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The light and dark side of TARP

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The light and dark side of TARP

Abstract: This paper empirically investigates the impact of the first announcement of TARP, the announcement of revised TARP, respective capital infusions under TARP-CPP and capital repayments on changes in shareholder value and the risk exposure of supported U.S. banks. Our analysis reveals a light and a dark side of TARP. While announcements as well as capital repayments may provoke positive wealth effects and a decrease in bank risk, equity capital injections to banks are observed to be a severe impediment to restore market confidence and financial stability. Furthermore, while TARP announcements and capital injections may increase systemic risk, no significant effect on systemic risk is found for capital repayments.

JEL classification: G14, G21, G28

Keywords: Financial crisis, TARP, Market efficiency, Event study

1. Introduction

The 2007-2009 global financial crisis triggered a unique liquidity shock affecting a number of banks worldwide. As a response, comprehensive governmental capital assistance programs have been introduced in many countries. As regards the U.S., under the “*Troubled Asset Relief Program*” (TARP) the Department of the Treasury provided USD 204.9 billion in capital to 707 institutions in 48 states helping banks to absorb losses from toxic and illiquid assets (U.S. Treasury, 2010). Similarly, in Europe 20 bank debt guarantees and 15 bank recapitalization schemes as well as 44 cases of individual bank aid were dealt with by the European Commission under the state aid rules during the crisis period. At the height of the crisis, the total of aid effectively committed amounted to 13 percent of the GDP of the EU (CEPS, 2010).

In most cases capital assistance programs were politically justified by the objective of liquidity creation to restore confidence in the banking industry, with the ultimate goal of overcoming the “loan freeze problem” by stimulating the banks’ lending activities and promoting financial stability for the economy as a whole. Nevertheless, partial nationalization of large banking groups revived the debate concerning the benefits and costs of providing a lender of last resort and government ownership of banks.

In this context, in particular capital injections into banks are questioned for the following aspects. It is argued that the effectiveness of bailout assistance may be challenged by an insufficient monitoring of supported banks in combination with inadequate reporting requirements as regards the supported banks’ reinvestment strategies after having received capital injections. Accordingly, although capital assistance is given to increase bank stability and to reduce incentives to take excessive risks, it was also given with the understanding that the injected capital would be used to expand lending during a period of financial crisis. Taking this into account capital assistance may plant the seed of future distress by

exacerbating moral hazard problems triggering excessive bank risk-taking through “zombie lending”. As a consequence, revitalizing bank lending activities and promoting financial stability may not work when market confidence is still weak (Beck et al., 2010).

Against this background and since no empirical consensus exists yet on whether capital assistance programs are reliable instruments, the analysis at hand empirically investigates if the U.S. “*Troubled Asset Relief Program*” may have contributed to restore market confidence and to promote financial stability. In particular, employing data on supported U.S. banks we analyze the impact of the first announcement of TARP, the announcement of revised TARP, respective capital infusions and capital repayments on changes in bank shareholder value and bank risk as perceived by the capital market through share price reactions.

Empirical results reveal a light and a dark side of TARP. While the first and revised announcement of TARP as well as capital repayments may provoke an increase in bank shareholder value and a decrease in systematic risk, equity capital injections are observed to be a severe impediment to restore market confidence and to promote financial stability. Furthermore, while TARP announcements and capital injections may increase systemic risk, no significant effect on systemic risk is found for capital repayments. Baseline regressions results hold even when performing a large variety of robustness checks while subsample regressions reveal further important insights into the impact of the four TARP events on bank shareholder value and risk.

Our analysis complements and extends previous event studies on TARP (Kim and Stock, 2012; Elyasiani et al., 2011; Veronesi and Zingales, 2010; King, 2009) for several aspects. *First*, to the best of our knowledge this is the first comprehensive study that empirically investigates the impact of the entire set of four TARP events on wealth effects and systematic risk. *Second*, additionally analyzing the decomposition of the beta factor (idiosyncratic risk and systemic risk) allows a deeper insight into the drivers of the change in bank systematic

risk due to the four TARP events. *Third*, as regards the variability of systematic and systemic risk during respective event windows we allow for (a) different model parameters of systematic and systemic risk before, during and after the event window and (b) gradually changing systematic and systemic risk within the event window. Consequently, our analysis reveals a significant change in systematic and systemic risk during the event window period which has remained undetected by related event studies on this issue so far. *Finally*, while previous studies have not accounted for conditional variance at all, we employ a GARCH structure throughout all regressions in order to address volatility clustering in our time series of bank stock returns which is even more important during periods of financial stress.

The remainder of the paper is organized as follows. Section 2 presents a brief description of TARP and introduces the theoretical background and related empirical studies. While Section 3.1 describes data and sources, the econometric approach is presented in Section 3.2 and elaborated in more detail in the Technical Appendix. Baseline regressions, robustness checks and subsample regressions are discussed in Section 4 and shown in the Statistical Appendix. Finally, Section 5 concludes.

2. Theoretical background and literature review

2.1. The Troubled Asset Relief Program (TARP)

As a response to the collapse of the U.S. investment bank *Lehman Brothers* on September 15, 2008 and in order to prevent further financial market distortions, the U.S. Department of the Treasury introduced a first draft of TARP on September 19, 2008. After having initially been rejected by the U.S. Congress on September 29, 2008 a modified and more detailed version of TARP finally passed the congress and was established under the *Emergency Economic Stabilization Act (EESA)* on October 3, 2008.

TARP was originally proposed as a means to insure U.S. banks' "toxic" and illiquid mortgage-related assets up to a value of USD 700 billion in order to provide financial institutions with necessary liquidity. However, though TARP was considered to be the largest government intervention into financial markets in the U.S. history so far, the announcement of TARP did not significantly restore confidence in financial markets. Given signs of a credit crunch it became obvious that U.S. banks needed additional funds by more rapid actions to sustain their business during the financial turmoil and economic downturn in the U.S. As a consequence, the Department of the Treasury decided to revise the primary TARP framework by additionally launching the Capital Purchase Program (CPP) as a sub-program of TARP (henceforth TARP-CPP) on October 14, 2008. In this context, USD 250 billion of the entire USD 700 billion from TARP were allocated to TARP-CPP in order to faster recapitalize the financial sector by purchasing preferred stocks and warrants from viable "qualifying" financial institutions. In this context, the nine largest U.S. commercial banks were forced by government to accept capital infusions in this manner of in total USD 125 billion while the remaining USD 125 billion were provided for qualifying financial institutions of all sizes and types. On October 28, 2008 first tranches (USD 115 billion) of TARP-CPP equity capital infusions via TARP were allocated to the eight largest U.S. commercial banks.¹ During the entire time period the U.S. Department of the Treasury provided capital to in total 707 financial institutions in 48 states, trying to restore capital market investors' confidence by helping banks to absorb losses from toxic and illiquid assets.

¹ First tranches of capital infusions via TARP-CPP were allocated to the following eight banks: Goldman Sachs Group Inc., Morgan Stanley, J.P. Morgan Chase & Co., Bank of America Corp. (including Merrill Lynch), Citigroup Inc., Wells Fargo & Co., Bank of New York Mellon and State Street Corp.

2.2. Literature review

Related literature provides contradictory evidence concerning the impact of governmental capital assistance programs on bank shareholder value and risk. This may be explained by the fact that likely effects may generally be attributed to *two different “transmission channels”*, i.e. (1) the direct impact of providing capital assistance on a supported bank’s leverage and its liquidity position (*direct effect*) and (2) the influence of capital assistance on a bank’s investment policy ex post and in particular a bank’s risk taking behavior (*indirect effect*).

As regards the *direct effect*, it is commonly suggested that capital assistance may increase financial stability of supported banks since capital infusions may directly provoke a decrease in bank leverage as well as an increase in its liquidity position in the short-run (e.g., Mehran and Thakor, 2011; Bayazitova and Shivdasani, 2012). However, it is also pointed out, that the impact of a recapitalization on bank risk may predominantly depend on the financial position of the supported bank ex ante. Thus, equity capital injections into banks with large portfolios of illiquid or distressed assets may not necessarily prevent future underpriced “fire sales” with its adverse consequences on bank financial soundness (Diamond and Rajan, 2011, 2010).

Furthermore, taking into account capital market expectations, public capital infusions may serve as a quality signaling device towards external investors. Accordingly, it is suggested that the bailout may reduce costs of financial distress and may induce a decrease in information asymmetries between the bank’s management and external investors, finally resulting in stronger incentives for shareholders to participate in subsequent equity capital offerings supporting the government intervention (Mehran and Thakor, 2011). In contrast, however, it is also proposed that external investors may interpret bank bailouts as signals of significantly higher expected credit default risks inherent in the bank’s asset portfolio (Hoshi and Kashyap, 2010). In addition, investors may also expect that capital-supported banks will

be protected again in case of future distress. Under this interpretation, the bailout is expected to encourage risk-taking by protected banks by reducing investors' monitoring incentives and increasing moral hazard (Flannery, 1998). Accordingly, capital assistance to banks may not definitely increase the risk bearing capacity of the financial system in the medium-run resulting in lower incentives of bank shareholders to participate in subsequent equity capital offerings (Hoshi and Kashyap, 2010).

The *indirect effect* of capital infusions to banks primarily depends on the bank's reinvestment policy *ex post*, i.e. the bank's incentives to bear more risk to fulfill capital market expectations, contractual agreements as well as regulatory requirements. Thus, the indirect effect of capital assistance is again not obvious but rather depends on a wide range of *ex post* investment policies and can more probably be defined by the way the bank's overall asset and liability portfolio is restructured.

On the one hand, using liquid capital available from government intervention to take on new assets may typically provoke a better diversification of the bank's asset portfolio if remaining total assets are less strongly correlated after rebalancing the overall asset portfolio. Obviously, however, the actual effect on the bank's overall risk exposure depends on the risk level of new assets, which again is determined by the current level of competition in the respective asset market, re-financing conditions in financial markets and the current state of the economy. On the other hand, employing liquid capital available from capital infusions to invest in free-of-risk assets and to release own liabilities typically leads to an increase in creditworthiness and a decrease in the bank's leverage both resulting in higher financial stability.

Turning the *special focus on TARP* at this point, two further effects of capital infusions may be important. *First*, capital assistance to viable banks via TARP compelled banks to further maintain or even foster credit lending to households and companies. This

“commitment”, however, may have turned out to be a severe impediment to financial stability since an increase in loan transactions during a phase of financial distress and economic downturn in the U.S. at that time may have directly increased the banks’ overall credit risk exposure (e.g., Black and Hazelwood, 2012; Delis and Kouretas, 2010; Altunbas et al., 2010).

Second and related to the first aspect, (a) declaring systemically relevant banks to be “too big and too interconnected to fail”, (b) extending the debt guarantee program under the *Temporary Liquidity Guarantee Program* provided by the Federal Deposit Insurance Corporation (FDIC)² as part of implementing the revised version of TARP on October 14, 2008 as well as (c) prohibiting short selling of any financial companies’ stocks by the Securities and Exchange Commission (SEC) one day before the first announcement of TARP may additionally have induced a reduction in market discipline as well as adverse effects of moral hazard during lending contracts, e.g. a reduction in risk perception and an increase in risk tolerance on the bank-level further fostering financial fragility (e.g., Gropp et al., 2011).

Related event studies investigating the impact of TARP on market confidence and financial stability are scarce. To begin with, King (2009) provides empirical evidence of positive wealth effects due to the announcement of different recapitalization programs (incl. TARP) in the short run whereas the study reveals a negative impact on bank shareholder on average in the long run. Elyasiani et al. (2011) confirm evidence provided by King (2009) and additionally find that capital infusions via TARP may induce an increase in the supported banks’ systematic risk one year after the intervention is enforced.

Veronesi and Zingales (2009) investigate the impact of the announcement of TARP employing data from the largest banks being forced to retrieve government capital assistance after the first stage of intervention. They find that the announcement of TARP may induce a

² The FDIC now guaranteed newly issued senior unsecured debt of banks, thrifts, and certain holding companies by providing full coverage of non-interest bearing deposit transaction accounts regardless of dollar amount.

decrease in current market values of bank common equity capital whereas the announcement may provoke an increase in current market values of preferred equity capital as well as current market values of the banks' debt positions. Kim and Stock (2012) confirm findings provided by Veronesi and Zingales (2009) and additionally provide evidence that the announcement of TARP as well as TARP transaction closings may have a significantly positive impact on the current market value of the supported banks' preferred stocks.

3. Econometric methodology

3.1. Data and sources

We retrieve TARP announcement dates from the online archive of press releases provided by the U.S. Department of the Treasury. Accordingly, the announcement of the first draft of TARP is based on the first press release and statement by the Department of the Treasury's Secretary Henry Paulson on September 19, 2008 whereas the announcement of the revised version of TARP refers to the press release and statement by Henry Paulson on October 14, 2008. Our initial sample of 737 equity capital infusions to 707 banks under the TARP-CPP is retrieved from the *TARP Transactions Report (6/18/2010)* provided online by the U.S. Department of the Treasury. The report provides information on all banks having received capital injections via TARP, purchase and repayment details of all transactions as well as transaction-specific information such as the pricing mechanism and the description of investment. Figure 1 illustrates the four TARP event dates as employed in this paper. Accordingly, the first announcement of TARP took place on September 19, 2008 followed by the announcement of the revised TARP on October 14, 2008. Banks received capital injections from October 28, 2008 to July 24, 2009 whereas they repayed TARP-capital between March 31, 2009 and June 16, 2010.

The history of bank stock returns is retrieved from the *Datastream Database* provided by *Thomson Financial Services*. Due to the fact that the event study methodology employed in this paper is based on share price information, data on transactions from banks which are not listed on any U.S. stock exchange are omitted from the initial sample of TARP-supported banks in a first step. In a second step, we exclude banks exhibiting at least 20 consecutive trading days of missing trading activities and hence, missing stock returns, in order to avoid biased estimation results if event windows are affected by high-illiquid stock returns and missing returns. These adjustments finally reduce the sample to 132 equity capital injections into 125 banks as well as 54 repayment transactions by 49 TARP-supported banks.³

The final sample of banks employed is heterogeneous. For example, the largest bank's mean (2007-2010) of total assets amounts to USD 2,005 billion USD (Bank of America Corp.) whereas the smallest bank's mean of total assets amounts to USD 923 million (Legacy Bancorp, Inc.). Furthermore, the highest mean of a bank's leverage factor is at 87.44 (Morgan Stanley) and the lowest is at 22.24 (Umpqua Holdings Corp.). While the highest and lowest means of returns on assets are at 3.90 and -4.74 percent (American Express Company and Guaranty Bancorp.), the highest and lowest means of the non-performing loans to total loans ratio are at 7.96 and 0.52 percent (Integra Bank Corp. and Westamerica Bancorp.). Finally, the mean of the ratio of TARP transaction volumes to supported banks' total equity is at 28.29 percent while the largest transactions amount to USD 25 billion respectively (Bank of America Corp. including Merrill Lynch, Citigroup Inc., JPMorgan Chase & Co. and Wells

³ The difference between the number of capital injections and the total number of banks is due to the fact that some banks in our sample received multiple capital infusions during the sample period. Similarly, the difference between the total number of repayments and the total number of banks results from the fact that five sample banks repaid capital in more than one tranche. We provide a comprehensive list of all sample banks on request.

