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**“Banks’ Liquidity Demand in the Presence of a
Lender of Last Resort”**

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Abstract

I use a natural experiment to estimate the effect that a Lender of Last Resort has on banks' liquidity demand. In December 1996 Argentina's Central Bank signed with a group of international banks a contingent credit line agreement that enhanced its ability to act as a LLR. I run difference-in-difference regressions of the effect of the announcement of the insurance contract on banks' liquidity holdings, using ownership status and size to identify the groups of treatment and control banks. Finally I rule out general equilibrium feedback effects through the interbank market between control and treatment banks. Results indicate a reduction of approximately 6.7 percentage points in banks' liquidity holdings in the presence of a LLR.

JEL Classification Codes: E58, G21, G28

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1 Introduction

Central Banks of most countries follow a policy of lender of last resort (LLR). Under this policy, first advocated by Bagehot (1873), Central Banks provide short-term loans to commercial banks that face liquidity¹ problems. The objective of this intervention is to stabilize the banking system, which by its nature is subject to recurrent crises, thus avoiding the negative consequences of a credit crunch on the real sector of the economy². Evidence suggests that the LLR facility has been very successful at avoiding bank panics, as shown by Miron (1986), and Bordo (1990) among others. But given the development of financial and interbank markets in modern economies, there is an increasing controversy about the need of a LLR, considering that such a facility has a potentially negative moral hazard effect on banks' behavior³. Critics say that the Central Bank should just manage aggregate liquidity through open market operations and leave the allocation of this liquidity to the interbank market.

In reality, participants in interbank markets do not have perfect information on the solvency of institutions with liquidity problems. And this information asymmetry is particularly severe precisely when there is a bank panic, and a widespread need for liquidity. Thus, we still continue to see the intervention of Central Banks in rare episodes as the stock market crash of October 1987, Russia's default and the failure of LTCM in 1998, or the terrorist attack of September 11 2001. Rochet and Vives (2002) model an economy characterized by a sophisticated interbank market, in which the presence of asymmetric information gives a rationale for LLR interventions.

In emerging countries, Central Banks are limited in their ability to act as a LLR in the event of a systemic shock. The reason for this limitation is that domestic financial markets are typically under-developed in these

¹A financial asset is said to be liquid if it can be sold in large quantities, in a short period of time, and without negatively affecting its price. While cash is liquid, bonds have varying degrees of liquidity, and loans are illiquid. I call a situation in which a financial intermediary experiences a sudden need of cash from the part of its customers a "liquidity shock", "liquidity squeeze", or "liquidity shortage".

²See Bernanke (1983), Bernanke and Gertler (1989).

³See Goodfriend and King (1988), and Repullo (2003) for an argument on the contrary.

countries. Thus, when a liquidity shock hits, and a country loses its access to international credit, government bond markets will also be illiquid. In this situation the Central Bank is unable to sterilize any injection of liquidity to the banking system. Trying to act as a LLR will put in jeopardy any previously held monetary target, inflation target, or exchange rate target.

Emerging countries provide a unique opportunity to study how changes in a Central Bank's ability to act as a LLR affect commercial banks' behavior. In particular, if an emerging economy's Central Bank is constrained in its ability to provide rediscounts, the funding cost of distressed banks could be very high, as it implies inefficient liquidation of illiquid assets. This large penalty rate makes it optimal for the bank to hoard a large amount of liquid assets, and banks' liquidity holdings will vary with the Central Bank's ability to act as a LLR. Among the reasons why this ability can change, there are changes in the Central Bank's charter determining the scope of intervention in the face of liquidity shocks, changes in exchange rate regimes⁴, or changes in the availability of funds from multilateral financial organizations.

In an attempt to shed light on this question, in this paper I study the case of Argentina. Between 1991 and 2001 Argentina had a fixed exchange rate under a currency board. This restricted the ability of its Central Bank to supply liquidity to foreign reserves in excess of those required to back domestic fiat money. This limitation became clear at the time of the Mexican crisis of December 1994, which spread to Argentina through a liquidity shock. To reduce the likelihood of future contagion to external shocks, the Central Bank pursued preventive liquidity measures ranging from high reserve requirements to the accumulation of a cushion of excess foreign reserves. And to enhance its power to act as a LLR in the event of a systemic liquidity shock it signed a contingent credit line agreement in December 1996 with a group of international banks.

I use micro data from bank's balance sheet to see the effect of the contingent credit lines on the holdings of liquid assets by private domestic commercial banks. Domestic banks only count with the assistance of the Central Bank in the event of a systemic liquidity shock, while their foreign-owned

⁴With a floating exchange rate, a Central Bank has more leeway to act as a LLR than under a fixed exchange rate regime.

counterparts also have the backing of their overseas central offices. Since the enhancement of the Central Bank's ability to act as a LLR in the event of a systemic crisis reduces domestic banks' cost of raising funds, we expect to see a reduction in the holdings of liquid assets by domestic banks when the insurance contract was signed. I test this prediction by running a difference-in-differences regression of the effect of the announcement⁵ of the Repo agreement on domestic banks' liquidity holdings using foreign banks' holdings as a control. The results give support to this prediction, with holdings decreasing approximately 6.7 percentage points. This effect is strongest for medium-sized banks, a result that serves as a robustness check, since domestic medium-sized banks were hit hard by the Mexican crisis while their foreign-owned counterparts were not. The results are robust to the introduction of individual controls, and interaction dummies before the announcement are insignificant showing that the change in bank behavior indeed takes place at the announcement date.

This results suggest that the enhancement of the Central Bank's ability to act as a LLR results in a more efficient redistribution of liquidity from banks to the rest of the economy. Following Holmstrom and Tirole (1998) I interpret this as evidence that there is a role for public liquidity, as provided by the Central Bank, to improve on the functioning of the banking sector. If the moral hazard costs of a LLR could be quantified, then we could compare them with the benefits and determine under what circumstances it is desirable to have a LLR. Unfortunately this cannot be done for the Argentine case, as a number of regulations taken at the time of the Mexican crisis make it impossible to disentangle the reaction of banks to the enhancement of the Central Bank's ability to act as a LLR and the lagged response to these regulations.

This paper is organized in the following way. In section 2.1 I provide a brief description of how the Mexican crisis of 1994 affected Argentina, and then review the prudential regulation measures taken by the Central Bank to strengthen the banking sector. Section 2.2 describes the Contingent Credit Line insurance agreement signed by the Central Bank in December 1996. In

⁵There was only a delay of ten days between the announcement of the agreement and its implementation.

section 3 I review the theoretical literature on the lender of last resort role of a central bank and how that might affect an individual bank's demand of liquid assets. Section 4 presents the empirical evidence, describing the specification strategy, and data used. Finally section 5 concludes.

