tag{1}$$

Substituting D with L–K the revenue of bank i can be expressed as:

$$R_{i,t} = (r_t^L - r_t^D) L_{i,t} + r_t^D K_{i,t} \tag{2}$$

Next consider costs. There is some benefit B_t, that comes from high capitalization. This benefit might include banks self-interest in maintaining a capital cushion to reduce the likelihood of bankruptcy, and it certainly also includes regulatory incentives, which are explained in detail below:

$$B_{i,t} = K_{i,t} h_\theta \left(\frac{K_{i,t}}{L_{i,t}} \right) \tag{3}$$

where $h_\theta(.)$ is a non-specified concave function, but it depends upon the regulatory state, θ, which in the empirical estimation will be a discrete state: banks that received TARP funds and therefore may be under stricter regulatory incentives, and banks that did not receive TARP and face the normal incentives to maintain an adequate capital cushion.

On the other hand, there is some adjustment cost, A_t, associated with changes in loan growth relative to a given loan demand as in Furfine (2001). This could include the costs of seeking out new customers to expand lending as well as adjustments such as cutting back on existing loans (see Diamond (1984) and Sharpe (1990)) or loss of economies of scale (Berger et al., 1993):

$$A_{i,t} = L_{i,t-1} f \left(\frac{L_{i,t} - L_{i,t-1}}{L_{i,t-1}} \right) \tag{4}$$

where $f(.)$ is a non-specified convex function.

[6] Senator Charles Schumer of New York is an example of one of the more vocal members of congress on this point.

[7] This is a short run simplifying assumption that banks set loans and then are able to obtain the necessary deposits to fund those loans at the market given interest rate on loans and deposits.

Finally, consider the value of the bank. In this stylized model, bank managers select loans at time t to maximize firm value $\pi_{i,t}$, which is equal to the expected future profit stream discounted to present value:

$$\max_{L_{i,t}} \pi_{i,t} = E_t \sum_{j=0}^{\infty} b^j \left[(r^L_{t+j} - r^D_{t+j}) L_{i,t+j} + r^D_{t+j} K_{i,t+j} + K_{i,t+j} h_\theta \left(\frac{K_{i,t+j}}{L_{i,t+j}} \right) - L_{i,t+j-1} f \left(\frac{L_{i,t+j} - L_{i,t+j-1}}{L_{i,t+j-1}} \right) \right] \quad (5)$$

where $0 < b < 1$ is the discount factor. Solving this maximization problem with respect to $L_{i,t}$ yields the Euler equation:

$$E_t \left[(r^L_{t+j} - r^D_{t+j}) + h'_\theta \left(\frac{K_{i,t+j}}{L_{i,t+j}} \right) - L_{i,t+j-1} f' \left(\frac{L_{i,t+j} - L_{i,t+j-1}}{L_{i,t+j-1}} \right) \right] = E_t \left[-bL_{i,t+j} f' \left(\frac{L_{i,t+j+1} - L_{i,t+j}}{L_{i,t+j}} \right) - bf \left(\frac{L_{i,t+j+1} - L_{i,t+j}}{L_{i,t+j}} \right) \right] \quad (6)$$

If we let

$$h'_\theta \left(\frac{K_{i,t+j}}{L_{i,t+j}} \right) = \Phi_\theta \left(\log \left(\frac{K_{i,t+j}}{L_{i,t+j}} \right) \right) \quad (7)$$

$$-L_{i,t+j-1} f' \left(\frac{L_{i,t+j} - L_{i,t+j-1}}{L_{i,t+j-1}} \right) = \psi(\Delta \log(L_{i,t+j})) \quad (8)$$

$$-bL_{i,t+j} f' \left(\frac{L_{i,t+j+1} - L_{i,t+j}}{L_{i,t+j}} \right) - bf \left(\frac{L_{i,t+j+1} - L_{i,t+j}}{L_{i,t+j}} \right) = \gamma(\Delta \log(L_{i,t+j+1})) \quad (9)$$

We can express the Euler equation in a log-linearized form:

$$E_t[\Delta \log(L_{i,t+j+1})] = E_t \left[\beta_1 \Delta \log(L_{i,t+j}) + \beta_2 (r^L_{t+j} - r^D_{t+j}) + \beta_{3,\theta} \log \left(\frac{K_{i,t+j}}{L_{i,t+j}} \right) \right] \quad (10)$$

Our main empirical results use a panel of data on 9042 commercial bank balance sheets and income statements for the years 2001–2010 to estimate a reduced form equation based on Eq. (10). The following sections explain our data and methodology in more detail.

4. Data

To construct our panel of data, we compiled annual balance sheets and income statements from the Report of Condition and Income (Call Report) data. We also use information such as the location and legal structure of each bank maintained and made public by the Federal Reserve along with the Call Report data. The amount of capital injected into individual institutions is based upon the TARP "Transactions Report", which are made publicly available by the U.S. Treasury Department Office of Financial Stability.[8] These sources provide a sample of 9042 commercial banks over the 10 year period of 2001–2010, or 64,711 total observations for analysis. Following the example of other researchers, we exclude from our sample banks that were subject to the SCAP stress tests because its institutional design was different from CPP (Duchin and Sosyura, 2014, p. 6) and in its attempt to assure the public of the safety of the financial system it essentially identified the 19 biggest banking organizations in the United States as "too-big-to-fail (TBTF)" (Berger and Roman, 2013, p. 27).[9]

Table 1 reports the summary statistics of those 64,711 observations used in our analysis. The choice of dependent and independent variables reported in Table 1 was guided by the model of bank behavior above and the choice of instrumental variables is explained in the following section.

Looking at Table 1, readers may note that the mean regulatory capital ratio for U.S. commercial banks over the period 2001–2010 was well above the required minimum at 15.03%.

Average loan growth proxied by log change over the period was about 7.57%. To avoid incorrect inferences about loan growth that are in fact biased by changes in loan write-offs and recoveries, loans outstanding in each period are corrected, following Woo (2003), by adding loan write-offs and subtracting loan recoveries.

Since direct information on interest rates is not available,[10] the interest rate spread between loans made by the bank and deposits taken in by the bank is approximated by the difference in the ratio of interest income to total loans and interest expenses to total deposits.[11] On average that spread is about 5% over the sample period. In addition to the interest rate spread, we control for the regulatory capital ratio, the log of which is 2.71% on average.

TARP is used as a dummy variable to indicate whether a bank received a TARP capital injection in a given year. A strict interpretation of our model suggests use of a TARP capital injection as a ratio of risk-weighted assets. However, as illustrated in Fig. 1, distribution of TARP, above, there is not much variability in the amount received as a ratio of risk-weighted assets.[12] So we follow the example of previous researchers and use it as a dummy variable (Berger and Roman, 2013; Black and Hazelwood, 2013; Duchin and Sosyura, 2014; Li, 2013).

In addition to our basic question of the effect of the capital injections on the TARP objectives of stimulating loan growth, we look at the impact of the program on the banks' asset risk weight categories to examine the decisions of banks in managing their balance sheet upon receiving capital injection, as they are the basis for calculating regulatory capital ratios. Asset risk weight categories are not reported by commercial banks in their Call Report, so for that we need to turn to analysis of the bank holding companies with assets of more than $500 million, which are required to submit detailed financial data every quarter in a format similar to the commercial bank call report to their regulator, the Federal Reserve.[13] This cuts our sample to 943 bank holding companies over the 6 years between 2005 and 2010, reducing the total number of observations to 3991. However, since most of the capital injections went to bank holding companies rather than directly to commercial banks, this still covers the majority of the funds distributed in 2008 (99%) and

[8] Data available at http://www.treasury.gov/initiatives/financial-stability/reports/Pages/TARP-Investment-Program-Transaction-Reports.aspx. Latest release: October 29, 2010.

[9] Results including the SCAP banks are qualitatively similar and included in the appendix as a robustness check.