Fargo & Company), and the smallest transaction amounts to USD 5,409 million (Legacy Bancorp, Inc.).

Figure 2 reports the distribution of the number and volume of capital infusions as well as repayment transactions in more detail. The cumulated volume of the entire sum of capital infusions to banks amounts to USD 186,519,598,000 covering approximately 91 percent of the face value of the total amount of capital assistance (USD 204,901,756,000) by TARP-CPP. The cumulated volume of all capital repayments amounts to USD 129,366,676,000 covering approximately 63 percent of the total amount of capital assistance under TARP-CPP.

3.2. *Econometric approach*

The empirical methodology employed is briefly discussed in the following sub-sections. Further details and an in-depth technical discussion of each regression model are provided in the *Technical Appendix*.

3.2.1. *Abnormal returns in stock prices*

Event study methodology provided by Brown and Warner (1985) is used to analyze the impact of TARP on changes in bank shareholder value. The objective of this strategy is to measure any share price reaction to TARP announcements and capital transactions by computing abnormal stock returns at and around the respective four TARP event dates.

Accordingly, cumulated average abnormal returns (CAARs) for N TARP events over event window periods moving around day t_0 (from day T_1 to T_2) are calculated as

$$CAARs_t = \frac{1}{N} \sum_{i=1}^N CARs_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} ARs_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} R_{i,t} - (\tilde{\beta}_{i,0} + \tilde{\beta}_{i,1} R_{m,t}). \quad (1)$$

An abnormal stock return ($AR_{i,t}$) is defined as the difference between the realized stock return ($R_{i,t}$) and a benchmark return, which is the expected return resulting from the assumption that there has been no further price sensitive event. We adopt the standard market model (CAPM) to predict the benchmark returns (expected returns). $R_{i,t}$ and $R_{m,t}$ are daily log returns on banks' stocks i and the market portfolio m at trading day t and β_i are the parameters to be estimated. β_i are estimated over a period of 240 trading days running from 251 to 11 days prior to the event day t_0 (four different TARP event dates).

We analyze CAARs over four different event windows of 4 [-2;+2], 2 [-1;+1], 1 [-1;0] and 1 [0;+1] trading days around TARP event dates t_0 to control for possible information leakages ex ante and delayed market reactions ex post. In addition, estimated abnormal returns (ARs) are reported and discussed for single days around the respective event dates. The largest event window of 4 [-2;+2] trading days around t_0 is observed to be the main event window period. To substantiate our hypothesis that the calculated CAARs are different from zero, we compute the standardized cross-sectional parametric test statistic suggested by Boehmer et al. (1991), which captures possible cross-sectional heteroskedasticity and changes of the variance of abnormal stock returns during the event window. We further adopt a non-parametric test statistic provided by Corrado and Zivney (1992) as well as Maynes and Rumsey (1993) which is more effective since it abstracts from any distributional assumptions concerning abnormal stock returns and thus, provides additional information on the robustness of the parametric test statistic. In addition, this non-parametric test statistic corrects for possible cross-sectional dependence of abnormal stock returns during the event window period.

3.2.2. Changes in systematic risk

The impact of TARP on the supported banks' systematic risk is analyzed employing an augmented Capital Asset Pricing Model (CAPM) which allows the banks' systematic risk to change gradually during and after the event window (Uhde and Michalak, 2010; Cyree and DeGennaro, 2002; Lockwood and Kadiyala, 1988). The final regression model is denoted as follows:

$$R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,0}D_{1,t} + \beta_{i,2}(T_1 - t)(t - T_2)D_{1,t}R_{m,t} + \beta_{i,3} \left[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t} \right] R_{m,t} + \varepsilon_{i,t} . \quad (2)$$

where $R_{i,t}$ and $R_{m,t}$ are the daily log returns on banks' stocks i and the market portfolio m at trading day t . $D_{1,t}$ is a dummy variable equaling one in a symmetrical window around day t_0 if $T_1 \leq t \leq T_2$ (with T_1 and T_2 being defined as the beginning and the end of the event period), and zero otherwise. $D_{2,t}$ is a dummy variable equaling one after the event period if $t > T_2$ and zero in all other cases. $\varepsilon_{i,t}$ is the error term and β_i are the parameters of systematic risk to be estimated. Finally, $\delta_{i,0}$ measures any abnormal stock return during the event window period.⁴

We observe 240 trading days per TARP event symmetrically moving around day t_0 $[-120 \leq t_0 \leq +120]$ which proxies for each of the four TARP events. Corresponding to estimations of CAARs our main event window of 4 trading days is symmetrically set around the four TARP event dates respectively. Estimated coefficients are averaged to mean values

⁴ Implementing the dummy variable $D_{1,t}$ allows for further robustness checks concerning calculated abnormal stock returns from Section 3.2.1. Since the process of calculating abnormal stock returns assumes a simplified stationary (time invariant, linear) run of estimated benchmark market model parameters, the integration of the dummy variable $D_{1,t}$ enables us to simultaneously control if abnormal stock returns are biased by time-varying beta factors during the event window period.

across N TARP events. To control if means of estimated beta coefficients are different from zero, we apply a parametric t-test. We further adopt a non-parametric Wilcoxon signed rank test which is more effective when assuming a non-normal distribution of stock returns and provides additional information on the robustness of the parametric t-test.

3.2.3. *Decomposition of the change in systematic risk*

Following Nijskens and Wagner (2011) determinants of the change in systematic risk are examined by decomposing the beta factor into (a) the change in the relative standard deviation of bank stock returns (idiosyncratic bank risk) and (b) the change in the correlation of bank stock returns with returns of the market portfolio (bank's contribution to systemic risk).

In a *first step*, we normalize individual bank stock returns and returns of the market portfolio by employing respective standard deviations of stock returns before, during and after the event window period. As a result, the standard deviation of normalized bank stock returns and normalized returns of the market portfolio as well as the relative standard deviation of normalized bank stock returns is equal to one.

In a *second step*, normalized bank stock and market portfolio returns are integrated into baseline regression specification (2) to obtain a modified regression model as follows

$$\begin{aligned} \tilde{R}_{i,t} = & \rho_{i,0} + \rho_{i,1} \tilde{R}_{m,t} + \delta_{i,0} D_{1,t} + \rho_{i,2} (T_1 - t)(t - T_2) D_{1,t} \tilde{R}_{m,t} \\ & + \rho_{i,3} \left[(t - T_1) D_{1,t} + (T_2 - T_1) D_{2,t} \right] \tilde{R}_{m,t} + \varepsilon_{i,t}. \end{aligned} \quad (3)$$

$\tilde{R}_{i,t}$ and $\tilde{R}_{m,t}$ are daily log normalized returns on banks' stocks i and the market portfolio m at trading day t . $D_{i,t}$ are dummy variables to specify the event windows and $\varepsilon_{i,t}$ is the error

term. Finally, $\rho_{i,1}$ are parameters to be estimated denoting the correlation of individual bank stock returns with returns of the market portfolio.

In line with the methodology to estimate changes in bank systematic risk, we observe 240 trading days symmetrically moving around day t_0 $[-120 \leq t_0 \leq +120]$ which proxies for each of the four TARP events. Again, an event window of 2 trading days is symmetrically set around TARP event dates respectively. D_i are dummy variables to specify the event windows (see Section 3.2.2). Estimated coefficients are averaged to mean values across N TARP events. We apply a parametric t-test and a non-parametric Wilcoxon signed rank test to determine if means of estimated coefficients are different from zero.

In a final *third step*, the change in the relative standard deviation of bank stock returns during the event window period is calculated as follows:

$$\frac{\sigma_i^{\Delta\text{after}}}{\sigma_m^{\Delta\text{after}}} = \frac{\sigma_i^{\text{after}}}{\sigma_m^{\text{after}}} - \frac{\sigma_i^{\text{before}}}{\sigma_m^{\text{before}}} = \frac{\beta_{i,1} + \beta_{i,1}^{\Delta\text{after}}}{\rho_{i,1} + \rho_{i,1}^{\Delta\text{after}}} - \frac{\beta_{i,1}}{\rho_{i,1}}. \quad (4)$$

Accordingly, the marginal change of the relative standard deviation of individual bank stock returns during the event window period is calculated by integrating estimated coefficients from regression specifications (3) and (2) into equation (4).

4. Empirical results

4.1. Baseline results

Baseline results are presented in Tables 1a-1c and plotted in Figures 3a-3c. While robustness checks are shown in Tables 2a-5b, results from subsample regressions are illustrated in Tables 6a-8c.

Changes in the supported banks' shareholder value, systematic risk and parameters of systematic risk are estimated by separate regressions for each single bank of the entire sample of 125 U.S. banks with regard to both TARP announcement dates, for a sample of 132 transactions concerning respective capital infusions and for a sample of 54 repayments by supported banks.⁵ Regressions include the *S&P 500 Index* as a reference blue chip index for the U.S. representing the largest and most solvent U.S. companies. Baseline regressions refer to a main (highlighted) event window period of 4 days $[-2; +2]$ symmetrically set around each TARP event date t_0 . Regression specifications are estimated by maximum likelihood assuming a standard normal distribution and implementing a GARCH(1,1) structure.⁶

Taking into account that the first announcement of TARP and the announcement of the revised TARP affect all banks in our sample whereas capital infusions and respective repayments involve a subsample and a further subset of this subsample of banks, we merge both TARP announcements during the following discussion of empirical results (Section 4.1.1) and discuss empirical findings on capital infusions (Section 4.1.2) and repayments (Section 4.1.3) separately. We control for the significance of net differences in calculated CAARs and estimated coefficients β_3 and ρ_3 for both TARP announcements applying the difference-in-means t-test.

⁵ We also perform an OLS regression including the four TARP events jointly as RHS variables and employing a first difference estimator to control for likely countervailing event-specific effects (in particular between the events of capital injections and repayments). Our baseline results are generally reconfirmed. We provide empirical results on request.

⁶ Results from the Phillips-Perron (1988) and the Box-Pierce (1970) statistic indicate that time series of daily log returns from banks in our sample are stationary and exhibit a leptokurtic distribution.

4.1.1. *First announcement of TARP and announcement of revised TARP*

As shown in Table 1a, investigating *wealth effects* due to the first announcement of TARP on September 19, 2008 and the announcement of the revised TARP on October 14, 2008 we find a significantly positive mean of estimated abnormal returns (ARs) at 8.55 percent (revised TARP: 3.95 percent) on announcement day t_0 while cumulated average abnormal returns (CAARs) are significantly positive at 10.81 percent (16.92 percent) for the main event window period of 4 days $[-2; +2]$ around announcement day t_0 (see also Figure 3a).

Empirical results initially reveal a positive share price reaction to both announcement dates while wealth effects are considerably higher as regards the announcement of the revised TARP. The difference in means of estimated CAARs for the first announcement and the revision of TARP is statistically significant at the one-percent level applying the difference-in-means t-test. Moreover, as compared to the event date t_0 a significantly higher positive mean of estimated ARs at 7.14 percent in t_1 as well as estimated CAARs at 11.08 for the event window period of 2 days $[0; +1]$ indicate a one-day delay of information-processing by capital market investors as regards the announcement of revised TARP.

Overall, empirical results correspond to previous findings provided by King (2009) for the U.S. market suggesting that TARP may be perceived by capital market investors as an effective instrument to provide single banks with necessary liquidity, to reduce bank risk and thus, to prevent further financial market distortions. In addition, we find that a more transparent and direct intervention strategy and in particular, more detailed information on the selection process of viable “qualifying” banks as provided by the revised TARP may be perceived as a stronger positive signal and hence, may provoke a stronger deceleration of market uncertainty compared to the first announcement of TARP. Furthermore, a higher share price response may also be due to the implementation of TARP-CPP under the revised

TARP forcing the eight (namely mentioned) largest U.S. commercial banks to accept equity capital infusions of in total USD 125 billion.

Considering daily abnormal returns (ARs) in more detail provides further important insights. The New York Fed's decision to bailout the American International Group (AIG) by providing up to USD 85 billion as a credit facility three days before TARP was announced for the first time may have additionally increased the credibility of government intervention plans from an investors' point of view. As shown, the mean of estimated ARs is significantly positive at 4.27 percent two days before the first announcement of TARP indicating a positive share price reaction to the AIG bailout with a one-day information delay. In contrast, the mean of estimated ARs is significantly negative at -3.06 percent two days after the first announcement of TARP. This might be explained by the fact that the first draft of TARP was rejected by the Senate Banking Committee two days after the first announcement of TARP which may have given rise to serious doubts concerning the realization of a coordinated and immediate government bailout plan.

As regards the announcement of the revised TARP, the mean of estimated ARs is significantly positive at 12.44 percent in t_{-2} whereas it is significantly negative at -7.71 one day before the event date. As our analysis is based on trading days only, t_{-2} denotes Friday (October 10, 2008) and t_{-1} represents Monday (October 13, 2008). We therefore suggest that capital market investors may have positively anticipated the G-7 weekend meeting on October 11 and 12 but that the meeting's outcome may have been below investors' expectations as information on a concrete and coordinated rescue plan for the U.S. banking market was not provided.

Turning to changes in bank *systematic risk*, Table 1b and Figure 3b report that the average value of estimated coefficients β_1 , reflecting the banks' systematic risk prior to the event window, is positive at 1.5342 (revised TARP: 1.5358). The mean of estimated coefficients

β_2 is positive at 0.1863 (negative at -0.2593) indicating a concave (convex) run of systematic risk during the event window finally resulting in a lower post-event level at 1.3666 (1.5339), which is implicated by the negative average value of estimated coefficients β_3 at -0.0419 (-0.0005).⁷ The difference in means of estimated coefficients of β_3 for both TARP events is statistically significant at the ten-percent level applying the difference-in-means t-test.

