The Impact of Government Intervention on the Stabilization of Domestic Financial Markets and on U.S. Banks' Asset Composition[‡]

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Abstract: The 2007-2009 financial crisis that evolved from various factors including the housing boom, aggressive lending activity, financial innovation, and increased access to money and capital markets prompted unprecedented U.S. government intervention in the financial sector. We examine changes in banks' balance sheet composition associated with U.S. government intervention during the crisis. We find that the initial round of quantitative easing positively impacts bank liquidity across all bank samples. Our results show a positive impact of repurchase agreement market rates on bank liquidity for small and medium banks. We conclude that banks have become more liquid in the post-crisis period, especially the larger banks (large and money center banks). We show that real estate loan portfolio exposures have reverted to pre-crisis levels for money center banks and remained flat for all other bank samples.

Keywords: Bank Liquidity, Government Intervention, Quantitative Easing, Dynamic Panel Data Methods
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1. Introduction

The 2007-2009 financial crisis that spawned from various factors such as the housing boom, aggressive mortgage lending activity, financial innovation through the creation of new funding products, and an increased access to money and capital markets culminated with unprecedented U.S. government intervention in the financial sector. Cecchetti (2009) and others claimed that by the summer of 2007 it was clear banks and other financial institutions stood to lose billions of dollars from their exposure to subprime mortgage loans. In the advent of the housing boom, Watson (2008) mentions that riskier loans to less creditworthy borrowers became common, and thus the market of potential borrowers had expanded beyond traditional bounds using a variety of non-traditional mortgage contracts. The aforementioned author claims the development that had a strong impact on the credit problems during the financial crisis was the funding of uninsured mortgage credit to borrowers whose credit history prevented them from obtaining conventional loans. Many researchers argue the housing finance model was predicated on rising real estate prices. After several years of double-digit increases, fueled in large part by real estate investor purchases rather than homeowner purchases, the market appreciably softened. Factors that contributed to the weakening of the housing market included rising interest rates between 2003 and 2006 and a reduced pool of qualified homeowners.

The ensuing bust in the housing market impacted the financial markets since falling house prices contributed to rising mortgage loan delinquencies and an increase in home foreclosures. The growing uncertainty with respect to the value of banks' balance sheets was at the core of the financial crisis and was captured by sharp increases in money market rates. The rising uncertainty about the value of banks' balance sheets prompted banks to hoard cash as they became concerned about their continued ability to tap into the capital markets to cover funding requirements. Rising liquidity constraints that initially arose in the interbank markets and perceived increases in counterparty risk eventually led to an overall disruption in the capital markets. With the financial system on the verge of collapse as a result of the spillover effects from the housing bust, and given the threat of a sharp contraction in credit and bank lending, it was clear government intervention would soon emerge. Due to the weak response to the Fed's monetary policy actions that involved reductions in target and primary lending rates, the Fed experimented with innovative short-term bank lending programs designed to inject liquidity into the financial system. Other important government-led efforts included debt and deposit guarantees, large scale asset purchases, and direct assistance through the U.S. Treasury's Troubled Asset Relief (TARP) and Capital Purchase (CPP) programs. The purpose of these programs was to stabilize the ailing financial system and to restore investor confidence.

An interesting area of research that has received some attention is the U.S. government's intervention in response to the 2007-2009 financial crisis. Some researchers focus on the effectiveness (or lack thereof) of the Fed's short term lending programs (e.g. Taylor and Williams (2009) and Cecchetti (2009)), while others examine the impact of the government bailout programs on bank lending (e.g. Lei (2013), Ivashina and Scharfstein (2010) and Egly and Mollick (2013)). Other researchers explore the impact of the government intervention on the stock market and overall investor confidence (e.g. Subrahmanyam et al. (2011) and Huerta et al. (2011)). To gain an overall economic perspective of the government intervention, Veronesi and Zingales (2010) calculate the costs (i.e. cost to tax-payers) and benefits (i.e. increased value of banks' financial claims) of the government bailout and determine it was an overall success. These authors contend that from an economic viewpoint the government intervention created value by preventing a run on banks and by providing capital that reduced banks' inefficiencies related to excessive leverage, which in turn impacted the banks' ability to exploit future investment opportunities. With the exception of the work of Ivashina and Scharfstein (2010), none of the referenced papers focus on the impact of the government intervention on the balance sheet composition of federally insured commercial banks. Moreover, Ivashina and Scharfstein (2010) examine bank lending during the crisis with a focus on loan level data on syndicated transactions. These authors conclude the stress placed on liquidity from drawdowns under existing credit commitments and the run by short-term bank creditors led to an overall reduction in bank lending.

This paper expands the literature by investigating whether changes in commercial banks' balance sheet composition are associated with the government intervention whose objective was to stabilize the financial system. This study investigates the following research questions:

- What was the impact of the government intervention on bank liquidity?
- Has the proportion of residential real estate loans with respect to the total bank loan portfolios reverted to pre-crisis levels?
- Have new differences emerged in balance sheet composition between large banks and small banks as a result of the government intervention?

Examining the liquidity behavior of banks is interesting given the recent environment of expansionary U.S. monetary policy. The Fed's unprecedented expansion of its balance sheet as a result of multiple rounds of quantitative easing (QE) beginning in late 2008 has led to massive increases in liquidity in the financial system that to a large extent is held by banks. The U.S. Government intervention offers a unique opportunity to explore changes in bank behavior that are manifested through their balance sheets. Researchers including Cornett et al. (2011) suggest that in times of crisis, banks tend to build up liquidity reserves as part of an overall strategy to manage liquidity risk. Liquidity risk in turn stems from multiple channels including exposure to unfunded loan commitments, withdrawal of wholesale deposits, or the loss of other sources of short term financing (i.e. debt rollover risk). This research is of interest to economic policy makers, regulators, bank managers, and the investor public. As noted by He et al. (2010), there has been a massive restructuring of the financial sector balance sheets since late 2007. These authors claim between 2007Q4 and 2009Q1 commercial bank holdings of securitized assets increased by approximately U.S. $550 billion while holdings of these asset types by hedge funds and broker/dealers decreased by roughly U.S. $800 billion. On the liability side of the balance sheet, the repurchase agreement (REPO) finance market declines by roughly U.S. $1.5 trillion whereas government backed debt issued by the banking sector, including FDIC insured deposits and FDIC guaranteed bonds, increases by approximately U.S. $1.3 trillion. These authors claim the balance sheet restructuring is driven by weakening financing conditions in debt and equity markets during the crisis as well as the loss of liquidity in the secondary markets for many asset classes.

This paper contributes to the literature in several distinct ways. First, we examine bank behavior capturing periods of economic expansion, financial crisis, and post-crisis. The work by He et al. (2010) that uses quarterly data spanning from 2007Q4 to 2009Q1 serves to motivate our research. Yet our paper differs from their work in several ways. Our paper focuses on the behavior of commercial banks while their work covers a broader base of the financial sector that includes hedge funds and broker/dealers, insurance companies, commercial banks, and the government. A deeper understanding of commercial bank behavior is driven by their role in stimulating business and economic activity. He et al. (2010) investigate balance sheet adjustments with respect to asset and mortgage-backed securities attempting to track how these assets have shifted across the institutions. Our paper also examines changes in balance sheet composition of commercial banks from a wider view examining various asset categories that exhibit varying degrees of liquidity. Second, the liquidity models presented in our paper that control for the Fed's expansion of its balance sheet through quantitative easing incorporate a macro perspective view on bank liquidity building. Notably QE had a large impact which began in late 2008 and subsequently led to massive increases in liquidity in the financial system that ended up on bank balance sheets. Finally, this paper explores whether banks have stabilized to pre-crisis levels and if there has been any permanent changes in banks' asset composition in the post-crisis period resulting from the impact of government intervention.

Dynamic panel data methods are applied to examine commercial bank liquidity behavior over a sample period 2005Q1 to 2010Q4. Our estimation approach allows agents to behave dynamically and form expectations, it controls for unobserved bank-specific characteristics, and controls for potentially endogenous regressors. We sample banks following a four-size classification scheme based on asset size that yields 4,982 small banks, 475 medium banks, 34 large banks, and 14 money center banks. Findings show the initial round of quantitative easing positively impacts bank liquidity across all bank samples and a positive impact of the repurchase agreement market rates on bank liquidity for small and medium banks. Our descriptive analysis shows banks have become more liquid in the post-crisis period, especially larger banks (large and money center banks). We also show real estate loan portfolio exposures have reverted to pre-crisis levels for money center banks and remained flat for all other bank samples.

The balance of the paper is organized as follows: Section 2 describes the data and sources and presents descriptive statistics. Section 3 introduces the methodology and empirical model, while Section 4 puts forth our hypotheses. Section 5 discusses the results, and in Section 6 we present our conclusion.

2. Data and Descriptive Statistics

The sample is taken from the population of commercial banks that are insured through the Federal Deposit Insurance Corporation (FDIC) over the sample time frame 2005Q1 to 2010Q4. The bank information is originally compiled in Consolidated Reports of Condition "call reports" that are submitted by insured banks on a quarterly frequency. Banks prepare and submit their call reports on Federal Financial Institutions Examination Council (FFIEC) forms FFIEC-031 or FFIEC-041. Banks choose the appropriate FFIEC form that is based on the bank's geographic scope of business (i.e. domestic offices only FFIEC-041 or domestic and foreign offices FFIEC-031). The bank data used for this study are available through Federal Deposit Insurance Corporation statistics on depository institutions (SDI) data base at the following website: http://www2.fdic.gov/sdi/index.asp (last accessed on 8/15/2012).