2 The case of Argentina

2.1 The Liquidity Shock of 1995

In the early 1990's Argentina implemented economic reforms that included trade and capital account liberalization, privatization of most public services and of the pension system, and widespread deregulation. These reforms were very successful in reducing inflation, increasing investment and producing higher growth, but they also exposed the economy to external shocks. This was made clear by the aftermath of the Mexican crisis in December of 1994 when fear of an overhaul of the currency board resulted in a loss of around 30% of foreign reserves in the Central Bank, and of 18% in deposits in less than five months. This led to a credit crunch⁶ that resulted in a contraction of output of around 4.5% for 1995. The liquidity squeeze and credit crunch can be seen in figure 1 showing the evolution of aggregate private-sector deposits and loans.

The Central Bank responded to the liquidity shock by reducing reserve requirements, allowing deposits to be redistributed within the banking sector, and by extending liquidity through repo and rediscount facilities within the constraints of the currency board law⁷. This measures proved insufficient to match the drop in the deposit base and in March banks had to cancel loans for 3% of outstanding credit. After the presidential election uncertainty had been resolved in May 1995, confidence in Argentina was restored and there

⁶A credit crunch takes place when a large fraction of the firms in a given economy become suddenly borrowing constrained.

⁷Argentina had a currency board between 1991 and 2001. According to this law, the Central Bank could buy treasury bonds denominated in dollars as long as this did not lead to a decline in the ratio of international reserves (net of these bonds) to monetary base below 2/3.

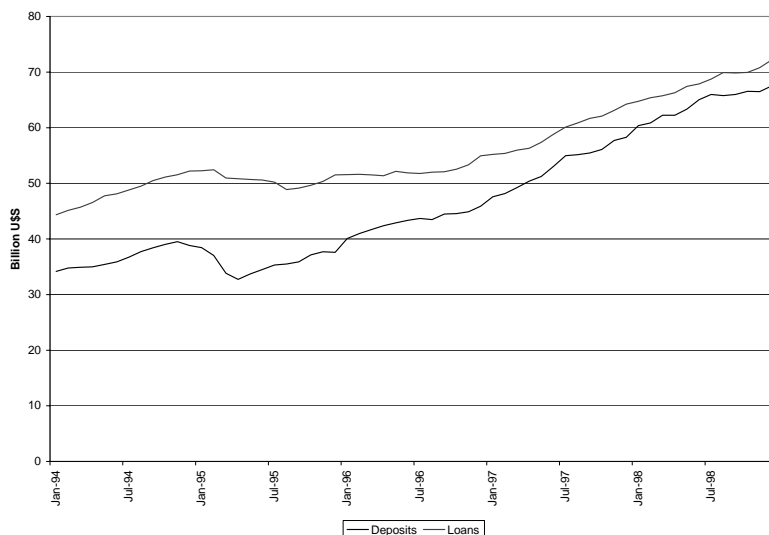


Figure 1: Private-Sector Deposits and Loans

was a sharp recovery in bank deposits and international reserves and a decline in interest rates.

This crisis made clear the need to reduce the country's contagion to external shocks, and to strengthen the banking sector. On this second front measures had been taken since 1991, and table 1 provides a summary of the prudential regulations. Among several policy measures taken to restore confidence was the implementation in April 1995 of a mandatory but privately funded and strictly limited deposit insurance⁸. The strengthening of prudential regulations and supervision enhanced confidence in financial institutions and led to a further deepening of financial intermediation⁹. Financial intermediation spreads declined, reflecting allocational efficiency improvements, partially induced by increased competition coming from a rapid surge of foreign investment in the sector¹⁰.

⁸Although deposit insurance might create incentives for excessive risk-taking behavior, the Central Bank's resolve during the crisis not to rescue insolvent institutions dampened any potential for moral hazard over the recovery period and induced banks to strengthen further their capabilities for proper credit risk management.

⁹M3 increased from 18% of GDP in 1995 to 26% in 1998.

¹⁰In December 1997 the proportion of foreign capital over the total net worth of private

Table 1: Summary of Argentina's Prudential Regulations

Time	Regulation and Events	Effects	
1991	March	Convertibility Law	The monetary base must be backed by international reserves and public bonds No more than a third of this backing may consist of public bonds
1992	September	Charter of the Central Bank	Strict limitations to the CB's ability to provide liquidity assistance
1993		Adoption of capital adequacy standards	Ratio of capital to assets at risk set at 8%, to be raised in stages
1994	December	Mexican devaluation	Liquidity shock in Argentina
1995	January	Ratio of capital to assets raised to 11.5 %	
	April	By law the CB is allowed to provide extraordinary liquidity assistance in the event of systemic liquidity shocks	
		By law a mandatory and privately funded limited deposit insurance is instituted and implemented in May	
	May	Presidential elections take place	Confidence returns and there is a sharp recovery in bank deposits
		The CAMEL system to adjust the capital requirements of individual banks is adopted	
	August	Liquidity requirements replace reserve requirements	This affects equally domestic and foreign banks. Initially set at 15 % of deposits, are scheduled to gradually increase up to 20 %
		International accounting practices adopted regarding the provisioning of loan losses	
	January to December		As a result of the liquidity shock and incentives provided by the CB, there are several mergers that result in the number of banks declining from 205 to 158
1996	December	BASIC banking oversight is established	All banks, except investment grade foreign-owned branches, must issue and place debt every year for 2% of their deposits In all other respects this regulation treats banks equally
	Dec. 20	The Repo Agreement is announced and signed January 1st of the following year	This provides the CB the necessary funds to act as a lender of last resort in the event of a systemic shock
1997	June	Liquidity Requirements are set at the level of 20%	

To reduce the country's exposure to contagion from external shocks, the central bank adopted a systemic liquidity policy that included high liquidity requirements and contingent credit lines. These measures improved the financial sector's resilience to external shocks. As can be seen in figure 1, the upward trend in deposit growth was not interrupted by the Asian crisis, and only flattened out after Russia's default. The Central Bank's liquidity policy created instruments that might be used, in times of turmoil and lack of access to international capital markets, to stifle the mechanisms of shock amplification. In Argentina the instruments used for this purpose are:

- Ensuring banks back a large proportion of their short-run liabilities with internationally liquid assets.
- Developing internationally liquid instruments such as standardized mortgages, and other securitized products.
- Generating excess international reserves at the Central Bank to provide liquidity support as a lender of last resort.
- Negotiating international contingent lines of credit for the Central Bank to enhance its excess reserves.

Having such liquidity available may prevent a serious problem from occurring if that problem is generated by a loss of confidence rather than by a substantive solvency reason¹¹. The basic building blocks of this policy consisted of two important instruments. First a set of liquidity requirements on banks, and second, an international contingent credit line facility.