[10] Actual interest rates on automobile loans and loans for consumer goods and personal expenditures are available in some Call Reports, but they are reported on a voluntary basis, so coverage is incomplete.

[11] More precisely, it is the difference in the ratio of interest and fee income on loans to net loans and leases and the ratio of interest expenses on deposits to total deposits.

[12] This evidence is also documented by Duchin and Sosyura (2014): "the vast majority (77%) of CPP investments were made at the maximum amount stipulated by the program (3% of RWA)" (pp. 6–7).

[13] From the first quarter of 2006 the threshold above which bank holding companies need to report detailed financial data rose from assets size of $150 million to $500 million. Thus, although the data for the earlier periods is available, one needs to use the data only from 2006 to have a consistent panel. However, we can use data from 2005 and still have consistent panel, since our equation includes lagged variables.

Table 1
Summary statistics for commercial banks, 2001–2010.

	Observations	Mean	Standard error
Dependent variables			
Total loans, Δlog, %	64,711	7.57	0.054
Explanatory variables			
Interest rate spread, %	64,711	4.93	0.004
Regulatory capital ratio, log	64,711	2.71	0.001
TARP			
TARP recipient dummy	64,711	0.01	0.000
Instrumental variables			
Exposure to subprime loans, % (see notes below)	64,711	0.74	0.006
Political connectedness (see notes below)	64,587	0.02	0.001

Note: 64,711 bank-year observations with 9042 banks, of which 712 banks received TARP (7.9% of the sample).
Exposure to subprime loans is average of real estate loans to total loans from 2000 to 2005 (in log). It is set to 0 for years other than 2008 and 2009 and when it falls below 20% threshold (before taking log) so that they better correspond to the TARP term.
Political connectedness takes a value between 0 and 1 in 2008 and 2009 to indicate potential political connections on two powerful House subcommittees (see text).

Table 2
Summary statistics for bank holding companies, 2005–2010.

	Observations	Mean	Standard error
Dependent variables			
Total assets, Δlog, %	3991	6.89	0.170
Assets with 0% risk weight, Δlog, %	3983	8.50	0.613
Assets with 20% risk weight, Δlog, %	3985	3.84	0.411
Assets with 50% risk weight, Δlog, %	3973	5.31	0.325
Assets with 100% risk weight, Δlog, %	3989	7.97	0.207
Explanatory variables			
Asset-liability spread, %	3991	0.86	0.016
Regulatory capital ratio, log	3991	2.59	0.004
TARP			
TARP recipient dummy	3991	0.04	0.003

Note: 3991 bank-year observations with 943 bank holding companies, of which 168 bank holding companies received TARP (17.8% of the sample).

2009 (80%). Also, these large bank holding companies made up 99% of total commercial bank assets at the end of 2007.

Table 2 reports the summary statistics for the bank holding companies. In the interest of brevity, only variables used in the asset risk weight analysis are included: total asset growth and growth in each of the asset risk-weight categories used in calculating regulatory capital ratios, 0%, 20%, 50% and 100%. The return on assets minus expenses on liabilities is also added to be used in place of interest rate spread, as it better represents the spread for risk weight assets.

5. Empirical methodology

5.1. Cross sectional analysis

We start with cross-sectional analysis of the effect of capital injections on loan growth that replicates the results of existing research (Li, 2013) and highlights the importance of controlling for pre-existing loan growth trends using panel data techniques.

5.1.1. Ordinary least squares

We first use simple OLS (ordinary least squares) analysis of the following equation, which is based on our rational expectations model presented above, but adapted to make it as close as possible to the model used in Li (2013):

$$\frac{L_i^{2009Q2} - L_i^{2009Q3}}{A_i^{2008Q3}} = \beta_0 + \beta_1 \mathrm{TARP}_i + \beta_2 (r_i^L - r_i^D)^{2008Q3} + \beta_3 \log\left(\frac{K_i}{L_i}\right)^{2008Q3} + \varepsilon_i \quad (11)$$

In Eq. (11) above, L_i^{2009Q2} and L_i^{2008Q3} represent total loans outstanding and A_i^{2008Q3} total assets outstanding, of bank i in 2009Q2 or 2008Q3, respectively. $(r_i^L - r_i^D)^{2008Q3}$ represents the loan–deposit interest rate spread faced by bank i in 2008Q3. $\log(K_i/L_i)^{2008Q3}$ is the log of the regulatory capital ratio of bank i at 2008Q3. ε_i is the error term.

The main variable of interest is TARP_i, a dummy variable equal to 1 if bank i received TARP capital between 2008Q4 and 2009Q4. This captures the effect of capital injections on loan growth (change of loans over 2008Q3 to 2009Q2 scaled by total assets at 2008Q3). To replicate Li's (2013) results as closely as possible, we limit our sample to poorly-capitalized banks for this cross-sectional analysis, although, as discussed below, we find that those banks do not behave significantly differently from other banks. In addition, we use White's heteroskedasticity-robust standard errors for all cross sectional analyses, as Li (2013) uses standard errors clustered at congressional district level.

5.1.2. Endogenous treatment effects

A concern with simple OLS analysis is that TARP may not be injected randomly: there may be factors that affect both loan growth and TARP applications and injection. As discussed in the instrumental variable regression section below, the error term and TARP may be correlated, or TARP may be endogenous. To address this potential endogeneity, we use an endogenous treatment effect model first proposed by Heckman (1978) and discussed in Wooldridge (2010, Section 21.4.1).

In our case, the latent variable of interest is TARP allocation. Let us represent that as TARP_i^*, a latent unobserved dummy variable that takes the value of 1 if Treasury injects capital and a value of 0 otherwise:

$$\mathrm{TARP}_i = \begin{cases} 1 & \text{if } \mathrm{TARP}_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (12)$$

Using proxies for banks' financial distress and political connectedness, both of which have been shown to affect Treasury's

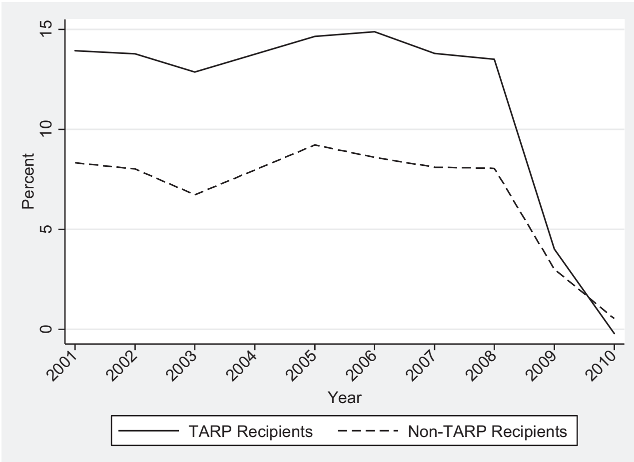

Fig. 2. Loan growth for TARP vs. non-TARP banks, 2001–2010.

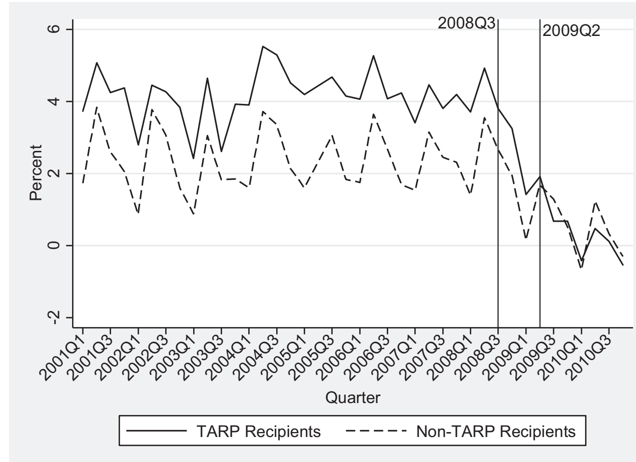

Fig. 3. Quarterly loan growth, 2001Q1–2010Q4.