Empirical evidence of a decrease in systematic risk due to the first announcement of TARP and the announcement of the revised TARP corresponds to our findings of a positive share price response during the main event window for both events. Results generally suggest that providing necessary liquidity to banks by purchasing “toxic” or illiquid assets may be expected to reduce future costs of bank financial distress (Mehran and Thakor, 2011). Moreover, investors may anticipate an acceleration of the risk bearing capacity of the entire financial system resulting from government intervention (Hoshi and Kashyap, 2010).

In addition, the convex run of systematic risk due to the announcement of the revised TARP initially reflects a positive assessment of revised TARP and TARP-CPP but a later re-evaluation of these programs. Hence, results from the time-varying change of systematic risk during the event window suggest that the direct impact of capital infusions may be generally associated with a decrease in bank leverage and an increase in the bank’s liquidity. However, the following increase in systematic risk during the event window also indicates that capital markets investors may anticipate possible adverse consequences (e.g. a reduction in risk perception and an increase in risk tolerance on the bank-level further fostering financial

⁷ Note that the parameter δ_0 is significantly positive at 0.0161 and 0.0403 respectively (Table 1b) indicating that our finding of a positive wealth effect due to both TARP announcements is reiterated even when introducing time-variant betas during the event window. As this result also holds for the following TARP events (capital infusions and repayments), we do not explicitly comment it for later regressions.

fragility) when following the “too big and too interconnected to fail”-doctrine and extending debt guarantee programs at the same time revised TARP was announced.

Finally, *decomposing the beta factor* by separating this factor into (a) the change in the relative standard deviation of bank stock returns (Δ RSD, idiosyncratic bank risk) and (b) the change in the correlation of bank stock returns with returns of the market portfolio (ρ_3 , systemic risk), Table 1c reports that idiosyncratic risk decreases by -0.2838 (-0.0895) while systemic risk significantly increases by 0.0376 (0.0208) on average. More precisely, Figure 3c shows a concave run of systemic risk during the event window for both TARP events respectively resulting in higher post-event levels at 0.6597 and 0.6721 . The difference in means of estimated coefficients of ρ_3 for both TARP events is statistically significant at the one-percent level applying the difference-in-means t-test.

Results from decomposing the beta factor reveal that the reduction in bank systematic risk is driven by a decrease in idiosyncratic bank risk. As a consequence, an increase in systemic risk is observed when TARP was announced for the very first time. Referring to the announcement of the revised TARP, empirical results reveal a smaller decline in idiosyncratic bank risk as compared to the first announcement of TARP while systemic risk also increases less heavily. However, still observing an increase in systemic risk due to the revised announcement of TARP underlines our suggestion that capital markets investors may anticipate an increase in systemic risk when following the “too big and too interconnected to fail”-doctrine and extending debt guarantee programs at the same time revised TARP was announced.

4.1.2. *Capital assistance to banks by respective dates*

Investigating the relationship between *wealth effects* and capital infusions under TARP by respective transaction dates, Table 1a reports a significantly negative mean of estimated ARs

at -1.03 percent on transaction day t_0 while CAARs are significantly negative at -2.26 percent for the main event window period of 4 days $[-2; +2]$ around event date t_0 (see also Figure 3a). Turning to changes in *systematic risk*, Table 1b and Figure 3b indicate that the average value of pre-event estimated coefficients β_1 is positive at 1.3378 . The mean of estimated coefficients β_2 is negative at -0.0676 indicating a convex run of systematic risk finally resulting in a higher post-event level at 2.1018 , which is implicated by the significantly positive average value of the post-event estimated coefficient β_3 at 0.1910 . Decomposing the beta factor (Table 1c), we find that the increase in systematic risk is driven by an increase in *idiosyncratic bank risk* (ΔRSD) by 0.2597 and an increase in *systemic risk* (ρ_3) by 0.0098 on average. In addition, Figure 3c shows a concave run of systemic risk during the event window resulting in a higher post-event level at 0.6871 .

In sum, empirical results reveal a significantly negative share price reaction and an increase in bank systematic risk due to capital infusions to U.S. banks which is in line with empirical evidence provided by Elyasiani et al. (2011). Investors' skepticism towards government capital assistance may result from the fact that de facto capital injections are perceived as a signal of higher expected default risks inherent in supported banks' asset portfolios. In addition, capital market investors may anticipate that capital infusions per se do not necessarily help mitigating default risks.

The effect of capital injections rather depends on the risk level of the supported banks' reinvestment policy ex post which again is determined by market conditions and the state of the economy. Thus, as supported U.S. banks were committed by TARP-CPP to maintain or even foster credit business during times of financial distress and economic downturns while relying on government guarantees and bailouts at the same time, capital injections to banks with large portfolios of illiquid or distressed assets may not necessarily prevent future "search

for yield-strategies” (e.g., Maddaloni and Peydró, 2011; Delis and Kouretas, 2010) and underpriced “fire sales” (e.g., Diamond and Rajan, 2011). Consequently, decomposing the beta factor reveals an increase in both idiosyncratic bank risk and systemic risk due to capital infusions to U.S. banks under TARP.

4.1.3. Capital repayment by banks by respective dates

Finally, investigating the relationship between *wealth effects* and respective capital repayments by TARP-supported banks, Table 1a reports that the mean of estimated ARs is insignificantly positive at 0.04 percent on transaction day t_0 and significantly positive at 0.73 percent in t_1 while CAARs are significantly positive at 0.90 percent for the main event window period of 4 days $[-2; +2]$ around transaction day t_0 (see also Figure 3a). Turning to *systematic risk*, Table 1b indicates that the average value of pre-event estimated coefficients β_1 is positive at 1.5888 while the mean of estimated coefficients β_2 is negative but not significantly different from zero at -0.0467 indicating a linear run of systematic risk during the event window (see also Figure 3b).⁸ The linear run of systematic risk finally results in a lower post-event level at 1.3442, which is indicated by a decrease of the average value of post-event estimated coefficients β_3 at -0.0611 . Finally, decomposing the beta factor (Table 1c), we find that *idiosyncratic bank risk* (Δ RSD) decreases by -0.0906 while *systemic risk* (ρ_3) insignificantly decreases by -0.0012 on average and remains unchanged ex post at 0.6426 (see also Figure 3c).

Empirical results reveal a slightly positive share price response to capital repayments with a one-day information delay suggesting that capital market investors may perceive

⁸ The linear run of systematic risk may be explained by the fact that in particular smaller banks in our sample provide information on capital repayments on the actual repayment day or right after.

repayments by banks as a general signal of financial recovery. Moreover, since the major part of repayments were transacted during a period of recovering capital market conditions and increasing interbank lending volumes, capital repayments may further implicate that banks opt for less expensive alternatives of funding as compared to government capital assistance. In addition, since corporate governance standards become obsolete under TARP after repayment, banks no longer have to limit executives' bonus pay for example, which in turn may result in higher incentives for bank managers to make efforts to increase bank shareholder value sustainably.

Empirical evidence of a slight decrease in bank systematic risk corresponds to findings of a weak positive share price reaction to capital repayments. The linear run of systematic risk additionally indicates that information on capital repayments is processed gradually by capital market investors. Results from decomposing the beta factor suggest that the decrease in systematic risk derives from a decline in idiosyncratic bank risk since we do not find any evidence for a significant change in systemic risk due to repayments by single banks (Table 1c, Figure 3c).

4.2. *Robustness checks*

Discussions of the results from robustness checks refer to the main event window period of 4 [-2;+2] trading days around the event date t_0 . Wherever reasonable, we control for the significance of net differences in calculated CAARs and estimated coefficients β_3 and ρ_3 between baseline findings and respective robustness checks applying the difference-in-means t-test. We do not comment test results in the following sections but report them in corresponding regression tables.

4.2.1. Technical robustness checks

To begin with, we employ *longer event window periods* of 10 [-5;+5] and 20 [-10;+10] trading days symmetrically set around the event date t_0 . In addition, the benchmark models are re-estimated by maximum likelihood assuming a more leptokurtic *Student's t distribution* and *Generalized Error Distribution (GED)*. Since empirical results do not remarkably differ from baseline findings, we do not include and comment them in this paper but provide results on request.

Furthermore, we substitute the standard market model by an augmented *Fama-French three-factor model* (Fama and French, 1992, 1993, 1996) and additionally control for the influence of momentum anomalies as suggested by Carhart (1997) for the *Carhart four-factor model*. Accordingly, our basic model specification is extended by a proxy for size (SMB; average return on three small portfolios minus the average return on three big portfolios), a book-to-market proxy (HML; average return on two value portfolios minus the average return on two growth portfolios) and a return momentum factor (Mom; average return on two high prior return portfolios minus the average return on two low prior return portfolios).⁹ As regards our entire sample period, the breakpoint to distinguish small from large stocks is the median capitalization of all stocks with an average value of 1,633.98 million USD. The breakpoints to determine three (value, neutral and growth) portfolios based on the BE/ME-ratio are the 30th and 70th percentiles with average values of 0.48 and 0.97 and the return breakpoints to determine the momentum factor are the 30th and 70th percentiles with average values of -18.09 and 15.53 respectively.¹⁰ As shown in Tables 2a-2c, baseline results are

⁹ In line with related studies (e.g., Huang et al., 2012; Chen et al., 2011) the relevant Fama and French factors as well as the risk-free rate are obtained from Kenneth French's data library available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

¹⁰ To be consistent, we adjust all Fama-French factors following the methodology from Section 3.2.3 when decomposing the beta factor.

generally reconfirmed while calculated CAARs and estimated coefficients β_3 and ρ_3 as well as Δ RSD slightly decrease in value which is due to the fact that the augmented Fama-French model additionally incorporates at least two factors (SMB, HML) that proxy for a bank's relative distress (risk exposure) not captured by the market index.

Finally, baseline results may be affected by the inflation of event-date variance and cross-sectional correlation among our time series of bank stock returns (Daniel and Titman, 1997). Thus, we address likely cross-sectional correlation between bank stock returns employing Zellner's (1962) *seemingly unrelated regression* (SUR) methodology.¹¹ As shown in Tables 3a-3c, baseline results are generally reiterated while calculated CAARs and estimated coefficients β_3 and ρ_3 as well as Δ RSD slightly increase or decrease in value which might be explained by the fact that cross-sectional correlations between bank stock returns are addressed by SUR.

4.2.2. *Control group regressions*

Baseline findings may be biased by further unobservable factors that affected the U.S. banking sector as a whole which is even more likely during the financial crisis period. Thus, to control for this aspect we examine the differences in calculated CAARs, systematic risk and systemic risk between our sample of capital-supported banks and a control group of similar banks which, however, did not receive any capital assistance under TARP within the corresponding estimation period.

¹¹ We perform an additional robustness check on calculated CAARs by substituting the standard two-sided parametric test (Boehmer et al., 1991) by an adjusted Boehmer et al. (1991) t-test proposed by Kolari and Pynnönen (2010). As a result, calculated ARs and CAARs retain signs and remain significant even when employing the cross-sectional correlation test by Kolari and Pynnönen (2010). We provide results on request.

We build different control groups of non-TARP (listed) banks located in the U.S. with regard to relevant TARP events, i.e. respective capital infusions and repayments. Following Hendricks and Singhal (2001) we employ a three-step modified iterative matching procedure to select appropriate banks for these control groups. Thus, in a first step eligible peers must not have received capital assistance under TARP during the relevant estimation period and event windows. In a second step we calculate differences in size (market capitalization) and market-to-book ratios between our sample banks and all eligible control banks (Barber and Lyon, 1997, 1996; Fama and French, 1993).¹² In a final third step we calculate the sum of both absolute percentage differences and select those banks exhibiting the minimum difference as our relevant control banks.¹³

Compared to our baseline results, Tables 4a-4c report insignificant CAARs with reverse signs as regards control group regressions on capital infusions and repayments. Against this background, we underline our conclusions from Sections 4.1.2 and 4.1.3 that capital infusions under TARP may provoke negative wealth effects for supported banks whereas capital repayments by TARP-banks may encourage positive share price reactions. Furthermore, means of estimated coefficients of β_3 for control groups retain signs but exhibit lower significant values for both event dates. Taking this into account, control group regressions reveal that the observed increase in post-event systematic risk is not *completely* induced by capital transactions under TARP but that it is *also* a result of other (completely unrelated) factors affecting the whole U.S. banking industry, e.g. different financial trends during the

¹² Employing “size” as a matching criterion is based on empirical evidence that the bank’s size is negatively correlated with its overall risk exposure (e.g., Boyd and De Nicoló, 2006). The purpose of employing the market-to-book ratio as a matching criterion is to incorporate a long-term performance characteristic and to proxy the bank’s franchise value since higher franchise values are found to deter excessive risk-taking behaviour by the bank’s management (Saunders and Wilson, 2001).

¹³ Calculated differences between our sample banks and control group banks from the third step are below 20 percent on average suggesting that the matching procedure employed is adequate.

crisis and recovery period (see Section 4.2.3). Nevertheless, as a remaining significant difference in estimated coefficients of β_3 still exists, we cannot reject our hypothesis of a change in the banks' systematic risk (and corresponding effects on the decomposition of the beta factor) due to capital transactions under TARP.

4.2.3. Financial trend regressions and reverse causality

Finally, and related to the previous robustness check, we control if baseline findings are biased by a general financial trend, i.e. bank systematic risk, idiosyncratic risk and systemic risk may generally increase during periods of financial stress (period of capital injections under TARP) and may generally decrease during periods of financial recovery (period of TARP-capital repayments). As a consequence, baseline findings may also be biased due to reverse causality arising from these financial trends. Hence, assuming that bank systematic risk generally increases and share prices decrease during the financial stress period, banks may be less able to lend on the capital and interbank market and thus, more strongly rely on governmental capital assistance. In contrast, assuming that bank systematic risk generally decreases and share prices increase during the recovery period, banks might be able to (stronger) re-finance on the capital and interbank market and thus might be more able to repay the capital they received under TARP. Against this background, we extend our regression models from Sections 3.2.2 and 3.2.3 by two different trend proxies controlling if likely financial trends and resulting reverse causality may bias our baseline findings.

Accordingly, we employ two further robustness checks with regard to relevant TARP events, i.e. respective capital infusions and repayments. During a first check, we include the Cleveland Financial Stress Index (CFSI) provided by the Federal Reserve Bank of Cleveland as a proxy for financial stress. The CFSI is a daily-updated, coincident indicator of systemic stress using data from 11 components reflecting four financial sectors (see Oet et al., 2011 for

further details). As higher values of the CFSI indicate higher systemic banking stress we expect a negative sign of the estimated coefficients of the CFSI trend measure throughout all regressions.