The most important role of the modern fractional reserve requirements has to do with prudential liquidity concerns. Emerging market economies, which face substantial liquidity shocks and have less possibilities of practising neutralizing open market operations¹², require relatively high reserve requirements. Thus it seems justifiable to remunerate them by holding them in international liquid assets. Due to the remuneration of the requirements

banks was around 55%. In the years following the Mexican crisis there has been a significant banking sector consolidation with the number of institutions declining from 205 to 158 during 1995.

¹¹In 2001 Argentina had a banking crisis as a result of investors fears of a default on government debt, to which banks were highly exposed. This was a solvency problem, not a liquidity one.

¹²I will clarify the origin of this limitation later in section 3.

held in the Central bank, and the fact that banks could hold part of these requirements outside the Central Bank, Argentine regulations denominate them "liquidity requirements". These requirements today were set to reach the level of 20% of the deposit base. This cushion has two roles, first to prevent a shock to the system by maintaining confidence and reducing the probability of a run, and secondly, to reduce the impact on banks' balance sheet should a liquidity shock take place.

In addition, the Central Bank had built up excess reserves that allowed it to extend rediscounts for some further 10% of the deposit base (under the provisions of the currency board law). However there is a cost of having high liquidity requirements and excess reserves as each dollar invested in foreign assets corresponds to one dollar less in domestic lending capacity. There is thus a trade-off between the preventive power of hoarding large amounts of liquid assets and banks' lending capacity¹³. The Contingent Repo Contract was designed as an instrument to improve this trade off, and provide systemic liquidity without crowding out other credit to Argentina.

2.2 The Repo Agreement

The Central Bank agreed in December 1996 with a group of international banks a contingent credit line. This gives the Central Bank the option to sell certain domestic assets receiving US dollars subject to a repurchase clause. The size of the program was initially U\$S 6.7 billion or about 10% of the deposit base. The minimum contract duration was two years and there was a clause such that every three months the life of the program was extended a further three months¹⁴. The insurance premia was initially of 32 basis points and the average cost of funds once drawn was roughly LIBOR plus 205 points. The option could be exercised at any time during the life of the program and the maturity of the repo was from the exercise date until the

¹³Although it must be noted that the effect on the level of credit in the economy is uncertain as higher liquidity requirements might increase depositors confidence and thus increase available deposits.

¹⁴This requirement is technically known as an "evergreen" clause. It implies that if the banks decided to cancel the program, Argentina would have a minimum of two years further cover.

end of the program¹⁵. Argentine bonds must be posted to a market value of 25% more than the actual funds delivered. There is only one circumstance under which the international banks may suspend the agreement: if the Argentine Republic defaults on an international debt commitment.

The purpose of the central's bank liquidity policy in general, and of the contingent credit lines in particular, was to provide a strong dissuasive effect that would shield the country from contagion to external shocks. Depositors and other investors would have greater confidence in the financial system such that the possibility of ever needing the liquidity insurance would be reduced. At the time of signing the Repo agreement, this was a conjecture. As can be seen in figure 1, the banking sector indeed showed increased resilience to the liquidity shocks originated with Asia's crisis and Russia's default. We can take this as evidence that the Repo had indeed dissuasive powers and has played a role in building confidence reducing the probability of a systemic liquidity shock¹⁶.

Although there is no contractual specification with respect to the use that the Central Bank might give to the insurance funds, the stated objective was to help solvent banks in need of liquidity through back to back operations¹⁷. Given that the Central Bank did everything in its power to create new liquidity during the Mexican crisis, it is straightforward to conclude that indeed the funds from the Repo agreement would have been used to enhance its lender of last resort capabilities in the event of a liquidity shock.

¹⁵As the cost of using the liquidity requirements and the Central Bank excess reserves is roughly the international overnight rate of interest, these would have been used before the more costly Repo lines. This means that although the option exercise is discretionary, the credit lines will only be used if there is a liquidity shock of more than 30% of the deposit base. Of course the previous reasoning presumes that the central bank is independent of any political pressures to use the funds for other purposes.

¹⁶It is hard to disentangle what is the actual contribution of the Repo compared to the other prudential measures taken after the Mexican crisis.

¹⁷At the same time that the Central Bank exchanges bonds for cash with the foreign insurers, it will exchange cash for bonds with domestic banks through repos. In this way it is not changing its net asset position.

3 Lender of Last Resort and Banks' Liquidity Demand

In the absence of any market failure there would be no role for a central bank to assist illiquid institutions, since these could borrow in the market to cover their needs. Even in the case of an aggregate shock the central bank should limit itself to provide extra cash to the system through open market operations and thus maintain the aggregate money stock at its desired level. But when there is an external shock to the banking system - as an adverse change in relative prices - it is likely that asymmetric information on the banks' solvency can produce contagious runs on solvent banks, leading to massive bank failures. Most central banks would argue that their supervisory role provides them with additional information not available in the market, and can therefore act as a lender of last resort (LLR).

In practice central banks of most countries have adopted a position of LLR along the guidelines set by Bagehot in 1873¹⁸. The evidence on the effect of a LLR points unambiguously to the conclusion that it has helped to avoid bank panics¹⁹. At the same time the effect of a LLR on the behavior of banks has proved to be difficult to measure, and only general empirical evidence has been collected by cross country comparisons.

If we contrast Bagehot's guidelines with the case of an emerging country's central bank, we clearly see its limitations to act as a LLR. In a developed country, the central bank has the option of supplying liquidity to the banking system while at the same time sterilizing this monetary injection to protect any other central bank objective. In an emerging country, a liquidity shock to its banking system is likely to occur at the same time as the country is cut off from international credit markets. In this situation, if domestic markets are underdeveloped, government bond markets will also be illiquid, implying that the sterilization option is either extremely expensive or simply not available to the central bank. Given that any monetary injection by the

¹⁸Bagehot states that the monetary authority should commit to provide short term loans at a penalty rate to illiquid but solvent banks.

¹⁹Bordo (1990) has obtained results that support this view. See Freixas and Rochet (1997) for further references.

central bank is unlikely to be met by a corresponding increase in the demand for the emerging country liabilities, when the central bank acts as a lender of last resort, it will put in jeopardy any previously held monetary target, inflation target, or exchange rate target. Thus not only the central bank has limited resources to lend to solvent institutions ex-post, but also cannot credibly commit itself to help ex-ante. These limitations are even stronger for the case of a country that has a fixed exchange rate under a currency board. The need to back domestic fiat money by foreign reserves further restricts the ability of the central bank to supply liquidity to the amount of foreign reserves in excess of those required to back domestic fiat money.

