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* El Comité Editorial de ECONOMÍA CHILENA lamenta profundamente el deceso del profesor Rosende el pasado agosto. Nuestras sentidas condolencias a su familia y cercanos.

A NEW LIQUIDITY RISK MEASURE FOR THE CHILEAN BANKING SECTOR*

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I. INTRODUCTION

Liquidity risk is inherent to banking activity because of maturity transformation. Long-term assets co-exist with short-term liabilities.

During the last decade, banks all over the world have been heavily reliant on short-term wholesale funding, more on the commercial papers market and less on retail. However, during 2007, in advanced economies, those markets froze when doubt over the quality of their asset/solvency emerged (Schmieder et al., 2012). This reliance on the deep and broad unsecured money market resulted in liquidity challenges for many banks. In spite of the lack of attention to liquidity risks in recent decades (Goodhart, 2008), it has attracted renewed concern since the last turmoil (2007-2008). Before the crisis, international regulatory standards were predominantly focused on credit risk (BIS, 2010).

Liquidity risk metrics are based on different sources of information. Some of them use *balance-sheet* data of banks. This information can be used to measure liquidity risk at bank—and systemic—level as in Federico (2012). For example, within the balance sheet (or other data collected by supervisors) based indicators we can find the liquidity coverage ratio (LCR), the net stable funding ratio (NSFR)—both introduced by Basel III—and the liquidity mismatch index (LMI), by Brunnermeier and Pedersen (2009). Other measures are *market based*, such as the ones proposed by the ECB (2007) and the BoE (2007). These ones are built as a composition of liquidity measures such as bid-ask spreads, return-to-volume ratio and liquidity premia. Finally, in the main interest of our paper, some indicators depend on banks' behavior in the context of monetary policy operations, i.e. how commercial banks' bid schedules behave in open market operations conducted by central banks. In this line, our reference work will be that of Drehmann and Nikolaou (2012). These authors construct a funding

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liquidity risk indicator from banks' asked bid rates and volumes in the main refinancing operations performed by the European Central Bank. Basically, the more liquidity constrained an institution, the higher the spread between a benchmark and their asked rate.

To contribute to growing research on liquidity risk measures, in this paper we adapt a metric for funding liquidity risk—proposed by Drehmann and Nikolaou (2012)—and apply it to the Chilean banking industry. In order to address this task it would be necessary to underline our assessment on the concept of liquidity. As described in Drehmann and Nikolaou (2012), funding liquidity is defined as the ability to settle obligations with immediacy. It is interesting to distinguish it from market liquidity; Brunnermeier and Pedersen (2009) note that market liquidity refers to the ease to sell an asset (therefore asset-specific), and funding liquidity to the ease to access funding (therefore agent-specific). In the previous definition, funding liquidity risk is driven by the probability that over a specific horizon the bank will become unable to settle its obligation with immediacy; therefore, it is forward looking.

We revise different liquidity risk measures —funding and market based— in order to check the ones that better fit the Chilean banking sector given the available information. Looking at their benefits and drawbacks we will build a selection of metrics of liquidity risk.

To replicate some of the measures of liquidity risk for Chile, it is necessary to understand the context and the objective of open market operations (OMOs) conducted by the Central Bank of Chile (CBC).

The CBC's liquidity policy is conducted differently from most of the international central bank policies (in particular the Fed and the European Central Bank, ECB). Unlike the ECB, which injects liquidity every week, the CBC mainly drains liquidity through the sale of short-term notes (PDBC of different maturities) and of long-term bonds (BCP and BCU). This is due to the excess of inflows that is typical of emerging economies. Thus, we need to alter the Drehmann and Nikolaou's *Liquidity Risk Premium* (LRP) indicator. The idea behind this measure is that banks reveal their liquidity risks through their bidding behavior in the OMOs conducted by the monetary authority.

We construct a unique (confidential) database using the OMOs of the CBC. From September 2002 to November 2012, our data contains all the OMO auctions for every bond and note offered by the CBC, including the volumes and asked bid rates by every authorized bank operating in Chile. Using this information, we introduce an adapted LRP indicator for an emerging market liquidity policy, such as that of Chile: the CALRP, or Chilean averaged liquidity risk premium. We show that our metric manages to capture reasonably well the main episodes of liquidity stress of the last decade, especially during the recent financial crisis. Once computed this metric, we test some features about the OMO's bidding behavior of local banks and describe the modified LRP dynamics. Finally, we compare our version of LRP metric (CALRP) against other

—local and international—liquidity risk indicators proposed by the literature, highlighting periods of local policy intervention or changes in regulation. As a robustness check, we also test the relationship between void processes on our CALRP indicator.

The paper is structured as follows. Section II provides a survey of existing measures of liquidity risk. Section III describes the OMO auctions and liquidity facilities performed by the CBC. Section IV presents the liquidity risk premium indicator adapted to the Chilean context. Section V describes the data. Section VI presents the results. Section VII explicates the relation between liquidity and credit. Section VIII presents a comparative analysis and, finally, section IX concludes.

II. A BRIEF SURVEY OF EXISTING MEASURES OF LIQUIDITY RISK

In this section we present different ways of modelling a liquidity risk measure. These alternatives use balance-sheet information (at bank and banking system level), market information, or bank behavior, revealed in the biding behavior in open market operation auctions conducted by central banks. Table 1 describes the liquidity metrics covered in this work.

We concentrate this investigation on a set of liquidity metrics that have been recently issued or applied by advanced and developing economies' financial authorities. In the next section we describe the rationale, construction, strengths and weaknesses of these metrics. Most of them are replicated using Chilean banking system information. However, in the cases of CLF and CALRP we make an effort to adapt these metrics to the Chilean financial system's idiosyncrasies. Additionally, in the analysis section (section VIII), we relate and compare the computed liquidity metrics.

Table 1

Metrics of liquidity

Metric	Sources	Liquidity dimension
Liquidity coverage ratio: LCR	Balance sheet constraints	Funding
LIBOR-OIS spread: LOIS	Global funding markets prices	Funding
Global Financial Liquidity: GFL	Equity and other market spreads	Market
Prime swap spread: PS	Local wholesale funding market prices	Funding
Chilean liquidity financial indicator: CLF	Equity and other market spreads	Market
Chilean averaged liquidity risk premium: CALRP	Monetary policy behavior	Funding

Source: Central Bank of Chile.

1. Balance sheet based indices

At bank level

After the recent global financial crisis (2007-2009), the BIS introduced two liquidity requirements. Based on balance sheet data, these measures provide information at bank level, and then aggregate, for the whole banking sector or cluster. These measures are the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). Both metrics intend to measure the fragility of each bank and of the system to a shock using a stress test based approach.[1]

Another measure is the Liquidity Mismatch Index (LMI) proposed by Brunnermeier et al. (2011). It is based on a weight earmarked to the assets and liabilities depending on their liquidity characteristics, for different stress scenarios. The LMI can give individual and aggregated information, can identify SIFIs and, also, takes into account market and funding liquidity information (similar to the balance sheet indices above).

One of the benefits of this kind of measures is that these can be presented at the bank and aggregate level. Another advantage is that these metrics take into account both market and funding liquidity, where the funding dimension is calculated as a function of the market liquidity of the assets on the balance sheet of each agent. On the other hand, the main drawback of these measures is that they depend on the stress scenario in place, and it is always difficult to assess the severity of shocks with only a few crises in the past.[2] Additionally, balance-sheet based measures are sensitive to the weight and categorization of assets and liabilities; besides the fact that banks' balance-sheet information is hard to read, it changes quickly, and is subject to changes in regulation, accounting standards and window dressing. In conclusion, these indices help to understand the fragility of a bank and the banking industry as whole, but there are reasons to explore other alternatives based on mark-to-market information.

At system level

To capture the banking systemic exposure to liquidity risk, Federico (2012), following a similar methodology to the one introduced by Basel III for the NSFR, constructs a set of indices that measure how vulnerable a banking system is to a sudden drying-up of liquidity in emerging markets. By assigning weights to assets and liabilities according to their liquidity characteristics, a "Cash Shortage" index for every bank in every country used in the sample is built. This is used to build two aggregate metrics, namely the "Coverage of New Lending" and "Impaired New Lending". The author claims that these are valid indicators

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1 In general, CBC instruments constitute an important portion of banks' liquid assets (see tables A4 and A5 in appendix A). There are only a few banks where these represent less than 10% of the volume. For the NSFR and LCR definitions and constructions, see BCBS (2010) and (2013).

2 Nevertheless, we acknowledge that in order to calibrate the parameters it is possible to use international data of similar economies.

since they are robust in explaining output contractions across Latin America's and other developing countries' markets after the Lehman event.

The metric elaborated by Federico (2012) has similar benefits and drawbacks as the previously described balance-sheet based indicator. Additionally, for its construction, as the author points out, depending on the source of information, the metrics need to be corrected for a breakdown of liabilities by currency.

Although this type of indicators are feasible using the Chilean banking system information, we do not generate them, since the supporting literature is still in a preliminary stage of development.

2. Market based indices

Market spreads

Numerous market based liquidity risk measures in the literature are mainly rate spreads. These metrics mainly measure the funding dimension of liquidity. The most commonly used are spreads between overnight interbank market rates and central bank policy rates, such as the Libor-OIS spread (LOIS). These measures are easy to understand and compute, and since daily measures can be obtained, liquidity stress episodes can be quickly revealed. However they are not bank-specific, and it is difficult to disentangle liquidity risk from other risks —like solvency risk—, and they are less easy to build when markets are shallow or in a development phase.

The local Chilean version of the Libor-OIS is the *prime-swap spread* (PS), proposed by Ahumada and Álvarez (2011), which is available for different maturities (90, 180 and 360 days). The information used to build this indicator comes from a survey and a marketed overnight SWAP rate, similar to the Libor-OIS.

Composite indices

Other types of market liquidity metrics use more aggregated data. The ECB (2007) and the BoE (2007) derive, build and propose global financial liquidity (GFL) indicators based on bid-ask spreads, exchange rates, stock returns, return-to-volume ratios, liquidity premia of corporate bonds and interest rate swaps, among others. These indicators are constructed by normalizing the series and adding them up into a composite metric.

In this paper, we replicate the composite metrics GFL and CFL. Although the complete set of market data needed for constructing the indicator could be difficult to obtain for Chile due to shallow markets (compared to the developed economies), we are able to build a local version: the Chilean financial liquidity indicator (CLF). We make some assumptions and use all the information available, to the best of our knowledge.

$$CLF_t = \sum_{i=1}^{n} \frac{C_t^i}{\sigma_T^{Ci}} \tag{1}$$

It can be noticed in the formula that the main assumption is that the components of the index are independently, identically and normally distributed; thus, they are comparable and the resulting liquidity indicator should be also normally distributed. In this case, C_t^i defines the indicator's i^{th} value at time t and T is the number of periods considered to calculate the standard deviation. The number of series considered for the CLF analysis (n) is equal to four, for the GLF is six, and the time period is set to seven years.[3]

The Libor-OIS, PS and the CLF are compared to other proposed liquidity metrics in section (8).

3. Bank behavior based index - Monetary based index

The liquidity risk premium (LRP) indicator introduced by Drehmann and Nikolaou (2012) measures funding liquidity risk using banks' biding behavior in the weekly open market operations of the ECB. As it is difficult to estimate the liquidity risk of a bank, the authors assume that banks have an idea about it and reveal their balance sheet liquidity situation and preferences their transactional behavior during OMOs.