Since our paper works with bank-level data, in the case of multibank holding companies, (BHC) data only from the lead bank is retained. In many instances the lead bank commonly represents over 80% of the total insured assets reported by the BHC[1]. Banks with missing balance sheet and/or income information required for this study were excluded from the sample. We apply several qualifiers to the population of commercial banks to minimize the impact of outliers. More specifically, we eliminate all bank-quarter data with asset growth over the preceding quarter in excess of 50%, total loan growth exceeding 100%, and total loans-to-assets ratio of less than 10%. By applying these qualifiers to the population of FDIC insured commercial banks, we remove 63,629 bank quarter observations from the initial data set with the full sample containing 126,234 bank quarters that covers a sample period from 2005Q1 to 2010Q4.

To explore behavior patterns of the commercial banks, the resulting sample is decomposed into

[1] To investigate the presence of multibank holding companies (MHC), we extracted a list of the largest 150 financial institutions as of the beginning of the sample. We matched each of these institutions against the FDIC website to determine if they were MHC. The number of banks excluded that formed part of a MHC represent less the 2% of the total sample (lead banks of MHC were retained for this research).

various subsample classifications following Verma and Jackson (2008). More specifically, the bank sample is divided into four groups based on average total asset size as follows: small banks (average total assets < U.S. $1 billion), medium banks (average total assets ≥ U.S. $1 billion and < U.S. $20 billion), large banks (average total assets ≥ U.S. $20 billion and < U.S. $90 billion) and money center banks (average total assets ≥ U.S. $90 billion). The bank information used in our paper includes: 1) loan balances on various loan categories (e.g. total loans and residential real-estate loans), 2) total assets, 3) balance sheet liquidity measures (e.g. securities held to maturity, securities available for sale, and cash and balances due), 4) Tier 1 risk-based capital ratio, 5) commercial letters of credit, 6) non-performing loans (e.g. includes loans and leases 90 days or more past due plus non-accrual loans), 7) two bank deposit measures (e.g. total deposits that include demand deposits, money market accounts, savings accounts and time deposits, and transaction deposits that include demand deposits and NOW accounts), 8) costs of deposits (e.g. interest expense on deposits to total deposits), and 9) net operating income. Appendix A provides further description of the bank variables.

The macro variable we employ in the liquidity models consists of a REPO spread measured as the difference between the 90-day REPO rate for a given bond class and the Overnight Index Swap (OIS) series over the sample period. The collateral for the REPO-OIS series consists of real estate mortgage-backed securities. Gorton and Metrick (2012) found increases in REPO spreads during the crisis signaled concern with respect to counterparty risk. These authors further explained that the location and size of subprime risks held by the counterparties in the REPO market were unknown which led to fear that liquidity would dry up for collateral in all asset classes. On this basis such concerns should lead banks to reassess their liquidity strategies. The REPO spread series are downloadable from Bloomberg's data base: http://www.bloomberg.com (last accessed on 8/15/12).

Table 1 depicts contemporaneous bivariate correlations for: 1) independent bank variables, 2) macro variables, and 3) quantitative easing indicator variable. The QE variable is assigned a value of one during the Fed's initial round of quantitative easing from 2008Q4 to 2010Q1 and zero otherwise. An examination of Table 1 shows that bank's behavior varies across the samples. To illustrate this point, Panel A shows bank total assets (lta) is positively correlated with bank loans (loans) with a value of 0.080 for small banks. The correlation turns negative, with values between -0.091 and-0.076, in the medium and large bank sample cases (refer to Panels B and C) and it decreases further to -0.430 in the money center bank case (see Panel D). This fairly strong negative co-movement between bank loans and total assets in the money center bank sample suggests increases in the loan portfolio are not accompanied by a contemporaneous increase in bank balance sheet assets. The negative correlation may capture the money center banks' ability to use off-balance activities associated with the securitization process that effectively allowed banks to remove loans (and the risk associated with these loans) from their balance sheets. Another interesting relationship exists between net operating income (nop) and bank tier 1 capital ratio (capt1r) which is positive, ranging from 0.045 for the large banks in Panel C to 0.183 for the medium banks in Panel B and turning negative at -0.220 only in the money center bank sample case in Panel D. The negative correlation suggests increases in net operating profits are met with a concurrent decrease in the bank's capital ratio, possibly associated with the effects of weaken balance sheets and or dividend distributions which are common among money center banks.

The relationship between commercial letters of credit (lc) and bank loans (loans) seems stronger as we move from the small bank sample towards the larger bank samples and turns negative in the money center bank sample case. The correlations are 0.039, 0.080, 0.245, and -0.596 in Panels A, B, C, and D accordingly. It is equally interesting that bank loans and letters of credit seem to serve as complementary products in the large bank sample case (i.e. positive co-movement) yet appear to behave as substitutes in the money center bank sample (i.e. negative co-movement). Non-performing loans (npl) are moderately and negatively related to net operating income (nop), with coefficients ranging from -0.379 for the large banks in Panel C to -0.499 for the small banks in Panel A. This finding is intuitive; plausibly, an increase in non-performing loans may be offset with a contemporaneous decrease in bank operating net income. With the exceptions of the high positive correlation of 0.636 between deposits I and II in the small bank sample, the high positive correlation of 0.676 between deposits I and loans in money center bank sample, the negative correlations of -0.596 and -0.764 that associate commercial letters of credit with loans and deposits I accordingly in the money center bank sample, and the positive correlation of 0.578 between QE and non-performing loans in the money center bank sample, all other correlations are either low or moderate. The low-to-moderate correlations help mitigate any potential collinearity issues that could impact the liquidity models, noting that in no model do we allow for the aforementioned highly correlated variables to jointly enter a single model simultaneously.

To gain some insight into the research questions posed in the introduction section, we present a comparative analysis of bank behavior based on sample size over the sample period. In order to accentuate differences in bank behavior, the analysis begins by contrasting the small bank sample with the money center bank sample and follows with further analysis that focuses on the medium and large bank samples. The analysis renders some noteworthy results. Figure 1 shows the trend in average total bank loan balances and the ratio of total bank loan balances to total average assets for the small bank sample (average total assets < U.S. $1 billion) over the period from 2005Q1 to 2010Q4 while Figure 2 depicts the same trend information for the money center banks (average total assets ≥ U.S. $90 billion). The trends in average total bank loan balances reveal somewhat similar patterns for both samples up through the end of the crisis period albeit with greater volatility exhibited in the money center bank sample case. For the remainder of the sample period average total bank loan balances seem to flatten out in the small bank sample case yet remain volatile with a general continued upward trend in the case of the money center bank sample. In the case of the small banks, the pattern in the loan balances may be a reflection of the continued, yet modestly improved, state of the economy and the cautionary stance of small businesses given the continued uncertainty regarding the economic outlook. The slight downward trend in the ratio of total bank loan balances to total average assets particularly in the post-crisis period are very similar for both the small and money center bank samples. The trends in these two series suggest continued liquidity hoarding by small and money center banks, recognizing that small banks may arguably have less access to capital markets and other external funding sources .Figures 3 and 4 show the trends in average total bank loan balances and the ratio of total bank loan balances-to-total average assets for the medium bank and large bank samples respectively. The trends for the medium bank sample reflected in Figure 3 closely resemble those of the small bank sample while those of large bank sample shown in Figure 4 seem to follow the trends of the money center bank sample, albeit with less volatility. Additionally, during the post-crisis period, the ratio of total bank loan balances-to-total average assets holds fairly steady in the case of the large banks, while the money center banks experience a continuous decline in their loan portfolios scaled by total average balance sheet holdings. In the medium and large bank samples cases loan portfolios scaled by total average balance sheet holdings during the post-crisis period are below the loan portfolio exposures which were carried in the pre-crisis period. This finding is also reflected in the small and money center bank samples as seen in Figures 1 and 2 accordingly.

We also examine the trend in the proportion of the residential real estate portfolio with respect to average total bank loan balances outstanding for small bank and money center banks respectively. In both bank samples, the residential real estate portfolio seems to hold fairly steady hovering at approximately 35% of the average total bank loan balances. The money center banks' residential real estate (R/E) loan portfolio exposure has reverted to pre-crisis levels while the small bank sample residential R/E loan portfolio exposure has remained stable throughout the entire sample period. The trend line for the residential real estate portfolio for the medium bank sample mirrors the trend line for the small bank sample. The residential R/E loan portfolio exposure for the large bank sample reflects a slight upward trend in the post-crisis period suggesting that the large banks in fact have increased their exposure beyond pre-crisis levels.

Given the stability exhibited in the residential real estate portfolio, the decline in the proportion of the total loan portfolios with respect to total average assets in the post-crisis period for the small banks as shown in Figure 1 would seem to be traced to other loan portfolio segments such as commercial and industrial loans. While the money center banks experience a comparable decline in the post-crisis period as seen in Figure 2, the decline in the small bank sample case may be attributed to differences in the scope of business activities performed by small versus money center banks. Small banks tend to focus on retail activities and typically support depository and borrowing needs of smaller businesses while large banks tend to lend to larger corporations. In contrast, large banks engage in both retail and wholesale banking and often concentrate on the wholesale side of the business. In their study on the cyclical behavior of large versus small manufacturing firms in response to monetary policy shocks, Gertler and Gilchrist (1994) conclude small firms tend to shed inventories at a rapid pace during an economic slowdown. Large firms initially borrow to build up inventories. These authors also point out short-term borrowing closely follows a similar pattern to that shown in the inventory trends. Under the premise that small banks focus on retail customers and accommodate mainly the small business sector, the results reflected in Figure 1 provide support to the findings by Gertler and Gilchrist (1994).