We can now ask the question of how the Repo agreement affects bank's behavior given that we can take the insurance as enhancing Argentina Central Bank's LLR capabilities. Since the Repo agreement is an insurance for the banking sector, moral hazard arguments predict an increase in risk-taking behavior. At the same time one can think banks might be affected by a risk reducing "value effect". This arises because the Repo reduces banks' probability of failure, increasing their value as an ongoing concern and thus giving managers incentives to reduce their risk exposure²⁰. Unfortunately, measuring risk-taking behavior over this period is very difficult due to a number of empirical problems²¹. It is for this reason that I concentrated on the the effect of the Repo agreement on bank's liquidity holdings.

Banks wish to maintain a good reputation concerning their ability to meet liquidity demands, be them from their depositors or from their borrowers. The uncertainty in the flows in and out of a bank thus leads to a precautionary motive for the bank to hold liquid assets. If a bank faces a penalty rate to raise funds in the event of a liquidity shortage, then it will hoard liquid assets. The optimal amount of these is decreasing with the opportunity cost of investing in liquid assets, increasing with the likelihood of shortage, and increasing in the penalty rate. There are several interpretations for

²⁰Cordella and Levy-Yeyati (1999) show how this value effect might offset the moral hazard component of a LLR policy, even in the case that insolvent banks are rescued in the event of an aggregate shock.

²¹It is hard to disentangle what are the effects of the Repo agreement and what are lagged responses to previous changes in prudential regulation. Besides there is no clearly defined control group to make an empirical test.

this penalty rate. We can take it to be the discount rate charged by the central bank, or the cost of liquidating illiquid assets. When we consider the banking sector as a whole, then there is another source of funds to cover liquidity needs: other banks. A well functioning interbank market lowers the need to hoard liquid assets. Nevertheless there is a limit to how much banks can count on the interbank market. If there are aggregate shocks, then all banks will be experimenting liquidity needs at the same time and cannot resort to the market²².

Let's go back now to the discussion about the monetary authority providing liquidity as a LLR in a situation like the one experienced by Argentina in 1995. The banking system is subject to an aggregate liquidity shock, and the Central Bank is constrained in its ability to provide rediscounts. Under these conditions the funding cost of distressed banks could be very high. If a bank is unable to get external finance at the time of the liquidity shock, then the only source of funds comes from inefficient liquidation of illiquid assets. This large penalty rate makes it optimal for the bank to hoard a large amount of liquid assets. A reduction in this financing cost should then lead to a reduction in banks' demand for liquid assets.

4 Empirical Evidence

4.1 Identification

I want to measure if Argentine banks' demand of liquid assets was affected by the announcement of the Repo agreement. The effects should take place mainly through two channels. First, the Central Bank has now improved its ability to help illiquid banks in the event of a systemic crisis. This reduces banks' effective penalty rate in the event of a liquidity shortage²³ and therefore reduces their precautionary demand of liquid assets. Second, having a large demonstrable quantity of liquidity available to the banking sector

²²But even in the absence of aggregate uncertainty, the interbank market may not provide all the liquidity that is needed, see Battacharya and Gale (1987).

²³There is no change in the cost of raising funds for an idiosyncratic shock, and there is a reduction of this cost for an aggregate shock.

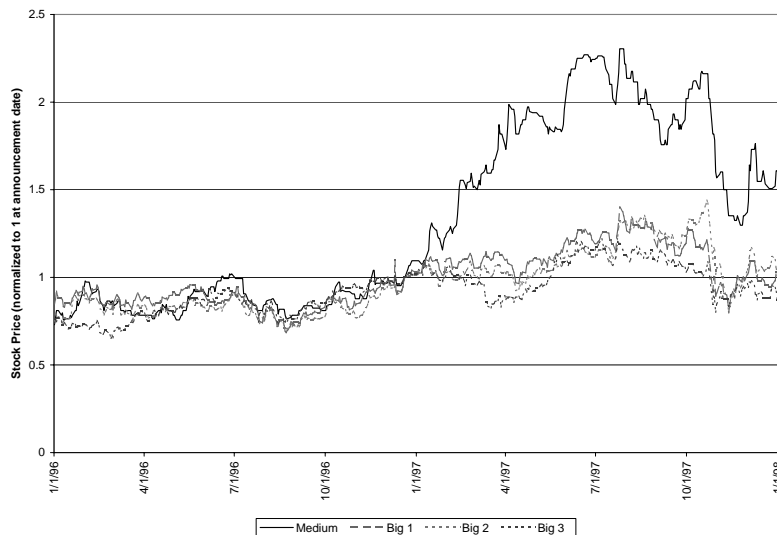


Figure 2: Bank Stock-Price Reaction to Repo Announcement

reduces the probability of contagion to external shocks. This also reduces banks' demand of liquid assets. Any analysis of the effect of the Repo agreement on banks' liquidity holdings will estimate the net effect from these two changes.

Let L_{it} be a particular bank's liquidity holdings as a percentage of total assets. Let R be a dummy that takes the value of 1 if the Repo agreement is in place, and takes the value of 0 otherwise. Thus we can describe the potential liquidity holdings of each bank by defining $\{L_{it}^{R=0}\}$ as the sequence of holdings with no insurance and defining $\{L_{it}^{R=1}\}$ as the sequence of holdings with insurance. The observed holdings are given by,

$$L_{it} = L_{it}^{R=0} + (L_{it}^{R=1} - L_{it}^{R=0}) * R_t \quad (1)$$

What needs to be estimated is the effect of the announcement of the Repo agreement on the sequences of bank liquidity holdings. This is given by the difference between the bank's liquidity demand once the Repo is announced $L_{it}^{R=1}$, and what would have been the bank's liquidity demand if the Repo had not been announced $L_{it}^{R=0}$. This is simply the sequence of conditional expectations,

$$\nu_t = E[L_{it}^{R=1} - L_{it}^{R=0} | R_t = 1] \quad (2)$$

In its simplest form the identification strategy is to use a difference-in-differences estimator. To answer this “what if” question we need to select comparison banks that can be used to estimate the counterfactual $L_{it}^{R=0}$, i.e. what would have been the banks’ liquidity holdings in the absence of the Repo agreement. The problem is that this insurance covers *all* banks working in Argentina. Two identification strategies seem possible. I could compare banks by size and take medium and small banks as the treatment group, and large banks as the control group. This would be motivated by the assumption that large banks don’t lose deposits in the event of a liquidity shock and therefore are unaffected by the insurance. Or I could compare banks by ownership, taking domestic banks as the treatment group and foreign-owned banks as the control group. The underlying assumption being that foreign-owned banks could rely on assistance from their overseas headquarters, making them immune to liquidity shocks and therefore not affected by the insurance.