TARP allocation decision, we model the Treasury's decision to inject capital as follows:

$$\mathrm{TARP}_i^* = \gamma_0 + \gamma_1 (r_i^L - r_i^D)^{2008Q3} + \gamma_2 \left(\frac{K_i}{L_i}\right)^{2008Q3} + \gamma_4\, SubprimeExposure_i + \gamma_4 PoliticalConnectedness_i + u_i \quad (13)$$

where, again, $(r_i^L - r_i^D)^{2008Q3}$ represents the loan–deposit interest rate spread faced by bank i in 2008Q3, $\log(K_i/L_i)^{2008Q3}$ the log of the regulatory capital ratio of bank i at 2008Q3 and u_i the error term. $SubprimeExposure_i$, a measure of bank i's subprime loan exposure, and $PoliticalConnectedness_i$, a measure of bank i's political connectedness, are assumed to (i) affect Treasury's decision as to whether or not to inject capital into bank i and (ii) be uncorrelated with the error term, u_i. These variable choices are discussed in detail below (in Section 5.2.1 on instrumental variables).

Estimating Eq. (13) jointly with Eq. (11) gives us an unbiased estimator for the coefficient on TARP. Specifically, we assume that $\varepsilon_i \sim N(0, \sigma^2)$, where ε_i is the error term of Eq. (11), and $u_i \sim N(0, 1)$, where u_i is the error term of Eq. (13) and $Corr(\varepsilon_i, u_i) = \rho$, and employ joint maximum likelihood approach developed by Maddala (1983, pp. 117–122).

5.1.3. *Controlling for pre-existing trends*

Although the endogenous treatment effect model discussed above can address endogeneity issues, there are still concerns with this cross-sectional analysis. Perhaps the most serious concern in this case is that cross-sectional analysis does not take into account pre-existing differences in loan growth between the two groups of banks. Fig. 2 illustrates quite vividly that TARP-recipient banks have *always* had higher loan growth than non-TARP recipient banks. Failure to control for those pre-existing trends has led to incorrect inferences about the effects of TARP on lending.

Another short-coming of cross-sectional analysis is that any results may be sensitive to the time period chosen for analysis. For example, Li (2013) examined the growth of loans from 2008Q3 to 2009Q2. However, Fig. 3 reveals that loan growth exhibits strong seasonality, peaking in Q2 every year for the past decade. Failure to adjust for this seasonality may have contributed to overestimates of loan growth following TARP.

Finally, cross-sectional analysis of the *contemporaneous* effects of TARP cannot fully capture the effects of TARP. Fig. 4 plots seasonally adjusted loan growth for all banks in the 6 quarters surrounding the TARP capital injections, separately for TARP recipients and non-recipients. As illustrated in the figure, the full effect of TARP is not

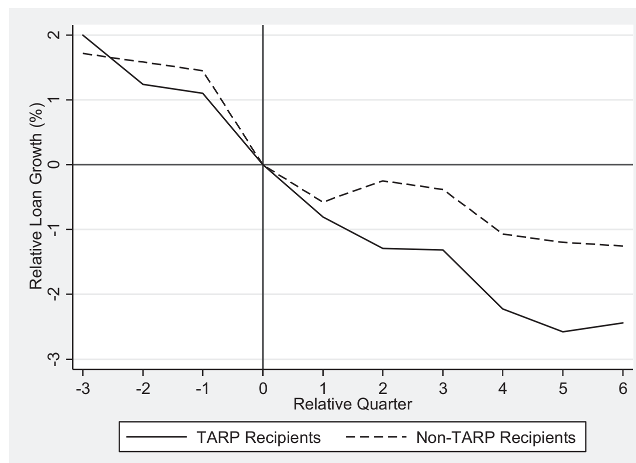

Fig. 4. Loan growth around receipt of TARP (seasonally adjusted).

evident until 4 quarters *after* receipt of capital. Existing studies based on cross-sectional analysis of the contemporaneous effect of TARP on lending, would not have captured the full effects of the program.

To investigate the significance of the first issue, the exclusion of pre-existing trends, using cross-sectional analysis, we supplement Eq. (11) with a control for pre-existing loan growth trends:

$$\frac{L_i^{2009Q2} - L_i^{2008Q3}}{A_i^{2008Q3}} = \beta_0 + \beta_1 \frac{L_i^{2009Q1} - L_i^{2008Q2}}{A_i^{2008Q2}} + \beta_2 \mathrm{TARP}_i + \beta_3 (r_i^L - r_i^D)^{2008Q3} + \beta_4 \log\left(\frac{K_i}{L_i}\right)^{2008Q3} + \varepsilon_i \quad (14)$$

Comparing estimates of Eqs. (11) and (14) allows us to examine the importance of controlling for pre-existing trends and therefore gives an indication of the relevance of using panel data methods.

5.2. *Panel data analysis*

Based on our findings, which are presented below, we then move on to developing a more correct specification based on dynamic panel analysis. Dynamic panel analysis allows us to take into account pre-exiting trends in loan growth and control for unobserved heterogeneity across banks using individual fixed effects.

Our baseline specification is a reduced form equation based on the model presented above. Replacing conditional expectations in Eq. (10) with actual values we have:

$$\Delta \log(L_{i,t+1}) = \beta_1 \Delta \log(L_{i,t}) + \beta_2(r^L_{i,t} - r^D_{i,t}) + \beta_3 \log\left(\frac{K_{i,t}}{L_{i,t}}\right) + \beta_4 \text{TARP}_{i,t} + \varepsilon_{i,t+1} \quad (15)$$

In Eq. (15), $\Delta\log(L_{i,t+1})$, the dependent variable, represents the growth rate, proxied by the log-change, in lending by bank i at time $t+1$. As implied by the model, lagged loan growth is also included as an explanatory variable on the right hand side. $(r^L_{i,t} - r^D_{i,t})$ is again the loan to deposit interest rate spread (the difference in the interest rate on loans and the interest rate on deposits) for bank i at time t. This spread was same for each bank in our theoretical model, but we allow it to vary among banks in our empirical analysis as banks slightly differentiate their product. $\log(K_{i,t}/L_{i,t})$ is the regulatory capital ratio for bank i at time t. The main variable of interest is $\text{TARP}_{i,t}$, a dummy variable indicating whether TARP capital injection is received by bank i at time t. The error term $\varepsilon_{i,t+1}$ is a rational expectations error term, which is orthogonal to information available at time $t, I_t : E[\varepsilon_{i,t+1}|I_t] = 0$. So our baseline specification is simple ordinary least squares (OLS), which yields robust parameter estimates.

We then proceed to refine our empirical analysis by estimating Eq. (15) with ordinary least squares including individual random and fixed effects, and a model that includes both individual fixed effects and a vector of time dummies, T_t. We then adopt clustered standard errors, which are robust to within-bank autocorrelation. Our preferred specification, the results of which are discussed below, includes individual fixed effects as suggested by a Hausman test to account for unobservable bank characteristics that may affect loan growth, time dummies to account for macroeconomic events that might affect loan growth at all banks within a given year, and standard errors that are robust to potential within-bank autocorrelation.

5.2.1. Instrumental variables

In our reduced-form specification, Eq. (15), the error term $\varepsilon_{i,t+1}$ is a rational expectations error term, which is orthogonal to information available at time t, I_t, $E[\varepsilon_{i,t+1}|I_t] = 0$, so ordinary least squares estimation is appropriate.[14] In addition, we use individual fixed effects to control for unobserved heterogeneity and clustered standard errors to address empirical concerns about possible autocorrelation in the error term within each bank i.

However, as with the cross-sectional analysis above, an additional empirical concern is that the TARP capital injection may be endogenous. That is, there is potential correlation between the TARP capital injections and the error term in Eq. (15). To address this concern, we turn to instrumental variables.