Figure 5 shows the trend in average liquid assets and the ratio of liquid assets-to-total average assets for the small bank sample over the period from 2005Q1 to 2010Q4. Figure 6 reflects the same liquidity measures for the money center banks. The liquidity measure includes cash and balances due from depository institutions, securities available for sale and securities held to maturity. The liquidity trends seem compatible with the loan trends in that these two core components of bank assets are usually strongly linked. Loutskina (2011) claims a decrease in liquid funds normally leads to an offsetting increase in lending. The higher proportion of liquidity holdings by the small banks compared to the money center banks is consistent with view that small banks have less access to capital markets and other external funding sources. In the case of the small bank sample, as shown in Figure 5, liquidity holdings in terms of dollars and as a proportion of the overall bank balance sheet continue on the rise well into the post-crisis period. At 2010Q4 average bank liquidity holdings are recorded at their highest levels in terms of dollars and balance sheet proportions over the sample period from 2005Q1 to 2010Q4 for the small bank sample. The liquidity trends under both measures during and after the crisis period, for the most part, have been rising at a faster pace in the money center bank sample case as depicted in Figure 6. Similar trends are noted for both the medium and large bank samples as shown in Figures 7 and 8 respectively.

In sum, the balance sheet composition for banks has shifted in general towards greater liquidity in the post-crisis period with the shift being more discernible for the larger bank samples over the entire sample period. The residential real estate portfolio exposure has reverted to pre-crisis levels in the case of the money center bank sample and has remained fairly consistent throughout the sample period in all other bank samples with a modest rise noted in the post-crisis period in the large bank sample case. Overall, bank loan portfolios scaled by total average balance sheet holdings seem to have trended downward during the post-crisis period with the exception of the large bank sample where post-crisis exposures have held fairly steady.

3. Methodology

We focus on examining changes in banks' balance composition resulting from the U.S. Government intervention aimed to stabilize the financial domestic markets that were disrupted during the 2007-2009 financial crisis. More specifically, we focus on the behavior of banks' primary earning assets, namely liquid assets and loans. Based on the co-existing relationship between deposit-taking and lending behavior as documented by Kashyap et al. (2002), Gatev et al. (2009) and Cornett et al. (2011), we present a liquidity model that accounts for the important synergies that arise from these two basic traditional banking activities (i.e. lending and deposit-taking). In addition to bank deposits and loans, the model incorporates various control variables including bank-specific variables measuring asset size, bank capitalization, deposit costs, non-performing loans, net operating income, and commercial letters of credit as described in the preceding Data Section. The bank-control variables such as assets, capitalization, and deposit costs are commonly viewed as supply-side constraints in liquidity models (see Cornett et al. (2011) and Loutskina (2011)). Bank liquidity is further impacted by loan portfolio performance. We control for this behavior through the non-performing loans variable in our liquidity model. The net operating income variable is intended to capture the banks' access to additional internal sources of funds while the commercial letters of credit variable proxies as a measure of banks' ability to raise funds externally (i.e. bank reputation). We also include the REPO spread as a macro variable to capture the liquidity crunch that prevailed during the crisis[2]. Gorton and Metrick (2012) point out that during the

[2] Cornett et al. (2011) employ a TED spread in their lending and liquidity models. The correlation between the TED spread and the REPO-OIS spread is 0.909 that is computed over the sample period of our research which covers

crisis both REPO spreads and REPO haircuts rose with such increases correlated with concerns about counterparty risk or uncertainty about collateral values. We propose a dynamic panel estimation to model bank liquidity behavior that is an improvement to the static specification presented by Loutskina (2011). The model is expressed as follows:

$$\Delta Liq_{i.t} = \beta_1 \Delta Liq_{i,t-1} + \beta_2 bk_{i,t} + \beta_3 macro_t + \beta_4 QE_t + \mu_i + \varepsilon_{i,t} \tag{1}$$

where the Δ prefix represents the change of the bank liquidity variable *Liq* which is expressed in log form and includes cash in banks and securities held to maturity and available for sale; *bk* represents a vector of the following bank-specific variables:1) total assets (TA) expressed in log from, 2) loans (loans) scaled by total assets, 3) capitalization (capt1r) measured as the Tier 1 risk-based capital ratio, 4) two deposit measures (Dep I and Dep II) that are scaled by total assets with Deposit I consisting of the sum of demand deposits, money market deposits, saving deposits and time deposits and Deposit II capturing demand deposits and NOW accounts that are collectively considered transaction deposits, 5) cost of deposits (depcost) defined as the ratio of interest-expense-on-deposits-to-total-deposits, 6) non-performing loans (npl) scaled by bank loans, 7) net operating income (nop) scaled by total assets, and 8) commercial letters of credit (lc) scaled by total assets; macro represents the economic variable proxied by the REPO-OIS spread; and QE is an indicator variable to capture the impact of the Fed's initial round of quantitative easing. The bank variables are normalized with respect to their average across all banks in a given sample similar to the specification used by Matousek and Sarantis (2009). Finally, μ captures the time-invariant bank-specific effects, while ε denotes the remaining disturbance term.

Equation 1 follows the static model introduced by Loutskina (2011), but with some important improvements. First, a static model simply assumes that agents are myopic and that observations in time are independent. Our dynamic approach allows agents to behave dynamically to form expectations about future values of the variables. Moreover, as Arellano and Bond (1991) explain, our estimation is consistent with rational expectation models in which agents use all available information to form

from 2005Q1to2010Q4.

expectations. This is important because, for example, expectations about bank-specific variables might affect the bank's decisions to hold more cash now. Our dynamic approach is also motivated by the fact that liquidity risk management is a dynamic process impacted by lending commitments, bank loan portfolio conditions, demand deposit claims, access to (and conditions of) capital and money markets, and other internal and external factors. Second, allowing for dynamics and our choice of estimators also helps us to control for potential endogeneity. Third, we introduce a macro variable (i.e. the REPO-OIS spread) into the model to account for the liquidity crunch and the perceived increased credit and counterparty risk that prevailed during the crisis. Commercial banks were exposed to funding liquidity risk concurrent with the development of the shadow banking system. The banks ran the risk that investors might (and did) cut back from buying asset-backed commercial paper which would place significant pressure on the operations of bank related special purpose vehicles (SPVs) that relied on this form of short-term financing. The argument is that tight liquidity conditions captured through increases in the REPO-OIS spread impact bank liquidity risk management strategies. For example, banks with high liquidity risk exposure would be expected to raise cash and other liquid investments (and possibly curb new lending) more than banks with low liquidity risk exposure when the REPO-OIS spread spikes. Fourth, unlike Loutskina (2011) we incorporate a quantitative easing (QE) dummy variable under alternative specifications to specifically control for the effects of the initial round of quantitative easing on bank liquidity behavior[3].

We employ the system GMM (SGMM) dynamic panel data estimator proposed by Blundell and Bond (1998).[4] This estimator starts by taking first differences in equation 1 to remove the time-invariant bank-specific effects μ. Then a vector of instruments Z is needed to construct moments $E(\Delta\varepsilon Z)=0$. Under

[3] Since the Fed's initial round of quantitative easing ran from November 2008 to April 2010, we create a dummy variable QE that takes the value of one from 2008Q4 to 2010Q1 and zero otherwise. We do not need to control for the second round of quantitative easing that covers the period from November 2010 to June 2011 (or subsequent rounds of QE) since our sample period ends in December 2010.

[4] We also employed the difference GMM (DGMM) dynamic panel estimator as proposed by Arellano and Bond (1991) and the central findings remain qualitatively unchanged. Blundell and Bond (1998) point out that when the series are persistent over time, the instruments in the DGMM are weak. Hence our focus on our preferred estimator, the SGMM.

serially uncorrelated ε, lags of the right-hand-side variables in equation 1 are valid instruments. The SGMM augments the moment conditions obtained in the difference equation with moments from the equation in levels, $E[(\mu+\varepsilon)W]=0$. Blundell and Bond propose using lags of the right-hand-side variables in the equation in differences as instruments W.[5] Altunbas et al. (2009) points out that SGMM is efficient and consistent contingent on the absence of first-order serial correlation and the validity of the instruments. We provide two tests to validate our empirical approach. A second-order serial correlation test on the differenced error term is used to assess whether the assumption of no first-order serial correlation is met. To test the overall validity of the instrument Z and W we use the Hansen test of over-identifying restrictions.

Some of our right-hand side regressors in equation 1 are potentially endogenous. For example, balance sheet liquidity and bank lending might be jointly determined because banks have managerial discretion to choose both, liquidity levels and lending, simultaneously during the same period. Banks need to choose an optimal level of liquid assets to meet demands from depositors and borrowers. If bank management perceives an increase in liquidity risk exposure new bank lending activity could be curtailed. Another example of potential endogeneity bias may arise between balance sheet liquidity and bank total assets. An increase in liquidity funded through an increase in deposits or other external liabilities, *ceteris paribus*, would lead to an increase in bank total assets. Changes in management-driven liquidity strategies may also have an effect on bank total assets for the simple reason that liquid holdings, from an accounting perspective, are included in banks' total assets. Based on this line of thinking we model bank total assets and loans as endogenous.

We employ several specifications based on the benchmark model. First, following Verma and Jackson (2008), the bank sample is divided into four asset size classes to discern whether bank behavior patterns that are manifested through the banks' balance sheet impact liquidity differently. Second, given the relatively high correlation of 0.636 between deposits I and II in the small bank sample case, (and in

[5] We use the two-step method of moments estimator.

the money bank sample case, the correlation of 0.676 between deposits I and loans and the correlations of -0.596 and -0.764 that associate commercial letters of credit with loans and deposits I respectively), we alternate between highly correlated variables under separate specifications that model bank liquidity behavior. In no model do we allow for the aforementioned highly correlated variables reported in Table 1 to jointly enter a single model simultaneously. This approach should help identification by avoiding multicollinearity problems. Third, our study allows for the interaction between an indicator variable identified as *Quantitative Easing* (QE) to capture the indirect impact of the Fed's initial round of quantitative easing on liquidity through bank lending. We also explore the interaction between bank loans and the Repo-OIS spread. The *Quantitative Easing* dummy variable is assigned a value of one during the initial round of QE period from 2008Q4 to 2010Q1 and zero otherwise. The purpose behind the interaction terms is to determine whether the substantial influx of liquidity into the financial system, captured through the QE indicator variable, and the effects of the crisis, measured through the REPO-OIS spread, operate through bank loans. For example, banks with high credit risk exposure in their loan portfolios would be expected to hoard more cash (i.e. high liquidity risk exposure) compared to banks with lower credit risk exposure in their loan portfolios during the crisis period when the REPO-OIS spread rises.