Identification by size is not satisfactory for two reasons. First, large and small and medium-sized banks might lend to different type of borrowers. Therefore bank’s balance sheets will reflect asymmetric effects to sectoral shocks. Second, while it is true that large banks resist better exogenous liquidity shocks, we shouldn’t forget that a large bank failure might produce the very same systemic risk that triggers the insurance. This endogeneity might have effects on large banks’ liquidity holdings. Identification by ownership is also not entirely satisfactory because large domestic banks were not affected by the Mexican crisis, while the shock hit hard some small foreign-owned banks .

An identification strategy that takes these problems into consideration is to take medium-sized domestic banks as the treatment group and medium-sized foreign-owned banks as the control. We thus have similar sized banks working with the same type of customers and clearly distinguished by the effect that the Mexican crisis had on them²⁴. A comparison of the change in

²⁴There are two reasons to exclude small banks. It appears that both foreign and

the liquidity holdings for medium-sized domestic banks relative to the change in liquidity holdings for their foreign-owned counterparts is an estimate of the effect of the Repo agreement.

I observe the change in liquidity holdings for domestic banks, but it is unclear whether this change is due to the introduction of the Repo agreement, or to other factors that vary over time²⁵. Assuming that these other potential determinants of liquidity holdings affect domestic and foreign-owned banks in a similar way, the change in liquidity holdings for foreign-owned banks is an estimate of what would have happened in the treatment group had the Repo not been announced. Suppose that banks' liquidity holdings satisfy,

$$E[L_{it}|t, D_i] = \beta_t + \gamma D_i + \delta B_t D_i \quad (3)$$

where D_i is an indicator function that takes the value of 1 if bank i is domestic and 0 if it is foreign-owned, β_t is an effect for period t common to all banks, γ is a time-constant effect specific to the treatment group, and δ is the effect of the Repo agreement on domestic bank liquidity holdings. Defining $T_{it} = B_t D_i$, i.e. an indicator for being a domestic bank after the Repo is announced, liquidity holdings can now be written as,

$$L_{it} = \beta_t + \gamma D_i + \delta T_{it} + \epsilon_{it} \quad (4)$$

where ϵ is an error term such that $E[\epsilon_{it}|t, D_i] = 0$. The simplest difference in difference comparison is (where $t = t_0$ is the time of the announcement of the Repo agreement),

$$\begin{aligned} & (E[L_{it}|t > t_0, D_i = 1] - E[L_{it}|t \leq t_0, D_i = 1]) \\ & - (E[L_{it}|t > t_0, D_i = 0] - E[L_{it}|t \leq t_0, D_i = 0]) = \delta \end{aligned} \quad (5)$$

domestic small banks were equally hit by the liquidity shock. Based on this fact we would also expect that there is no differential change in their relative liquidity holdings. Also, the insurance contract is for a limited amount of funds (10% of the deposit base) and given the Central Bank's policy of helping larger solvent banks first, we can expect that the effect of the Repo agreement will be weaker for small banks.

²⁵During this period there is a reduction in the spreads of sovereign bonds and GDP is growing at an average rate of 7%.

The difference-in-difference estimate δ can be computed in a regression of stacked micro data. This regression framework allows convenient control for a vector of individual characteristics X_i , by estimation of the equation,

$$L_{it} = X_i' \beta_0 + \beta_t + \gamma D_i + \delta T_{it} + \epsilon_{it} \quad (6)$$

where β_0 is a vector of coefficients. Validity of the estimate of δ now only requires that, conditional on X_i , inclusion in the treatment group is uncorrelated with unobserved time-varying determinants of liquidity holdings.

4.2 Data

I use data from bank's balance sheet that is published by the Central Bank²⁶. It is the population of banks and not a random sample. I work with quarterly aggregates of the original data set, using for the analysis the subset of privately-owned commercial banks. I thus discard public and wholesale banks. The reason for doing so is that public banks usually are under pressure by the corresponding government, be it federal or state, to allocate funds according to their public objectives²⁷. Besides there has been a significant process of privatization of public banks following the Mexican crisis. Because there was some financial aid to privatized banks, their balance sheet data during the period I want to analyse is not reliable. With respect to wholesale banks they have different liquidity requirements than commercial banks²⁸.

I take the beginning of my sample to be the fourth quarter of 1995 and its end to be the second quarter of 1998. Starting at an earlier date might give spurious results as in the first two quarters we see the liquidity shock and the recovery taking place. Besides, the Central Bank took a wide range of

²⁶Bulletin of Monetary and Financial Affairs, available on internet at www.bcra.gov.ar

²⁷In this sense, the largest national public banks were called to provide liquidity to smaller banks during the Mexican crisis, and state banks repeatedly assist in financing their corresponding state government's deficits.

²⁸Another argument is that the Central Bank main objective is the protection of small depositors, and that since these are not customers of wholesale banks, these banks are not going to be as covered by the Repo agreement as their commercial counterparts.

Table 2: Change in Bank's Deposits 1995:1 (%)

Bank by Size	Ownership	All	Domestic	Foreign
All		-16.3	-19.7	-1.5
Large		-0.2	-0.4	1.1
Medium		-15.3	-23.6	4.5
Small		-21.5	-21.6	-20.4

regulatory measures at this time and it might be the case that domestic and foreign-owned banks reacted differently to these measures. Although some measures of bank performance (like non-performing loans) might respond with significant lags to regulatory changes, I assume that liquidity holdings can be adjusted fast enough such that actual holdings reflect desired holdings every period²⁹. Under this assumption, holdings reflect current changes in the environment and in regulation, and not past changes³⁰. In August 1998 the Russian crisis took place and growth in aggregate deposits declined markedly. At the same time there was a mild “flight to quality” with some deposits leaving smaller domestic banks for larger and foreign-owned ones. Extending the data set beyond 1998:2 would therefore include asymmetric changes in banks’ balance sheets that violate the identifying assumptions.

As I mentioned in the previous section, the two main dimensions of heterogeneity among banks are size and whether the ownership is domestic or foreign. This distinction made not because they are subject to different regulations, but because of the impact that the Mexican crisis had on them³¹.

²⁹This assumption is an approximation to reality, since banks face costs in transforming illiquid assets into liquid one and viceversa. This costs decrease with the degree of development of asset backed security markets and increase with the degree of asymmetric information between banks and borrowers. But in an expanding economy, as was the case for Argentina in this period, banks counted with an increase in their deposit base that they could marginally allocate to new lending or to expanding their liquidity positions.

³⁰Figure 4 gives grounds to this assumption as it shows that the behavior of liquidity holdings of domestic and foreign-owned banks mirrored each other before the introduction of the Repo, and later table 5 shows that the banks adjust almost completely to the new liquidity levels in one quarter.