The intuition behind the LRP indicator is that there is a cost in obtaining liquidity from a central bank, and that this cost reflects banks' funding liquidity risk. Accordingly, banks with bigger liquidity problems will be more willing to incur a higher cost of getting liquidity. Along this line of thought, Nyborg and Strebulaev (2004) show that illiquid banks bid more aggressively than liquid ones. In Chile this means that banks would ask for lower prices on the CBC papers and notes.[4]

We also find that the mechanics behind the relationship between banks' liquidity and their bidding behavior at monetary auctions is rather intuitive. Furthermore, as Drehmann and Nikolaou (2012) indicate—apart from mere instinct—that it has been shown theoretically that this relationship exists (Nyborg and Strebulaev, 2004; Valimaki, 2006).

Using data from 175 main refinancing operations (MROs) conducted by the ECB from 2005 to 2008 with information on 1055 banks, Drehmann and Nikolaou (2012) measure the LRP, interpreted as the average insurance premium banks are willing to pay in the OMOs to insure themselves against funding liquidity risk.

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3 For details about the series included, please refer to table 2.

4 It should be noted that the main source of financing for commercial banks in Chile are deposits (over 50%). Thus, metrics that use information from the deposits market —such as the PS spread— would be a direct approach. However, the focus of the present work is the analysis of a source of information that has not yet been explored in the literature for the Chilean case: the demand for CBC papers through the auctions data of the open market operations.

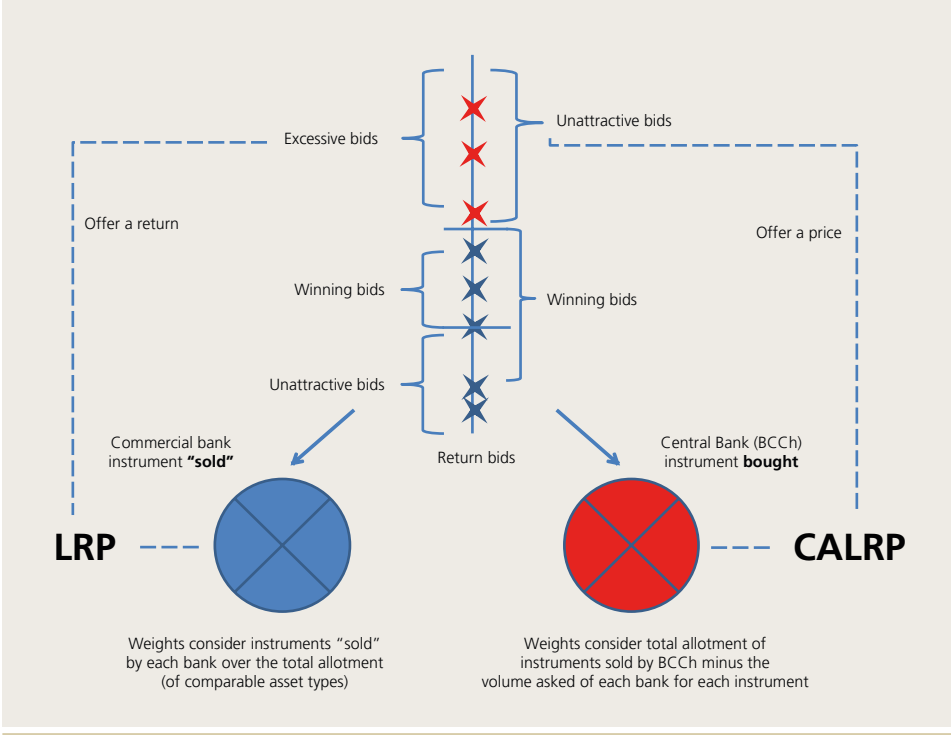
In order to build a Chilean version of the LRP index, we need to use information from the OMOs performed by the CBC. However, its definition must be adapted, since the ECB injects liquidity and the CBC mainly drains it through an auction process managed by the respective central banks.

In figure 1, we can observe the differences between both auction processes and the interpretation of liquidity risk in each of them. In Drehmann and Nikolaou (2012) we observe a direct mechanism. If a commercial bank needs liquidity, this bank will pay a higher return than others in order to get liquidity. On the other hand, in the Chilean case the liquidity risk also is represented by a high spread, but here it means that the liquidity constrained commercial banks are willing to participate in the auctions if and only if they obtain a sufficiently attractive return from the CBC and the offer to buy a lower volume.

Finally, for completeness, in the next section we describe the details about the CBC's liquidity management and how the described CBC instruments' auction processes frame.

Figure 1

Comparison between auction processes



Source: Central Bank of Chile.

III. OPEN MARKET OPERATIONS AND LIQUIDITY FACILITIES OF THE CBC

Open market operations (OMO) are a valuable tool in the implementation of monetary policy, due to their high degree of effectiveness and flexibility. Open market operations generally include, among others, purchase and sale of securities, repurchase (Repo), liquidity deposits (which replaced the anti-repo) and currency swaps. These operations, which act in conjunction with standing facilities, are intended to absorb or provide overnight liquidity at interest rates (which are dependent on the MPR), establishing a price channel where interbank market transactions are performed overnight.

OMOs can be classified into "adjustment" and "structural" operations, depending on the extent and duration of their impact on the monetary base. The CBC conducts adjustment operations in order to neutralize transitory liquidity fluctuations in the financial system, which might drive the interbank rate (IBR) away from the monetary policy rate (MPR). These operations are performed at the monetary policy rate, both to supply and absorb liquidity. As to terms, they are generally performed on an overnight basis.

The CBC, through its Open Market Operations Department (DOMA), keeps monitoring of the liquidity status of the financial system, considering its global conditions as well as the financial microstructure of the agents involved in the interbank market, for which purpose it establishes permanent communication with those responsible for managing the liquidity of the banking corporations. The CBC's instruments for doing these adjustments to the liquidity of the system are used by taking into account—among other variables—the circumstances the banking system is going through, the availability of collaterals of participating agents and the term of each operation. These operations are informed at market pre-opening times so as not to create information inconsistencies regarding trades taking place on the market that day. The regular communications channel is through direct telephone conferences and the website.

Structural operations are those conducted through changes in promissory note (PDBC) and bond (BCP, BCU and BCD) stocks. The first ones, with issuance terms ranging from 28 to 360 days, allow to manage and regulate the liquidity level of the financial system within a month or from one month to another. Bonds which have maturity periods equal to or longer than one year, are used to regulate liquidity in more permanent time periods (from one year to another) and, usually, their schedule is not altered as they respond to structural factors and are also intended for the development of the capital market. Planning of these promissory notes takes place every year and the monthly schedule of operations of the Bank is informed to the public in advance. This schedule contemplates liquidity demand expectations, maturity of previous period issuances, required reserve fulfillment strategies and seasonal effects affecting liquidity in the period. In turn, the scheduling of bonds is executed according to an annual schedule, usually announced to the market during the first days of the year. This schedule states instruments to be issued, with a description of terms, adjustments and total amounts to be bid.

The planning of these operations takes into account the main flows known for the year and demand and growth prospects of the monetary base consistent with the available economic scenario and the monetary policy course. Although the conduct of these operations has the primary goal of affecting the monetary base for extensive periods of time, the resulting rates of the bidding process have a direct bearing on the interest rates of the secondary market at different terms, reflecting and consolidating the economic expectations and the course of the monetary policy on the part of the agents at longer time horizons. That is why these operations are an important means of transmission and orientation of the monetary policy. Daily, and at the end of the day, the CBC offers standing overnight liquidity facilities (SLF) and deposit facilities (SDF) to authorized financial institutions, which are used by banking corporations to handle the deficits or surpluses that are not directly managed through the interbank market. With this mechanism, the CBC at all times sets a floating band with a ceiling and a floor of ±0.25 bp of the MPR and permits a fluctuation of the IBR around the MPR without CBC intervention. The Bank compensates the SDF at MPR –25 basis points and charge the SLF at MPR +25 basis points.

Additionally, and with a view to facilitating the liquidation of operations carried out through the real time gross settlement system (RTGS), the CBC offers an intraday liquidity facility (ILF), which corresponds to a loan that must be repaid on the same day without cost of interest to the bank. All these facilities are always open to banking corporations. While the ILF is available for a large part of the day, liquidity and deposit facilities are only open at the end of the day. In case of operations injecting money into the system (bank loans), such as the SLF and the ILF, they must be implemented as securities repurchase operations.[5]

1. Term structure management

The CBC's monetary operations manage not only the MPR, but the whole term structure. In this section we analyze these actions and the effects on the yield curve, providing a classification in terms of maturity and availability of the instruments: permanent or transitory.

The SDF, SLF and Repo are permanent operations for the monetary policy management and implementation. On the other hand, the fine tuning of the term structure is performed by the CBC instrument auctions in the primary market —that are less frequent— and some occasional and unconventional operations, such that of the FLAP. In this sense, the CBC instruments auctions contribute in the margin to the shape of the term structure (slope and curvature) and reflect the banking sector immediate liquidity conditions. The amount associated to the permanent operations is considerably higher than those associated with the CBC instruments (over a million times higher). However, the CBC auctions are comparable in volume to the unconventional policies, such as the FLAP. To

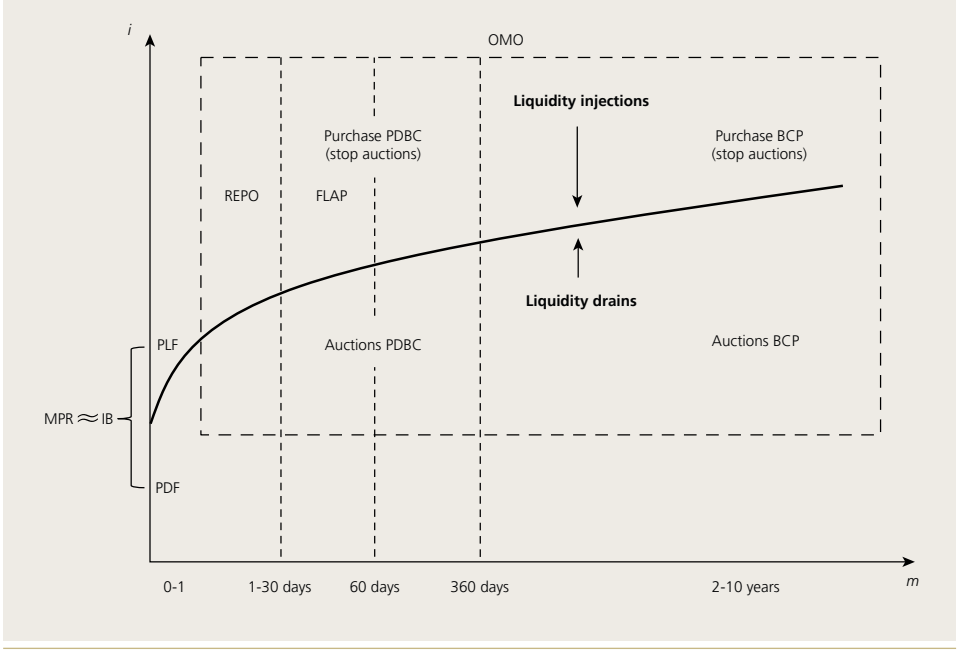
5 For more information about the CBC's liquidity management, see Central Bank of Chile (2011).

give a context, the FLAP was implemented between 2009 and 2010 and their total amount for each year accounted for 22.5% and 4.4% of all papers tendered by the CBC, respectively.