During a second robustness check, we simulate financial trends for the U.S. banking market running a Monte Carlo simulation to control if bank risk generally increased during the period of capital infusions (the crisis period; first capital infusion to the first capital repayment in our sample) and generally decreased during the period of capital repayments (the recovery period; first capital repayment to the last capital repayment in our sample).

The underlying data generating process to model respective crisis and recovery scenarios follows a random walk (Campbell et al., 1997) with drift and is given by $I_t = I_{t-1} + T_i^{MC} + \varepsilon_t$.

I_t and I_{t-1} are the index values at trading days t and t_{-1} . T_i^{MC} is the drift rate depending on

the regime i defined as $\begin{cases} \text{if } i = \text{crisis, } T_i^{MC} = -0.2 \\ \text{if } i = \text{recovery, } T_i^{MC} = 0.1 \end{cases}$ and ε_t is the independent and identically

distributed (iid) random error term with $\mu_\varepsilon = 0$ and $\sigma_\varepsilon = 1$. The drift rate T_i^{MC} is based on the average performance of all stock-listed non-TARP U.S. banks during the crisis and recovery period as defined above (Section 4.2.2).

We simulate 241 index values in order to calculate 240 index returns $R_t^{MC} = \ln(I_t / I_{t-1})$ symmetrically moving around event date t_0 . This procedure is reiterated 1,000 times so that we obtain 132,000 simulated time series for the infusion events and 54,000 simulated time series for the repayment events. Finally, simulated time series of logs of index returns are included as a trend variable into respective benchmark models while the average of estimated coefficients is calculated subsequently. As bank stock returns should increase with increasing simulated market index returns we expect a positive sign of the estimated coefficients of the trend measure throughout all regressions.

As shown in Tables 5a and 5b, both trend measures turn out to be significant and exhibit expected signs throughout all regression specifications indicating that financial trends do matter. Compared to our baseline regressions, estimated coefficients of β_1 , ρ_1 and δ_0 retain signs and significances while β_3 and ρ_3 only marginally decrease in value for the infusion event and only slightly increase in value for the repayment event. Thus, robustness checks reveal that the negative impact of capital injections and the positive effect of capital repayments are slightly overestimated during baseline regressions which might be explained by a general financial trend and in particular, resulting reverse causality effects.

4.3. *Subsample regressions*

Discussions on the results from subsample regressions refer to the main event window period of 4 [-2;+2] trading days around the event date t_0 . We control for the significance of net differences in calculated CAARs and estimated coefficients β_3 and ρ_3 between baseline findings and respective robustness checks applying the difference-in-means t-test. We do not comment test results in the following sections but report them in corresponding regression tables.

4.3.1. *Controlling for multiple vs. single injections*

We initially build two subsamples of banks having received multiple capital injections (1 forced bank in this sample) or single capital infusions. Tables 6a-6c report significantly negative CAARs for the subsample of banks with single infusions only. In contrast, a significant increase in the post-event systematic risk is observed for both subsamples while values do not remarkably differ. Finally, while the increase in post-event systematic risk is driven by an increase in idiosyncratic risk for banks with multiple capital injections we observe both an increase in idiosyncratic and systemic risk for single-supported banks.

4.3.2. *Controlling for the volume of capital assistance*

We subsequently explore how the market reacts to capital injections of various sizes suggesting that different volumes of capital assistance may lead to differences in calculated CAARs, estimated beta coefficients and coefficients from decomposing systematic risk. We control for this effect by generating three subsamples of 33 small, 66 midsize and 33 large capital infusions. Since capital-supported banks in our sample significantly differ in size, we proxy “volume of capital assistance” as the ratio of a bank’s volume of capital assistance received to the bank’s market capitalization. Subsequently, we divide the entire set of capital injections into three groups over four quartiles as follows. Quartile 1 comprises small capital assistance volumes accounting for less than 18 percent of a bank’s market capitalization with a mean value of 13 percent. Quartiles 2 and 3 include midsize capital assistance volumes accounting for a value between 18 and 32 percent of market capitalization with a mean value of 25 percent. Finally, quartile 4 comprises large capital assistance volumes accounting for more than 32 percent of market capitalization with a mean value of 52 percent.

As shown in Tables 7a-7c, we find significantly negative CAARs throughout all regressions while the highest wealth effects are observed for the subsample of large capital injections. Since the subsample of large capital injections mainly consists of smaller viable “qualifying” banks, results suggest that larger volumes of capital assistance to (mainly) smaller banks may be perceived as a stronger signal of higher expected default risks inherent in the supported banks’ asset portfolios. Corresponding to this, we find that post-event systematic risk, idiosyncratic bank risk and systemic risk more strongly increase for the subsample of large capital infusions to smaller banks. Hence, referring to systematic, idiosyncratic and systemic risk, results from subsample regressions additionally suggest that larger amounts of capital-aid from TARP towards smaller “qualifying” U.S. banks may be a severe impediment to restore market confidence and promote financial stability.

4.3.3. *Controlling for forced vs. unforced banks*

We finally build two subsamples of forced and unforced banks in order to investigate if constraining the eight largest U.S. commercial banks to accept capital infusions under the TARP-CPP may provoke differences in estimation results. As reported in Tables 8a-8c and corresponding to our baseline results, we find significantly negative CAARs for both subsamples, however, with higher values for the subsample of unforced banks as regards the infusion event which is in line with empirical evidence provided by Kim and Stock (2012) and Veronesi and Zingales (2010). Furthermore, the analysis reveals a significant increase in post-event systematic risk, idiosyncratic risk and systemic risk with higher values for the subsample of unforced banks. Turning to the repayment event, we find a positive share price response to capital repayments and a significant decrease in post-event systematic risk and idiosyncratic bank risk due to capital repayments for both subsamples which is in line with our baseline findings. In contrast to capital infusions, however, respective coefficients exhibit higher values for the subsample of forced banks.

5. **Conclusion**

Employing four event dates of the U.S. “Troubled Asset Relief Program” (TARP) this paper empirically investigates the impact of the first announcement of TARP (September 19, 2008), the announcement of revised TARP (October 14, 2008), respective capital infusions and capital repayments on changes in shareholder value and risk exposure of 125 supported U.S. banks as perceived by the capital market through share price reactions for an entire sample period from September 19, 2008 to June 16, 2010.

The empirical analysis at hand suggests that both announcements of TARP and respective capital repayments by banks may provoke an increase in bank shareholder value and a decrease in systematic risk whereas equity capital injections are observed to be an

impediment to restore market confidence and to promote financial stability. In addition, while announcements and capital injections may increase systemic risk, no significant effect on systemic risk is found for capital repayments. Subsample analyses further reveal that TARP may fail to encourage a decrease in market uncertainty and bank systemic risk even when forcing the largest U.S. commercial banks to accept capital assistance under the TARP-CPP. In contrast, empirical results rather indicate that in particular capital-aid towards smaller U.S. banks may be an impediment to restore market confidence and promote financial stability. Finally, capital injections into “qualifying”, unforced banks may be anticipated by capital market investors as a signal of higher financial distress whereas evidence suggests that repayments by forced banks are perceived as a signal of stronger financial recovery during a period of recovering capital market conditions.

Empirical findings remain robust even when performing a large variety of robustness checks, especially when employing control group regressions. However, as we cannot completely rule out that the statistical impact of capital injections and repayments on bank risk may be slightly biased by a general financial trend and resulting reverse causality effects, findings must be observed with caution.

Nevertheless, the analysis at hand generally reveals a light and a dark side of TARP. While the announcement of TARP and revised TARP including the TARP-CPP may help restore confidence and promote financial stability in the U.S. banking sector, respective capital infusions seem to harm bank financial soundness and confidence among capital market investors. If this is true, an increasing uncertainty due to capital assistance could be the result of an insufficient monitoring of supported banks in combination with inadequate reporting requirements as regards the supported banks’ reinvestment strategies after having received TARP capital injections. Therefore, future financial rescue programs should account for a consistent framework setting clear standards concerning (a) the selection of viable

“qualifying” banks, (b) the instruments of intervention and (c) an effective ex post-monitoring of supported banks in order to avoid adverse effects from capital assistance.

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Statistical Appendix

Figure 1

Timeline of TARP events

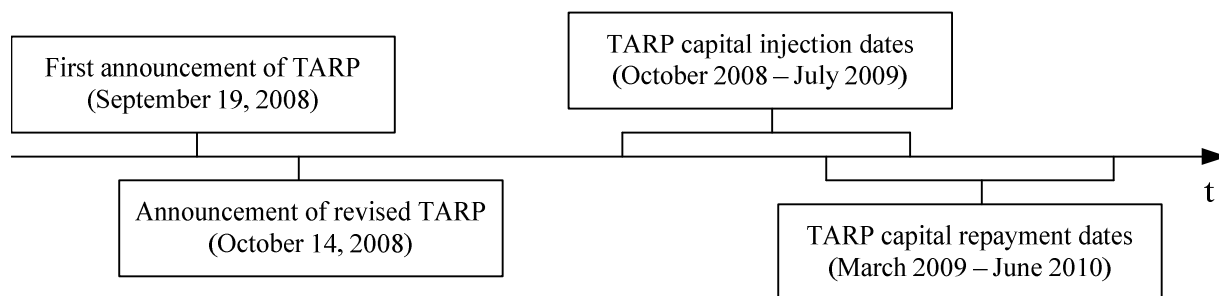


Figure 2

Volumes and numbers of capital injections and repayments under TARP in the sample.

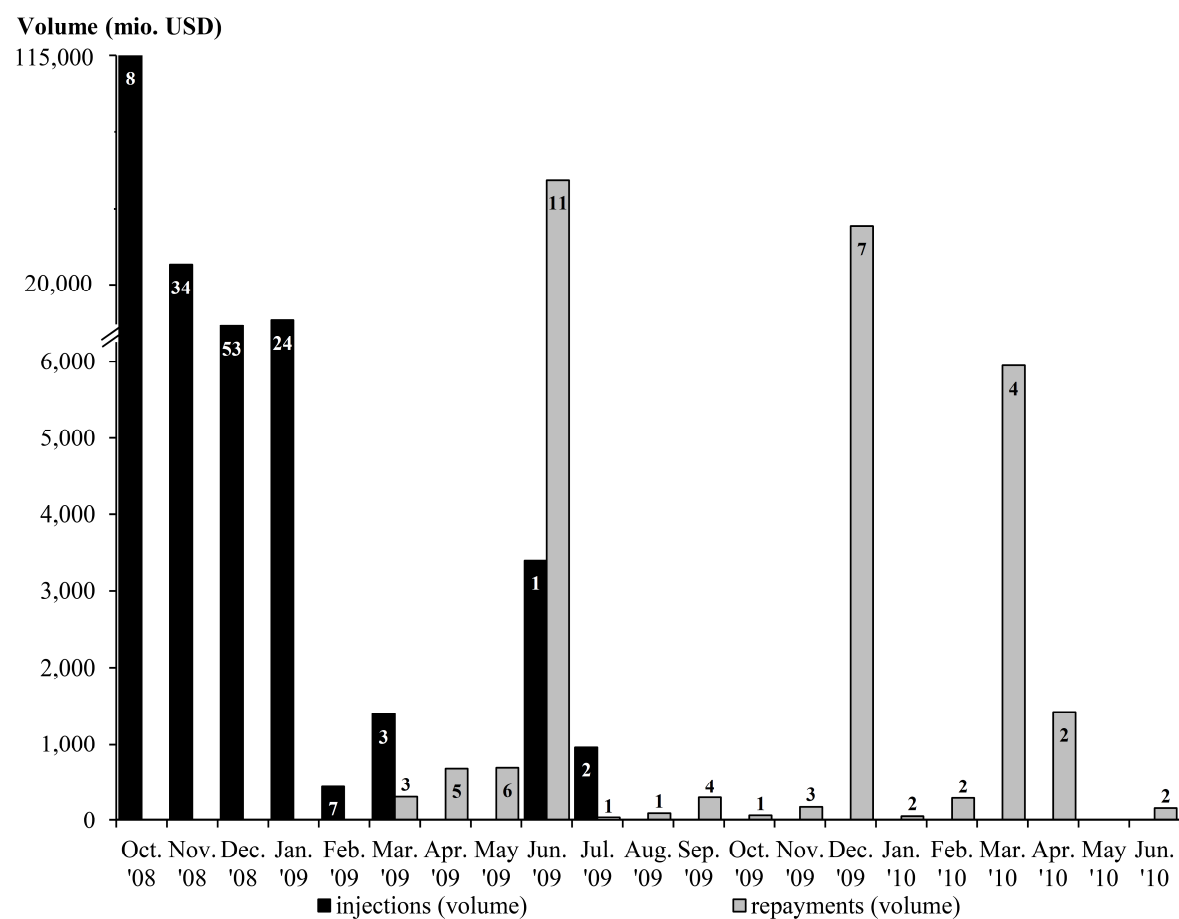


Table 1a

Changes in wealth effects around TARP event dates

$$\text{The model estimated is } CAAR_{i,t} = \frac{1}{N} \sum_{i=1}^N CAR_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} AR_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} R_{i,t} - (\tilde{\beta}_{i,0} + \tilde{\beta}_{i,1} R_{m,t}).$$

Daily average abnormal stock returns (AR_{it}) and cumulative average abnormal stock returns (CAAR_{it}) are calculated for single event days and different event window periods of 4 [-2;+2], 2 [-1;+1], 1 [-1;0] and 1 [0;+1] trading days around four TARP event dates t_0 . Coefficients of the market model are obtained from jointly maximum likelihood GARCH(1,1) regressions assuming a standard normal distribution. Standard errors are received from the two-sided parametric test proposed by Boehmer et al. (1991) and the two-sided non-parametric test proposed by Corrado and Zivney (1992) applied to AR_{it} and CAAR_{it}. ***, **, * indicates significance of the two-sided parametric tests proposed by Boehmer et al. (1991) at 1 %, 5 % and 10 %. ^a, ^b, ^c indicates significance of the two-sided non-parametric tests proposed by Corrado and Zivney (1992) at 1 %, 5 % and 10 %. The significance of net differences in calculated CAARs for the main event window period of 4 [-2;+2] trading days around the first announcement and the announcement of revised TARP is determined applying the difference-in-means t-test (DIMIT). +++, ++, + indicates significance at the 1 %, 5 % and 10 % level respectively. Regressions include daily log-normalized returns of bank stocks and the market portfolio which is proxied by the S&P 500 Index as the reference index for the U.S.