³¹Banks with assets above 3% of the total assets of the banking sector are classified as

Table 2 summarizes the change in bank's deposits for the first quarter of 1995 according to bank size and ownership. From this table we can see that the bulk of the shock concentrated for medium and small-sized banks, while for large banks the liquidity squeeze had almost no effect. This can be due to the perception that big banks have a larger survival probability to the shock arising from economies of scale in bank operation³².

With respect to ownership, foreign banks would be better able to raise funds in the event of a liquidity shortage than domestic ones. They can do this by requesting the funds from its overseas central offices³³. Besides, and as can be seen in table 2, foreign-owned banks are less prone to an attack. A reason for this might be that the public perceive that foreign-owned banks have better assets, or management, than their domestic counterparts. Or it could be just that the presence of their overseas central offices rules out inefficient bank runs, while the lack of explicit backing for domestic banks made them more susceptible to runs.

The next point is the definition of the liquidity variable and regression controls. There are various measures of liquidity, but I take the view that it is composed of cash, interbank loans of short maturity, and securities. These items together with loans and other credits constitute the bulk of a bank's asset side, the remainder being basically physical assets owned directly by the bank. For lack of data for the whole sample period on the components of this measure of liquidity, I use as a proxy the ratio of assets net of loans to assets. Now, some operations of interbank lending result in double accounting, as a bank registers both the current transaction of securities and

large, those with assets between 0.5% and 3% of the total as medium, and those with less than 0.5% as small. Ownership is considered to be foreign if a controlling state of the bank is in foreign hands, otherwise it will be considered domestic.

³²There are two stylised facts that provide evidence in favour of this interpretation. During the Mexican crisis these banks had no trouble in securing funds in international capital markets through collateralized repurchase operations. And, as mentioned earlier, when the Russian crisis hit the domestic banking sector, although there was no effect on the aggregate level of deposits, there was a "flight to quality" effect with deposits leaving small banks for the largest ones.

³³Although it is not clear that any need of funds will be met under all possible circumstances, the point here is that the informational asymmetry problem is less acute for foreign-owned banks.

the expected future reverse transaction. These operations are always registered twice under an Other Credits item of a bank's balance sheet, and they constitute the bulk of the items registered there. Therefore I construct a corrected asset measure of a bank as the difference between the registered asset position and half the registered position of Other Credits. Thus the measure of liquidity is given by

$$L_{it} = \frac{Assets_{it} - \frac{1}{2}OtherCredits_{it} - Loans_{it}}{Assets_{it} - \frac{1}{2}OtherCredits_{it}}$$

Although this measure will overestimate liquidity holdings, I assume that over my sample period a change in this ratio mainly reflects a change in liquidity holdings³⁴. With respect to controls, I use the log of assets to control for bank size. I also use the ratio of actual bank capital to requirements to control for owner's exposure to bank risk³⁵. An ownership dummy is used to control for the ownership of the bank and it is 1 if the bank is domestic, and an interaction dummy that takes the value of 1 for a domestic bank after the signing of the insurance contract.

4.3 Results

Before testing the effect of the Repo agreement on the liquidity holdings of banks, let's look at average liquidity holdings for the whole banking sector and see if there is an effect on the aggregate level. After all, we can interpret the contract as a contingent supply of liquidity for the banking sector, therefore there could be a substitution effect on an aggregate level. Figure 3 plots the ratio of total liquidity to total assets showing that there is no apparent change around the date of the contract and its increase through time

³⁴A counter-example to this statement comes from mergers, when there is no a priori reason to assume that different banks will have the same ratio of physical assets to total assets. I take account of this by controlling for mergers in the regressions.

³⁵Initially I was using the ratio of capital to assets but there were problems of endogeneity, as both assets and capital might change as a response to the Repo agreement. Using the ratio of capital to requirements for the quarter before the regulation I find that a Hausman test does not reject the hypothesis that the model specification is incorrect.

Table 3: Balance-Sheet Data for Medium-Sized Commercial Banks in US\$ Millions

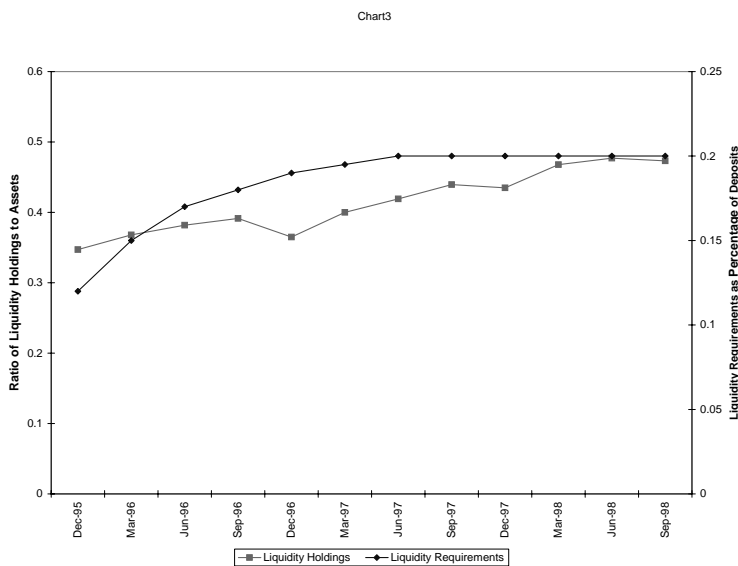
		1995:4-1996:4	1997:1-1998:2
Domestic	Number of banks	11	11
	Assets	791.5	1092.2
	Loans	485.9	645.3
	Deposits	491.3	721.5
	Capital	98.8	125.3
	Liquidity ratio	0.346	0.368
Foreign	Number of banks	6	6
	Assets	775.8	1101.5
	Loans	512.8	600.9
	Deposits	432.4	573.9
	Capital	96.5	112.2
	Liquidity ratio	0.283	0.362

can be partially accounted for by the increase in liquidity requirements in this period. Another reason behind the trend increase in liquidity holdings is increased competition among banks in providing liquidity services to their customers. During this period they expanded their ATM networks, which require a substantial amount of operational cash³⁶. Table 4 shows a significant increase in the size of ATM networks, both for domestic and foreign banks.

³⁶Data for the number of ATMs per bank started to be collected in the second quarter of 1997.