Since the Sargan test on the validity of over-identifying restrictions is not robust to heteroskedasticity or autocorrelation in the error terms, for model diagnostic purposes we choose to apply and report the Hansen J statistic which is a well-accepted standard specification check used with two-step SGMM which we employ in this paper. Roodman (2009b) explains the J-test is usually and reasonably thought of as a test of instrument validity, but it can also be viewed as a test of structural specification. The Hansen test is robust to the presence of heteroskedasticity and autocorrelation but is usually weakened in the presence of a high instrument count; the latter is not a matter of concern in our specifications. Using system GMM estimation, we have between 12 and 20 instruments depending on the model specification after imposing restrictions on the instrument matrix[6].

4. Hypotheses

We put forth two testable hypotheses dealing with the impact of the government intervention on the stabilization of the domestic financial markets, particularly on U.S. banks' asset composition and performance. From an economic perspective the success of the government intervention has been established by Veronesi and Zingales (2010). These authors contend that the intervention created value by averting a run on the banks and by furnishing capital that reduced bank inefficiencies with regards to excessive leverage that impeded the banks' ability to exploit future viable investment opportunities. The Fed's intervention through quantitative easing also had a substantial impact on banks' balance sheets as demand deposits, small time, and saving deposits increased by some estimated U.S. $800 billion between 2007Q4 and 2009Q1 according to He et al. (2010). During this time frame, these authors suggest commercial banks and the government were net purchasers of securitized assets while hedge funds, broker dealers and insurance companies were net sellers of these asset types. Since conditions of improved bank capitalization (prevalent among the larger banks due to the TARP/CPP government initiatives) and increased deposits coupled with soft loan demand would translate to increased bank liquidity, *ceteris paribus* banks would have a cushion which would be available to support an ensuing increase in loan demand. Any increase in lending activity would most likely need to be supported by a concurrent improvement in overall economic conditions, yet this issue is blurred by the mixed empirical findings on the causation between bank lending and output. Reasonably, during the crisis period, banks with high loan exposures would most likely refrain from further expanding their loan portfolios and opt

[6] The SGMM estimation was performed on STATA software using xtabond2 program code written by Roodman (2009a). Under this program code, "gmmstyle" variable list includes endogenous variables while "ivstyle" variable list includes exogeneous variables. In our model gmmstyle variables include bank total assets and loans. All other model variables are ivstyle variables. The collapse command restricts the number of instruments in a manner that a single instrument is created for each variable and lag distance rather than an instrument for each time period, variable, and lag distance. This is useful to support our choice of the Hansen statistic to validate the instrument list.

for a strategy of liquidity building. This rationalization leads to our first hypothesis:

H_1: During the financial crisis period quantitative easing has a positive effect on liquidity.

We hypothesize $\beta 4 > 0$ in equation 1.

An active securitization market provided banks with an additional source of loan funding and liquidity while the REPO markets were an important funding source for securitized banking activities. Loutskina (2011) suggests that as the bank's ability to securitize loans increases, its holdings of balance sheet liquid assets decline. The banking literature also suggests securitization activity is impacted by business cycle conditions such that securitization activity rises during periods of economic expansion when investors exhibit lower uncertainty regarding the valuation of securitized assets. On the other hand during the crisis we witnessed a loss of "funding liquidity" in terms of the relative ease (or lack thereof) in which an investor is able to borrow against assets (e.g. REPO markets). During the crisis we also experienced a loss of "market liquidity" driven by forced sales which further depressed the market value of assets. A rise in the REPO rates would signal concern with regards to counterparty risk or increased uncertainty about valuation of the securitized assets which, *a-priori*, would lead the banks to take precautionary measures to preserve liquidity. Gorton and Metrick (2012) point out the location and size of subprime risks held by counterparties in the REPO market were unknown which led to fear that liquidity would dry up for collateral in all asset classes. The crisis is viewed as a disruptive event which had a negative impact on bank liquidity due to its effects (i.e. bank losses, loan portfolio write-offs, loss of bank stock market capitalization). While it may be argued that the crisis may have not been accurately forecasted by most banks, it is plausible a rise in the REPO rates could trigger banks to build liquidity to support borrower and depositor demand. The second hypothesis is as follows:

H_2: During the financial crisis period REPO-OIS spread has a positive effect on liquidity. Since REPO-OIS spread is a variable contained in *macro* in equation 1, we hypothesize $\beta_3 > 0$ in equation 1.

5. Results

Table 2 - Panel A reflects model specifications using the system GMM estimator applied to the sample of small banks with total assets less than U.S. $1 billion as of the beginning of the sample period. Under these specifications we allow for feedback effects from bank liquidity to bank total assets and loan variables. Across all model specifications we see a significant positive effect of an increased balance sheet (i.e. bank total assets) on bank liquidity with coefficients ranging from 0.136 to 0.179. This result is consistent with expectations, given we are dealing with a small bank sample as opposed to a large bank sample. Following Loutskina (2011) we can rationalize a negative relationship between asset size and liquidity for large banks since large banks have fewer frictions in accessing capital markets and therefore can afford to hold fewer liquid funds on their balance sheet at any given point in time. Interestingly, the coefficients on the bank loan variable are also positive and statistically significant at the 5% level, with the exception of Model 7, ranging from 0.091 to 0.155 as reported in Models 1, 4, 5, 6, and 7 in Table 2 - Panel A. This finding is consistent with the small bank results reported by Cornett et al. (2011) and suggests banks with higher illiquid asset portfolios (i.e. holding more loans) are pressured to increase liquidity holdings. The coefficients on the bank net operating income variable are negative and statistically significant ranging from -0.009 to -0.013 in the small bank sample case. This finding would suggest that, although net operating income is commonly viewed as an internal source of liquidity creation, this income may be channeled to other uses in the case of small banks. The coefficient on the Tier 1 capital ratio variable is positive yet very small at 0.003 and significant only in Model 3 suggesting a rebuilding of capital leads to restored liquidity in the small bank sample case. For the most part however, the Tier 1 capital ratio variable has no impact on bank liquidity based on the zero coefficients reported across all other models except for Model 3 as previously noted. The coefficients on the bank deposit variables are positive and highly significant in all models ranging from 0.273 to 0.942. This finding is at odds with Cornett et al. (2011) who find a negative relationship between core deposits and liquidity. Banks are able to (and did) rely on core deposits to sustain bank lending, however, they also received a significant influx of liquidity through Fed expansion activity (multiple rounds of quantitative

easing), and as a result of a massive restructure of the financial sector balance sheets as explained by He et al. (2010). The reliance on core deposits to support lending would explain a negative relationship between deposits and liquidity while the liquidity influx offers support for a positive relationship between deposits and liquidity. Loutskina (2011) also finds a positive relationship between transaction deposits (dep II in our model) and balance sheet liquidity in her model. Consistent with expectations, rising deposit costs have a negative and significant impact on bank liquidity creation with coefficients ranging from -0.121 to -0.216. Rising costs of funds place downward pressure on banks operating margins which commonly lead to balance sheet adjustments that are mostly observed in liquidity realignments for small banks. There are two interpretations to the negative and statistically significant coefficient of -2.563 on the letters of credit variable. First, to the extent commercial letters of credit are viewed as bank commitments that facilitate businesses' ability to conduct trade, they represent a form of bank financing to businesses. In this regard, increases in the banks' commercial letter of credit portfolios bring about added liquidity risk. Second, Loutskina (2011) suggests a "reputation effect" associated with banks that issue commercial letters of credit since under this type of bank product the creditworthiness of the bank is being substituted for that of the buyer of goods. The implication is that large, strong reputable banks that would normally engage in commercial letters of credit activity could afford to maintain lower levels of on-balance sheet liquidity at any given point in time. This second interpretation, however, seems more appropriate for large bank samples as opposed to the small bank samples. The non-performing loans variable has no impact on bank liquidity given the statistically insignificant negative coefficients ranging from -0.001 to -0.002 reported in Models 1, 4, 5 and 7.

The positive and significant coefficients on the REPO-OIS spread ranging from 0.042 to 0.058 suggest banks build liquidity in response to rising REPO-OIS spreads which would signal concern with regards to counterparty risk or increased uncertainty about valuation of securitized assets. The coefficients on the QE variable in Models 4 through 7 are positive and highly significant ranging from 0.030 to 0.042, suggesting the Fed's initial round of quantitative easing had a positive impact on bank liquidity. With respect to bank loans with the REPO-OIS spread, the positive and statistically significant coefficient of

0.240 on the interaction term in Model 6 suggests that, as the REPO-OIS spread rises, compared to their lower lending exposure counterparts, banks with greater loan portfolio exposures scaled by bank total assets would tend to build liquidity. In their liquidity model, Cornett et al. (2011) use a similar interaction term (employing a TED spread) to the one presented in Model 6 which was not significant in their small bank sample. These authors do find a positive significant relationship between the interaction term and liquidity in their large bank sample, defined as banks with total assets greater than U.S. $1 billion. The positive and statistically significant coefficient of 0.241 on the interaction term on Model 7 with respect to bank loans with the QE indicator variable would suggest banks with higher loan exposures place greater reliance (than banks with lower loan exposure) on funds received through the Fed's QE process to help alleviate liquidity pressures.