To investigate the validity of concerns about possible endogeneity, we perform an endogeneity test – a version of Hausman test that can be performed with clustered standard errors comparing OLS to 2SLS-IV estimates – on the TARP capital injection in our data. Under the assumption that our instruments are valid, which we will show below, 2SLS-IV estimates are consistent regardless of whether the capital injection variable is exogenous or not. However, OLS estimates are consistent only when the capital injection variable is exogenous. So if the capital injection variable is exogenous, the two estimates are asymptotically equivalent (or at least the two estimates become closer as sample size gets larger). But they are not equivalent if the capital injection variable is not exogenous. Thus, a comparison of the two estimates tells us whether the capital injection variable is really exogenous.

An endogeneity test on the capital injections cannot rule out endogeneity of the capital injections in commercial bank loan growth regressions at the 95% confidence interval, suggesting that instrumental variable estimation is preferred for our lending data.

The ideal instrumental variables meet two conditions, (i) they are correlated with the endogenous variables of interest: in this case, the capital injection, and (ii) they are uncorrelated with the error term ε_{t+1}. Existing research gives us guidance on the choice of appropriate instruments. Bayazitova and Shivdasani (2012), for example, find evidence that TARP funds were more likely to go to banks that posed systemic risk or faced high financial distress costs. Duchin and Sosyura (2012) find that politically connected firms were more likely to be funded under the TARP program. Thus, we construct instrumental variables that reflect the financial distress and political connectedness of each bank. We use these variables as instruments for the TARP capital injection[15] and estimate Eq. (15) using two-stage least squares technique.

As a measure of the first criteria, financial distress, we construct a measure of each banks' exposure to subprime loans by calculating the ratio of mortgage loans to total loans for each bank in our sample. There is some precedence for this in the case of Japan, where a similar bank recapitalization program was carried out in 1997 and 1998. Ueda (2000) and Hoshi (2001) perhaps first noted that for Japanese banks real estate sector lending in the 1980s best explained non-performing loan ratios in the late 1990s. Watanabe (2007) applied this in later work, using the share of real estate lending in the late 1980s as an instrumental variable for bank capital. Although the originate and distribute model used in the U.S. means that the ratio of mortgage loans to total loans on bank books may not accurately represent the bank's origination of mortgage loans, it does still accurately reflect the bank's exposure to the subprime market. To ensure exogeneity with the error term, we take the average ratio of mortgage loans to total loans for each bank from the start of our sample in 2000 (which also corresponds to one year after the passage of the Gramm–Leach–Bliley Act, which abolished the Glass–Steagall Act to allow bank holding companies to operate both commercial banks and investment banks), to 2005, three years before the first public capital injections.

As a measure of political connectedness we construct an instrumental variable proposed by Duchin and Sosyura (2012) that indicates whether a bank is likely to have political connections to either of two key subcommittees of the House Financial Services Committee that played a key role in the TARP program: the Subcommittee on Financial Institutions or the Subcommittee on Capital Markets. We compare the location of the headquarter of each bank's parent holding company in our sample with the district represented by members of these two powerful subcommittees in 2008 and 2009 and create a political connectedness variable that takes the value between 0 and 1 in each year, depending on whether or not that location is represented on both, one or neither of the two powerful subcommittees.[16]

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[14] In our rational expectations model, banks choose loan growth at time t given I_t, which includes TARP and lagged dependent variable, so they are exogenous state variables.

[15] So that they better correspond to the capital injection terms, the instrument reflecting financial distress is set to 0 if it falls under 20%.

[16] For both years of the TARP capital injections, 2008 and 2009, these political connectedness dummy variables take a value of 0, 0.5 or 1. For example, if a bank is headquartered in an area represented by a member of the House Financial Services Committee who is serving on one of these key subcommittees in 2008, the dummy variable is assigned a value of 0.5 in 2008 for that bank. If a bank is headquartered in an area represented by a member of the House Financial Services Committee who is serving on two of these key subcommittees in 2008, the dummy variable would take a value of 1 in 2008 for that bank.

We then check the statistical properties of our chosen instruments. First stage regression suggests that the first condition is met. As reported in Appendix Table A3, first stage coefficient estimates on the instruments were generally highly statistically significant, with p-values less than 0.01. Corroborating this, F-statistic for the joint significance of the instruments are high; well over ten (see Table 4, which is discussed below).

In addition, coefficient estimates on the instruments in the reduced form regression results, reported in Appendix Table A3 are also highly statistically significant, suggesting that the second condition – that instruments affect loan growth only through the first stage and are correctly excluded from the causal model of interest – is satisfied. Generally high p-value for Hansen's test statistic (again, see Table 4, which is discussed below) supports observations from the reduced form. There is no significant evidence that the instruments are correlated with the error term: the null hypothesis that the instruments are uncorrelated with the error term cannot be rejected at the 5% level in any specifications.

5.2.2. Generalized method of moments

The panel data analysis we employ is an improvement over existing cross-sectional studies because it can take into account pre-existing trends in loan growth and unobserved heterogeneity across banks in the form of individual fixed effects. The inclusion of lagged loan growth on the right-hand side also improves on existing analysis both theoretically, by recognizing the importance of adjustment costs for banks, and empirically since, as we can see in the regression results, the parameter estimates on lagged loan growth are generally positive and highly statistically significant. However, we recognize concerns that the lagged dependent variable in the right hand side of Eq. (15) introduces possible dynamic panel bias – endogeneity in the lagged dependent variable – especially given our large cross-section and comparatively short time-series.

To address this concern, the commonly used statistical tools are Arellano and Bond's (1991) generalized method of moments (difference GMM) and Arellano and Bover (1995) and Blundell and Bond's (1998) augmented GMM (system GMM). Difference GMM addresses the potential dynamic panel bias by instrumenting for the lagged dependent variable with further lags in level form, while system GMM instruments for the lagged dependent variable with its further lags, but in difference form. We estimate both system and difference GMM and find little difference between estimates of Eq. (15) using the two approaches. In our results reported below we focus on the difference GMM estimation, as that approach requires fewer assumptions. We use two-step GMM since it is asymptotically more efficient than one-step GMM. Since standard errors for two-step difference GMM can be downward biased with a finite sample (Arellano and Bond, 1991; Blundell and Bond, 1998), we make a finite sample correction to the variance estimate as proposed by Windmeijer (2005).

For the moment conditions used in GMM estimation to be valid, there should *not* be any serial correlation in the first-differenced errors in orders at and higher than the lag of the dependent variables used as instruments. Table 4, discussed below, reports p-values for the following specification tests: the Arellano–Bond test for autocorrelation and Hansen test for joint validity of the instruments. The specification tests indicate that GMM instruments are valid. The p-value for the Arellano–Bond test demonstrate that the null hypothesis of no autocorrelation in the first-differenced errors at order six[17] cannot be rejected at the 5% confidence level. The high p-value for Hansen test indicates that the null hypothesis that the instruments are uncorrelated with the error term cannot be rejected at the 5% level. Thus, there is strong evidence that the sixth moment conditions are valid.

5.2.3. Generalized method of moments with instrumental variables

Our use of instrumental variables addresses potential endogeneity of TARP injection, and GMM addresses potential dynamic panel bias or endogeneity of lagged dependent variable. However, the instrumental variables parameter estimate on TARP may still be biased due to potential endogeneity of lagged dependent variable and the GMM parameter estimate on TARP may still be biased due to potential endogeneity of TARP. Thus, in our final specification, we address both potential sources of endogeneity by using GMM with internal (lagged explanatory variables) as well as external instruments (variables that come from outside of the model). We use subprime loan exposure and political connectedness as our external instruments as in instrumental variables estimation within difference GMM. We follow Roodman (2009) for practical implementation.