Event Window	1st Announcement	Revision	Infusion	Repayment
[-2;+2]	ARs (n = 125)	ARs (n = 125)	ARs (n = 132)	ARs (n = 54)
-2	4.27 ^{***a}	12.44 ^{***a}	-0.41	-0.11
-1	0.64 ^b	-7.71 ^{***a}	-0.05	0.25
0	8.55 ^{***a}	3.95 ^{***a}	-1.03 ^{***b}	0.04
1	0.40	7.14 ^{***a}	-0.86 ^{**a}	0.73 ^{**c}
2	-3.06 ^{***a}	1.11	0.09	-0.01
	CAARs (n = 125)	CAARs (n = 125)	CAARs (n = 132)	CAARs (n = 54)
[-2;+2]	10.81 ^{***a}	16.92 ^{***a}	-2.26 ^{***a}	0.90 ^{*c}
[-1;+1]	9.59 ^{***a}	3.37 ^{***b}	-1.94 ^{***a}	1.02 [*]
[-1; 0]	9.19 ^{***a}	-3.76 ^{***a}	-1.08 ^{**}	0.29
[0;+1]	8.95 ^{***a}	11.08 ^{***a}	-1.89 ^{***a}	0.77 ^{*c}
DIMIT		+++		

Figure 3a

The figures refer to Table 1a. They plot the development of cumulative abnormal returns (CAARs) for the 1st announcement of TARP, the revised announcement of TARP, 132 capital injections and 54 repayments within the event window period of 4 [-2;+2] trading days symmetrically set around the respective event dates t_0 .

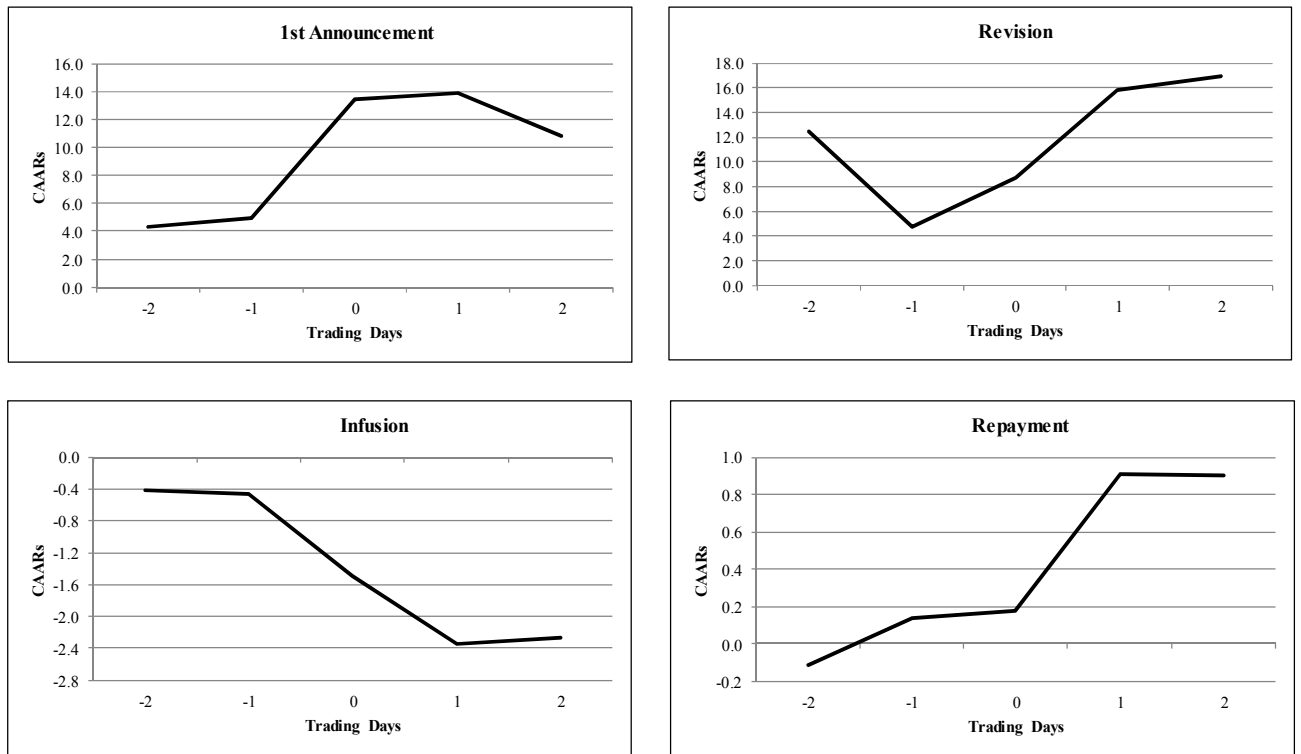


Table 1b

Changes in systematic risk around TARP event dates

The model estimated is $R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,0}D_{1,t} + \beta_{i,2}(T_1 - t)(t - T_2)D_{1,t}R_{m,t} + \beta_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}]R_{m,t} + \varepsilon_{i,t}$.

The estimations are based on a symmetrical event window period of 4 [-2;+2] trading days around four TARP event dates t_0 . Coefficients are obtained from maximum likelihood estimates of a GARCH(1,1) model assuming a normal distribution while standard errors are received from two-sided t-tests and Wilcoxon signed rank tests applied to means of estimated coefficients. Values in parentheses indicate the total number of each coefficient being significantly different from zero at the five-percent level. β_1 denotes the pre-event level of systematic risk, β_2 and β_3 describe time-variant betas during and after the event window, δ_0 measures any abnormal stock return during the event window period. ***, **, * indicates significance of the two-sided t-tests at 1 %, 5 % and 10 %. ^a, ^b, ^c indicates significance of the two-sided Wilcoxon signed-rank tests at 1 %, 5 % and 10 %. The significance of net differences in estimated coefficients β_3 for the main event window period of 4 [-2;+2] trading days around the first announcement and the announcement of revised TARP is determined applying the difference-in-means t-test (DIMIT). +++, ++, + indicates significance at the 1 %, 5 % and 10 % level respectively. Regressions include daily log-normalized returns of bank stocks and the market portfolio which is proxied by the S&P 500 Index as the reference index for the U.S.

Event Window	1st Announcement	Revision	Infusion	Repayment
[-2;+2]	Mean (n = 125)	Mean (n = 125)	Mean (n = 132)	Mean (n = 54)
β_1	1.5341568 ^{***a} (118)	1.5357888 ^{***a} (121)	1.3378430 ^{***a} (130)	1.5887690 ^{***a} (54)
δ_0	0.0161082 ^{***a} (32)	0.0402947 ^{***c} (48)	-0.0042238 ^{***b} (5)	0.0030577 ^{*b} (2)
β_2	0.1862715 ^{***a} (34)	-0.2592466 ^{***a} (34)	-0.0676285 ^a (6)	-0.0467336 (0)
β_3	-0.0418881 ^{***a} (33)	-0.0004837 ^{***b} (40)	0.1909932 ^{***a} (106)	-0.0611423 ^{***a} (21)
DIMIT		+		

Figure 2b

The figures refer to Table 3b. They plot the development of systematic risk (β_3) for the 1st announcement of TARP, the revised announcement of TARP, 132 capital injections and 54 repayments within the event window period of 4 [-2;+2] trading days symmetrically set around the respective event dates t_0 .

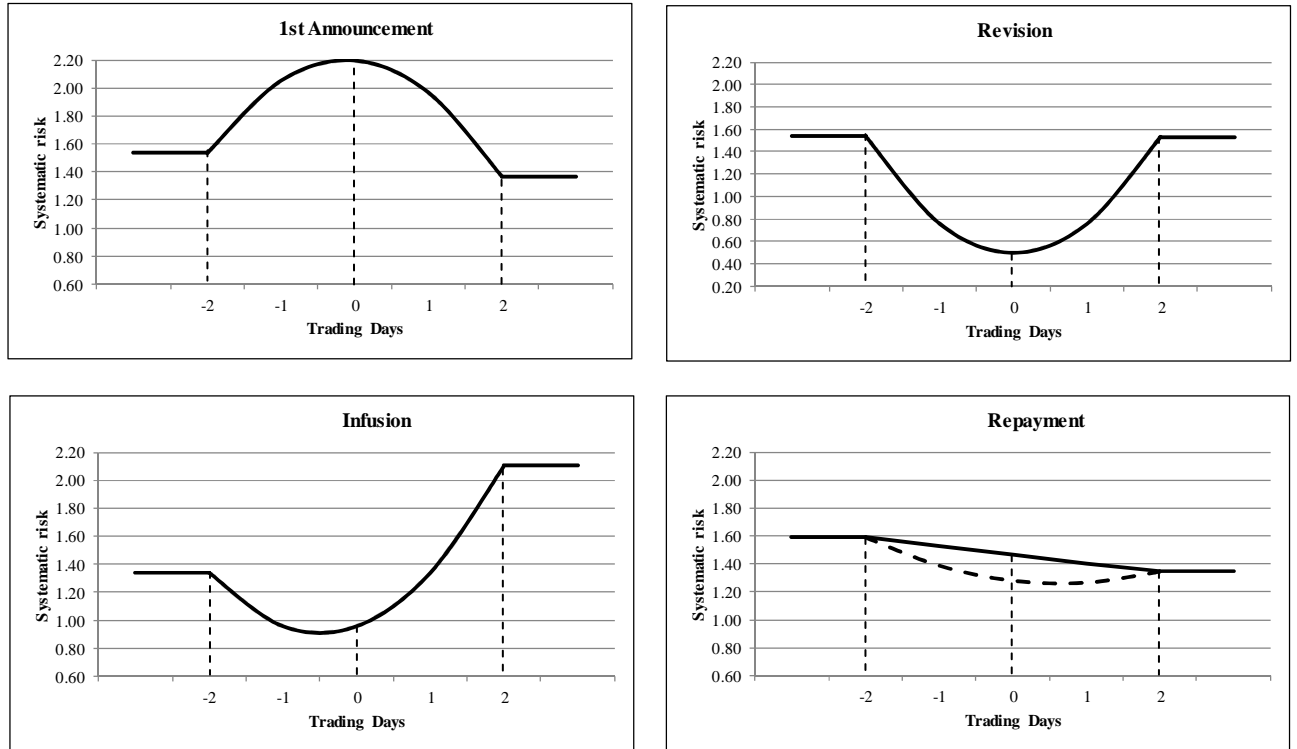


Table 1c

Decomposition of systematic risk around TARP event dates

The model estimated is $\tilde{R}_{i,t} = \rho_{i,0} + \rho_{i,1} \tilde{R}_{m,t} + \delta_{i,0} D_{1,t} + \rho_{i,2} (T_1 - t)(t - T_2) D_{1,t} + \rho_{i,3} [(t - T_1) D_{1,t} + (T_2 - T_1) D_{2,t}] \tilde{R}_{m,t} + \varepsilon_{i,t}$.

The estimations are based on a symmetrical event window period of 4 [-2;+2] trading days around four TARP event dates t_0 . Coefficients are obtained from maximum likelihood estimates of a GARCH(1,1) model assuming a normal distribution while standard errors are received from two-sided t-tests and Wilcoxon signed rank tests applied to means of estimated coefficients. Values in parentheses indicate the total number of each coefficient being significantly different from zero at the five-percent level. ρ_1 denotes the pre-event level of the correlation of individual bank stock returns with returns of the market portfolio, ρ_2 and ρ_3 describe time-variant correlation coefficients during and after the event window. ***, **, * indicates significance of the two-sided t-tests at 1 %, 5 % and 10 %. ^a, ^b, ^c indicates significance of the two-sided Wilcoxon signed-rank tests at 1 %, 5 % and 10 %. Δ RSD indicates the average change in the banks' individual standard deviation. The significance of net differences in estimated coefficients ρ_3 for the main event window period of 4 [-2;+2] trading days around the first announcement and the announcement of revised TARP is determined applying the difference-in-means t-test (DIMIT). +++, ++, + indicates significance at the 1 %, 5 % and 10 % level respectively. Regressions include daily log-normalized returns of bank stocks and the market portfolio which is proxied by the S&P 500 Index as the reference index for the U.S.

Event Window	1st Announcement	Revision	Infusion	Repayment
[-2;+2]	Mean (n = 125)	Mean (n = 125)	Mean (n = 132)	Mean (n = 54)
ρ_1	0.5092714 ^{***a} (121)	0.5890775 ^{***a} (121)	0.6479825 ^{***a} (130)	0.6426007 ^{***a} (53)
δ_0	0.2859398 ^{***a} (17)	0.7787971 ^{***a} (58)	-0.0449246 ^b (5)	0.0705438 (3)
ρ_2	0.0486227 ^{***a} (0)	0.0347543 ^{**b} (1)	0.0279866 ^{**a} (6)	-0.0277831 (1)
ρ_3	0.0376140 ^{***a} (57)	0.0207490 ^{***a} (49)	0.0097669 ^{***a} (106)	-0.0012372 (16)
DIMIT		+++		
Δ RSD	-0.2837864	-0.0894984	0.2597162	-0.0905624

Figure 3c

The figures refer to Table 1c. They plot the development of systemic risk (ρ_3) for the 1st announcement of TARP, the revised announcement of TARP, 132 capital injections and 54 repayments within the event window period of 4 [-2;+2] trading days symmetrically set around the respective event dates t_0 .