The significant Hansen and Arellano Bond (AB) statistics cast doubt on the analysis of the results in Table 2 - Panel A. The instruments as a group used for estimation are not orthogonal to the disturbance terms, and the first differenced error terms are auto correlated, thus violating key assumptions of the system GMM estimator. Violations of assumptions typically lead to the reassessment of the model or consideration of alternative estimators, but the proposed bank liquidity model meets the assumptions of the system GMM estimator when applied to the medium, large, and money center banks samples. Furthermore, our model parallels other liquidity models presented in the literature (see Loutskina (2011) and Cornett et al. (2011), among others). In the small bank sample case, where the assumptions do not hold, the behavior of this random sample is plausibly triggering this problem[7].

Table 2 - Panel B reports results for the sample of medium banks with total assets ranging between U.S. $1 billion and U.S. $20 billion as of the beginning of the sample period. The coefficients on bank

[7] A common practice to address specifications issues that are detected through Sargan and AB diagnostic tests is to reconsider models with various lag lengths to eliminate serial correlation in first order residuals or to reduce the number of instruments. Through the use of the SGMM estimator technique and the restrictions imposed on the instrument matrix, we reduced the number of instruments to only 16 in my benchmark model in all 4 subsample cases. While acknowledging that the Hansen and AB statistics are acceptable in all other bank subsamples, an obvious material difference between the small bank sample and all other bank samples is the small banks' "large" sample size (i.e. there are 4,982 small banks, 475 medium banks, 34 large banks, and 14 money center banks). On this basis, the behavior (or the characteristics) of the small bank sample should not in and of itself motivate an attack on the model.

total assets are positive yet statistically insignificant, ranging from 0.149 to 0.212. The coefficients on the bank loan variable remain positive in the medium bank sample ranging from 0.128 to 0.281 as reported in Models 1, 4, 5, 6, and 7 yet they are statistically insignificant. As in the small bank sample case, the coefficients on the net operating income variable are negative and small in magnitude ranging from -0.002 to -0.003 however statistically insignificant. The coefficients on the Tier 1 capital ratio variable are zero across all models suggesting the Tier 1 capital ratio variable has no impact on bank liquidity. Unlike the small bank sample case, the deposit variables are no longer significant in explaining liquidity behavior in the medium bank sample case. Even though the deposit variables are no longer significant, the deposit costs variable remains important in explaining liquidity behavior, as seen by the deposit costs' coefficients which are negative and statistically significant ranging from -3.311 to -3.722. Contrary to expectations and in contrast to the small bank sample case, the coefficient on the letters of credit variable in Model 2 is positive and is statistically significant; suggesting the issuance of letters of credit fosters liquidity creation for the medium banks. However, the significant Hansen and Arellano Bond (AB) statistic in Model 2 diminishes the importance of this finding. Consistent with the small bank sample, the coefficients on the non-performing loans remain negative ranging from -0.005 to -0.006; however, they become statistically significant in the 5 specifications reported in Table 2 - Panel B implying that a deterioration in the quality of the bank's loan portfolio is expected to negatively impact bank liquidity.

As in the small bank sample case, the coefficients on the REPO-OIS spread remain positive, ranging from 0.021 to 0.053, and statistically significant in 5 of the 6 models implying banks build liquidity in response to rising REPO-OIS spreads. The coefficients on the QE variable remain positive and significant with values between 0.062 in Model 6 and 0.068 in Model 4. Contrary to the small bank sample case, the interaction of bank loans with the REPO-OIS spread in Model 6 and the interaction of bank loans with the QE indicator variable in Model 7 have no impact on bank liquidity given the statistically insignificant coefficients.

Table 2 - Panel C reports results for the sample of large banks with total assets ranging between U.S. $20 billion and U.S. $90 billion as of the beginning of the sample period. Similar to the medium bank

sample case, the coefficients on the bank total assets variable are statistically insignificant with values between -0.307 and 0.111. Contrary to the small bank sample case, the coefficients on the bank loan variable are negative and insignificant, ranging from -0.503 to -0.962, in Models 1, 4, 5, 6, and 7 of Table 2 - Panel C. Cornett et al. (2011) find a positive and significant relationship between illiquid asset portfolios (i.e. holding more loans) and liquidity in their large bank sample defined as banks with total assets greater than U.S. $1billion. The coefficients on the bank net operating income variable remain negative across all models and significant only in Model 7 with the coefficient reported at -0.025. This finding is counter-intuitive in that an increase in net operating income, which is considered an internally generated source of funding, does not necessarily translate to liquidity creation in the large bank sample case. Possibly, the net operating income represents a supplemental funding source for loan generation for the large banks. The coefficients on the Tier 1 capital ratio variable are positive ranging from 0.006 to 0.028 and statistically insignificant across all models. Transaction deposits (dep II) regain importance as a source of liquidity creation in the large bank sample case. The coefficients on dep II are positive with values between 1.034 to 3.230 and statistically significant in 4 of the 6 models. Cornett et al. (2011) do not find a statistically significant relationship between core deposits (holding more deposits) and liquidity in the large bank sample case. The negative yet insignificant coefficient of -0.895 reflected on the dep I variable in Model 3 implies that increases in the banks' broader based deposit holdings do not necessarily translate to increases in bank liquidity. In other words, while increases in transaction deposits (dep II) seem to be associated with liquidity creation, it remains unclear whether or not other broader deposit claims primarily represent loan funding sources in the large bank sample case. The coefficients on the deposit costs variable remain negative ranging from -3.420 to -9.943 however insignificant across all models in the large bank sample case. Consistent with expectations, the coefficient on the letters of credit variable is negative yet statistically insignificant. Contrary to the small and medium bank sample cases, the coefficients on the non-performing loans are positive with values between 0.028 to 0.040 yet statistically insignificant.

Unlike the small and medium bank samples, the REPO-OIS spread has no impact on liquidity based on the insignificant coefficients ranging from 0.001 to 0.122 reported across all models with the exception of Model 7, which reflects a marginally significant coefficient of 0.122. Bank liquidity may not be impacted by an increase in the REPO-OIS spread given the influx of liquidity that the larger banks experienced via the government intervention. As in the small and medium bank samples, the QE variable continues to have a positive impact on liquidity based on the significant coefficients ranging from 0.089 to 0.119 in Models 4 through 7. Similar to the medium bank sample case, the interaction of bank loans with the REPO-OIS spread has no impact on bank liquidity given the statistically insignificant coefficient reported in Model 6. We also find that the interaction of bank loans with the QE indicator variable has no impact on liquidity based on the insignificant coefficient of -0.266 reported in Model 7.

Table 2 - Panel D reports results for the sample of money center banks with total assets greater than U.S. $90 billion as of the beginning of the sample period. As in the medium and large bank sample cases, the bank total assets variable has no impact on bank liquidity based on the insignificant coefficients, which range from -0.482 to 0.173. The coefficients on the bank loan variable are positive and insignificant in Models 1, 4, 5, and 7, with values between 0.036 to 1.815, while negative and significant reported at -2.183 in Model 6. As in the medium bank sample case, net operating income has no impact on liquidity since none of the coefficients are statistically significant. The Tier 1 capital ratio variable displays negative coefficients reported at -0.005 and -0.018 in Models 1 and 5 respectively and positive coefficients ranging from 0.001 to 0.003 in the remaining models; however, they are statistically insignificant across all models. Similar to the medium bank sample case, the deposit variables do not help explain liquidity behavior of money center banks, with the exception of transaction deposits (dep II) in Model 6. Similar to the large bank sample case, the deposit cost variable does not seem to impact liquidity behavior since none of the coefficients are statistically significant. The coefficient on the letters of credit variable reported at -61.035 is of the expected sign and is statistically significant suggesting money center banks may enjoy “reputational effects”, which allow them to maintain lower levels of balance sheet liquidity.

The coefficients on the REPO-OIS spread are positive ranging from 0.044 to 0.163 yet only marginally significant in 1 of the 6 models reported in Table 2 - Panel D. The weak impact of the REPO-OIS spread on money center banks' liquidity may be attributed to: 1) the influx of liquidity that the money center banks received primarily through the U.S. Treasury's CPP and 2) from a redistribution of liability claims as REPO-markets shrunk, as suggested by He et al. (2010).The coefficients on the QE variable are positive and statistically significant with values between 0.070 to 0.127 in 2 of the 4 models. Similar to the small bank sample case, the positive and significant coefficient of 0.979 on the interaction term in Model 6 between bank loans with REPO-OIS spread suggests as the REPO-OIS spread increases, banks with greater loan portfolio exposures (scaled by bank total assets) would tend to build liquidity compared to their counterparts, which have lower lending exposures. Similar to the medium and large bank sample cases, the interaction of bank loans with the QE indicator variable has no impact on liquidity given the insignificant coefficient of -0.231 reported in Model 7.

Overall this paper finds empirical support for H_1, which suggests during the financial crisis period quantitative easing has a positive effect on bank liquidity (i.e. $\beta_4 > 0$ in equation 1). This relationship is well captured across all bank samples based on the positive and statistically significant coefficients reported on the QE indicator variable. The positive relationship is consistent with the view that during the crisis period the Fed's initial round of quantitative easing had a positive impact on bank liquidity. During this time frame commercial banks were net purchasers of significant amounts of securitized assets which were treated as liquid assets (i.e. securities) on the banks' balance sheets (see, He et al.2010). Possibly the results capture the absence of strong loan demand during the crisis period and a general tendency for businesses to postpone borrowing activity, given the heightened uncertainty that existed during the crisis period. From a banking viewpoint, any increase in lending activity would require some indication of a concurrent improvement in overall economic conditions. *A priori* during the crisis period banks with high loan exposures should curb lending and choose to build liquidity with quantitative easing, serving as an important channel through which banks' liquidity objectives could potentially be attained. However, the evidence only supports the presence of direct effects of quantitative easing on bank liquidity since for example the interaction of quantitative easing with bank lending does not help to explain bank liquidity.