5.2.4. Difference-in-difference

Given that a number of existing studies employ difference-in-difference methods of analysis (Berger and Roman, 2013; Duchin and Sosyura, 2014) as opposed to our treatment of TARP as a "one-shot" variable, we confirm the robustness of our results using the difference-in-difference technique as follows:

$$\begin{aligned}\Delta\log(L_{i,t+1}) = {} & \beta_1 TARPRecipent_i + \beta_2 PostTARP_t \\ & + \beta_3 TARPRecipent_i \cdot PostTARP_t + \beta_4 \Delta\log(L_{i,t}) \\ & + \beta_5 (r^L_{i,t} - r^D_{i,t}) + \beta_6 \log\left(\frac{K_{i,t}}{L_{i,t}}\right) + \varepsilon_{i,t+1} \qquad (16)\end{aligned}$$

As in Eq. (15) above, the dependent variable, $\Delta\log(L_{i,t+1})$ is the growth, proxied by the log-change, in lending for bank i at time $t+1$. $(r^L_{i,t} - r^D_{i,t})$ is again the loan to deposit interest rate spread (the difference in the interest rate on loans and the interest rate on deposits) for bank i at time t. $\log(K_{i,t}/L_{i,t})$ is the regulatory capital ratio for bank i at time t. Additionally, $TARPRecipent_i$ is a dummy variable indicating whether bank i is a TARP capital recipient. This variable captures the trend in loan growth of TARP recipients, which, as shown in Fig. 2, may be statistically significantly different from other banks. $PostTARP_t$ is a dummy variable indicating the post-TARP period, 2008 and after. This variable captures any shift in loan growth trends after the implementation of TARP for both TARP recipients and non-recipients. Again, the data plotted in Fig. 2 suggests this may be negative. The interaction of these two dummy variables, $TARPRecipient_i \cdot PostTARP_t$, is the main variable of interest in this specification: the difference-in-difference term. The coefficient estimate on the difference-in-difference term, β_3, captures any shift of loan growth trend specific to TARP recipients induced by the implementation of TARP.

5.3. Details by asset risk-weight

The methodology used in our preferred specification rigorously addresses our main research question, but we then proceed to expand upon those findings with additional data on asset risk weight categories. Analysis of bank asset risk weight categories enables us to examine the decisions of banks in managing their balance sheet upon receiving a capital injection, as they are the basis for calculating the banks' regulatory capital ratios. With the exception of a few large banks that have already switched over to Basel II, the original Basel Accord (now called "Basel I") had been

[17] As implied by Hansen test, we use dependent variable of sixth lag and earlier as instruments.

used with some modifications in the U.S. throughout our sample period between 2001 and 2010 (Eubanks, 2006; Jickling and Murphy, 2010). The aim of Basel I was to categorize asset items according to their riskiness and require banks to have 8% or more capital against their risk weighted assets (RWA):

$$\text{Regulatory Capital Ratio} = \frac{\text{Tier I Capital} + \text{Tier II Capital}}{0\%\text{RWA} \times 0 + 20\%\text{RWA} \times 0.2 + 50\%\text{RWA} \times 0.5 + 100\%\text{RWA} \times 1} \geq 8\%$$

Risk weighted assets fall into four categories: 0% risk weight (0%RWA), 20% risk weight (20%RWA), 50% risk weight (50%RWA) and 100% risk weight (100%RWA). 0% risk weight assets include items such as cash and due from central banks, as well as OECD government bonds, 20% risk weight assets include items such as claims on depository institutions, 50% risk weight assets include items such as residential first mortgages and 100% risk weight assets include items such as business and consumer loans. Tier I capital consists of common equity, most retained earnings and certain perpetual noncumulative preferred stocks. Tier II capital consists of subordinated debt, non-perpetual preferred stocks and loan loss reserves up to 1.25% of the risk weight assets.

To explore how banks that received capital injections may have adjusted their portfolios in response to regulatory incentives, we keep the same basic specification in Eq. (15), but replace the dependent variable $\Delta\log(L_{i,t+1})$ with growth in total assets and the four risk-weight asset classes, all again proxied by the log-change of those variables. Risk-weighted asset classes do not follow as closely to our model of bank behavior: we might not expect adjustment costs to be high for all asset classes, for example. Nonetheless, for consistency, the control variables here are the same as in the previous specification for loan growth, with the exception of the interest rate spread, which is replaced with the return on assets minus expenses on liabilities to more accurately represent the "spread" on various assets.

Again, we check for possible endogeneity of TARP and lagged growth in the various asset classes, but an endogeneity test does not reject the null that the capital injection was exogenous to asset growth at the 5% level. As discussed above, the endogeneity test relies on the assumption that instruments are valid, meaning that they are uncorrelated with the error term. We confirmed this assumption holds: a Hansen test in the instrumental variable regressions cannot reject the null that that instruments are uncorrelated with the error term. Although endogeneity of TARP is not a concern, we continue to employ difference GMM to address potential dynamic panel bias.

6. Results

6.1. Cross sectional analysis

The results of cross sectional analysis are presented in Table 3.

First, in column 1 we report the results of a simple OLS estimation. The effect of the TARP capital injection on loan growth is estimated to be positive and highly statistically significant. That result is robust to MLE estimation of the endogenous treatment effect model, as reported in column 2. It is still estimated to be positive, highly statistically significant at the 1% level, and rather large at an estimated 3.08.

The estimated effect of TARP on loan growth changes dramatically, however, when we control for pre-existing trends in loan growth in column 3. Before discussing that result, however, note that the coefficient estimate on the pre-exiting trend in loan growth is positive and highly statistically significant at the 1% level. The coefficient estimate on the interest rate spread remains statistically insignificantly different from zero, as in columns 1 and 2. The regulatory capital ratio remains highly statistically significant and positive, suggesting that, as in the other empirical specifications, banks with higher regulatory capital in the third quarter of 2008 tended to grow loans faster over the period 2008Q3 to 2009Q2. But the coefficient estimate on the TARP capital injection dummy changes dramatically to a negative, highly statistically significant, and economically meaningful −9.49.

These results from cross sectional analysis illustrate the importance of controlling for pre-existing trends in loan growth and motivate the next step in our empirical analysis: dynamic panel data analysis.

6.2. Panel data analysis

In the dynamic panel analysis reported in Table 4, we again begin with simple OLS estimates in column 1. However, using panel data, we are able to include time fixed effects to control for time-specific factors that affect all banks' loan growth such as business cycles or loan demand conditions and individual bank fixed effects to control for time constant factors specific to each bank that may affect loan growth such as difference in business lines or manager's stance towards risk. In addition, based on the theoretical model and empirical evidence presented above, lagged loan growth is included

Table 3
The Effect of TARP on commercial bank lending – cross sectional analysis.

	(1)	(2)	(3)
Sample	Poorly Capitalized Banks (tier 1 ratio below sample median)		
Specification	OLS	MLE (endogenous treatment-effects model)	
Dependent variable	$\frac{Loans_{2009Q2} - Loans_{2008Q3}}{Assets_{2008Q3}}$		
TARP	3.78***	3.08***	−9.49**
	[0.880]	[1.014]	[4.773]
Loan deposit interest rate spread	0.61	1.52*	−0.78
	[0.899]	[0.914]	[1.414]
Regulatory capital ratio, log	8.28***	7.11***	3.51**
	[2.485]	[2.550]	[1.674]
Pre-existing trend			0.90***
			[0.057]
Constant	−19.47***	−17.63***	−6.90
	[5.927]	[6.041]	[4.967]
Observations	3388	3272	3272

Note: Heteroskedasticity-robust standard errors in brackets below each coefficient estimate.
*, **, ***, indicate statistical significance at the 10%, 5% and 1% level respectively.
Explanatory variables are defined at 2008Q3.

Table 4
The effect of TARP on commercial bank lending – panel analysis.