Table 4: Number of ATMs per Assets (in million)

	Domestic	Foreign
1997:2	26.3	16.1
1997:3	34.3	29.5
1997:4	42.7	44.6
1998:1	42.2	44.9
1998:2	51.2	48.3



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Figure 3: Aggregate Liquidity Holdings and Requirements

A different picture emerges if one distinguishes banks by ownership, and figure 4 reports the average liquidity ratio for domestic and foreign banks. It can be seen from the graph that domestic banks held more liquid assets than foreign banks before the Repo agreement, but afterwards this relation reverses through a slowdown in the accumulation of liquid assets by domestic banks, and an increase by the foreign-owned ones. This change in behavior could be due to a differential reaction of banks in their competition strategies, with foreign banks becoming more aggressive than domestic banks in the expansion of their ATM networks. Although there is no data on the extension of ATM networks for the whole sample period, the fact that the increase of networks between the second quarter of 1997 and the second quarter of 1998 is similar between foreign and domestic banks leads me to reject this hypothesis.

Another possibility is that by enhancing the ability of the central bank to act as a LLR in the event of a systemic liquidity shock, the Repo agreement is effectively reducing the financing cost of banks in distress. In this case

Table 5: D-D Estimates of the Effect of the Repo Agreement on Domestic Banks' Liquidity Demand: Summary Results

	All Banks	Large	Medium	Small
Domestic*Repo	-0.043	0.018	-0.067	-0.063
(t-statistic)	(-3.121)	(0.878)	(-4.051)	(-1.755)
Domestic	0.048	0.031	0.062	0.036
(t-statistic)	(1.405)	(0.793)	(1.750)	(0.443)
No. Obs.	544	95	175	274
R^2	0.06	0.18	0.12	0.05

one would expect to see that domestic banks, being the most affected by the newly acquired ability of the central bank to guarantee them assistance in the event of a liquidity shock, respond by reducing their holdings of liquid assets. Figure 4 seems to imply that after the Repo agreement foreign banks have higher liquidity than their domestic counterparts. I must rule out that there is an effect of the Repo on foreign banks, otherwise the identification strategy would not work. For the quarters for which data on the number of ATM's per bank is available I found that controlling for this results in lower liquidity for foreign banks than for domestic ones, and liquidity ratios that are stable for this period. Another candidate explanation for the observed increase in liquidity holdings by foreign-owned banks would be that before the Repo foreign-owned banks were free-riding on the liquidity holdings of domestic banks large holdings made the interbank market liquid. With the decrease in liquid assets hoardings by domestic banks, foreign banks need to increase their buffer stocks as the interbank market loses depth. This explanation is rejected by data on interbank transactions (see table 10). Thus we can safely conclude that foreign banks' behavior was largely unaltered by the Repo agreement, constituting a well defined control group.

As can be seen in the means presented in table 3, both domestic and foreign-owned banks increased their liquidity holdings between 1996 and 1997. I already gave two reasons for this upward trend. A continuing increase in the liquidity requirements, and increased competition among banks

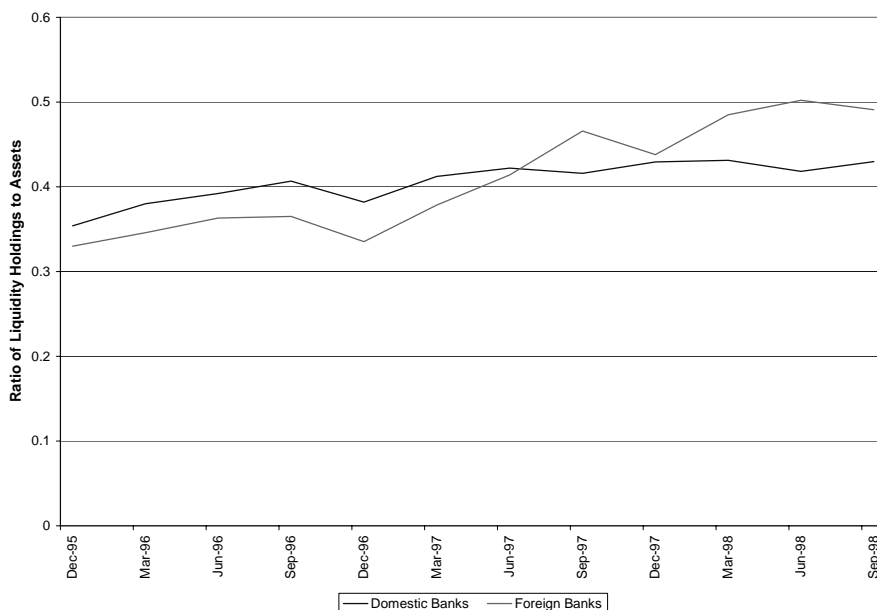


Figure 4: Liquidity Holdings for Private Domestic and Foreign Banks

leading to larger ATM's networks. The simplest difference-in-differences estimate as specified in equation (5) compares the change in liquidity holdings for domestic medium-sized banks (2.2 %) to the change in liquidity holdings for foreign-owned medium-sized banks (11.9 %). The relative change (-9.7 %) is a first estimate of the effect of the Repo agreement on the hoarding of liquid assets.

A more precise method of obtaining the simple difference-in-differences estimate is by estimation of equation (4). Estimates in table 6 show that the change in liquidity holdings after the announcement of the Repo agreement indeed is substantial³⁷. From column (2) we see that before the announcement domestic banks hoarded 3.4 percentage points more liquid assets than their foreign-owned counterparts, this difference not being statistically significant. After the announcement the difference is -7.3 percentage points and

³⁷Column (1) reports OLS results, but since the assumption of independence within groups is too strong for this dataset, for the rest of the regressions I estimate a random effects model, unless a Hausman test rejects the specification in which case the coefficients reported correspond to a fixed effects model.

highly significant.

The difference-in-differences method is useful because it allows convenient control for individual characteristics that could potentially explain differential trends in liquidity holdings for domestic or foreign-owned banks. I control for size by including the log of asset in the quarter before the regulation. Since banks with relatively more equity have more to lose if they are not able to withstand a liquidity shock, they might decide to hoard more liquid assets. I therefore use the ratio of actual bank capital to assets to control for owner's exposure to bank risk. Finally, I control for mergers by including a merger dummy and its value lagged one period. Estimates that include this controls, shown in column (3) of table 6 produce nearly identical point estimates of the effect of the Repo announcement.

In column (4) I report results of an estimation that uses current bank size instead of size at the time of the announcement. The reason for doing this is that although there might be an endogeneity problem with using current balance sheet data as a regressor, it is relatively safe to assume that banks don't choose their size in the short run, but that changes in their size reflect events outside their control³⁸. An example of the type of mechanism I have in mind is an increase in deposits triggered by higher investors' confidence in the Argentine banking system. Results show that the effect of the Repo is now smaller, but still significant.