Some evidence supports H_2 (during the financial crisis period REPO-OIS spread has a positive effect on bank liquidity, i.e. $\beta_3>0$ in equation 1). The positive effect is well captured in the small and medium bank samples as seen in Table 2, Panels A and B. The positive effect diminishes as we move towards the larger bank samples since only one specification reflects a significant coefficient on the REPO-OIS variable in the large and money center bank sample cases. Nonetheless, the positive relationship is consistent with the view that increases in the REPO rates signal concern with regards to counterparty risk or increased uncertainty about valuation of the securitized assets, which would lead banks to take precautionary measures to preserve liquidity. The direct relationship is also in line with the view that during the crisis period there was a loss of funding liquidity in terms of the relative ease (or lack thereof) in which banks are able to borrow against assets in the REPO markets. *A priori* during the crisis period banks with greater loan exposures should tend to build liquidity compared to their counterparts, which have lower lending exposures, concurrent with a rise in the REPO-OIS spread. The evidence supports the presence of an indirect impact of the REPO-OIS spread on liquidity through bank lending in the small and money center bank sample cases as seen in Model 6 in Table 2, Panels A and D.

6. Conclusion

The 2007- 2009 financial crisis, while unfortunate, has spawned a new wave of research opportunities that are of interest to academicians, economic policy makers, regulators, bank managers, investors, and other affected parties, including households and businesses. The 2007-2009 financial crisis, like previous crises, was rooted in lax monetary policy with interest rates at historic lows and was accompanied by a housing market boom and bust. What is unique to this latest financial crisis is the transformation of the banking system leading to the development of securitized banking, the shift towards short-term funding sources provided through the money and capital markets, and the ensuing government intervention by both the Federal Reserve and the U.S. Treasury to revive the frail U.S. economy. The need to build liquidity became a common theme among banks during the crisis period, and the results reported in our paper suggest the Fed's initial round of quantitative easing (QE) may have served as an important channel through which bank liquidity objectives were attained. We set out to investigate whether changes in banks' balance sheet composition, primarily in terms of liquid asset holdings and loan portfolio exposures, are associated with the government intervention, whose objective was to stabilize the financial system.

Dynamic panel data methods are applied to examine bank liquidity behavior over a sample period 2005Q1 to 2010Q4. The sample of banks follows a four-size classification scheme based on asset size that yields 4,982 small banks, 475 medium banks, 34 large banks, and 14 money center banks. We find the initial round of QE positively impacts bank liquidity across all bank samples, and a positive impact of the repurchase agreement market rates on bank liquidity for small and medium banks. While size, measured in terms of bank assets, seems to influence the magnitude of the impact of QE on bank liquidity, we conjuncture that size coupled with other balance sheet metrics disproportionately benefits the "stronger-larger" banks. Moreover, it is plausible that larger banks based on their access to capital markets and reputation effects are less likely to depend on extraordinary liquidity sources. We believe that regulatory persistence directed toward adequate bank capitalization levels and appropriate balance composition (including the need for adequate liquidity), largely prompted by the financial crisis, will result in a permanent shift in overall bank liquidity. The statistically significant impact of the interaction of REPO-OIS spread with bank lending on bank liquidity in the small and money center bank samples suggests as the REPO-OIS spread rises, banks with greater loan portfolio exposures (scaled by bank total assets) would tend to build liquidity compared to their counterparts, which have lower lending exposures. In their liquidity model, Cornett et al. (2011) find a similar result in their large bank sample (defined as banks with total assets greater than U.S. $1 billion) and no significance in the small bank sample(banks with total assets under U.S. $1 billion). We show banks have become more liquid in the post-crisis period, especially the larger banks (large and money center banks). We also show real estate loan portfolio exposures have reverted to pre-crisis levels for money center banks and remained level for all other bank samples. We would expect QE to enhance average investor's portfolio holdings and returns due to lower borrowing costs resulting in improved project financial performance and increased cash flow available for new real estate projects.

Overall the findings in our paper have important implications primarily for bank regulators. We find not all banks (i.e. small, medium, large, and money center) behave in the same manner and therefore strong consideration should be given to re-assessing the existing pre-established guidelines that are used in determining a bank's level of safety and soundness. For example Bozos et al. (2013) estimate a bivariate EGARCH dynamic market model with time-varying betas to examine stock price movements following 177 large bank merger announcements between 1998 and 2010 and suggest that acquiring bank's beta rises and remains elevated for up to a two year period. They conclude that newly consolidated large banks entail higher systematic risk as opposed to providing risk diversification. Unlike Bozos et al. (2013) who focus on investigating bank and systemic risk associated with mergers initiated by publicly traded banks, relying on a large sample of banks (publicly traded and privately owned) we explore changes in banks' balance sheet composition associated with U.S. government intervention during the crisis. Although we do not investigate bank merger activity in our paper, we believe that QE provided liquidity to the financial system enabling banks to remain independent that otherwise might have failed, merged or been subject to a takeover. While there arguably may have been a rise in bank consolidation in recent years as suggested by Bozos et al. (2013), we also conjecture that QE may have had a net effect of reducing bank consolidations by ebbing the effect of the crisis (i.e. we do not believe that QE would serve as the root cause for consolidation). Furthermore, if we accept bank losses have been adequately recognized, liquidity levels have been restored and now exceed pre-crisis levels, interest rates remain at historic low levels, and banks have been appropriately recapitalized, then the stage has been set for business recovery. This leads us to contemplate the following questions: Will we witness a loosening of bank credit standards to promote bank lending to help revive the economy? Have lessons been learned from the 2007-2009 financial crisis, and are the bank regulators prepared to handle the new challenges that face them? How will an eventual subsequent contraction of the Federal Reserve's balance sheet, which should hypothetically have a negative impact on liquidity in the financial system, impact bank lending? These questions and many others become the spring board for ongoing research in this interesting field of study.

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Figures 1 - 4
Loan Trend Analyses

Figure 1
Small Banks
Average Total Assets < U.S. $1 billion

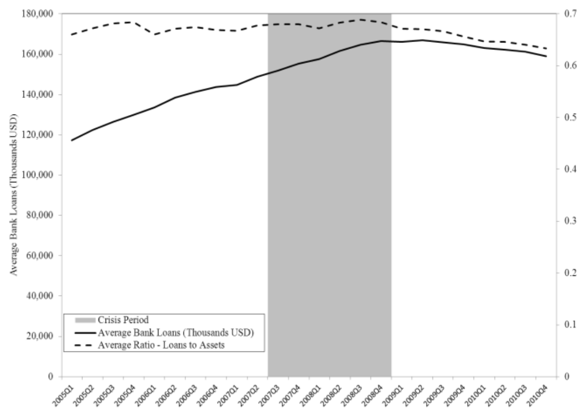


Figure 2
Money Center Banks
Average Total Assets ≥ U.S. $90 billion

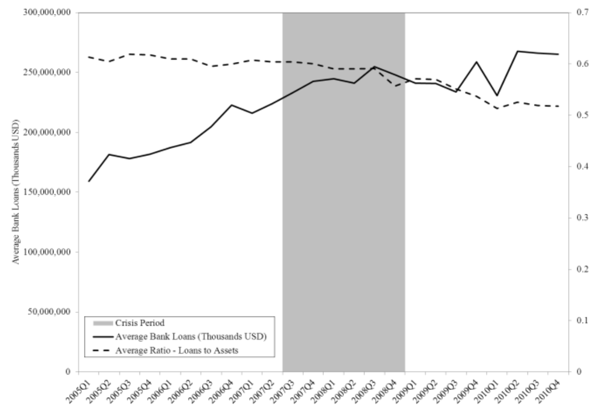


Figure 3
Medium Banks
Average Total Assets ≥ U.S. $1 billion and < U.S. $20 billion

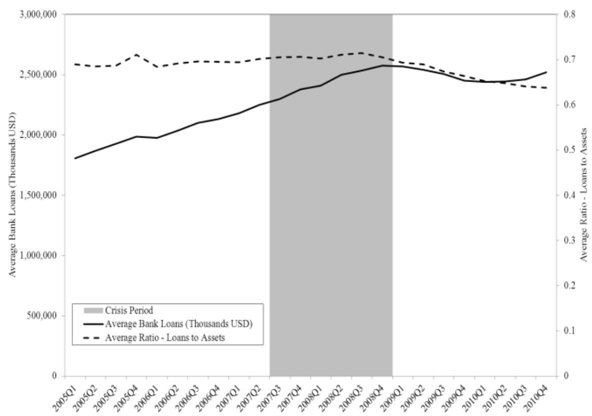
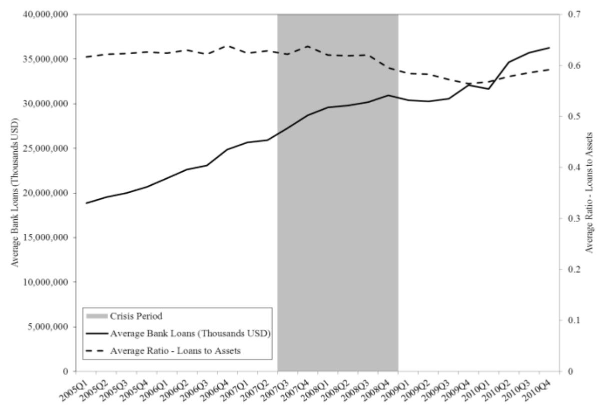


Figure 4
Large Banks
Average Total Assets ≥ U.S. $20 billion and < U.S. $90 billion



Notes: The solid lines represent the average of bank total loans computed quarterly for banks that hold average total assets as listed in the figure subtitles. The dollar amounts are expressed in thousands of U.S. dollars. The dotted line shows the proportion of average total bank total loans to average total bank assets. The left axis reflects the average total bank loans while the right axis shows the proportion of loans to total assets. The shaded areas represent the crisis period that covers from 2007Q3 to 2008Q4. These series represent author's calculations. Bank data obtained from FDICs statistics on depository institutions (SDI) website http://www2.fdic.gov/sdi/index.asp last accessed 8/15/12.