	(1)	(2)	(3)	(4)
Dependent variable	Total loans, $\Delta \log t+1$			
Specification	OLS	2SLS-IV	Difference GMM	Difference GMM with IV
TARP, *t*	−6.44***	−10.77***	−5.44***	−5.14***
	[0.513]	[1.515]	[1.355]	[1.049]
Loan deposit interest rate spread, *t*	1.31***	0.59***	18.41***	8.52***
	[0.151]	[0.216]	[4.415]	[2.968]
Regulatory capital ratio, log *t*	16.67***	21.78***	56.61***	42.51***
	[0.618]	[1.102]	[9.031]	[5.627]
Dependent variable, $\Delta \log t$	0.23***	0.19***	1.49***	0.52*
	[0.008]	[0.013]	[0.441]	[0.290]
Instrumented TARP	No	Yes	No	Yes
Year dummies	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	(Differenced out)	(Differenced out)
Observations	53,567	52,918	44,361	44,264
Number of banks	8083	7541	7498	7497
Number of years	9	9	8	8
R-squared	0.40			
TARP endogeneity test (*p*-value)		0.00		
F statistic for instruments		38.48		
Hansen test (*p*-value)		0.79	0.21	0.14
Arellano–Bond test (6th order autocorrelation) (*p*-value)			0.36	0.88

Note: Heteroskedasticity- and autocorrelation-robust standard errors in brackets below each coefficient estimate. OLS and 2SLS-IV standard errors are clustered at individual bank level. GMM is estimated via two-step with Windmeijer-correction to address the finite-sample bias.
*, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table 5
The effect of TARP on commercial bank lending – difference-in-difference.

	(1)	(2)	(3)	(4)
Specification	OLS			2SLS-IV
Dependent variable	Total loans, $\Delta \log t+1$			
TARP recipient, *t*	3.51***	3.49***		
	[0.208]	[0.208]		
Post TARP, *t*	−5.41***			
	[0.121]			
TARP recipient × post TARP, *t*	−4.19***	−4.19***	−5.64***	−5.29***
	[0.401]	[0.401]	[0.460]	[0.740]
Loan deposit interest rate spread, *t*	0.23***	0.21***	1.28***	0.66***
	[0.058]	[0.058]	[0.151]	[0.194]
Regulatory capital ratio, log *t*	0.72***	0.72***	16.61***	18.90***
	[0.177]	[0.177]	[0.617]	[0.801]
Dependent variable, $\Delta \log t$	0.37***	0.37***	0.23***	0.20***
	[0.006]	[0.006]	[0.008]	[0.011]
Instrumented TARP	No	No	No	Yes
Year dummies	No	Yes	Yes	Yes
Bank fixed effects	No	No	Yes	Yes
Observations	53,567	53,567	53,567	52,918
Number of banks	8083	8083	8083	7541
Number of years	9	9	9	9
R-squared	0.22	0.22	0.41	
TARP endogeneity test (*p*-value)				0.00
F statistic for instruments				38.52
Hansen test (*p*-value)				0.34

Note: Standard errors clustered at individual bank level in brackets below each coefficient estimate. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.
TARP recipient term is absorbed in individual fixed effects. Post TARP term is subsumed in time fixed effects.

as a right hand side variable. As with the cross sectional results, lagged loan growth and the lagged regulatory capital ratio are positive and highly statistically significant. The loan-deposit interest rate spread is also positive and highly statistically significant. The main variable of interest, the coefficient estimate on the TARP capital injections, is again negative and highly statistically significant at -6.44.[18]

This main result is robust to two-stage least squares estimation using instrumental variables (column 2), difference GMM (column 3) and difference GMM with instrumental variables for TARP (column 4).

The difference-in-difference specification reported in Table 5 confirms our main results. Simple OLS (column 1), OLS with time fixed effects (column 2), OLS with time and individual bank fixed effects (column 3) and two-stage least squares using instrumental

[18] An alternate specification defining TARP as a “step” variable which takes a value of 1 as long as TARP fund remains on banks' book, rather than a “one-shot” variable, confirmed the robustness of these main results. These results were reported to an anonymous reviewer and are available from the authors.

Table 6
The effect of TARP on bank holding company assets – panel analysis.

	(1)	(2)	(3)	(4)	(5)
Specification	Difference GMM				
Dependent variable	Total, $\Delta \log t+1$	0% Risk weight, $\Delta \log t+1$	20% Risk weight, $\Delta \log t+1$	50% Risk weight, $\Delta \log t+1$	100% Risk weight, $\Delta \log t+1$
TARP, *t*	−7.63***	0.70	−6.09	−2.97	−8.87***
	[2.247]	[4.814]	[5.006]	[2.024]	[2.014]
Asset-liability spread, *t*	0.18	1.30	−0.04	1.15	0.69
	[0.587]	[1.916]	[1.297]	[1.119]	[0.861]
Regulatory capital ratio, log *t*	30.68***	−11.30	−12.33*	5.59	49.03***
	[11.466]	[12.236]	[6.764]	[10.023]	[13.349]
Dependent variable, $\Delta \log t$	0.30	−0.47	−0.40	−0.43	0.41
	[0.329]	[0.479]	[0.344]	[0.365]	[0.308]
Instrumented TARP	No	No	No	No	No
Year dummies	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	(Differenced out)	(Differenced out)	(Differenced out)	(Differenced out)	(Differenced out)
Observations	1706	1702	1703	1698	1705
Number of banks	690	688	689	686	690
Number of years	4	4	4	4	4
TARP endogeneity test (*p*-value)	0.34	0.26	0.55	0.25	0.09
Hansen test (*p*-value)	0.10	0.53	0.94	0.24	0.08
Arellano–Bond test (3rd order autocorrelation) (*p*-value)	0.96	0.69	0.50	0.30	0.41

Note: Heteroskedasticity- and autocorrelation-robust standard errors in brackets below each coefficient estimate. GMM is estimated via two-step with Windmeijer-correction to address the finite-sample bias.
*, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

variables (column 4) all suggest that TARP recipients drop loan growth after TARP.

6.3. *Details by asset risk-weight*

In Table 6 we report the results of difference GMM estimation of the same basic specification, but using growth in various risk weight asset classes as the left hand side variable. The results suggest that banks were responding to regulatory pressure. In column 1 we see that banks that received TARP capital tended to shrink total assets, as indicated by the negative, highly statistically significant parameter estimate on the TARP dummy. Also note that, as might be expected, growth of total assets is very sensitive to the regulatory capital ratio.

Interestingly, columns 2–5 illustrate that the reduction in asset growth was not implemented across the board. Only the heaviest risk-weighted assets have a statistically significant parameter estimate on the TARP injection dummy, and it is large and negative at −8.87. Also note that it is only the heaviest risk-weighted assets that are sensitive to the regulatory capital ratio.

7. Conclusions

What were the economic consequences of the TARP? Using an empirical specification based on a rational expectations model of representative bank behavior, we estimate the impact of capital injections carried out under the TARP on bank portfolios. Our findings demonstrate that, contrary to the stated objectives of the program, TARP did not stimulate bank lending. In fact, we find evidence of the opposite result: recipient banks shrunk their assets, in particular heavily risk-weighted assets such as loans. Banks receiving TARP funds show statistically and economically significantly lower loan growth than other banks. These findings, which overturn the results of the existing literature on the effectiveness of capital injections on bank lending, are robust to a variety of empirical specifications, including two-step difference GMM and instrumental variables.