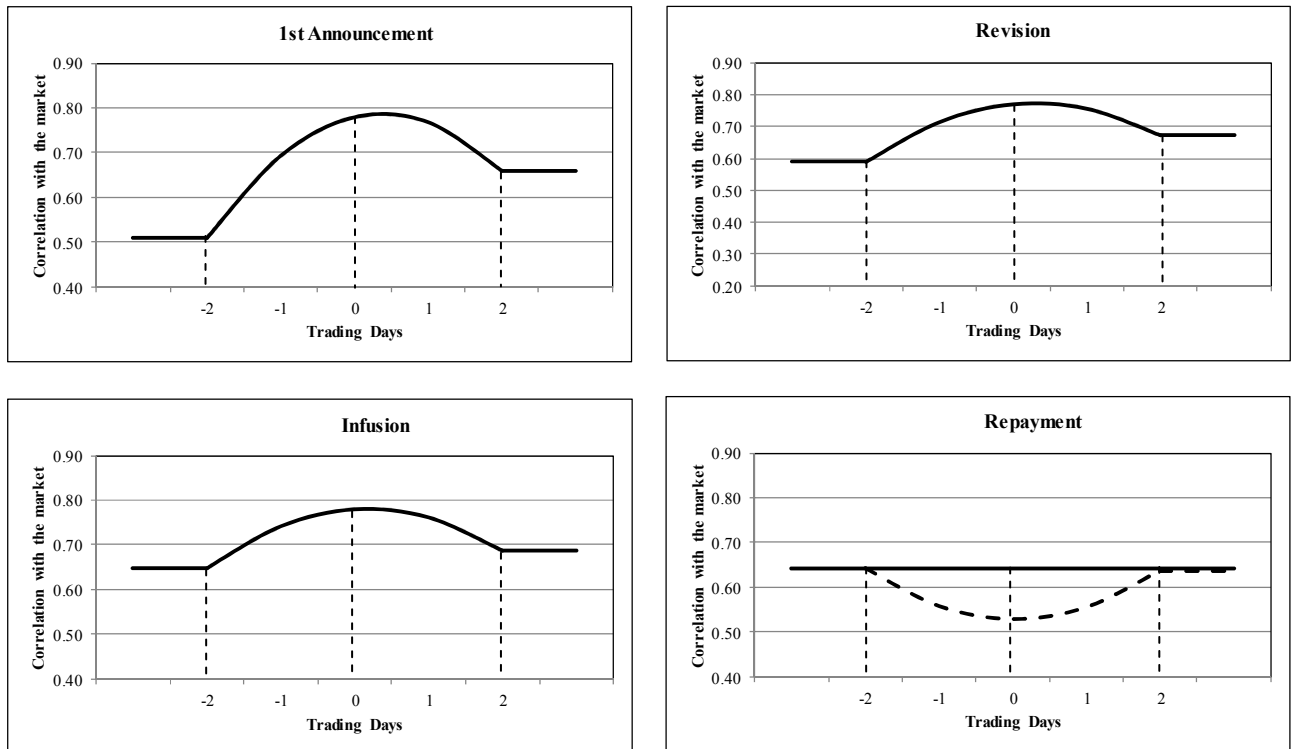


Table 2a

Robustness checks: Augmented Fama-French model (wealth effects)

The model estimated is

$$CAARs_t = \frac{1}{N} \sum_{i=1}^N CARs_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} ARs_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} R_{i,t} - R_{i,t}^* \text{ with } R_{i,t}^* = R_i - R_f = \alpha_i + \beta_1(R_{m,t} - R_f) + s_iSMB + h_iHML + m_iMom + \varepsilon_i.$$

Daily average abnormal stock returns (ARs_t) and cumulative average abnormal stock returns ($CAARs_t$) are calculated for single event days and different event window periods of 4 [-2;+2], 2 [-1;+1], 1 [-1;0] and 1 [0;+1] trading days around four TARP event dates t_0 . The wealth effects are calculated using the augmented Fama-French model (Carhart four-factor model). Coefficients are obtained from jointly maximum likelihood estimates of a GARCH(1,1) model assuming a standard normal distribution. The relevant test statistics and estimation parameters are defined in Table 1a.

Event Window	1st Announcement	Revision	Infusion	Repayment
[-2;+2]	ARs (n = 125)	ARs (n = 125)	ARs (n = 132)	ARs (n = 54)
-2	3.14 ^{***a}	5.35 ^{***a}	-0.08	-0.26
-1	0.94 ^{*a}	-0.33 ^b	-0.16	0.05
0	2.80 ^{***b}	3.01 ^{***a}	-0.92 ^{***a}	0.51
1	0.56	4.28 ^{***a}	-0.78 [*]	0.64 ^{**c}
2	-0.99 ^{**b}	1.83	0.10	-0.18
	CAARs (n = 125)	CAARs (n = 125)	CAARs (n = 132)	CAARs (n = 54)
[-2;+2]	5.34 ^{***a}	14.14 ^{***a}	-1.52 ^{***c}	0.76 ^{**a}
[-1;+1]	3.19 ^{***b}	6.95 ^{***b}	-1.55 ^{**b}	1.11 ^{**b}
[-1; 0]	3.74 ^{***a}	2.68 ^{**}	-0.76 ^{*c}	0.47
[0;+1]	2.24 ^{**}	7.28 ^{***a}	-1.70 ^{***a}	1.16 ^{**b}
DIMT		+++		

Table 2b

Robustness checks: Augmented Fama-French model (systematic risk)

The model estimated is

$$R_{i,t} - R_{f,t} = \beta_{i,0} + \beta_{i,1}(R_{m,t} - R_{f,t}) + \delta_{i,0}D_{1,t} + \beta_{i,2}(T_1 - t)(t - T_2)D_{1,t}(R_{m,t} - R_{f,t}) + \beta_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}](R_{m,t} - R_{f,t}) + s_iSMB_t + h_iHML_t + m_iMom_t + \varepsilon_{i,t}.$$

The systematic risk is calculated using the augmented Fama-French model (Carhart four-factor model). Coefficients are obtained from maximum likelihood estimates of a GARCH(1,1) model assuming a standard normal distribution. Relevant test statistics and estimation parameters are defined in Table 1b.

Event Window	1st Announcement	Revision	Infusion	Repayment
[-2;+2]	Mean (n = 125)	Mean (n = 125)	Mean (n = 132)	Mean (n = 54)
β_1	1.4682340 ^{***a} (117)	1.0850148 ^{***a} (115)	1.0930804 ^{***a} (127)	1.1712934 ^{***a} (53)
δ_0	0.0092648 ^{***a} (33)	0.0244205 ^{***a} (20)	-0.0023666 ^{***a} (8)	0.0026261 ^{**a} (3)
β_2	0.1621207 ^{**a} (27)	-0.0272220 ^{*b} (6)	-0.0448095 ^b (4)	-0.0518090 (0)
β_3	-0.0221933 ^{***a} (27)	-0.0002843 ^{*b} (43)	0.0772629 ^{***a} (65)	-0.0584410 ^{***a} (22)
s_i	-0.0035551 ^{***a} (53)	0.0119190 ^{***a} (98)	0.0114698 ^{***a} (102)	0.0063810 ^{***a} (40)
h_i	0.0002399 (124)	0.0141211 ^{***a} (122)	0.0177517 ^{***a} (129)	0.0090312 ^{***a} (53)
m_i	0.0002636 ^c (16)	-0.0013516 ^{***a} (42)	0.0010062 ^{**a} (56)	-0.0017745 ^{***a} (28)
DIMT		++		

Table 2c

Robustness checks: Augmented Fama-French model (decomposition of systematic risk)

The model estimated is

$$\tilde{R}_{i,t} - R_{f,t} = \rho_{i,0} + \rho_{i,1}(\tilde{R}_{m,t} - R_{f,t}) + \delta_{i,0}D_{1,t} + \rho_{i,2}(T_1 - t)(t - T_2)D_{1,t}(\tilde{R}_{m,t} - R_{f,t}) + \rho_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}](\tilde{R}_{m,t} - R_{f,t}) + s_iSMB_t + h_iHML_t + m_iMom_t + \varepsilon_{i,t}.$$

The decomposition of the systematic risk is calculated using the augmented Fama-French model (Carhart four-factor model). Coefficients are obtained from maximum likelihood estimates of a GARCH(1,1) model assuming a standard normal distribution. The relevant test statistics and estimation parameters are defined in Table 1c.

Event Window	1st Announcement	Revision	Infusion	Repayment
[-2;_t+2]	Mean (n = 125)	Mean (n = 125)	Mean (n = 132)	Mean (n = 54)
ρ_1	0.4822258 ^{***a} (123)	0.4321619 ^{***a} (117)	0.5481805 ^{***a} (128)	0.4477794 ^{***a} (47)
δ_0	0.3136331 ^{***a} (17)	0.4903527 ^{***a} (23)	-0.0259049 ^c (14)	0.0917171 (6)
ρ_2	0.0321916 ^{**a} (0)	0.2115106 ^{***b} (9)	0.0251274 ^{**b} (12)	-0.0241271 ^{**c} (0)
ρ_3	0.0461154 ^{***a} (71)	0.0157219 ^{***a} (50)	0.0222267 ^{***a} (44)	-0.0152651 (22)
s_i	-0.0560457 ^{***a} (33)	0.1902976 ^{***a} (95)	0.1765384 ^{***a} (105)	0.2047713 ^{***a} (40)
h_i	-0.0039555 (122)	0.2267498 ^{***a} (30)	0.2699250 ^{***a} (22)	0.2471617 ^{***a} (20)
m_i	0.0050322 ^{*b} (5)	-0.0192609 ^{***a} (36)	0.0228172 ^{***a} (55)	-0.0668284 ^{***a} (17)
DIMT		+++		
ΔRSD	-0.2336763	-0.0874963	0.0473715	-0.0110238

Table 3a

Robustness checks: Seemingly unrelated regressions (wealth effects)

The empirical model, estimation parameters and the relevant test statistics are defined in Table 1a. The model is estimated employing Zellner's (1962) seemingly unrelated regressions (SUR) to address likely cross-sectional correlation among the time series of bank stock returns.

Event Window [-2;+2]	1st Announcement ARs (n = 125)	Revision ARs (n = 125)	Infusion ARs (n = 132)	Repayment ARs (n = 54)
-2	3.95 ^{***a}	12.42 ^{***a}	-0.34 ^{**}	-0.15
-1	1.12 ^{*a}	-9.09 ^{***a}	-0.04	0.24
0	7.93 ^{***a}	3.86 ^{***a}	-0.81 ^{***a}	0.01
1	-0.19	8.06 ^{***a}	-0.71 ^{**b}	0.68 ^{**c}
2	-2.68 ^{***a}	0.50	-0.01	-0.04
	CAARs (n = 125)	CAARs (n = 125)	CAARs (n = 132)	CAARs (n = 54)
[-2;+2]	10.13 ^{***a}	15.76 ^{***a}	-1.91 ^{***b}	0.73 ^c
[-1;+1]	8.86 ^{***a}	2.83 ^{***a}	-1.56 ^{***b}	0.93
[-1; 0]	9.05 ^{***a}	-5.22 ^{***a}	-0.85 ^{***}	0.24
[0;+1]	7.73 ^{***a}	11.92 ^{***a}	-1.52 ^{***a}	0.69 ^c
DIMT		+++		

Table 3b

Robustness checks: Seemingly unrelated regressions (systematic risk)

The empirical model, estimation parameters and the relevant test statistics are defined in Table 1b and 3a.

Event Window [-2;+2]	1st Announcement Mean (n = 125)	Revision Mean (n = 125)	Infusion Mean (n = 132)	Repayment Mean (n = 54)
β_1	1.6592848 ^{***a} (123)	1.5265989 ^{***a} (123)	1.3044773 ^{***a} (132)	1.6498436 ^{***a} (54)
δ_0	0.0158842 ^{***a} (22)	0.0348853 ^{***a} (17)	-0.0040643 ^{**a} (19)	0.0028315 ^{*b} (8)
β_2	0.1683145 ^{***a} (29)	-0.2817382 ^{***a} (84)	-0.0703323 ^{*a} (54)	-0.0603836 (22)
β_3	-0.0719625 ^{***a} (39)	-0.0045126 ^{**b} (11)	0.2159610 ^{***b} (109)	-0.0716323 ^{***a} (25)
DIMT		++		

Table 3c

Robustness checks: Seemingly unrelated regressions (decomposition of systematic risk)

The empirical model, estimation parameters and the relevant test statistics are defined in Table 1c and 3a. "n.s." indicates no significance according to the difference-in-means t-test (DIMT) concerning estimated coefficients ρ_3 .

Event Window [-2;+2]	1st Announcement Mean (n = 125)	Revision Mean (n = 125)	Infusion Mean (n = 132)	Repayment Mean (n = 54)
ρ_1	0.5570153 ^{***a} (123)	0.5841668 ^{***a} (123)	0.6294597 ^{***a} (132)	0.6533993 ^{***a} (54)
δ_0	0.2557398 ^{***a} (19)	0.6967509 ^{***a} (24)	-0.0501281 ^c (19)	0.0674045 (8)
ρ_2	0.0503930 ^{***a} (14)	-0.0073493 (16)	0.0252690 ^{**a} (42)	-0.0370547 [*] (16)
ρ_3	0.0257105 ^{***a} (17)	0.0281643 ^{***a} (18)	0.0092297 ^{***a} (12)	-0.0008044 (16)
DIMT		n.s.		
Δ RSD	-0.2949246	-0.1275687	0.2714856	-0.1018258

Table 4a

Robustness checks: Control group regressions (wealth effects)

The empirical model, estimation parameters and test statistics are defined in Table 1a. Wealth effects refer to the baseline and control group regressions of non-TARP banks for respective dates of capital infusions and repayments.

Event Window	Infusion (baseline)	Infusion (control group)	Repayment (baseline)	Repayment (control group)
[-2;+2]	ARs (n = 132)	ARs (n = 132)	ARs (n = 54)	ARs (n = 54)
-2	-0.41	0.21	-0.11	-0.91 ^{***a}
-1	-0.05	1.03 ^{***b}	0.25	0.65 ^{***b}
0	-1.03 ^{***b}	0.05	0.04	-0.81
1	-0.86 ^{**a}	-0.36 ^b	0.73 ^{**c}	-0.38
2	0.09	-0.42 ^c	-0.01	0.51
	CAARs (n = 132)	CAARs (n = 132)	CAARs (n = 54)	CAARs (n = 54)
[-2;+2]	-2.26 ^{***a}	0.41	0.90 ^{*c}	-0.94
[-1;+1]	-1.94 ^{***a}	0.62	1.02 [*]	-0.54
[-1; 0]	-1.08 ^{**}	0.98 ^{**c}	0.29	-0.16
[0;+1]	-1.89 ^{***a}	-0.41	0.77 ^{*c}	-1.19 [*]
DIMT		++		++

Table 4b

Robustness checks: Control group regressions (systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1b. Changes in systematic risk refer to the baseline and control group regressions of non-TARP banks for respective dates of capital infusions and repayments.