Figures 5 – 8
Liquidity Trend Analyses

Figure 5
Small Banks
Average Total Assets < U.S. $1 billion

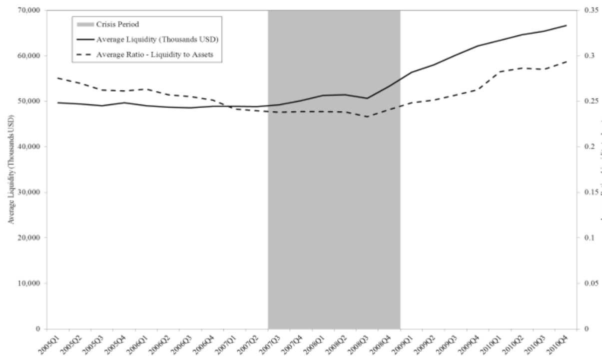


Figure 6
Money Center Banks
Average Total Assets ≥ U.S. $90 billion

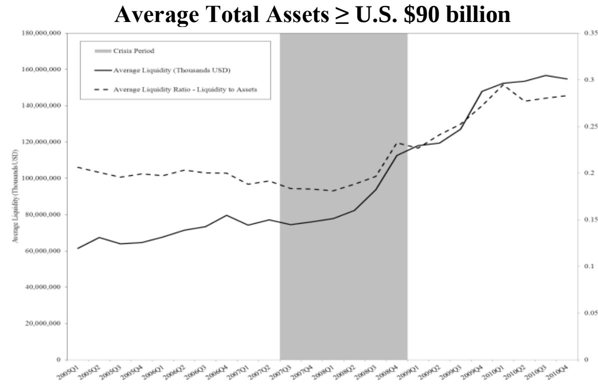


Figure 7
Medium Banks
Average Total Assets ≥ U.S. $1 billion and < U.S. $20 billion

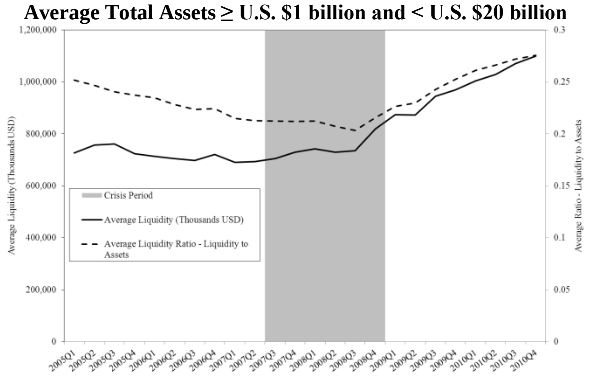
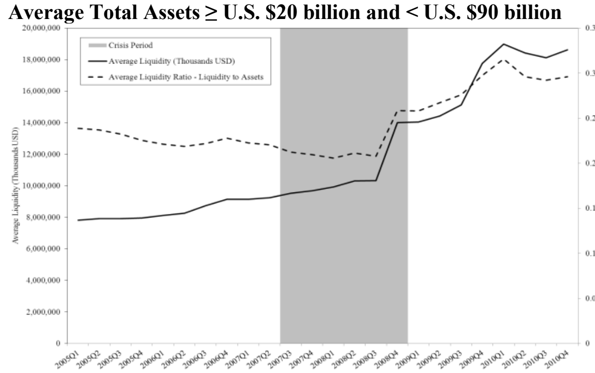


Figure 8
Large Banks
Average Total Assets ≥ U.S. $20 billion and < U.S. $90 billion



Notes: The solid line represents the average of bank total liquidity computed quarterly for banks that hold average total assets as listed in the figure subtitles. The liquidity amount includes cash and balances due from depository institutions, securities available for sale and held to maturity. The dollar amounts are expressed in thousands of U.S. dollars. The dotted line shows the proportion of average total bank liquidity to average total bank assets. The left axis reflects the average total bank liquidity while the right axis shows the proportion of liquidity to total assets. The shaded area represents the crisis period that covers from 2007Q3 to 2008Q4.These series represent author's calculations. Bank data obtained from FDICs statistics on depository institutions (SDI) website http://www2.fdic.gov/sdi/index.asp last accessed 8/15/12.

Table 1 - Correlation Matrixes - Independent Variables

Panel A - Small Bank Subsample (TA < U.S. $1 billion)

	lta	loans	nop	capt1r	dep I	dep II	depcost	lc	npl	repo	QE
lta	1.000										
loans	0.080	1.000									
nop	-0.045	-0.034	1.000								
capt1r	-0.175	-0.267	0.084	1.000							
dep I	-0.252	-0.045	0.008	-0.129	1.000						
dep II	-0.417	-0.050	0.083	-0.028	0.636	1.000					
depcost	0.044	0.043	-0.001	0.074	-0.146	-0.118	1.000				
lc	0.018	0.039	0.015	-0.014	-0.008	-0.003	-0.001	1.000			
npl	0.080	0.013	-0.499	-0.069	-0.004	-0.065	-0.004	-0.017	1.000		
repo	0.058	0.032	-0.090	-0.067	-0.054	-0.061	-0.033	-0.005	0.093	1.000	
QE	0.076	-0.008	-0.201	-0.056	-0.026	-0.044	-0.056	-0.013	0.227	0.482	1.000

Panel B - Medium Bank Subsample (TA ≥ U.S. $1 billion and < U.S. $20 billion)

	lta	loans	nop	capt1r	dep I	dep II	depcost	lc	npl	repo	QE
lta	1.000										
loans	-0.091	1.000									
nop	-0.078	-0.029	1.000								
capt1r	-0.045	-0.317	0.183	1.000							
dep I	-0.231	0.093	-0.112	-0.245	1.000						
dep II	-0.125	0.090	0.087	-0.060	0.202	1.000					
depcost	-0.070	0.196	-0.008	-0.056	-0.081	-0.138	1.000				
lc	0.012	0.080	0.035	-0.047	-0.261	-0.035	0.017	1.000			
npl	0.122	-0.028	-0.469	-0.105	0.064	-0.138	-0.020	-0.014	1.000		
repo	0.079	0.047	-0.148	-0.061	-0.053	-0.126	0.135	-0.008	0.134	1.000	
QE	0.092	-0.026	-0.262	-0.032	0.040	-0.087	-0.126	-0.016	0.332	0.482	1.000

Panel C - Large Bank Subsample (TA ≥ U.S. $20 billion and < U.S. $90 billion)

	lta	loans	nop	capt1r	dep I	dep II	depcost	lc	npl	repo	QE
lta	1.000										
loans	-0.076	1.000									
nop	-0.175	0.077	1.000								
capt1r	-0.128	-0.540	0.045	1.000							
dep I	-0.151	0.029	-0.155	-0.296	1.000						
dep II	-0.037	-0.127	-0.093	-0.011	0.155	1.000					
depcost	-0.162	0.227	0.185	-0.117	-0.034	-0.201	1.000				
lc	0.167	0.245	-0.040	-0.298	0.098	0.145	-0.103	1.000			
npl	0.161	0.007	-0.379	0.034	0.021	0.210	-0.208	0.031	1.000		
repo	0.183	-0.031	-0.296	-0.074	-0.001	0.000	0.092	-0.061	0.175	1.000	
QE	0.216	-0.103	-0.398	0.014	0.066	0.054	-0.203	-0.076	0.433	0.482	1.000

Panel D - Money Center Bank Subsample (TA ≥ U.S. $90 billion)

	lta	Loans	nop	capt1r	dep I	dep II	depcost	lc	npl	Repo	QE
lta	1.000										
loans	-0.430	1.000									
nop	-0.008	-0.033	1.000								
capt1r	0.116	-0.351	-0.220	1.000							
dep I	-0.471	0.676	-0.067	-0.113	1.000						
dep II	-0.187	-0.279	0.213	0.079	0.167	1.000					
depcost	-0.079	0.259	-0.021	-0.320	-0.005	-0.279	1.000				
lc	0.198	-0.596	0.069	0.046	-0.764	-0.083	-0.024	1.000			
npl	0.314	-0.112	-0.424	0.547	0.091	-0.046	-0.372	-0.217	1.000		
repo	0.079	-0.038	-0.404	-0.024	-0.007	-0.072	0.035	-0.151	0.197	1.000	
QE	0.081	-0.113	-0.388	0.284	0.076	0.009	-0.270	-0.191	0.578	0.482	1.000

Notes: Bank total assets (lta) expressed in log form. The loans (loans), net operating income (nop), deposit (dep I & II), and commercial letters of credit (lc) variables are scaled by bank total assets. The non-performing loans (npl) variable is scaled by bank total loans. Tier1 risk-based capital (capt1r) and deposit cost (depcost) variables are in ratio form. Bank data was obtained from FDICs statistics on depository institutions (SDI) website http://www2.fdic.gov/sdi/index.asp last accessed pm 8/15/12. The REPO spread (REPO) variable was computed by subtracting the Overnight Index Swap (OIS) series from the 90-day REPO rate for a given bond class collateralized by mortgage-backed securities. Quantitative easing (QE) is a dummy variable assigned a value of one during the Fed's initial round of quantitative easing from 2008Q4 to 2010Q1 and zero otherwise. Sample period 2005Q1 to2010Q4.