These findings do not, in and of themselves, mean that TARP was a failure. First, this study looks at just one of TARP's objectives: to boost lending and prevent a potential credit crunch. Pundits have pointed out that in comparison to banking crises in other countries, the U.S. authorities reacted with remarkable speed (Shimizutani and Montgomery, 2008; Takenaka, 2008). This enabled U.S. banks to get bad loans off their books and achieved what was arguably the most critical objective, preventing bank runs. Secondly, as we noted at the outset, although policymakers often declare loan growth as a policy objective for bank recapitalization programs, whether loan growth actually *should* be a policy objective is open for debate. Certainly, it makes sense to try to limit the economic damage from a capital crunch, where even good borrowers cannot access loan financing. But research on Japan, the only other developed country with a large presence in the global banking industry to have experienced a banking crisis in the post-Bretton Woods era, has shown that capital injections carried out there may have stimulated lending to unhealthy "zombie" firms, (Peek and Rosengren, 2005; Watanabe, 2010), in which case the documented increase in bank lending in response to the capital injections in Japan (Montgomery and Shimizutani, 2009; Watanabe, 2007) may not be cause to celebrate. Thinking about how those findings may relate to the case of the U.S., if the cut in bank lending by recipient banks after the TARP capital injection indicates restructuring of bank balance sheets towards higher-quality borrowers, then perhaps the "failure" of the banks to realize policy makers stated objectives are not as disappointing as they appear at first pass.

Thus, this study contributes on piece to the puzzle. We can see that U.S. banks are not falling into the trap seen in Japan where banks that received capital injections continued to evergreen loans to low-growth industries and kept "zombie firms" alive. But we still cannot rule out regulatory arbitrage. We can see that riskiest asset class, and in particular lending, is shrinking, but not what kind of borrowers are being cut off. Unfortunately, the evidence emerging at this time from current research by Black and Hazelwood (2013) and Duchin and Sosyura (2014) suggests that bank portfolios are shifting toward riskier borrowers. Combined with the evidence presented here, the picture that is emerging is of a banking industry that shrunk in order to shore up capital ratios and respond to stricter regulation, but maintained profit margins by extending the loans they did make to riskier borrowers.

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Appendix A. Supplementary Tables

See Tables A1–A3, A4a and A4b.

Table A1
List of involuntary TARP participants.

Institution name	TARP amount
Bank of America	$25 billion
Bank of New York Mellon	$3 billion
Citigroup	$25 billion
Goldman Sachs	$10 billion
JP Morgan Chase	$25 billion
Morgan Stanley	$10 billion
State Street	$2 billion
Wells Fargo	$25 billion

Note: These are initial 8 banks that received TARP funds on October 28, 2008.

Table A2
List of "stress test (SCAP)" participants.

Institution name	TARP amount
Bank of America	$25 billion
Bank of New York Mellon	$3 billion
Citigroup	$25 billion
Goldman Sachs	$10 billion
JP Morgan Chase	$25 billion
Morgan Stanley	$10 billion
State Street	$2 billion
Wells Fargo	$25 billion
BB&T	$3.13364 billion
Fifth Third	$3.408 billion
KeyCorp	$2.5 billion
PNC Financial	$7.5792 billion
Regions Financial	$3.5 billion
SunTrust Banks	$4.85 billion
U.S. Bancorp	$6.599 billion
American Express	$3.38889 billion
Capital One Financial	$3.555199 billion
Ally Financial (GMAC)	$16.29 billion
Metlife	$0

Note: These are 19 banks participated in SCAP (Supervisory Capital Assessment Program) from February to April 2009.
Ally Financial received capital not under the CPP but under the Automotive Industry Financing Program (AIFP), so not included in our initial sample of TARP recipients.
Metlife did not receive TARP fund.

Table A3
The effect of TARP on commercial bank lending – first stage and reduced form estimates for 2SLS-IV.

	(1)	(2)
Specification	OLS (first stage for 2SLS-IV)	OLS (reduced form for 2SLS-IV)
Dependent variable	TARP, $t+1$	Total loans, $\Delta \log t+1$
Subprime exposure, log t	0.19***	−2.09***
	[0.023]	[0.220]
Political connectedness, t	0.24***	−2.39***
	[0.083]	[0.464]
Loan deposit interest rate spread, t	−0.07***	1.31***
	[0.011]	[0.150]
Regulatory capital ratio, log t	0.49***	16.54***
	[0.051]	[0.618]
Loan growth, $\Delta \log t$	−0.00***	0.23***
	[0.001]	[0.008]
Year dummies	Yes	Yes
Bank fixed effects	Yes	Yes
Observations	53,459	53,459
Number of banks	8082	8082
Number of years	9	9

Note: Standard errors clustered at individual bank level in brackets below each coefficient estimate.

Table A4a
The effect of TARP on commercial bank lending – panel analysis (poorly capitalized banks only).

	(1)	(2)	(3)	(4)
Specification	OLS	2SLS-IV	Difference GMM	Difference GMM with IV
Dependent variable	Total toans, $\Delta \log t+1$			
TARP, t	−5.32***	−8.53***	−5.03***	−1.79**
	[0.517]	[1.512]	[0.785]	[0.875]
Loan deposit interest rate spread, t	1.46***	0.77***	6.45**	7.07***
	[0.216]	[0.289]	[3.268]	[2.509]
Regulatory capital ratio, log t	16.40***	24.91***	31.76***	34.81***
	[0.912]	[2.015]	[5.832]	[4.421]
Dependent variable, $\Delta \log t$	0.24***	0.23***	0.27	0.32
	[0.010]	[0.013]	[0.303]	[0.231]
Instrumented TARP	No	Yes	No	Yes
Year dummies	Yes	Yes	Yes	Yes

Table A4a (*Continued*)

	(1)	(2)	(3)	(4)
Specification	OLS	2SLS-IV	Difference GMM	Difference GMM with IV
Dependent variable	Total toans, $\Delta \log t+1$			
Bank fixed effects	Yes	Yes	(Differenced out)	(Differenced out)
Observations	26,905	26,782	22,674	22,602
Number of banks	3613	3568	3544	3543
Number of years	9	9	8	8
R-squared	0.42			
TARP endogeneity test (*p*-value)		0.00		
F statistic for instruments		20.06		
Hansen test (*p*-value)		0.83	0.05	0.07
Arellano–Bond test (6th order autocorrelation) (*p*-value)			0.68	0.75

Note: Heteroskedasticity- and autocorrelation-robust standard errors in brackets below each coefficient estimate. OLS and 2SLS-IV standard errors are clustered at individual bank level. GMM is estimated via two-step with Windmeijer-correction to address the finite-sample bias.
*, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table A4b
The effect of TARP on commercial bank lending – panel analysis (small banks only).

	(1)	(2)	(3)	(4)
Specification	OLS	2SLS-IV	Difference GMM	Difference GMM with IV
Dependent variable	Total Loans, $\Delta \log t+1$			
TARP, *t*	−5.66***	−12.49***	−4.69***	−4.18***
	[0.578]	[2.001]	[1.288]	[1.071]
Loan deposit interest rate spread, *t*	1.45***	0.59**	16.17***	6.93**
	[0.159]	[0.255]	[5.206]	[2.775]
Regulatory capital ratio, log *t*	16.80***	21.87***	51.77***	38.92***
	[0.644]	[1.217]	[9.855]	[5.045]
Dependent variable, $\Delta \log t$	0.26***	0.21***	1.23**	0.35
	[0.008]	[0.015]	[0.505]	[0.263]
Instrumented TARP	No	Yes	No	Yes
Year dummies	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	(Differenced out)	(Differenced out)
Observations	47,246	46,968	39,845	39,790
Number of banks	6424	6207	6182	6182
Number of years	9	9	8	8
R-squared	0.38			
TARP endogeneity test (*p*-value)		0.00		
F statistic for instruments		28.63		
Hansen test (*p*-value)		0.83	0.10	0.03
Arellano–Bond test (6th order autocorrelation) (*p*-value)			0.39	0.24

Note: Heteroskedasticity- and autocorrelation-robust standard errors in brackets below each coefficient estimate. OLS and 2SLS-IV standard errors are clustered at individual bank level. GMM is estimated via two-step with Windmeijer-correction to address the finite-sample bias.
*, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Appendix B. Results with SCAP Banks

See Tables B1–B6.

Table B1
Summary statistics for commercial banks, 2001–2010.