Figure 2 describes the implementation of monetary policy in the CBC. There are various instruments in its toolkit to drive market liquidity (affecting bank's funding liquidity). On the permanent type of operations we have the Standing Deposit Facility (SDF) and Standing Liquidity Facility (SLF), which operate overnight. These instruments allow commercial banks to manage liquidity shortages and surpluses that are not resolved in the interbank market during the day. Since the CBC charges MPR+25bp by SLF and MPR-25bp by SDF it ensures that the interbank interest rate (IB) is aligned with the monetary policy rate (MPR). Other short maturity—frequently traded—instruments are those with a repurchase agreement (Repos). With a lower frequency and longer maturity (more than 30 days), we have the CBC assets auctions. These are scheduled in advance every year. Finally, the CBC also has implemented unconventional policies facing temporary liquidity shortages, such as the term liquidity facility (FLAP) during the last financial crisis (2009-2010).

Figure 2

Monetary policy implementation



Source: Central Bank of Chile.

As shown in figure 2, Repos are considered liquidity injections. They would pull the yield curve down, making it flatter. This is because in the Repo, the CBC buys financial assets in exchange for an amount in pesos and simultaneously agrees to sell them within a specified period (1-30 days). These operations generate incentives to hold CBC instruments because these (and other safe assets) are required as collateral. The FLAP works similarly to the Repo, but with longer periods (60 days).

In case of longer maturities (2, 5 and 10 years), the CBC instrument auctions are less frequent, and drain liquidity from the market. The CBC sells fixed income assets of its own issue, in exchange for an amount in pesos. This would push the yield curve upwards making it steeper. The opposite occurs when the CBC decides to stop the auctions program, perceived as a liquidity relief, pulling the yield curve down, making it flatter.

IV. THE CALRP INDICATOR

We elaborate our local version of the LRP (the CLRP) by following the structure of the previously described local OMO mechanism. In contrast to the original LRP, the idea behind our measure is that given the Chilean financial sectors particularities—due to the OMO structure—banks are less willing to use their cash to *purchase* notes and bonds from the central bank in case of increased illiquidity. Intuitively, banks with tighter liquidity either submit higher bid rates—equivalently a lower price—for the notes, submit lower bid volumes, or do not participate at all in the auction.[6]

The original Drehmann and Nikolaou LRP definition appears in (2). It is the aggregate difference between the bid and a *marginal* rate[7] for each bank at each auction, weighted by the volume of each bank's allotment.

$$LRP_t = \frac{\sum_{i=1}^{N}\sum_{b=1}^{B}\left(max\left\{0, BidRate_{b,i,t} - E_t(MarginalRate)\right\}\cdot Volume_{b,i,t}\right)}{E_t(allotment)}\cdot 100 \qquad (2)$$

where $BidRate_{b,i,t}$ and $Volume_{b,i,t}$ are the rate and the volume of bank i (from 1 to N), which submits b bids (from 1 to B) at time (auction) t. $E_t(MarginalRate)$ is the expected marginal rate. These are instruments auctioned by the commercial banks that the central bank buys. It is calculated as the aggregate difference

6 It has to be mentioned that a possible drawback of the LRP type of liquidity metrics is that we cannot extract from the data the exact reasons motivating the agents to participate. We can just infer (and test) that is due to illiquidity. However, for small banks (investment banks in the Chilean case)- since their balance sheets are more volatile - their liquidity decisions could greatly variate over time and would make the auction participation decisions less informative for liquidity management purposes.

7 That is, the closest expected financial alternative or benchmark rate, which is calculated using a combination of swaps.

between the bid and the corresponding *marginal* rate, where the marginal rate is the closest expected financial alternative or benchmark rate. The LRP indicator is calculated for each bank at each auction, weighted by the volume of each bank's allotment. In this case, the higher the spread, the lower the liquidity.

As previously mentioned, in the case of the CBC's OMO mechanism, the buyer and the seller switch places. Thus, we need to alter the original definition of the LRP by adapting the weights and benchmark rates for every asset sold by the CBC.[8]

In (3) we show the local version of the LRP (i.e. the CLRP). The transformed weights are calculated as the portion of the central bank's total allotment of the specific asset acquired by the specific commercial bank. Thus, the weights take into consideration the differences in spread but regarding the volume that the agents are offering to buy in each auction. Notice also the absence of the expectations operator on the denominator. Given that all the CBC auctions are programmed in advance, there is certainty about the total volume of assets to be allocated at every auction.

$$CALRP_t = \sum_{i=1}^{N_t}\sum_{b=1}^{B_t} \frac{\left(max\left\{0, BidRate_{b,i,t} - E_t\left(MarginalRate\right)\right\}\right)}{\left(N_t \cdot B_t - 1\right)} \cdot \frac{\left(TotalBidVolume_j - BidVolume_{b,i,t}\right)}{TotalBidVolume_t} \cdot 100 \qquad (3)^{9}$$

where $BidRate_{b,i,t}$ and $BidVolume_{b,i,t}$ are the rate and volume of bank i (from to N), which submits b bids (from to B) at time (auction) t. E_t ($MarginalRate$) is the expected marginal rate and $TotalBidVolume_t$ is the total volume of the auctioned CBC instrument. These are instruments auctioned by the central bank that the commercial banks buy in the primary market: PDBC30, PDBC90, PDBC180, PDBC360, BCP2, BCP5, BCP10, BCU2, BCU5, BCU10 and BCU20. The CLRP is computed as the aggregate difference between the bid and the corresponding *marginal* rate, where the marginal rate is the closest expected financial alternative or benchmark rate, which in the Chilean case is calculated using a combination of swaps. As for the weights, these are calculated as the portion of the central bank's total allotment of the specific asset acquired by the specific commercial bank. Thus, these weights take into consideration the

8 The CLRP metric is constructed for a variety of CBC assets traded in the OMOs' primary market, covering maturities of 30 days to 20 years: PDBC30, PDBC90, PDBC180, PDBC360, BCP2, BCP5, BCP10, BCU2, BCU5, BCU10 and BCU20.

9 Banks with few transactions of CBC instruments have greater weight in the CALRP. The rationale behind this characterization is that if banks trade a low volume it means that they are less willing to give up their liquidity. We acknowledge that this definition woul make the CALRP outweigh some longer maturity CBC instruments due to infrequent trading. However, we have checked that in most of the instruments we have sufficient trading information to overcome this issue.

volume that the agents are offering to buy at each auction. If the volume is high we assume that the particular commercial bank is less liquidity constrained.

In some cases, due to the infrequent participation of any specific bank, the CLRP indicator becomes too sensitive to volume acquisition at a specific auction. In order to overcome this issue, we compute another version of the weights. In (4), we depict the more robust version of the Chilean liquidity indicator, the CALRP,[10] where we average the weights of a set of auctions (i.e. 10) in which the bank participates.[11] This modification allows the liquidity metric to become less dependent in the current operation and thus more structural.

$$CALRP_t = \sum_{i=1}^{N_t} \sum_{b=1}^{B_t} \sum_{j=k-9}^{k} \frac{\left(max\left\{0, BidRate_{b,i,t} - E_t\left(MarginalRate\right)\right\}\right)}{(N_t \cdot B_t - 1)} \cdot \frac{\left(TotalBidVolume_j - BidVolume_{b,i,j}\right)}{TotalBidVolume_j} \cdot 100 \quad (4)$$

As shown in (3) and (4), the CLRP and CALRP formulas depend —apart from bid rates and volumes— on a reference rate (i.e. the *MarginalRate*), which is the expected future comparable rate for each instrument. Consequently, this rate relies upon the CBC asset that is auctioned. In the case of PDBC30 instrument auctions, as the comparable swap instrument does not exist, we compute the benchmark as a composite of swap rates of different maturities (90d, 180d and 1y). In this case we have that

$$\text{SWAP30}_t = \frac{7 \cdot \text{SWAP90}_t - 5 \cdot \text{SWAP180}_t + \text{SWAP360}_t}{3}$$

In all the other assets auctioned, the comparable maturity instrument is available.

In the same spirit of the original LRP, and in contrast to other liquidity metrics, the Chilean version (CALRP) has the advantage of being calculated at bank level. However, the CALRP results can be also aggregated at other levels. In this work, in order to protect the anonymity of the CBC auction participants, we present the results at a cluster or system level.[12]

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10 CALRP stands for the Chilean averaged liquidity risk premium.

11 In this case we need to add an aggregation term. That is a sum operator for 10 auctions. This operation goes between k –9 and k, where k represents the auction that is occurring at time t.

12 For the long-term instrument auctions, it should be noted that there are institutional investors with greater participation. It is observed that these institutions absorb a high percentage of CBC instruments. For the case of 5-year bonds, over the last 10 years they have a 38% average participation; whereas in the 10-year bonds they have a 44% share. Of course this makes our indicator less accurate for these instruments, especially in the definition of weights, because the preferences of institutional investors could contaminate our results. However, the banking sector is still an important player even in these long-term assets.

V. THE DATA

Our CALRP data set comes from the transactional information of all the instruments auctioned by the CBC. Those instruments are the PDBC, BCP and BCU but only nominal instruments are considered to make the analysis consistent with the monetary policy interest rate.[13]

The auctions considered were conducted from September 2000 to November 2012. This data allows us to follow the bidding behavior of the 21 major banks in the Chilean financial system. The information includes the submitted bid schedule—bid rate and bid volume—of each bank, and the allotted volume earmarked by the authority. These data is not publicly available. However, information of benchmark marginal rates is obtainable through the CBC web site. The rest of the data sources are described in table 2.

Table 2

Data and sources

Data series	Frequency	Source	Metric	Comments
Bids for CBC PDBC notes (30d, 90d, 180d, 1y; in CLP)	weekly	CBC	CALRP	private
Bids for CBC BCP bonds (2y, 5y, 10y, 20y; in UF)	weekly	CBC	CALRP	private
Swap rates (30d, 90d, 180d, 1y, 2y, 5y, 10y, 20y)	weekly	CBC	CALRP/PS/CLF	public
Banks' balance sheet data (C08 file)	monthly	SBIF	LCR	private
Prime deposit rate (90d)	daily	LVA indices	PS	private
Bid-Ask spread (Stock Mkt Index IPSA, SWAP CLP Rates 3y)	daily	Santiago SE/ Blomberg	CLF	private
Return to volume ratio (IPSA, Central bank bonds (secondary market))	daily	Santiago SE/ CBC	CLF	private
Bid-Ask spread (FTSE 100)	daily	Bloomberg	GFL	public
Return to volume ratio (FTSE 100, SP500)	daily	Bloomberg	GFL	public
Libor – Gov't bond spread (US, EUR, GBP)	daily	Bloomberg	GFL	public
Libor - OIS spread	daily	Bloomberg	LOIS	public

Source: Central Bank of Chile.

13 The objective of this research is to relate the preference for CBC instruments in the context of the implementation of monetary policy, leaving out the implications of fiscal policy related to BTP. Hence, these instruments are not included in the analysis.

Now we turn to the descriptive statistics. As shown in tables 3 and 4, the peaks of void auctions are distributed along the financial crisis and at the end of 2009, 2010 and 2011. For the short maturity instruments, the percentage of void auctions increased during the financial crisis, but peaked in 2011 and 2012.

In the case of long-term instruments, as presented in table 5, the evidence is somewhat mixed. On one hand, the 2-year bonds in pesos (BCP2) void auctions peak in 2009, right after the crisis. On the other hand, longer maturity instruments' void auctions represent a greater percentage between 2007 and 2010.