Table 2 - Dynamic panel models

Dependent variable: Bank liquidity growth

Panel A - Small Bank Subsample (TA < U.S. $1 billion)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Liquidity growth (1-lag)	.017(.039)	.034(.039)	.039(.042)	.018(.039)	.018(.039)	.018(.039)	.017(.039)
Bank Total Assets normalized	.177***(.030)	.170***(.031)	.136***(.031)	.176***(.030)	.179***(.030)	.177***(.029)	.175***(.029)
Bank Loans normalized	.153**(.077)			.151**(.076)	.155**(.077)	.116**(.053)	.091(.057)
Bank Net Operating Income normalized	-.010**(.005)	-.011**(.005)	-.013***(.005)	-.011**(.005)	-.011**(.005)	-.011**(.005)	-.009**(.005)
Bank Tier 1 Capital normalized	.000(.001)	.000(.001)	.003***(.001)	.000(.001)	.000(.001)	.000(.001)	.000(.001)
Bank Deposits- I normalized			.273***(.007)				
Bank Deposits- II normalized	.941***(.027)	.942***(.027)		.941***(.027)	.941***(.027)	.936***(.027)	.942***(.027)
Bank Deposit Costs normalized	-.215***(.075)	-.212***(.070)	-.121***(.046)	-.216***(.075)	-.216***(.075)	-.215***(.075)	-.215***(.075)
Letters of Credit normalized		-2.563**(1.232)					
Non–Performing Loans normalized	-.001(.002)			-.001(.002)	-.001(.002)	-.000(.002)	-.002(.002)
REPO-OIS spread	.058***(.006)	.057***(.006)	.058***(.006)		.042***(.008)	.047***(.007)	.042***(.008)
QE dummy				.042***(.007)	.031***(.008)	.030***(.008)	.031***(.008)
Bank Loans normalized*REPO-OIS spread						.240***(.061)	
Bank Loans normalized*QE							.241***(.057)
Hansen Test-Chi square	52.90	46.03	127.49	52.17	52.23	56.84	55.51
Prob> Chi-square	.000	.000	.000	.000	.000	.000	.000
AB(1) z	.000	.000	.000	.000	.000	.000	.000
AB(2) z	.000	.000	.000	.000	.000	.000	.000

Panel B - Medium Bank Subsample (TA ≥ U.S. $1 billion and < U.S. $20 billion)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Liquidity growth (1-lag)	-.640**(.251)	-.723***(.116)	-.756***(.183)	-.637**(.264)	-.637**(.262)	-.647***(.216)	-.664***(.169)
Liquidity growth (2-lags)	-.057*(.033)	-.062*(.034)	-.072*(.037)	-.059*(.034)	-.058*(.034)	-.058*(.036)	-.059*(.032)
Bank Total Assets normalized	.188(.200)	.150(.224)	.149(.255)	.212(.202)	.209(.203)	.191(.179)	.206(.174)
Bank Loans normalized	.172(.332)			.189(.336)	.191(.335)	.281(.306)	.128(.203)
Bank Net Operating Income normalized	-.002(.004)	-.002(.004)	-.003(.004)	-.003(.004)	-.003(.004)	-.003(.004)	-.002(.004)
Bank Tier 1 Capital normalized	.000(.003)	.000(.004)	.000(.004)	.000(.003)	.000(.003)	.000(.004)	-.000(.004)
Bank Deposits- I normalized			-.229(.300)				
Bank Deposits- II normalized	.138(.274)	.062(.252)		.137(.277)	.136(.276)	.114(.230)	.117(.224)
Bank Deposit Costs normalized	-3.601**(1.459)	-3.311**(1.407)	-3.381**(1.531)	-3.621**(1.476)	-3.638**(1.479)	-3.722**(1.570)	-3.451***(1.158)
Letters of Credit normalized		18.038***(2.775)					
Non–Performing Loans normalized	-.006**(.003)			-.005*(.003)	-.005*(.003)	-.005*(.003)	-.006**(.003)
REPO-OIS spread	.053***(.017)	.045**(.018)	.047**(.020)		.023(.015)	.022*(.012)	.021*(.013)
QE dummy				.068***(.011)	.063***(.010)	.062***(.009)	.063***(.010)
Bank Loans normalized*REPO-OIS spread						-.070(.448)	
Bank Loans normalized*QE							.169(.148)
Hansen Test-Chi square	6.32	3.57	4.21	6.66	6.66	7.50	7.68
Prob> Chi-square	.276	.311	.240	.247	.247	.379	.362
AB(1) z	.365	.374	.432	.374	.372	.322	.297
AB(2) z	.323	.000	.028	.361	.360	.220	.097

Table 2 - Dynamic panel models - Continued

Dependent variable: Bank liquidity growth

Panel C - Large Bank Subsample (TA ≥ U.S. $20 billion and < U.S. $90 billion)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Liquidity growth (1-lag)	-.310(.270)	-.641*(.353)	-.583(.395)	-.275(.278)	-.266(.288)	-.329(.285)	-.211(.274)
Bank Total Assets normalized	-.037(.194)	-.307(.263)	-.258(.307)	.015(.195)	.008(.198)	-.084(.243)	.111(.220)
Bank Loans normalized	-.684(1.121)			-.503(1.130)	-.519(1.175)	-.627(.755)	-.962(1.105)
Bank Net Operating Income normalized	-.022(.014)	-.015(.014)	-.013(.015)	-.019(.015)	-.020(.016)	-.013(.014)	-.025*(.015)
Bank Tier 1 Capital normalized	.011(.020)	.006(.022)	.008(.025)	.012(.020)	.012(.022)	.008(.024)	.028(.018)
Bank Deposits- I normalized			-.895(.650)				
Bank Deposits- II normalized	2.505*(1.382)	3.230**(1.575)		2.417*(1.317)	2.405*(1.300)	2.922(2.065)	1.034(1.309)
Bank Deposit Costs normalized	-3.754(9.222)	-3.420(6.947)	-8.543(6.081)	-6.721(9.855)	-6.737(9.942)	-3.876(8.658)	-9.943(8.815)
Letters of Credit normalized		-11.741(22.273)					
Non–Performing Loans normalized	.029(.028)			.029(.033)	.030(.033)	.028(.049)	.040(.028)
REPO-OIS spread	.107(.092)	.070(.093)	.067(.103)		.053(.076)	.001(.098)	.122*(.066)
QE dummy				.117**(.059)	.104**(.051)	.089*(.049)	.119**(.051)
Bank Loans normalized*REPO-OIS spread						.734(1.339)	
Bank Loans normalized*QE							-.266(.475)
Prob> Chi-square	.665	.566	.524	.653	.644	.706	.493
AB(1) z	.354	.762	.745	.331	.341	.409	.220
AB(2) z	.523	.318	.348	.626	.648	.484	.797

Panel D - Money Center Bank Subsample (TA ≥ U.S. $90 billion)

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Liquidity growth (1-lag)	-.040(.876)	-.441(.442)	-.318(.731)	-.232(.928)	-.016(1.078)	-.599**(.263)	-.003(1.311)
Bank Total Assets normalized	-.034(.159)	-.121(.293)	-.077(.293)	.088(.210)	-.047(.183)	-.482(.376)	.173(.785)
Bank Loans normalized	.250(.804)			.036(.987)	.057(.882)	-2.183**(.895)	1.815(2.882)
Bank Net Operating Income normalized	.017(.072)	.004(.052)	.009(.049)	.020(.057)	.017(.060)	-.033(.039)	.007(.096)
Bank Tier 1 Capital normalized	-.005(.035)	.003(.037)	.002(.048)	.003(.043)	-.018(.040)	.001(.023)	.001(.059)
Bank Deposits- I normalized			.504(1.513)				
Bank Deposits- II normalized	-3.246(3.307)	1.125(2.099)		1.188(2.160)	-3.228(4.776)	7.606***(2.719)	-1.554(11.561)
Bank Deposit Costs normalized	-4.695(25.921)	-8.354	-6.519(11.326)	13.093(24.356)	2.620(34.198)	-14.053(15.373)	-16.383(49.522)
Letters of Credit normalized		-61.035***(23.64)					
Non–Performing Loans normalized	-.003(.054)			-.001(.050)	.001(.050)	.042***(.006)	-.073(.057)
REPO-OIS spread	.085(.100)	.149(.113)	.163*(.098)		.044(.094)	.065(.058)	.154(.132)
QE dummy				.113**(.053)	.052(.069)	.127**(.051)	.070(.099)
Bank Loans normalized*REPO-OIS spread						.979***(.167)	
Bank Loans normalized*QE							-.231(.766)
Hansen Test-Chi square	6.07	5.28	4.36	6.04	5.35	2.02	7.43
Prob> Chi-square	.415	.260	.359	.419	.500	.980	.491
AB(1) z	.543	.605	.639	.669	.582	.631	.645
AB(2) z	.976	.346	.725	.920	.966	.074	.953

Notes: The dependent variable liquidity includes cash in banks and securities held to maturity and available for sale. Bank total assets and loans are treated as endogenous in all models. Liquidity and bank total assets enter the models in log form. The bank loans, net operating income, deposit measures (I&II) and letters of credit are scaled by bank total assets while the non-performing loans variable is scaled by bank total loans. Deposit I measures domestic deposits consisting of the sum of demand deposits, money market deposits, saving deposits and time deposits. Deposit II captures demand deposits and NOW accounts aka transaction deposits. The bank Tier 1 capital and the bank deposit cost variables are expressed in ratio form. All right hand side bank variables are normalized with respect to their averages across all banks in a given sample. The models employ the Blundell-Bond (1998) two-step estimator. The Hansen tests report the orthogonal conditions of over-identifying restrictions of the instruments as a group under the null that over-identifying restrictions are valid, i.e. exogeneity of instruments. AB (1) and AB (2) refer to Arellano-Bond serial correlation tests under the null of no autocorrelation in the first differenced error terms. Corrected standard errors are reported in parentheses. The symbols *, **, and *** refer to levels of significance of 10, 5, and 1% respectively. There are 4,982 banks in the sample of small banks defined as those banks with total assets less than U.S. $1 billion as of the beginning of the sample period. Panels A, B, C, and D have 95417, 9353, 650, and 285 observations respectively in each model run. Models 1, 2, 3, 4, 5, and 6 employ 16, 13, 12, 16, 17, and 20 instruments respectively. Sample period: 2005Q1-2010Q4.