Another concern is that some domestic banks are being sold to foreign investors during this period. Among medium-sized banks two of them switch ownership status between 1995:4 and 1998:2. Dropping them from the subsample might bias the results, but I find that it doesn't significantly change the estimates. Furthermore I do the regressions with two definitions for the ownership dummies. In table 6 results were reported for an ownership dummy that uses current ownership status, in table 7 I report the results of the same estimations taking ownership as determined by whether the bank was domestic or not in 1996:4. The point estimates of the effect of the Repo announcement are very similar.

The results would be spurious if the decline in domestic liquidity hold-

³⁸An obvious exception being mergers decisions, but the Repo agreement appears to produce no change in the pace at which mergers take pace.

ings relative to that of foreign-owned banks is due to mean-reversion. This would happen if my assumption that actual holdings reflect desired holdings was not true, and there are significant lags in the adjustment to changes in regulation. Figure 4 shows that this does not appear to be the case as the movement in liquidity holdings of domestic and foreign-owned banks mirror each other before the Repo announcement. I test for mean reversion by including interaction dummies for two quarters before the announcement date, 1996:2 and 1996:3³⁹. Estimates in table 8 that include these dummies, show them to be highly insignificant. We can also see from that table that the adjustment in holdings starts to take place in the first quarter of 1997, and is strongly significant for every quarter after the insurance contract is signed, and relatively stable.

Finally I check the identification assumptions by estimating the Repo effect on large and small banks. Table 9 reports the results, and shows that the effect was insignificant for large banks but significant for small banks. Table 8 shows that for this last case the result is entirely driven by a significant drop in liquid asset holdings of small domestic banks in the first quarters of 1998, but was insignificant for all the quarters of 1997. The most likely explanation for this result being an asymmetric response of small banks to the Asian crisis. Either small foreign-owned banks became extremely risk averse and decided to cut on their lending, or the small domestic banks lost deposits to larger or foreign banks.

5 Conclusions

My findings show that domestic banks reduced their demand of liquid assets with respect to foreign-owned banks as a result of the announcement of the Repo agreement. This result being strongest for the comparison between medium-sized banks. This evidence supports the view that, before the announcement, domestic banks were hoarding liquidity as a buffer to meet liquidity shocks, both idiosyncratic and systemic. The Repo agreement, by enhancing the ability of the Central Bank to act as a lender of last resort,

³⁹Results don't change if I use other quarters, or with a dummy for the three quarters just before the announcement.

reduces banks' cost of raising external finance in the event of a systemic liquidity shock. This leads to a reduction in their demand of liquid assets. Foreign-owned banks are not directly affected by this liquidity insurance because they counted with their overseas central offices as a source of funds in the event of an aggregate shock.

Table 6: D-D Estimates of the Effect of the Repo Agreement on Domestic Medium-Sized Banks' Liquidity Demand (Current Ownership)

	(1)	(2)	(3)	(4)
Domestic*Repo	-0.058 (-2.055)	-0.073 (-4.385)	-0.068 (-4.201)	-0.043 (-3.216)
Domestic	0.060 (2.887)	0.034 (1.286)	0.040 (1.504)	0.024 (0.872)
Assets (log 1996:4)			0.025 (0.527)	
Assets (log current)				0.298 (8.321)
Capital/ Assets			-0.518 (-2.347)	-0.203 (-1.073)
Merge Dummy			0.015 (0.866)	-0.029 (-1.957)
Lagged Merge Dummy			-0.021 (-1.386)	-0.037 (-3.031)
Model	OLS	RE	RE	FE
R^2	0.94	0.09	0.14	0.06
No. Obs.	175	175	174	174

Table 7: D-D Estimates of the Effect of the Repo Agreement on Domestic Medium-Sized Banks' Liquidity Demand (Ownership as of 1996:4)

	(1)	(2)	(3)	(4)
Domestic*Repo	-0.057 (-2.024)	-0.067 (-4.051)	-0.063 (-3.869)	-0.042 (-3.155)
Domestic	0.063 (3.078)	0.062 (1.750)	0.069 (1.908)	dropped
Assets (log 1996:4)			0.030 (0.654)	
Assets (log current)				0.302 (8.565)
Capital/ Assets			-0.543 (-2.477)	-0.208 (-1.110)
Merge Dummy			0.016 (0.887)	-0.029 (-1.986)
Lagged Merge Dummy			-0.021 (-1.400)	-0.037 (-3.074)
Model	OLS	RE	RE	FE
R^2	0.94	0.12	0.18	0.05
No. Obs.	175	175	174	174

Table 8: D-D Estimates of the Effect of the Repo Agreement on Domestic Banks' Liquidity Demand: Quarter Interaction Coefficients

	Medium	Large	Small
Domestic	0.065 (1.736)	0.033 (0.800)	0.014 (0.172)
Domestic* 1996:2	-0.009 (-0.290)	-0.007 (-0.171)	0.027 (0.503)
Domestic* 1996:3	-0.001 (-0.035)	-0.003 (-0.074)	0.109 (1.680)
Domestic* 1997:1	-0.056 (-1.772)	0.032 (0.817)	0.084 (1.284)
Domestic* 1997:2	-0.068 (-2.121)	0.030 (0.759)	0.035 (0.534)
Domestic* 1997:3	-0.091 (-2.796)	-0.020 (-0.506)	-0.035 (-0.539)
Domestic* 1997:4	-0.060 (-1.828)	0.023 (0.578)	0.023 (0.352)
Domestic* 1998:1	-0.071 (-2.135)	0.004 (0.098)	-0.087 (-1.316)
Domestic* 1998:2	-0.073 (-2.180)	0.026 (0.590)	-0.247 (-3.736)
Model	RE	RE	RE
R^2	0.12	0.19	0.06
No. Obs.	175	95	274

Table 9: D-D Estimates of the Effect of the Repo Agreement on Domestic Large and Small Banks' Liquidity Demand

	Large	Small
Domestic*Repo	-0.001 (-0.087)	-0.073 (-2.073)
Domestic	0.008 (0.177)	dropped
Assets (log 1996:4)	0.015 (0.233)	dropped
Capital/ Assets	-2.675 (-6.268)	0.039 (0.408)
Merge Dummy	0.007 (0.431)	-0.021 (-1.434)
Lagged Merge Dummy	0.012 (0.717)	-0.024 (-1.703)
Model	RE	FE
R^2	0.36	0.00
No. Obs.	95	272

Table 10: D-D Estimates of the Effect of the Repo Agreement on the Inter-bank Market Net Borrowing position

	Medium Banks	Large Banks
Domestic*Repo	-0.021 (-2.27)	0.025 (2.32)
Domestic	-0.012 (-0.40)	-0.034 (-4.35)
Model	RE	RE
R^2	0.08	0.28
No. Obs.	175	95

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