Table 3

Descriptive statistics: auctions and effectiveness - short-term papers

	PDBC30				PDBC90			
Year	Auctions	Amount	Banks (%)	Void (%)	Auctions	Amount	Banks (%)	Void (%)
2005	54	12,524	99.8	0	54	7,348	100	0
2006	100	15,376	99.9	3	97	8,036	100	1
2007	86	13,708	100.0	1	84	4,533	100	0
2008	95	12,633	100.0	3	60	2,585	99.3	5
2009	102	21,691	100.0	1	96	7,922	100	9
2010	115	47,676	87.1	1	64	6,054	97.5	11
2011	95	54,224	94.4	7	91	7,266	96	21
2012	74	53,118	94.7	4	37	4,597	95	32
Total	721	230,951	94.9	3	583	48,341	98.7	9

Source: Central Bank of Chile.

Table 4

Descriptive statistics: auctions and effectiveness - short-term papers

	PDBC180				PDBC360			
Year	Auctions	Amount	Banks (%)	Void (%)	Auctions	Amount	Banks (%)	Void (%)
2005	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-
2007	2	77	100	0	2	77	100	0
2008	22	700	100	27	22	782	99	23
2009	54	985	100	44	15	432	100	0
2010	31	719	86	23	36	911	92	22
2011	15	331	97	73	-	-	-	-
2012	10	189	98	60	-	-	-	-
Total	134	3000	96	40	75	2202	97	18

Source: Central Bank of Chile.

Table 5

Descriptive statistics: auctions and effectiveness - long-term papers

	BCP2				BCP5				BCP10			
Year	Auctions	Amount	Banks (%)	Void (%)	Auctions	Amount	Banks (%)	Void (%)	Auctions	Amount	Banks (%)	Void (%)
2005	24	702	82	4	33	377	95	3	33	318	98	6
2006	9	339	87	0	13	336	76	0	5	155	78	0
2007	13	530	92	23	14	420	91	21	1	19	35	100
2008	25	773	95	20	23	657	89	9	11	160	68	18
2009	18	242	87	33	12	198	70	17	-	-	-	-
2010	37	829	98	16	40	1119	72	28	-	-	-	-
2011	13	476	99	15	30	1421	56	7	20	972	56	5
2012	17	514	91	6	24	719	76	17	17	719	40	12
Total	156	4405	92	15	189	5247	74	13	87	2344	60	9

Source: Central Bank of Chile.

We are interested in the auctions' effectiveness. The intuition tells us that there is a relation between void auctions and liquidity. The rationale is that when liquidity conditions are more stringent, commercial banks are more constrained to acquire CBC papers. Thus, the auctions are more prone to be declared ineffective. In section (VI.2), we will test this hypothesis.

Marginal rates are a key element in the construction of our CALRP indicator, since the results depend on the choice of this variable. That is how these interest rates are constructed using the relevant swap rates, in order to account for expectations. In table 6 we present the relevant benchmark (or marginal) rates moments across different time windows. We can see that all marginal rates (i.e. the benchmark rate for equivalent alternative investments) peak in 2008, during the financial crisis period. The standard deviations of the different marginal rates are shown in parentheses. These tables show that during the financial crisis there was an increase in the time-series volatility that remained high for two more years, after it stabilized to pre-crisis levels in 2011.

Another element of the CALRP indicator we are constructing is the bidding behavior. Table 7 shows the bidding behavior of banking institutions when operating at the OMO of the Central Bank. It can be observed that—similar to the marginal rates—the peaks in all the instruments are reached during the crisis period in 2008. In the case of volatility, we see that the time-series variability (i.e. volatility of the average bids) and its cross-section counterpart (average of bids' volatility) increased in 2008 and remained high until 2010, but decreased to pre-crisis levels in the following years.

Table 6

Descriptive statistics: marginal rates

(percentage)

Year	PDBC30	PDBC90	PDBC180	PDBC360	BCP2	BCP5	BCP10
2005	3.83[1]	4.19	4.04	4.32	5.05	5.95	6.63
	(0.45) [2]	(0.43)	(0.74)	(0.67)	(0.74)	(0.56)	(0.38)
	3.38 [3]	3.78	3.69	3.90	4.59	5.62	6.36
	3.93 [3]	4.18	4.01	4.17	4.81	5.82	6.49
	4.21 [3]	4.62	4.52	4.69	5.41	6.27	6.69
2006	4.93	5.09	5.25	5.43	5.99	6.47	6.85
	(0.26)	(0.16)	(0.11)	(0.12)	(0.23)	(0.33)	(0.39)
	4.79	4.92	5.17	5.35	5.81	6.19	6.59
	5.02	5.18	5.23	5.41	6.05	6.57	6.98
	5.12	5.22	5.35	5.51	6.16	6.71	7.16
2007	5.33	5.41	5.47	5.48	5.77	6.10	6.35
	(0.34)	(0.39)	(0.44)	(0.46)	(0.49)	(0.42)	(0.36)
	5.03	5.00	4.99	4.95	5.19	5.60	5.97
	5.21	5.30	5.41	5.52	5.93	6.28	6.46
	5.74	5.83	5.88	5.91	6.21	6.45	6.61
2008	7.10	7.18	7.20	7.05	7.07	6.96	6.95
	(0.86)	(0.83)	(0.83)	(0.77)	(0.73)	(0.64)	(0.56)
	6.27	6.33	6.38	6.33	6.46	6.44	6.48
	6.84	7.18	7.12	6.89	6.81	6.83	6.86
	8.12	7.96	7.95	7.65	7.80	7.59	7.47
2009	1.96	1.69	1.57	1.86	2.91	4.64	5.35
	(2.22)	(1.89)	(1.56)	(1.19)	(0.76)	(0.56)	(0.58)
	0.54	0.51	0.63	1.24	2.41	4.29	4.92
	0.76	0.66	0.76	1.39	2.64	4.70	5.45
	2.19	1.96	1.77	1.78	3.11	5.13	5.73
2010	1.53	1.76	2.09	2.72	3.72	5.11	5.86
	(1.01)	(1.11)	(1.17)	(1.03)	(0.63)	(0.19)	(0.22)
	0.57	0.59	0.78	1.53	3.16	4.97	5.71
	1.17	1.62	2.14	2.87	3.79	5.07	5.92
	2.62	2.96	3.25	3.68	4.26	5.19	6.05
2011	4.76	4.78	4.82	4.88	5.19	5.56	5.83
	(0.77)	(0.60)	(0.50)	(0.50)	(0.61)	(0.57)	(0.54)
	4.13	4.54	4.53	4.46	4.58	4.92	5.22
	5.26	5.02	4.89	4.73	5.46	5.86	6.02
	5.32	5.22	5.30	5.45	5.75	6.07	6.29
2012	5.00	4.93	4.87	4.80	4.96	5.21	5.45
	(0.07)	(0.07)	(0.13)	(0.23)	(0.31)	(0.28)	(0.23)
	4.98	4.89	4.78	4.62	4.72	5.04	5.29
	5.00	4.95	4.88	4.81	4.95	5.16	5.45
	5.02	4.99	4.99	5.01	5.23	5.44	5.57

Source: Central Bank of Chile.
(1) Mean. (2) Standard deviations. (3) Quartiles 1,2,3.

Table 7

Descriptive statistics: bids' average rates

(percentage)

Year	PDBC30	PDBC90	PDBC180	PDBC360	BCP2	BCP5	BCP10
2005	3.74(1)	3.96			4.61	5.56	6.04
	(0.68)(2)	(0.71)			(0.29)	(0.45)	(0.30)
	[0.65](3)	[0.68]			[0.28]	[0.44]	[0.3]
	3.04(4)	3.17			4.52	5.26	5.85
	3.96(4)	4.19			4.66	5.47	5.96
	4.28(4)	4.51			4.75	5.68	6.15
2006	4.71	4.84			5.90	6.08	6.25
	(0.37)	(0.34)			(0.26)	(0.24)	(0.59)
	[0.3]	[0.27]			[0.3]	[0.27]	[0.36]
	4.40	4.58			5.75	6.01	6.11
	4.73	4.80			5.97	6.11	6.25
	5.01	5.11			6.07	6.19	6.40
2007	5.00	5.14	6.18	6.23	5.86	5.98	5.45
	(0.47)	(0.50)	(0.16)	(0.18)	(0.42)	(0.52)	(0.05)
	0.39	[0.44]	[0.12]	[0.19]	[0.45]	[0.42]	n.a.
	4.60	4.79	6.20	6.05	5.65	5.60	5.40
	4.95	5.07	6.24	6.29	6.00	6.20	5.45
	5.25	5.50	6.25	6.36	6.20	6.32	5.50
2008	7.58	6.98	7.32	7.19	7.31	7.12	7.75
	(1.22)	(0.85)	(0.69)	(0.61)	(0.70)	(0.78)	(0.44)
	[1.15]	[0.72]	[0.65]	[0.59]	[0.72]	[0.74]	[0.41]
	6.60	6.55	6.69	6.69	6.65	6.48	7.36
	7.50	6.65	7.16	6.95	7.15	7.10	7.65
	8.30	7.50	8.00	7.66	7.95	7.77	7.99
2009	1.79	2.11	1.49	2.99	3.25	4.71	
	(2.15)	(2.17)	(1.58)	(1.74)	(0.92)	(0.45)	
	[2.10]	[2.00]	[1.37]	[1.37]	[0.86]	[0.42]	
	0.44	0.48	0.60	1.80	2.67	4.48	
	0.58	1.10	0.80	1.99	2.89	4.76	
	2.25	3.13	1.57	3.60	3.60	4.96	
2010	1.27	1.82	2.69	3.16	4.26	5.67	
	(1.05)	(1.12)	(0.94)	(1.08)	(0.70)	(0.20)	
	[1.05]	[1.14]	[0.94]	[0.94]	[0.66]	[0.15]	
	0.40	0.50	1.80	2.20	3.69	5.56	
	0.60	1.79	3.02	3.31	4.36	5.68	
	2.43	2.92	3.49	4.15	4.87	5.79	
2011	4.65	4.97	5.43		5.49	5.71	5.99
	(0.79)	(0.67)	(0.48)		(0.58)	(0.67)	(0.63)
	[0.76]	[0.66]	[0.49]		[0.56]	[0.65]	[0.64]
	3.99	4.70	5.12		4.93	5.06	5.45
	5.10	5.22	5.49		5.69	5.95	6.15
	5.25	5.43	5.79		6.02	6.30	6.49
2012	4.93	4.99	5.02		5.24	5.39	5.56
	(0.19)	(0.20)	(0.27)		(0.26)	(0.26)	(0.24)
	[0.12]	[0.17]	[0.21]		[0.26]	[0.24]	[0.24]
	4.80	4.84	4.80		5.03	5.20	5.38
	4.91	4.98	5.00		5.27	5.36	5.46
	5.04	5.15	5.24		5.41	5.62	5.76

Source: Central Bank of Chile.
(1) Mean from banks by date. (2) Standard deviations from banks by date. (3) Deviations from system by date. (4) Quartiles 1,2,3.
(5) n.a.=not available.