	Observations	Mean	Standard error
Dependent variables			
Total loans, Δlog, %	64,962	7.57	0.054
Explanatory variables			
Interest rate spread, %	64,962	4.93	0.004
Regulatory capital ratio, log	64,962	2.71	0.001
TARP			
TARP recipient dummy	64,962	0.01	0.000
Instrumental variables			
Exposure to subprime loans, % (see notes below)	64,962	0.74	0.006
Political connectedness (see notes below)	64,836	0.02	0.001

Note: 64,962 bank-year observations with 9078 banks.
Exposure to subprime loans is average of real estate loans to total loans from 2000 to 2005 (in log). It is set to 0 for years other than 2008 and 2009 and when it falls below 20% threshold (before taking log) so that they better correspond to the TARP term.
Political connectedness takes a value between 0 and 1 in 2008 and 2009 to indicate potential political connections on two powerful House subcommittees (see text).

Table B2
Summary statistics for bank holding companies, 2005–2010.

	Observations	Mean	Standard error
Dependent variables			
Total assets, Δlog, %	4024	6.89	0.169
Assets with 0% risk weight, Δlog, %	4016	8.61	0.610
Assets with 20% risk weight, Δlog, %	4018	3.85	0.409
Assets with 50% risk weight, Δlog, %	4006	5.31	0.324
Assets with 100% risk weight, Δlog, %	4022	7.97	0.206
Explanatory variables			
Asset-liability spread, %	4024	0.86	0.016
Regulatory capital ratio, log	4024	2.59	0.004
TARP			
TARP recipient dummy	4024	0.04	0.003

Note: 4,024 bank-year observations with 950 bank holding companies.

Table B3
The effect of TARP on commercial bank lending – cross sectional analysis.

	(1)	(2)	(3)
Sample	Poorly Capitalized Banks (tier 1 ratio below sample median)(Explanatory variables defined at 2008Q3)		
Specification	OLS	MLE (endogenous treatment-effects model)	
Dependent variable	$\frac{Loans_{2009Q2} - Loans_{2008Q3}}{Assets_{2008Q3}}$		
TARP	3.54***	3.07***	−9.75**
	[0.849]	[0.949]	[4.612]
Loan deposit interest rate spread	0.78	1.72*	−0.84
	[0.882]	[0.898]	[1.386]
Regulatory capital ratio, log	8.00***	6.92***	3.66**
	[2.450]	[2.518]	[1.621]
Pre-existing trend			0.90***
			[0.056]
Constant	−18.96***	−17.42***	−7.08
	[5.843]	[5.969]	[4.708]
Observations	3419	3301	3301

Note: Heteroskedasticity-robust standard errors in brackets below each coefficient estimate. *, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table B4
The effect of TARP on commercial bank lending – panel analysis.

	(1)	(2)	(3)	(4)
Dependent variable	Total toans, Δlog $t+1$			
Specification	OLS	2SLS-IV	Difference GMM	Difference GMM with IV
TARP, *t*	−6.47***	−11.66***	−5.52***	−4.96***
	[0.518]	[2.039]	[1.304]	[1.043]
Loan deposit interest rate spread, *t*	1.29***	0.44*	16.51***	7.06**
	[0.152]	[0.253]	[4.026]	[2.790]
Regulatory capital ratio, log *t*	16.62***	22.42***	53.20***	39.77***
	[0.618]	[1.363]	[8.289]	[5.278]
Dependent variable, Δlog *t*	0.23***	0.18***	1.31***	0.38
	[0.008]	[0.015]	[0.403]	[0.274]
Instrumented TARP	No	Yes	No	Yes
Year dummies	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	(Differenced out)	(Differenced out)
Observations	53,748	53,096	44,496	44,399
Number of banks	8118	7573	7528	7527
Number of years	9	9	8	8
R-squared	0.40			
TARP endogeneity test (*p*-value)		0.00		
F statistic for instruments		19.78		
Hansen test (*p*-value)		0.33	0.10	0.08
Arellano–Bond test (6th order autocorrelation) (*p*-value)			0.60	0.71

Note: Heteroskedasticity- and autocorrelation-robust standard errors in brackets below each coefficient estimate. OLS and 2SLS-IV standard errors are clustered at individual bank level. GMM is estimated via two-step with Windmeijer-correction to address the finite-sample bias.
*, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

Table B5
The effect of TARP on commercial bank lending – difference-in-difference.

	(1)	(2)	(3)	(4)
Specification	OLS			2SLS-IV
Dependent variable	Total loans, $\Delta\log t+1$			
TARP recipient, *t*	3.46***	3.45***		
	[0.205]	[0.204]		
Post TARP, *t*	−5.41***			
	[0.121]			
TARP recipient × post TARP, *t*	−4.12***	−4.12***	−5.64***	−5.39***
	[0.401]	[0.401]	[0.459]	[0.832]
Loan deposit interest rate spread, *t*	0.22***	0.20***	1.26***	0.59***
	[0.058]	[0.058]	[0.152]	[0.204]
Regulatory capital ratio, log *t*	0.71***	0.71***	16.57***	19.13***
	[0.177]	[0.177]	[0.617]	[0.846]
Dependent variable, $\Delta\log t$	0.37***	0.37***	0.23***	0.19***
	[0.006]	[0.006]	[0.008]	[0.011]
Instrumented TARP	No	No	No	Yes
Year dummies	No	Yes	Yes	Yes
Bank fixed effects	No	No	Yes	Yes
Observations	53,748	53,748	53,748	53,096
Number of banks	8118	8118	8118	7573
Number of years	9	9	9	9
R-squared	0.22	0.22	0.40	
TARP endogeneity test (*p*-value)				0.00
F statistic for instruments				28.02
Hansen test (*p*-value)				0.13

Note: Standard errors clustered at individual bank level in brackets below each coefficient estimate. *, **, ***, indicate statistical significance at the 10, 5 and 1 percent level respectively.
TARP recipient term is absorbed in individual fixed effects. Post TARP term is subsumed in time fixed effects.

Table B6
The effect of TARP on bank holding company assets – panel analysis.

	(1)	(2)	(3)	(4)	(5)
Specification	Difference GMM				
Dependent variable	Total, $\Delta\log t+1$	0% Risk weight, $\Delta\log t+1$	20% Risk weight, $\Delta\log t+1$	50% Risk weight, $\Delta\log t+1$	100% Risk weight, $\Delta\log t+1$
TARP, *t*	−8.22***	2.44	−6.35	−2.37	−10.06***
	[2.394]	[5.134]	[5.604]	[1.956]	[2.239]
Asset-liability spread, *t*	0.19	1.62	-0.14	0.85	0.76
	[0.572]	[1.874]	[1.222]	[1.101]	[0.789]
Regulatory capital ratio, log *t*	31.18***	-14.31	-13.11*	6.79	51.12***
	[11.841]	[12.407]	[6.723]	[9.994]	[14.017]
Dependent variable, $\Delta\log t$	0.32	-0.52	-0.38	-0.39	0.45
	[0.340]	[0.521]	[0.322]	[0.368]	[0.309]
Instrumented TARP	No	No	No	No	No
Year dummies	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	(Differenced out)	(Differenced out)	(Differenced out)	(Differenced out)	(Differenced out)
Observations	1724	1720	1721	1716	1723
Number of banks	696	694	695	692	696
Number of years	4	4	4	4	4
TARP endogeneity test (*p*-value)	0.48	0.45	0.47	0.17	0.06
Hansen test (*p*-value)	0.09	0.50	0.93	0.28	0.17
Arellano–Bond test (3rd order autocorrelation) (*p*-value)	0.70	0.55	0.56	0.29	0.53

Note: Heteroskedasticity- and autocorrelation-robust standard errors in brackets below each coefficient estimate. GMM is estimated via two-step with Windmeijer-correction to address the finite-sample bias.
*, **, *** indicate statistical significance at the 10%, 5% and 1% level respectively.

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