Event Window	Infusion (baseline)	Infusion (control group)	Repayment (baseline)	Repayment (control group)
[-2;+2]	Mean (n = 132)	Mean (n = 132)	Mean (n = 54)	Mean (n = 54)
β_1	1.3378430 ^{***a} (130)	1.0027157 ^{***a} (128)	1.5887690 ^{***a} (54)	1.0585394 ^{***a} (47)
δ_0	-0.0042238 ^{***b} (5)	0.0009900 (2)	0.0030577 ^{*b} (2)	-0.0011334 (5)
β_2	-0.0676285 ^a (6)	-0.0234630 (4)	-0.0467336 (0)	0.1392899 (2)
β_3	0.1909932 ^{***a} (106)	0.0920554 ^{***a} (99)	-0.0611423 ^{***a} (21)	-0.0317315 ^{*c} (20)
DIMT		+++		+

Table 4c

Robustness checks: Control group regressions (decomposition of systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1c. Changes in idiosyncratic risk and systemic risk refer to the baseline and control group regressions of non-TARP banks for respective dates of capital infusions and repayments.

Event Window	Infusion (baseline)	Infusion (control group)	Repayment (baseline)	Repayment (control group)
[-2;+2]	Mean (n = 132)	Mean (n = 132)	Mean (n = 54)	Mean (n = 54)
ρ_1	0.6479825 ^{***a} (130)	0.5914992 ^{***a} (126)	0.6426007 ^{***a} (53)	0.4803669 ^{***a} (48)
δ_0	-0.0449246 ^b (5)	0.0458793 ^b (13)	0.0705438 (3)	-0.0202432 (4)
ρ_2	0.0279866 ^{**a} (6)	0.0256068 ^{*a} (7)	-0.0277831 (1)	-0.0151125 (2)
ρ_3	0.0097669 ^{***a} (106)	0.0105948 ^{***a} (33)	-0.0012372 (16)	-0.0012601 (24)
DIMT		++		++
Δ RSD	0.2597162	0.0932572	-0.0905624	-0.0147486

Table 5a

Robustness checks: Financial trend (systematic risk)

The models estimated are $R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,0}D_{1,t} + \beta_{i,2}(T_1 - t)(t - T_2)D_{1,t}R_{m,t} + \beta_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}]R_{m,t} + CFSI_t + \varepsilon_{i,t}$

and $R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,0}D_{1,t} + \beta_{i,2}(T_1 - t)(t - T_2)D_{1,t}R_{m,t} + \beta_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}]R_{m,t} + R_t^{MC} + \varepsilon_{i,t}$.

Estimation parameters and test statistics are defined in Table 1b. The first regression includes the Cleveland Financial Stress Index (CFSI) as a trend variable and the second regression includes Monte Carlo simulated index returns containing financial trends. “n.s.” indicates no significance according to the difference-in-means t-test (DIMIT) concerning estimated coefficients β_3 from baseline regressions in Table 1b.

Event Window	CFSI		Monte Carlo Simulation	
	Infusion Mean (n = 132)	Repayment Mean (n = 54)	Infusion Mean (n = 132,000)	Repayment Mean (n = 54,000)
[-2;+2]				
β_1	1.3495570 ^{***a} (129)	1.5888844 ^{***a} (53)	1.3475833 ^{***a} (131,098)	1.5894859 ^{***a} (53,403)
δ_0	-0.0040293 ^{**a} (4)	0.0031338 ^{*c} (3)	-0.0040065 ^{**b} (4,865)	0.0026050 ^{*b} (1,765)
β_2	-0.0709951 [*] (6)	-0.0465253 (0)	-0.0669470 [*] (5,872)	-0.0453817 (134)
β_3	0.1881084 ^{***a} (104)	-0.0606296 ^{***a} (20)	0.1887685 ^{***a} (104,203)	-0.0602598 ^{***a} (19,872)
Trend	-0.0028821 ^{**b} (12)	-0.0017893 ^{***a} (7)	0.0098409 ^{**a} (12,408)	0.0070564 ^{*c} (6,431)
DIMIT	n.s.	n.s.	n.s.	n.s.

Table 5b

Robustness checks: Financial trend (decomposition of systematic risk)

The models estimated are $\tilde{R}_{i,t} = \rho_{i,0} + \rho_{i,1}\tilde{R}_{m,t} + \delta_{i,0}D_{1,t} + \rho_{i,2}(T_1 - t)(t - T_2)D_{1,t}\tilde{R}_{m,t} + \rho_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}]\tilde{R}_{m,t} + CFSI_t + \varepsilon_{i,t}$

and $\tilde{R}_{i,t} = \rho_{i,0} + \rho_{i,1}\tilde{R}_{m,t} + \delta_{i,0}D_{1,t} + \rho_{i,2}(T_1 - t)(t - T_2)D_{1,t}\tilde{R}_{m,t} + \rho_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}]\tilde{R}_{m,t} + R_t^{MC} + \varepsilon_{i,t}$.

Estimation parameters and test statistics are defined in Table 1c and 5a. “n.s.” indicates no significance according to the difference-in-means t-test (DIMIT) concerning estimated coefficients ρ_3 from baseline regressions in Table 1c.

Event Window	CFSI		Monte Carlo Simulation	
	Infusion Mean (n = 132)	Repayment Mean (n = 54)	Infusion Mean (n = 132,000)	Repayment Mean (n = 54,000)
[-2;+2]				
ρ_1	0.6553143 ^{***a} (126)	0.6465883 ^{***a} (53)	0.6544129 ^{***a} (130,647)	0.6490537 ^{***a} (53,698)
δ_0	-0.0506244 ^c (9)	0.0994183 (2)	-0.0553089 ^c (5,123)	0.0922465 (2,749)
ρ_2	0.0283456 ^{**c} (7)	-0.0281172 (1)	0.0287464 ^{**} (5,967)	-0.0260459 (156)
ρ_3	0.0081573 ^{***a} (27)	-0.0024942 (20)	0.0082354 ^{***a} (103,452)	-0.0027635 (22,456)
Trend	-0.0578868 ^{***b} (11)	-0.0474688 ^{***b} (6)	0.1114677 ^{**b} (11,872)	0.0556884 ^{**c} (7,653)
DIMIT	n.s.	n.s.	n.s.	n.s.
Δ RSD	0.2582013	-0.0846158	0.2592778	-0.0827681

Table 6a

Subsamples: Multiple vs. single capital infusions (wealth effects)

The empirical model, estimation parameters and test statistics are defined in Table 1a. The entire sample is divided into banks that received more than one capital infusion under TARP (multiple transactions) and those that received capital assistance only once. All estimation results are based on the respective dates of capital assistance to banks.

Event Window	Multiple capital infusions	Single capital infusions
	ARs (n = 7)	ARs (n = 125)
[-2;+2]		
-2	0.49	-0.47
-1	0.41 ^{***b}	-0.07
0	-0.96	-1.04 ^{***b}
1	-1.44 ^b	-0.83 ^{***b}
2	-0.90 ^c	0.15
	CAARs (n = 7)	CAARs (n = 125)
[-2;+2]	-2.39	-2.25 ^{***b}
[-1;+1]	-1.98	-1.94
[-1;0]	-0.55 ^{***c}	-1.11
[0;+1]	-2.40	-1.86 [*]
DIMT	n.s.	

Table 6b

Subsamples: Multiple vs. single capital infusions (systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1b and 6a.

Event Window	Multiple capital infusions	Single capital infusions
	Mean (n = 7)	Mean (n = 125)
[-2;+2]		
β_1	1.5170863 ^{***b} (7)	1.3164044 ^{***a} (123)
δ_0	0.0029984 (0)	-0.0043021 ^{**b} (5)
β_2	-0.0523502 ^c (0)	-0.0756118 ^{*a} (6)
β_3	0.1869956 ^{***c} (5)	0.1917135 ^{***a} (100)
DIMT	n.s.	

Table 6c

Subsamples: Multiple vs. single capital infusions (decomposition of systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1c and 6a.

Event Window	Multiple capital infusions	Single capital infusions
	ARs (n = 7)	ARs (n = 125)
[-2;+2]		
ρ_1	0.6513601 ^{***b} (7)	0.6456434 ^{***a} (119)
δ_0	-0.1244713 (0)	-0.0377370 (8)
ρ_2	0.0403028 (0)	0.0269718 ^{**a} (8)
ρ_3	0.0087696 (1)	0.0103312 ^{***a} (29)
DIMT	n.s.	
Δ RSD	0.3227887	0.2601460

Table 7a

Subsamples: Volume of capital assistance to market capitalization (wealth effects)

The empirical model, estimation parameters and test statistics are defined in Table 1a. The entire sample is divided into three sub samples based on small, medium and large capital assistance relative to the banks' market capitalization. All estimation results are based on the respective dates of capital infusions to TARP-banks.

Infusion	Small	Midsize	Large
Event Window			
[-2;+2]	ARs (n = 33)	ARs (n = 66)	ARs (n = 33)
-2	-0.78	-0.34	-0.21
-1	-1.52 ^b	-0.39	-0.93
0	-1.77 ^{**b}	-1.02 ^{**b}	-0.31
1	-1.25 ^{*a}	-0.61	-0.97 ^{*c}
2	-0.31	0.41	-0.77
	CAARs (n = 33)	CAARs (n = 66)	CAARs (n = 33)
[-2;+2]	-1.97^{**b}	-1.94^{*c}	-3.19^{**c}
[-1;+1]	-1.50^b	-2.02^{**b}	-2.21^{**c}
[-1; 0]	-0.25	-1.41^{*c}	-1.25
[0;+1]	-3.02^{*c}	-1.63^{**c}	-1.28^{*c}
DIMT	++large	++large	++small ++midsize

Table 7b

Subsamples: Volume of capital assistance to market capitalization (systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1b and 7a.

Infusion	Small	Midsize	Large
Event Window			
[-2;+2]	Mean (n = 33)	Mean (n = 66)	Mean (n = 33)
β_1	1.3546316 ^{***a} (33)	1.3061867 ^{***a} (65)	1.3843671 ^{***a} (32)
δ_0	-0.0026334 ^{*c} (3)	-0.0036075 ^c (5)	-0.0070469 ^{*b} (3)
β_2	0.0390475 (2)	-0.1110784 ^{**a} (2)	-0.0874046 ^b (2)
β_3	0.1427611 ^{***a} (25)	0.2045829 ^{***a} (57)	0.2120458 ^{***a} (24)
DIMT	++midsize ++large	++small ++large	++small ++midsize

Table 7c

Subsamples: Volume of capital assistance to market capitalization (decomposition of systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1c and 7a.

Infusion	Small	Midsize	Large
Event Window			
[-2;+2]	Mean (n = 33)	Mean (n = 66)	Mean (n = 33)
ρ_1	0.6902050 ^{***a} (33)	0.6396517 ^{***a} (64)	0.6224216 ^{***a} (32)
δ_0	-0.0787975 ^{*c} (3)	-0.0093719 (5)	-0.0821571 (1)
ρ_2	0.0325197 (2)	0.0217671 ^c (6)	0.0358925 ^{*b} (1)
ρ_3	0.0031095 ^{***a} (25)	0.0163732 ^{***a} (16)	0.0192117 ^{**b} (7)
DIMT	++midsize ++large	++small ++large	++small ++midsize
Δ RSD	0.1971087	0.2608870	0.3275121

Table 8a

Subsamples: Forced vs. unforced banks (wealth effects)

The empirical model, estimation parameters and test statistics are defined in Table 1a. The entire sample is divided into banks being forced to receive capital assistance under TARP and banks that applied for capital assistance as qualifying banks. Estimation results are based on respective dates of capital assistance to banks and repayment dates.

Event window	Infusion		Repayment	
	Forced ARs (n = 8)	Unforced ARs (n = 124)	Forced ARs (n = 7)	Unforced ARs (n = 47)
[-2;+2]	0.46	-0.35	0.75	-0.24
-1	-0.04	-0.18	0.57	0.20
0	-0.69 ^{***a}	-6.41 ^{**c}	1.39 ^{***a}	0.25
1	-0.84	-1.17 ^{**b}	0.37	0.78 ^{**}
2	0.24	-2.26	0.76	-0.12
	CAARs (n = 8)	CAARs (n = 124)	CAARs (n = 7)	CAARs (n = 47)
[-2;+2]	-1.78 ^{***b}	-9.67 ^{**b}	1.06 ^{**c}	0.87 ^{*c}
[-1;+1]	-1.56 ^{***b}	-7.76 ^{*b}	-0.44	1.24 ^{*c}
[-1; 0]	0.72 [*]	-6.59 [*]	-0.82	0.46
[0;+1]	-1.52 ^{***a}	-7.58 ^{**a}	-1.02	1.04 [*]
DIMT		+++		+

Table 8b

Subsamples: Forced vs. unforced banks (systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1b and 8a.

Event window	Infusion		Repayment	
	Forced Mean (n = 8)	Unforced Mean (n = 124)	Forced Mean (n = 7)	Unforced Mean (n = 47)
β_1	1.8471286 ^{***b} (8)	1.3049859 ^{***a} (122)	2.1830624 ^{***b} (7)	1.5002572 ^{***a} (47)
δ_0	-0.0034496 ^{***b} (1)	-0.0163228 ^{**b} (4)	0.0075984 ^{*c} (1)	0.0023814 ^{*c} (1)
β_2	-0.2101598 ^{***b} (1)	-0.0584329 ^a (5)	-0.0073262 (0)	-0.0526028 (0)
β_3	0.1017305 ^{***b} (4)	0.1967521 ^{***a} (102)	-0.1621684 ^{***b} (5)	-0.0460959 ^{***a} (16)
DIMT		++		++

Table 8c

Subsamples: Forced vs. unforced banks (decomposition of systematic risk)

The empirical model, estimation parameters and test statistics are defined in Table 1c and 8a.