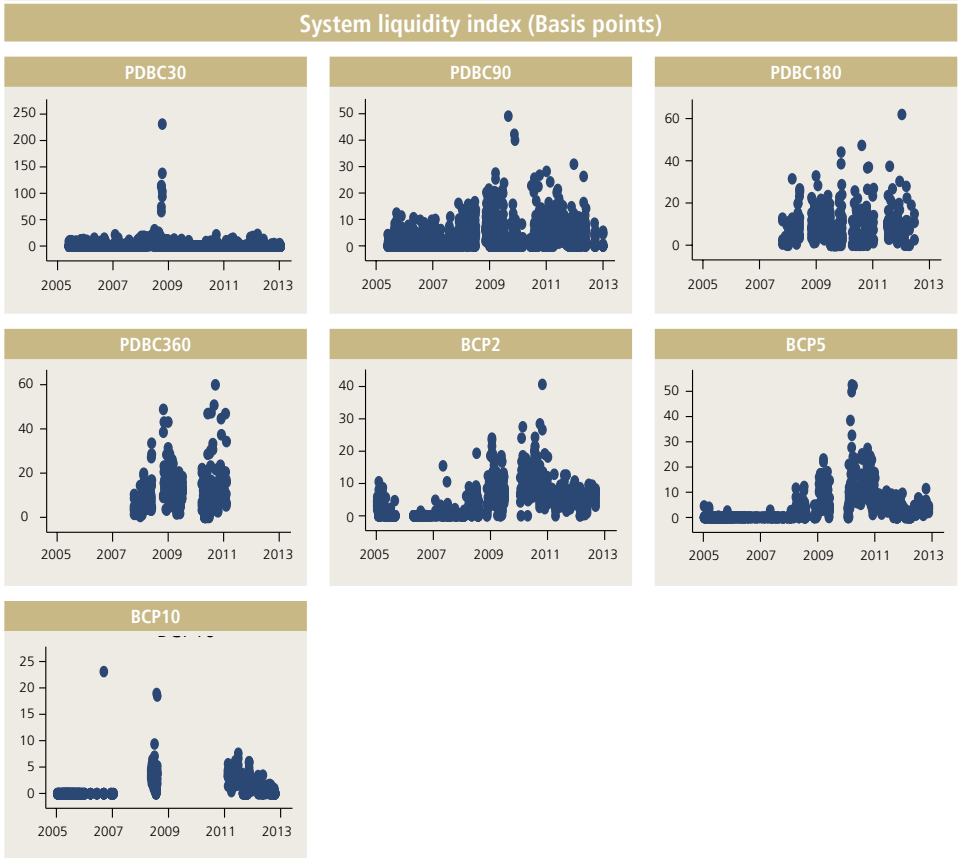
Now we have described the data; in the next section we present our results for the CALRP indicator.

VI. CALRP RESULTS[14]

In this section we present the results of our major contribution: the CALRP. As we previously mentioned, this indicator can be built at bank level. However, we must avoid the presentation of individual data because of confidentiality concerns, so we aggregate the results. Figure 3 shows the Chilean banking systems aggregate results (by CBC instrument). We can observe that for the shortest maturity assets (PDBC30), the CALRP indicates that this part of the yield had an approximate increase of 100bp of risk premium at the end of 2009, coinciding with shortages in international financial markets funding.

Figure 3

Agregated results by instrument



Source: Central Bank of Chile.

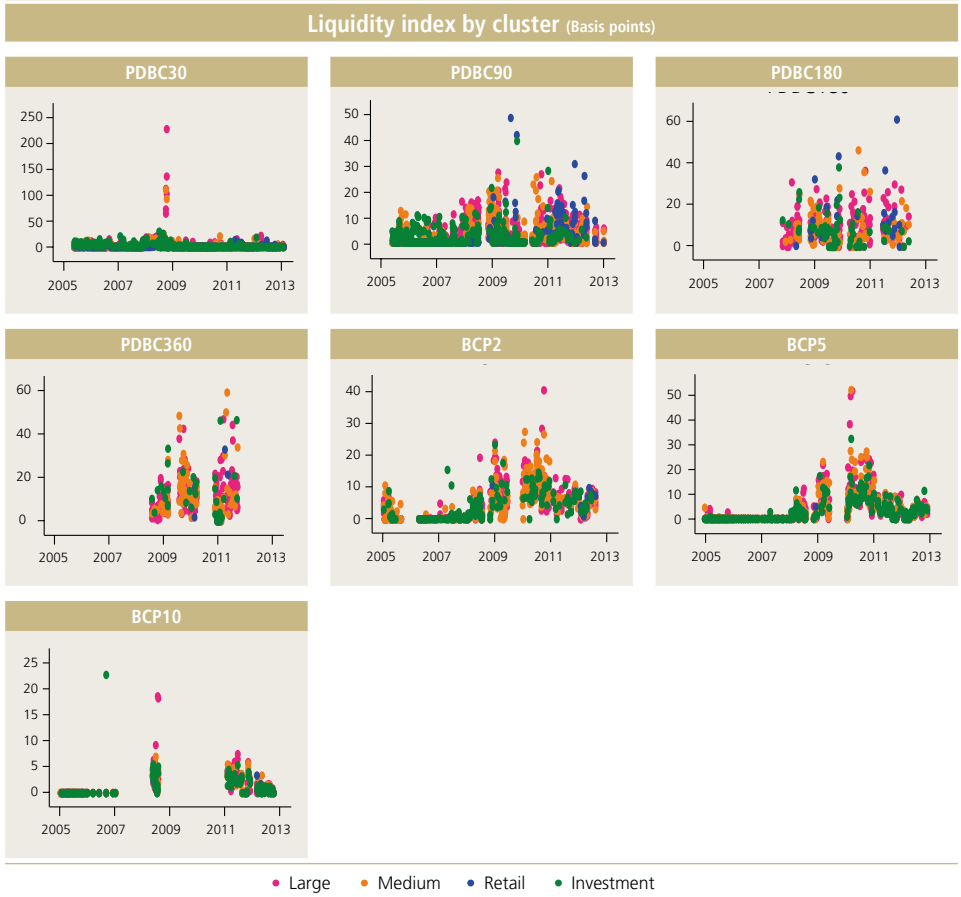
14 The participation of pension funds and other institutional investors is highly relevant in the Chilean economy. Thus, their impact in the final adjudication rates should be a matter of further analysis. As a robustness check of our results, we have revised that their influence on final rates is only binary (see figures 10 and 11 in appendix A). When they participate, the adjudicated rates are lower and their interval of variation is shorter. However, in the auctions where institutional investors are not present, we observe higher levels and a wider range of settled rates.

On the other hand, we see that the longer maturity instruments show an increase in the CALRP in 2010 and 2011.

At a more detailed level, in figure 4, we present the results of CALRP aggregated at cluster level. These cluster's groupings are defined by size and are described in Central Bank of Chile (2007). In cluster 1 appear the biggest banks of the Chilean banking system, the rest of the groups are medium-sized banks (1 and 2) and small banks. The plot shows that large and medium banks present a similar liquidity behavior, as measured by the CALRP. However, investment and retail banks follow different patterns. This would be explained by the fact that the latter banks' businesses are of a different nature. Investment banks have excess liquidity with virtually no consumer deposit or external financing, that is used mainly for trading purposes. On the other hand, retail banks—as opposed to commercial banks—do not use external financing, and mainly provide low volume and high revenue consumer-type of credit. Thus, they have relatively lower liquidity needs [15].

Figure 4

Aggregate results by instrument and cluster (size)



Source: Central Bank of Chile.

15 For details about the annual averages, please see tables A1, A2, and A3 in appendix A.

Table 8

CALRP Liquidity indicator by instrument and year

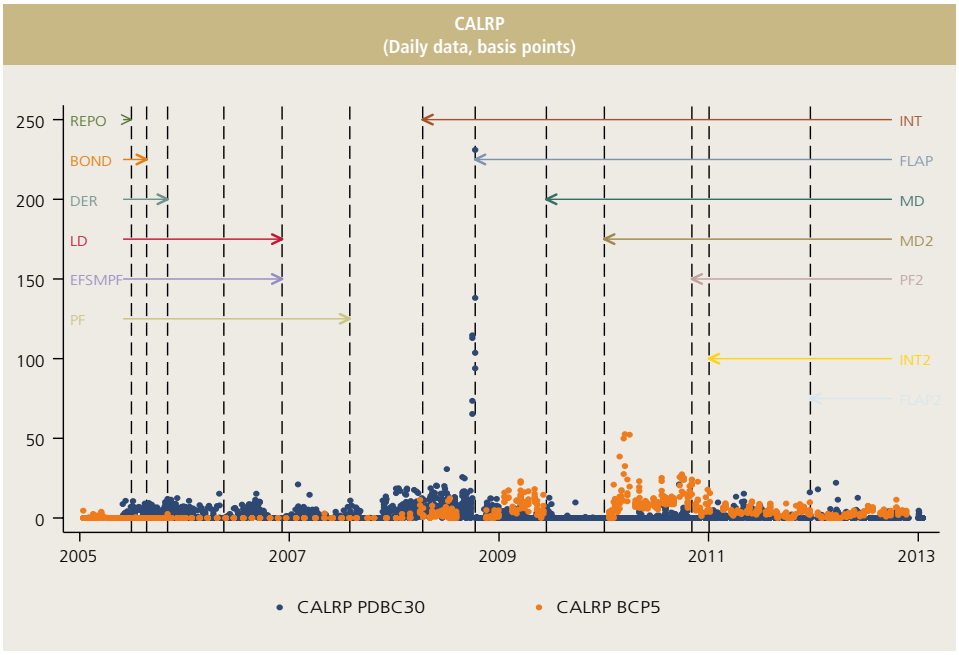
(basis points)

Year	PDBC30	PDBC90	PDBC180	PDBC360	BCP2	BCP5	BCP10
2005	2.1 [1]	1.1	0	0	1.3	0.1	0
	(2.7) [2]	(1.9)	(0)	(0)	(2.2)	(0.6)	(0)
	0 [3]	0	0	0	0	0	0
	0.8 [3]	0	0	0	0	0	0
	3.4 [3]	1.7	0	0	1.9	0	0
2006	1.1	0.5	0	0	0	0	0.6
	(2.4)	(1.7)	(0)	(0)	(0.2)	(0)	(3.8)
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0.5	0	0	0	0	0	0
2007	0.9	0.8	4.2	4.3	0.8	0	0
	(2.3)	(1.9)	(4.7)	(2.6)	(2.3)	(0.3)	(0)
	0	0	1.1	3	0	0	0
	0	0	2.4	3.8	0	0	0
	0.3	0.4	4.2	5	0.6	0	0
2008	7.2	5.9	9.3	11.4	3	1.8	3.1
	(15.7)	(4.2)	(5.8)	(8.2)	(3.1)	(2)	(2.9)
	1.8	3.3	5.3	5.6	0.6	0.1	1.4
	4.7	5.4	8.2	9.1	2.3	1.4	3
	7.9	7.9	11.1	14.6	4.4	2.7	4
2009	0.4	2.9	6.1	13.6	7.7	9.7	0
	(1.4)	(5.2)	(7.3)	(6.9)	(5.3)	(5.2)	(0)
	0	0	0	8.8	4.4	5	0
	0	0.9	4	12	6.2	10	0
	0	3.9	9.4	17.2	10.2	13.1	0
2010	0.2	2.1	8	13.3	10.8	11	0
	(1.2)	(4.3)	(8.9)	(12.2)	(5.3)	(7.8)	(0)
	0	0	1.2	5.4	7.2	6.9	0
	0	0	5.5	10.6	10	9.1	0
	0	2.6	11.5	17.1	12.8	12.7	0
2011	0.9	4.6	12.1	18.9	6.3	3.9	2.4
	(1.9)	(4.5)	(10.2)	(14.2)	(3.1)	(2.6)	(1.7)
	0	1.4	5.4	6.4	4.1	2.1	1.6
	0	3.4	9.9	16	6	3.6	2.4
	0.8	6.2	14.3	34.4	8	5.3	3.5
2012	0.7	2.7	8.3	0	4.4	2.4	0.7
	(1.8)	(3.8)	(7.6)	(0)	(2.6)	(2)	(0.7)
	0	0	1.6	0	2	0.6	0
	0	1.2	7.6	0	4.1	2.2	0.7
	0.9	4.4	11.4	0	6.6	3.6	1
2013	0.4	1.2	0	0	0	0	0
	(1.1)	(2.1)	(0)	(0)	(0)	(0)	(0)
	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
	0	0.6	0	0	0	0	0
Total	1.6	2.4	7.8	12.4	4.9	3.7	1.2
	(6.2)	(4)	(7.9)	(9.6)	(5.2)	(5.5)	(2.1)
	0	0	1.4	6.2	0.3	0	0
	0	0.2	6.5	10.5	3.8	1.8	0
	1.3	3.5	10.9	15.9	7.6	5.3	2.1

Source: Central Bank of Chile.
(1) Mean by date. (2) Standard deviation from banks by date. (3) Quartiles 1,2,3.

Figure 5

CALRP and economically significant events



Source: Central Bank of Chile.

Table 8 contains the CALRP yearly average, calculated by CBC instrument. We can observe that all instruments evidence a liquidity spike in 2008, during the crisis. We can also see that the peaks—describing lower banks' funding liquidity—of short-maturity instruments were achieved in the same year. However, for the higher-maturity instruments, peaks were achieved in 2010 and 2011.

Additionally, figure 5 depicts different time events that could coincide with or be related to developments in the banking system's liquidity. On one hand, short-term liquidity—as measured by the CALRP of PDBC30—is associated to regulations events affecting the short-term market. Whereas CALRP calculated using longer-maturity instruments is naturally more correlated to regulations affecting the long-term market operations.

First, we present examples of short-term financial market regulations and their influence on the short-maturity instruments'—PDBC30—CALRP. In June 2005, the CBC authorized the purchase of credit securities through Repos with the CBC. This coincided with the increase of the liquidity premium of short-maturity CBC instruments, mainly because the Repos constitute an alternative source of short-term financing/investment. Another short-term measure was introduced in May 2006, namely an electronic deposit facility of the CBC, for monetary operations purposes. This new system introduced a liquidity friction that lasted

for one quarter, until the institutions adapted their operations. We also observe an increase in the short-maturity CALRP after the CBC authorized to raise the pension fund (PF) limits on foreign investment. This imposed a constraint in local financing of commercial banks operating in Chile. Finally, the peak was achieved right after the Lehman event in 2008 and it decreased following the CBC's announcement of its flexible liquidity policy program (FLAP).[16]

Second, we present events that coincide with longer maturity CALRP—BCP5—fluctuations. In the case of the long term CALRP indicator, we see that there is some increase after the FLAP in 2008, because these instruments were competing against short-term CBC securities with relatively better pricing conditions. In June 2009 the BCP5 instruments were suspended, coinciding with a Chilean government bond issuance. The instruments were allowed back in 2010 showing an increased CALRP premium and volatility across banks, mainly due to rebalancing of the commercial banks' investment portfolios, after the measure.

1. CALRP term structure

As we have shown previously, the CALRP indicator reasonably captures episodes of commercial banks' liquidity contraction at different maturities or horizons. However, to get a better view of the CALRP term structure and put our metric in historical/maturity context, we analyze the liquidity risk premium yield over time (figure 6).

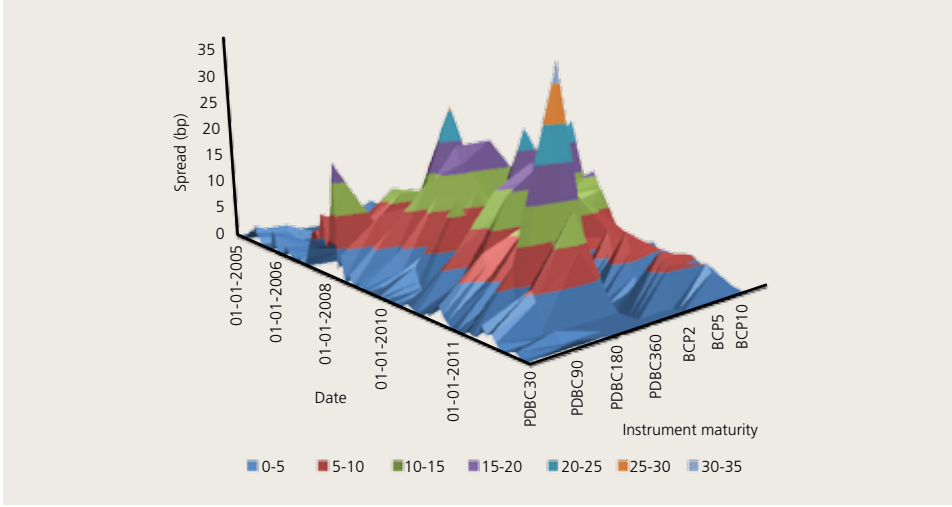
On one hand, we have that, for the short-maturity instruments, the 2008-2009 period was particularly problematic in terms of liquidity. On the other hand, in contrast to the short maturity instruments, the longer maturity ones observed other peaks occurred more recently.

The sources of different timing structures of CALRP are explained by large scale adjustments in commercial banks' balance sheets for the longer instruments' maturity case. However, in the case of short-term maturity CALRP, we observe that liquidity is more sensitive to events of global or local financial fragility. Additionally, we observe reversions in the CALRP term structure curves, especially in 2008. This would be in favor of Borio and Zhu (2008) and others that describe this phenomenon as one indicator of financial vulnerability, due to non-anticipation of monetary policy.

16 For more details, please refer to appendix B.

Figure 6

CALRP term structure



Source: Central Bank of Chile.

2. Void auctions analysis

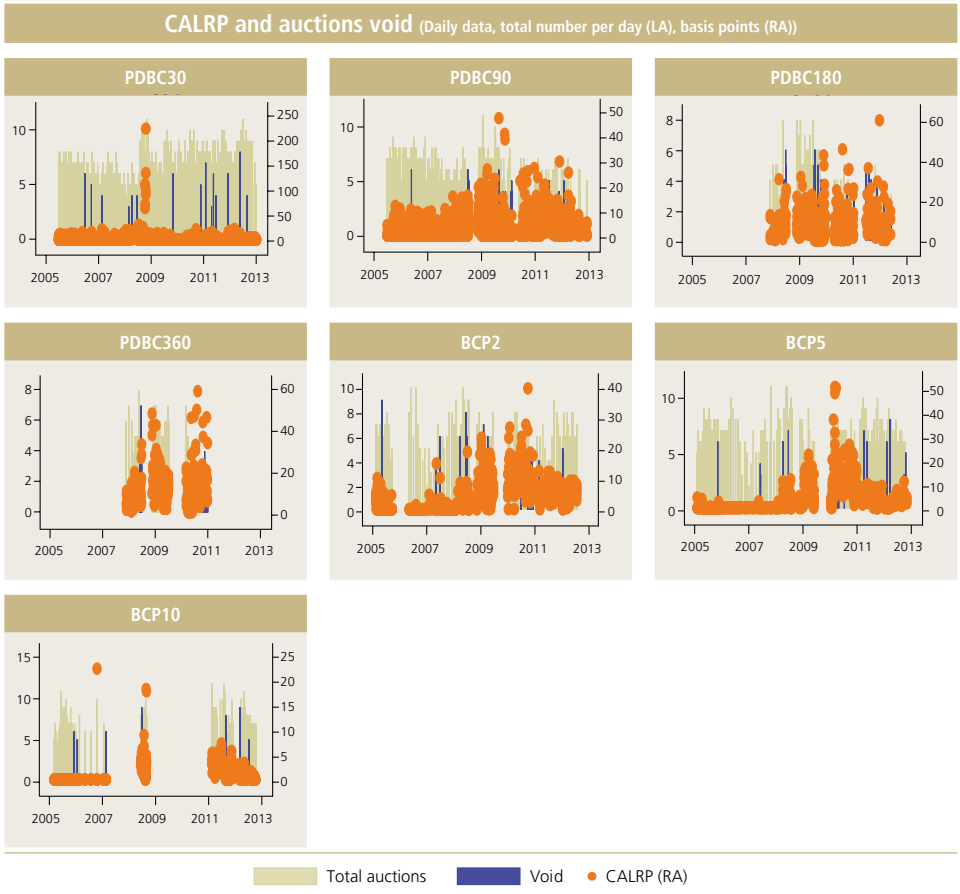
There is an outcome to which every auction is exposed: a void process. This occurs when the seller does not accept any of the bids. In this case, the CBC determines that an auction is void by using expert criteria. These criteria are based on different pieces of market information: surveys, the banking system and the auction history data. The CBC staff basically draws an implicit price threshold for every auction. When the bids are not attractive enough, the CBC declares the auction void.

We are interested in understanding the reasons behind a void auction. This would serve as robustness check for our proposed liquidity indicator. Figure 7 shows certain correlation between the level of the CALRP indicator and the frequency of void auctions. To confirm this relationship, we perform a statistical analysis. Specifically, we test the hypothesis indicating that when liquidity is scarce, commercial banks will be *excessively* unwilling to participate in a CBC auction. Thus, we can check the correlation of our metric of liquidity (the CALRP) with the appearance of a void auction process. Equation (5) shows our model specification for each CBC asset j and auction occurred at time t^*.

$$P\left(\text{Voidauction}=1\right)_{j,t^*}=\text{P}\left(\varepsilon_{j,t^*}>-\left[\alpha+\beta\cdot\text{CALRP}_{j,t^*}\right]\right)=\Phi\left(\alpha+\beta\cdot CALRP_{j,t^*}\right) \quad (5)$$

FIGURE 7

CALRP and void auctions



Source: Central Bank of Chile.

Tables 9 and 10 show the results of our probit regressions of a void auction dummy as independent variable, and the associated CALRP indicator as explanatory variable. These tables refer to long- and short-maturity CBC papers, respectively.

Table 9

Probit void auctions: BCP

	(1)	M.E.	(2)	M.E.	(3)	M.E.
CALRP BCP2	-0.028	-0.002				
	(0.052)	(0.003)				
CALRP BCP5			0.006	0.000		
			(0.031)	(0.002)		
CALRP BCP10					0.202	0.009
					(0.166)	(0.007)
Constant	-1.813***		-2.059		-2.342	
	(0.313)		(0.262)***		(0.473)***	
Observations	156		188		87	
Pseudo *R* squared	0.009		0.001		0.076	

Source: Author's elaboration.
Coefficients and standard errors of individual univariate regression between *Void auction* ∈ {0,1} and the corresponding CALRP for each instrument maturity. Monthly data, 2005-2013. Standard errors in parentheses. Marginal effects (M.E.) reportedM.E. ***p<0.01, **p<0.05, *p<0.1.

Table 10

Probit void auctions: PDBC

	(1)	M.E.	(2)	M.E.	(3)	M.E.	(4)	M.E.
CALRP PDBC30	0.008	0						
	(0.015)	(0)						
CALRP PDBC90			0.152***	0.001***				
			(0.039)	(0.001)				
CALRP PDBC180					0.052***	0.007 ***		
					(0.023)	(0.003)		
CALRP PDBC360							0.017	0.002
							(0.034)	(0.004)
Constant	-2.356***		-3.269***		-1.940***		-1.833***	
	(0.146)		(0.389)		(0.291)		(0.538)	
Observations	723		580		131		73	
Pseudo R-squared	0.003		0.300		0.077		0.008	

Source: Author's elaboration.
Coefficients and standard errors of individual univariate regression between *Void auction* ∈ {0,1} and the corresponding CALRP for each instrument maturity. Monthly data, 2005-2013. Standard errors in parentheses. Marginal effects (M.E.) reported. ***p<0.01, **p<0.05, *p<0.1.