Event window	Infusion		Repayment	
	Forced Mean (n = 8)	Unforced Mean (n = 124)	Forced Mean (n = 7)	Unforced Mean (n = 47)
ρ_1	0.7682803 ^{***b} (8)	0.6402213 ^{***a} (117)	0.7271220 ^{***b} (7)	0.6300125 ^{***a} (46)
δ_0	-0.0381716 ^{**c} (0)	-0.1295538 ^{*c} (8)	0.0116899 ^{*c} (1)	0.0827914 ^{*c} (2)
ρ_2	0.0374001 ^{**c} (0)	0.0273793 ^{**a} (8)	-0.0324613 (0)	-0.0270864 (1)
ρ_3	0.0124862 ^{*c} (4)	0.0244606 ^{***a} (26)	-0.0110428 (1)	-0.0030661 (15)
DIMT		+		n.s.
Δ RSD	0.1880399	0.2660675	-0.2646056	-0.0618786

Technical Appendix

1. Calculating abnormal returns in stock prices

We measure share price reactions to the four TARP events by computing abnormal stock returns ($AR_{i,t}$) as the differences between the realized stock returns ($R_{i,t}$) and benchmark returns at and around each event date. Benchmark returns are predicted by employing the standard market model (CAPM). The CAPM parameters are estimated by

$$R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \varepsilon_{i,t}. \quad (A1)$$

We assume that the variance of the standard error $\varepsilon_{i,t}$ is not constant but more probably conditionally heteroskedastic and thus, predictable by including (G)ARCH structures (Bollerslev et al., 1992; Bera and Higgins, 1992). Thus, we employ a more general GARCH(1,1) model to account for volatility clustering. Allowing the conditional variance of the error term $\varepsilon_{i,t}$ to follow a GARCH(1,1) process, we generalize

$$\sigma_{i,t}^2 = \alpha_{i,0} + \alpha_{i,1}\varepsilon_{i,t-1}^2 + \alpha_{i,2}\sigma_{i,t-1}^2 \quad (A2)$$

where $\sigma_{i,t}^2 = \text{Var}(\varepsilon_{i,t} | I_{t-1})$ with I_{t-1} denoting the information set at time $t-1$. We estimate the mean and conditional variance (Equations (A1) and (A2)) jointly by maximum likelihood while assuming a standard normal distribution.

Finally, CAARs for N TARP events over event window periods moving around day t_0 (from day T_1 to T_2) are calculated as

$$CAARs_t = \frac{1}{N} \sum_{i=1}^N CARs_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} ARs_{i,t} = \frac{1}{N} \sum_{i=1}^N \sum_{t=T_1}^{T_2} R_{i,t} - (\tilde{\beta}_{i,0} + \tilde{\beta}_{i,1} R_{m,t}). \quad (A3)$$

2. Calculating changes in systematic risk

Under the framework of the CAPM, a change in bank systematic risk is described by a change in the beta factor which again is determined by (1) varying *standard deviations* of bank stock returns and (2) *correlations* of bank stock returns with returns of the market portfolio (market returns). Accordingly, a significant change in systematic risk may be triggered by either component of the beta factor.

Against this background we derive our basic regression model from the CAPM as

$$R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,0}D_{1,t} + \beta_{i,1}^{\Delta\text{event}}D_{1,t}R_{m,t} + \beta_{i,1}^{\Delta\text{after}}D_{2,t}R_{m,t} + \eta_{i,t}, \quad (A4)$$

where $R_{i,t}$ and $R_{m,t}$ are the daily log returns on banks' stocks i and the market portfolio m at trading day t . D_i are dummy variables to specify the event windows, $\eta_{i,t}$ is the error term and β_i are the parameters of systematic risk to be estimated. Finally, $\delta_{i,0}$ measures any abnormal stock return during the event window period.

$D_{1,t}$ is a dummy variable equaling one in a symmetrical window around day t_0 if $T_1 \leq t \leq T_2$ (with T_1 and T_2 being defined as the beginning and the end of the event period), and zero otherwise. $D_{2,t}$ is a dummy variable equaling one after the event period if $t > T_2$ and zero in all other cases.

Following the methodology provided by Lockwood and Kadiyala (1988) as well as Cyree and DeGennaro (2002), we assume that the change in systematic risk does not necessarily have to follow a linear function. We therefore set time varying betas as follows:

$$\beta_{i,1}^{\Delta\text{event}} = \beta_{i,2}(T_1 - t)(t - T_2) + \beta_{i,3}(t - T_1) + v_{i,t}, \quad (\text{A5})$$

$$\beta_{i,1}^{\Delta\text{after}} = \beta_{i,3}(T_2 - T_1) + \xi_{i,t}. \quad (\text{A6})$$

Specification (A5) describes $\beta_{i,1}^{\Delta\text{event}}$ as the marginal change of systematic risk within the event window and allows $\beta_{i,1}$ following a continuous concave, convex or linear function. Hence, we observe significant changes in systematic risk during the event window period, which may have remained undetected by related event studies on the impact of TARP events on systematic risk (Elyasiani et al., 2011).¹ Specification (A6) describes $\beta_{i,1}^{\Delta\text{after}}$ as the marginal change of systematic risk within the post-event period. Hence, $\beta_{i,1}$ may exit the event period at a higher or lower level compared to the period foregoing the event. Obviously, $\beta_{i,1}$ may also follow a constant course if $\beta_{i,2}$ and $\beta_{i,3}$ become insignificant.

As a result of introducing time varying betas and implementing $\beta_{i,2}$ and $\beta_{i,3}$ in equations (A5) and (A6), the coefficients $\beta_{i,1}^{\Delta\text{event}}$ and $\beta_{i,1}^{\Delta\text{after}}$ cannot be observed directly but need to be estimated as $\hat{\beta}_{i,1}^{\Delta\text{event}}$ and $\hat{\beta}_{i,1}^{\Delta\text{after}}$

¹ Basically, $\beta_{i,1}^{\Delta\text{event}}$ can take any form, however, modelling any possible function is beyond the scope of our analysis. Nevertheless, as the impact of TARP announcements and TARP transactions on the bank's overall risk exposure depends on both a direct and indirect (dynamic) impact it is compulsory to provide this minimum of flexibility.

including an error-term. Integrating equations (A5) and (A6) into the basic equation (A4) we obtain a modified regression model:

$$R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,1}D_{1,t} + [\beta_{i,2}(T_1 - t)(t - T_2) + \beta_{i,3}(t - T_1) + v_{i,t}]D_{1,t}R_{m,t} + [\beta_{i,3}(T_2 - T_1) + \xi_{i,t}]D_{2,t}R_{m,t} + \eta_{i,t} . \quad (A7)$$

Rearranging equation (A7), we attain the modified regression model as

$$R_{i,t} = \beta_{i,0} + \beta_{i,1}R_{m,t} + \delta_{i,0}D_{1,t} + \beta_{i,2}(T_1 - t)(t - T_2)D_{1,t}R_{m,t} + \beta_{i,3}[(t - T_1)D_{1,t} + (T_2 - T_1)D_{2,t}]R_{m,t} + \varepsilon_{i,t} . \quad (A8)$$

The development of systematic risk during and after the event window is calculated as follows. Equation (A8) serves as the starting point. Setting dummy variables $D_1 = 1$, $D_2 = 0$ we obtain

$$\beta_{i,1} + \beta_{i,2}(T_1 - t)(t - T_2) + \beta_{i,3}(t - T_1) \quad (A8a)$$

and setting dummy variables $D_1 = 0$; $D_2 = 1$ we obtain

$$\beta_{i,1} + \beta_{i,3}(T_2 - T_1). \quad (A8b)$$

The parameters T_1 and T_2 define the main event window of 4 trading days symmetrically set around the respective TARP event date t_0 so that $T_1 = -2$ and $T_2 = +2$ while t denotes the actual trading day within the event window running from $t = -2$ to $t = +2$. Inserting means of estimated coefficients β_1 , β_2 and β_3 into term (A8a) allows calculating the development of systematic risk during the event window and per trading day t . Inserting means of estimated coefficients β_1 and β_3 into term (A8b) allows calculating the development of systematic risk after the event window period.

Allowing for time varying betas during and after the event period introduces the error term $\varepsilon_{i,t}$ in equation (A8) as a function of the market return $R_{m,t}$ with (a) $\varepsilon_{i,t} = \eta_{i,t}$ over the whole estimation period, (b) $\varepsilon_{i,t} = \eta_{i,t} + v_{i,t}R_{m,t}$ during the event period and (c) $\varepsilon_{i,t} = \eta_{i,t} + \xi_{i,t}R_{m,t}$ within the post-event period. Corresponding to our methodology employed to estimate market parameters in order to calculate abnormal bank stock returns we allow the conditional variance of the error term $\varepsilon_{i,t}$ to follow a GARCH(1,1) process and generalize

$$\sigma_{i,t}^2 = \alpha_{i,0} + \alpha_{i,1}\varepsilon_{i,t-1}^2 + \alpha_{i,2}\sigma_{i,t-1}^2, \quad (A9)$$

where $\sigma_{i,t}^2 = \text{Var}(\varepsilon_{i,t} | I_{t-1})$ with I_{t-1} denoting the information set at time $t-1$.

3. Calculating the decomposition of the change in systematic risk

Defining β_i as

$$\beta_i = \rho_{i,m} \frac{\sigma_i}{\sigma_m}, \quad (\text{A10})$$

the beta factor is described by the product of the correlation of individual bank stock returns with returns of the market portfolio ($\rho_{i,m}$) and the relative standard deviation of bank stock returns (σ_i / σ_m), defined as the standard deviation of bank stock returns (σ_i) in relation to the standard deviation of the returns of the market portfolio (σ_m). Consequently, a significant change in a bank's systematic risk may be triggered by either component of the beta factor.

Following the methodology provided by Nijskens and Wagner (2011), a three-step approach is used to decompose systematic risk.

(i) Individual bank stock returns and returns of the market portfolio are normalized by employing respective standard deviations of stock returns before, during and after the event window period.

(ii) Normalized bank stock and market portfolio returns are integrated into baseline regression specification (A4) to obtain a modified regression model as

$$\tilde{R}_{i,t} = \rho_{i,0} + \rho_{i,1} \tilde{R}_{m,t} + \delta_{i,0} D_{1,t} + \rho_{i,1}^{\Delta \text{event}} D_{1,t} \tilde{R}_{m,t} + \rho_{i,1}^{\Delta \text{after}} D_{2,t} \tilde{R}_{m,t} + \eta_{i,t}, \quad (\text{A11})$$

where $\rho_{i,1}^{\Delta \text{event}}$ and $\rho_{i,1}^{\Delta \text{after}}$ are defined as

$$\rho_{i,1}^{\Delta \text{event}} = \rho_{i,2}(T_1 - t)(t - T_2) + \rho_{i,3}(t - T_1) + v_{i,t}, \quad (\text{A12})$$

$$\rho_{i,1}^{\Delta \text{after}} = \rho_{i,3}(T_2 - T_1) + \xi_{i,t} \quad (\text{A13})$$

$$\text{with } \tilde{R}_{i,t} = \begin{cases} R_{i,t} / \sigma_{i,t < T_1} & \text{if } t < T_1 \\ R_{i,t} / \sigma_{i,T_1 \leq t \leq T_2} & \text{if } T_1 \leq t \leq T_2 \\ R_{i,t} / \sigma_{i,t > T_2} & \text{if } t > T_2 \end{cases} \quad \text{and} \quad \tilde{R}_{m,t} = \begin{cases} R_{m,t} / \sigma_{m,t < T_1} & \text{if } t < T_1 \\ R_{m,t} / \sigma_{m,T_1 \leq t \leq T_2} & \text{if } T_1 \leq t \leq T_2 \\ R_{m,t} / \sigma_{m,t > T_2} & \text{if } t > T_2 \end{cases}$$

being daily log normalized returns on banks' stocks i and the market portfolio m at trading day t . $D_{i,t}$ are dummy variables to specify the event windows and $\eta_{i,t}$ is the error term. Finally, $\rho_{i,l}$ are parameters to be estimated denoting the correlation of individual bank stock returns with returns of the market portfolio.

Integrating equations (A12) and (A13) into equation (A11) and rearranging equation (11), we attain

$$\begin{aligned} \tilde{R}_{i,t} = & \rho_{i,0} + \rho_{i,1} \tilde{R}_{m,t} + \delta_{i,0} D_{1,t} + \rho_{i,2} (T_1 - t)(t - T_2) D_{1,t} \tilde{R}_{m,t} \\ & + \rho_{i,3} \left[(t - T_1) D_{1,t} + (T_2 - T_1) D_{2,t} \right] \tilde{R}_{m,t} + \varepsilon_{i,t}. \end{aligned} \quad (A14)$$

Corresponding to the methodology employed to calculate abnormal bank stock returns and estimate bank systematic risk we allow the conditional variance of the error term $\varepsilon_{i,t}$ to follow a GARCH(1,1) process and generalize

$$\sigma_{i,t}^2 = \alpha_{i,0} + \alpha_{i,1} \varepsilon_{i,t-1}^2 + \alpha_{i,2} \sigma_{i,t-1}^2, \quad (A15)$$

where $\sigma_{i,t}^2 = \text{Var}(\varepsilon_{i,t} | I_{t-1})$ with I_{t-1} denoting the information set at time $t-1$.

(iii) Given that $\beta_{i,1}^{\text{after}}$ proxies bank systematic risk after the event window period, it is defined as

$$\beta_i^{\text{after}} = \beta_{i,1} + \beta_i^{\Delta \text{after}}. \quad (A16)$$

Integrating equation (A10) into equation (A16), we obtain a “modified” version of $\beta_{i,1}^{\text{after}}$ as

$$\beta_i^{\text{after}} = \rho_{i,m}^{\text{after}} \frac{\sigma_i^{\text{after}}}{\sigma_m^{\text{after}}} = (\rho_{i,1} + \rho_{i,1}^{\Delta \text{after}}) \frac{\sigma_i^{\text{after}}}{\sigma_m^{\text{after}}}. \quad (A17)$$

Rearranging equation (A16) and employing the “modified” version of $\beta_{i,1}^{\text{after}}$ (A17), we attain the basic equation of the relative standard deviation of bank stock returns after the event window period ($\sigma_i^{\text{after}} / \sigma_m^{\text{after}}$) as

$$\frac{\sigma_i^{\text{after}}}{\sigma_m^{\text{after}}} = \frac{\beta_{i,1} + \beta_i^{\Delta \text{after}}}{\rho_{i,1} + \rho_{i,1}^{\Delta \text{after}}}. \quad (A18)$$

The change in the relative standard deviation of bank stock returns during the event window period ($\sigma_i^{\Delta \text{after}} / \sigma_m^{\Delta \text{after}}$) is then obtained by rearranging equation (A18) as

$$\frac{\sigma_i^{\Delta \text{after}}}{\sigma_m^{\Delta \text{after}}} = \frac{\sigma_i^{\text{after}}}{\sigma_m^{\text{after}}} - \frac{\sigma_i^{\text{before}}}{\sigma_m^{\text{before}}} = \frac{\beta_{i,1} + \beta_i^{\Delta \text{after}}}{\rho_{i,1} + \rho_{i,1}^{\Delta \text{after}}} - \frac{\beta_{i,1}}{\rho_{i,1}}. \quad (A19)$$

Finally, the marginal change of the relative standard deviation of individual bank stock returns during the event window period is calculated by integrating estimated coefficients from regression specifications (A4) and (A11) into equation (A19).