As shown in tables 9 and 10, there is a positive and statistically significant relation between a void auction and our liquidity indicator. This means that the greater the spread between the proposed and the marginal rate—or lower

liquidity—, the higher the probability of observing a void action. The regularity is more pronounced in the cases where the regression has a high R-squared. Those regressions coincide with a high number of observations, or instruments' trading frequency. That is the case of PDBC instruments at 90 days.

Clearly, the results in this section need to be read carefully. This is because the higher value of our indicator often coincides with the exact date where an auction is declared null. Thus, the results cannot be directly interpreted as a predictor of void auctions.[17] Nevertheless, the CALRP metric allows us to understand one important determinant of CBC null auctions: banking system liquidity.

VII. LIQUIDITY AND CREDIT

As Cornett et al. (2011) suggest, one of the most regarded—and potentially dangerous—consequences of a considerable liquidity shortage is the possibility that this financial tension is translated into a credit contraction. The problem is worse in case two elements are present. The first element is creditworthiness. If credit quality does not considerably change through the liquidity crisis period, the banking deleveraging process causes a—potentially inefficient—financial contraction. There are no apparent reasons to consider that there is a relationship between credit quality and banks liquidity. The second element to be considered is financial dependence. The higher the financial dependence on banking credit, the worse the outcome for households and firms.

Table 11 indicates that there is a statistically significant correlation between liquidity shortages and credit supply. This evidence is consistent with that of Alfaro et. al. (2003), where the authors find that monetary policy (i.e. aggregate funding liquidity) is transmitted to credit supply.

We observe that shorter-maturity liquidity is more correlated with consumer credit and is not correlated with longer-maturity types of credit (i.e. mortgage and commercial loans). We also observe that the relationship between banks' funding liquidity and credit supply is economically higher for consumer credit. This suggests that shorter-maturity credits are more sensitive to liquidity fluctuations, whereas longer-maturity loans are more "irreversible," so banks cannot adjust them in times of financial turmoil.

Finally, we also tested the same regression by using PS spread as dependent variable. The results are similar but weaker than when using CALRP.[18]

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17 Additionally, there is a potential selection bias since the participation of a bank in a particular auction determines the level of both the probability of a void auction and the CALRP indicator (although it has to be noticed that there are no auctions with zero bids). Since the bias does not change the direction and objective of our results, we deal with this issue in appendix D.

18 These results are presented in the appendix D.

Table 11

Liquidity (CALRP) and credit growth

	Consumer	Commercial	Housing	Total
PDBC30	-1.17***	-0.77***	-0.44*	-1.00***
	(0.26)	(0.22)	(0.20)	(0.23)
	[0.20]	[0.13]	[0.05]	[0.18]
PDBC90	-1.58***	-0.94***	-1.38***	-1.42***
	(0.31)	(0.26)	(0.21)	(0.26)
	[0.25]	[0.14]	[0.37]	[0.28]
BCP2	-0.32	-0.63***	-0.83***	-0.62***
	(0.21)	(0.14)	(0.11)	(0.16)
	[0.02]	[0.23]	[0.45]	[0.17]
BCP5	-0.32	-0.54***	-0.63***	-0.48**
	(0.19)	(0.12)	(0.11)	(0.14)
	[0.03]	[0.22]	[0.32]	[0.12]
BCP10	-4.00***	-1.11*	-2.17***	-2.04***
	(0.65)	(0.42)	(0.36)	(0.45)
	[0.54]	[0.16]	[0.52]	[0.38]

Source: Author's elaboration.
This table shows the coefficients, standard errors and *R*-squared of individual univariate regression between the CALRP (grouped by instrument) and credit growth (by type of credit). Monthly data, 2005-2013. Constants not reported. Standard errors in parentheses. In brackets, adjusted *R*-squared. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

As a robustness check, we have calculated the correlation of non-performing loans and the CALRP in table 12. We observe very low or virtually no correlation,[19] especially in the case of consumer loans. Although this analysis does not imply any direction of causality, we can infer that the effect of liquidity in credit growth is only partially related with agents' creditworthiness. It would correspond more to a supply effect given by banks' financial opportunities.

19 Recall that the standard deviation of the CALRP is greater than 1 bp; thus, the correlation is lower than the reported regression coefficient found in table 13.

Table 12

Liquidity (CALRP) and non-performing loans

	Consumer	Commercial	Housing	Total
PDBC30	0.03***	0.01*	0.015	0.01
	(0.01)	(0.01)	(0.02)	(0.01)
	[0.22]	[0.05]	[-0.00]	[0.03]
PDBC90	0.01	0.03***	0.09***	0.04***
	(0.01)	(0.01)	(0.02)	(0.01)
	[0.01]	[0.22]	[0.18]	[0.23]
BCP2	-0.02***	0.01***	0.07***	0.02***
	(0.00)	(0.00)	(0.01)	(0.00)
	[0.21]	[0.15]	[0.48]	[0.35]
BCP5	-0.01***	0.01***	0.07***	0.02***
	(0.00)	(0.00)	(0.01)	(0.00)
	[0.19]	[0.16]	[0.54]	[0.39]
BCP10	0.03*	0.03*	0.20***	0.07***
	(0.01)	(0.01)	(0.02)	(0.01)
	[0.14]	[0.16]	[0.74]	[0.61]

Source: Author's elaboration.
This table shows the coefficients, standard errors and R-squared of individual univariate regression between the CALRP (grouped by instrument) and non-performing loans (by type of credit). Monthly data, 2005-2013. Constants not reported. Standard errors in parentheses. In brackets, adjusted *R*-squared. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

VIII. COMPARATIVE LIQUIDITY ANALYSIS

In this section, we put all the metric calculation results into context. First, figure 7 suggests that there is covariation among different metrics for liquidity. All the liquidity metrics included in this work experience considerable movements during the crisis period, especially during 2008. Second, table 13 shows that there is a significant and positive correlation amongst all the indicators replicated and/or proposed in this work. Nevertheless, there are some differences to be analyzed.

The Chilean metric for liquidity of the local fixed income market—the PS—is very close with the LOIS and VIX. This suggests that the Chilean economy is highly dependent on global liquidity and/or external financial conditions. The mechanism operating this relationship appears in a recent paper. Bruno and Shin (2013) indicate that the mechanism through which international liquidity is transmitted into the domestic economies is through the leverage cycle.

In the case of market liquidity metrics, we can observe that the Chilean and international composite indices (CLF and GFL) are closely related. This suggests that the transmission channel of market liquidity is also relevant and significant.

Table 13

Correlation between liquidity indices

	CALRP	GFL	CLF	VIX	LOIS	PS
CALRP	1					
GFL	0.22*	1				
CLF	0.06	0.59*	1			
VIX	0.30*	0.65*	0.33*	1		
LOIS	0.34*	0.75*	0.45*	0.88*	1	
PS	0.35*	0.16	-0.12	-0.10	0.05	1

Source: Author's elaboration.
Represents correlation coefficients significance at the 5% level or better. Monthly data, 2005-2013.

In the case of our proposed CALRP, we observe that it captures well local market liquidity conditions, because of its high correlation with the PS indicator. However, we appreciate that it captures more the systemic variations and it does not vary too much in other episodes that are perhaps less relevant for aggregate liquidity risk.

We have shown that our local counterparts of liquidity metrics reasonably capture liquidity stress episodes. With our local version of liquidity metrics, there are certain differences to be highlighted, we find advantages and drawbacks for each measure. In the case of the CLF, although it captures the episodes in a great manner, it has also an excessive variation, this volatility makes the metric less useful as early warning indicator, since it `jumps' too much. As for the PS, it is less volatile than the CLF, which is an advantage. It has also a good relation with historically tight liquidity periods. However, there are some issues. The PS depends partially on a survey, and it has only a system level interpretation. In the case of our CALRP indicator, it has certainly a low variation, except during the global crisis. Thus, it is a good measure for high magnitude events, but it does not capture well minor stress episodes.

IX. CONCLUSION

This paper presents a novel indicator of funding liquidity of the Chilean banking system inspired by the methodology proposed by Drehmann and Nikolaou (2012). It is based on banks' biding behavior, through their bidding schedule (bid rate and volume), on notes and bonds auctions conducted by the CBC.

Compared to other liquidity indices, the CALRP indicator can be constructed at the same time as information about the auctions becomes available, which is easily accessible from within the CBC; it captures well the liquidity crisis episode; is not expert dependent; and we argue that it measures only liquidity risk.

We acknowledge that one of the main drawbacks of our liquidity indicator is that the decision not to participate at all in the auctions is not captured; then, a

more reliable measure of the LRP (or CALRP) indicator should account for this fact. However, as a mitigating factor, we find that there is significant correlation between a void auction process and our liquidity indicator. Additionally, it would be interesting to see how CBC notes and bonds are traded in the interbank (secondary) market. Further research will address these concerns.

One limitation in building the CALRP indicator for instruments of higher maturity is that these instruments are generally auctioned less frequently than instruments of lower maturity (e.g. 30-day notes or PDBC30), and therefore it is harder to build a more reliable version of the CALRP for this kind of instruments.

Like many—if not all—liquidity indicators, our CALRP suffers from the possibility of being contaminated by other effects, such as that of institutional investors' participation (e.g. because of regulatory changes) or other market phenomena that could be happening simultaneously. However, our analysis suggests that this indicator provides a good summary statistic of the banks' reactions when facing monetary policy operations. Moreover, since, as we have pointed out, we observe a high correlation with banking credit. Acknowledging all the statistical caveats, the evidence suggests that our metric reflects the tradeoffs between banking liquidity hoarding and credit supply decisions.

To sum up, we propose this indicator as a complementary metric that would help to explain risk and transmission of funding liquidity in the Chilean financial market, specifically in the commercial banking sector.

REFERENCES

Ahumada, A. and N. Álvarez (2011). "Alternative Measures of Liquidity on the Chilean Government Fixed Income Market." In: Proceedings of the IFC Conference on 'Initiatives to Address Data Gaps Revealed by the Financial Crisis,' Basel, 25-26 August.

Alfaro R., H. Franken, C.A. García and A. Jara (2003). "Bank Lending Channel and the Monetary Transmission Mechanism: the Case of Chile." Working Paper No. 223, Central Bank of Chile.

Bank of England (2007). *Financial Stability Report* (21), April.

Basel Committee on Banking Supervision (2010). "Basel III. International Framework for Liquidity Risk Measurement, Standards and Monitoring." BIS Consultative Document. Basel, Switzerland: Bank for International Settlements.

Basel Committee on Banking Supervision (2013). "Basel III: The Liquidity Coverage Ratio and Liquidity Risk Monitoring Tools" BIS Consultative Document. Basel, Switzerland: Bank for International Settlements.

Borio, C. and H. Zhu (2008). "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" BIS Working Paper No. 268.

Brunnermeier, M. and L. Pedersen (2009). "Market Liquidity and Funding Liquidity." *Review of Financial Studies* 22(6): 2201–38.

Brunnermeier, M. K., Gorton, G., & Krishnamurthy, A. (2011). Risk topography. In NBER Macroeconomics Annual 2011, Volume 26 (pp. 149-176). University of Chicago Press.

Bruno, V. and H.S. Shin (2013). "*Capital Flows, Cross-Border Banking and Global Liquidity*." NBER Working Paper No. 19038.

Central Bank of Chile (2007). *Financial Stability Report*, second half.

Central Bank of Chile (2011). *Central Bank of Chile's Liability Management*.

Cornett, M.M., J.J. McNutt, P.E. Strahan and H. Tehranian (2011). "Liquidity Risk Management and Credit Supply in the Financial Crisis." *Journal of Financial Economics* 101(2): 297–312.

Drehmann, M. and K. Nikolaou (2012). "Funding Liquidity Risk: Definition and Measurement." *Journal of Banking and Finance* 37(7): 217–382.

European Central Bank (2007). *Financial Stability Review*, December.

Federico, P.M. (2012). "Developing an Index of Liquidity-Risk Exposure: An Application to Latin American and Caribbean Banking Systems." IDB Technical note No. IDB-TN-426.

Goodhart, C.A.E. (2008). "Liquidity Risk Management." *Financial Stability Review - Special issue on liquidity* 11: 39–44, Banque de France.

Heckman, J.J. (1979). "Sample Selection Bias as a Specification Error." *Econometrica* 47(1): 153–62.

Nyborg, K.G. and I.A. Strebulaev (2004). "Multiple Unit Auctions and Short Squeezes." *Review of Financial Studies* 17(2): 545–80.

Schmieder, C., H. Hesse, B. Neudorfer, C. Puhr and S.W. Schmitz, (2012). "Next Generation System-Wide Liquidity Stress Testing." IMF Working Paper WP/12/3.

Valimaki, T. (2006). "Why the Marginal MRO Rate Exceeds the ECB Policy Rate?" Bank of Finland, Research Discussion Paper No. 200/2006.

APPENDIX A

Table A1

CALRP annual average by cluster level - short-term papers

(basis points)

	PDBC30				PDBC90			
Year	Large	Medium	Retail	Investment	Large	Medium	Retail	Investment
2005	1.33	2.34	1.21	5.20	0.47	2.36	0.00	1.63
2006	0.75	1.08	0.00	5.01	0.28	0.27	0.03	2.32
2007	0.60	0.42	0.00	3.04	0.74	0.59	0.01	1.59
2008	8.47	6.9	0.98	6.23	6.00	7.84	1.38	5.30
2009	0.47	0.45	0.11	0.34	2.74	2.76	5.42	2.69
2010	0.34	0.22	0.00	0.14	1.87	3.22	2.55	0.78
2011	0.81	0.71	1.92	0.59	4.45	3.54	7.15	3.26
2012	0.96	0.49	0.84	0.72	2.9	1.52	5.98	2.72
2013	0.94	0.03	0.00	0.04	1.47	1.03	0.00	n.a.

Source: Central Bank of Chile.
n.a. = not available.

Table A2

CALRP annual average by cluster level - short-term papers

(basis points)

	PDBC180				PDBC360			
Year	Large	Medium	Retail	Investment	Large	Medium	Retail	Investment
2005								
2006								
2007	3.23	2.42		12.98	3.70	4.23		7.07
2008	9.04	9.25	6.65	13.48	9.74	13.91		16.09
2009	5.32	6.02	12.01	6.96	12.92	14.9	8.85	14.72
2010	9.17	7.14	15.05	4.92	14.52	11.89	27.52	10.03
2011	11.91	8.01	19.22	7.43	11.20	34.36		
2012	8.02	11.11	5.34	3.46				
2013								

Source: Central Bank of Chile.

Table A3

CALRP annual average by cluster level - long-term papers

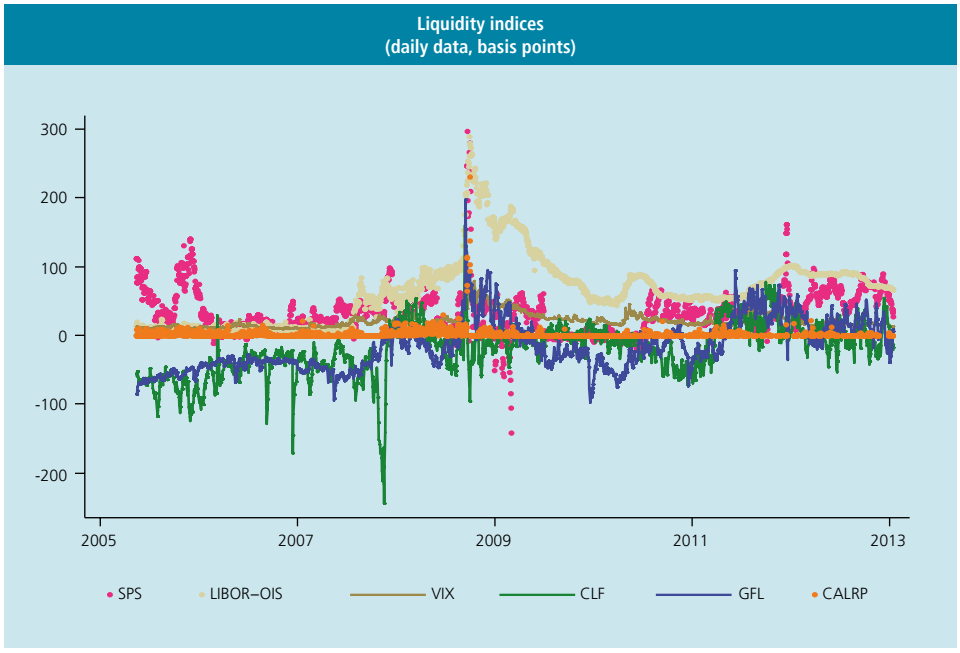
(basis points)

	BCP2				BCP5				BCP10			
Year	Large	Medium	Retail	Investment	Large	Medium	Retail	Investment	Large	Medium	Retail	Investment
2005	1.26	1.26		2.1	0.19	0.09	0	0.01	0	0	0	0
2006	0.01	0.08	0	0	0	0		0	0	0		2.1
2007	0.51	0.48	0	1.5	0	0	0	0.12	0	0		0
2008	3.09	2.96	6.89	2.73	1.83	1.7	3.78	1.8	4.48	2.74	2.73	2.48
2009	8.16	6.77		9.84	10.73	9.28		8.86				
2010	11.2	11.24	6.39	8.68	12	10.81		9.58				
2011	6.71	6.4		5.66	3.96	3.92	6.65	3.69	2.63	2.4	2.3	2.25
2012	4.3	3.96	5.08	5.34	2.33	2.34	1.78	2.67	0.64	0.82	1.92	0.52
2013												

Source: Central Bank of Chile.

Figure 8

Liquidity metrics comparison

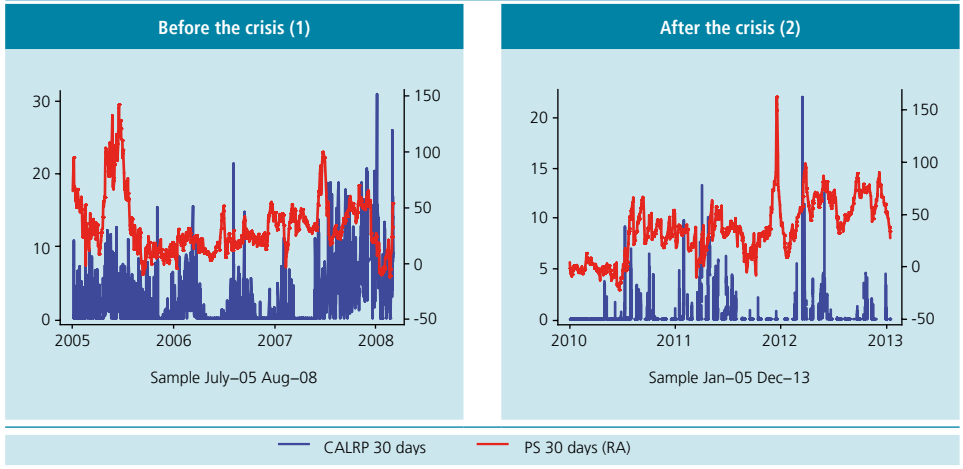


Source: Central Bank of Chile.

Figure 9

CALRP and Prime Swap-Spread before and after the financial crisis

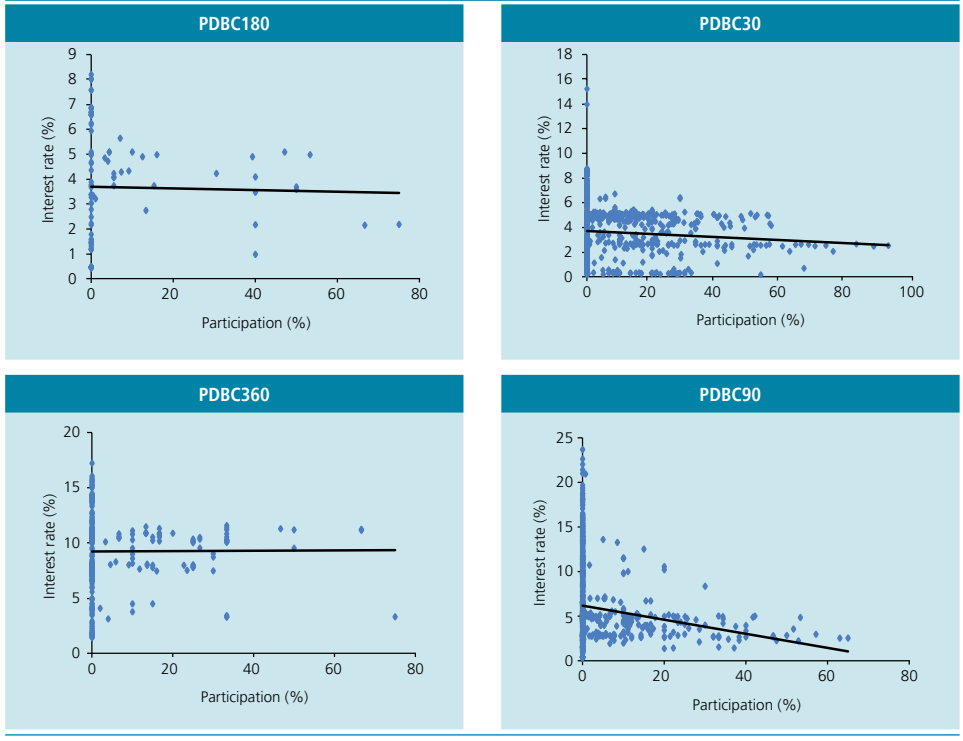
(basis points)



Source: Central Bank of Chile.

Figure 10

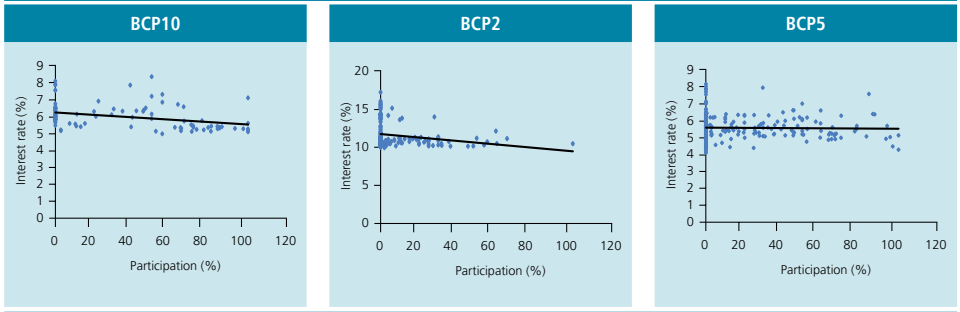
Participation of pension funds and other institutional investors in PDBC auctions



Source: Central Bank of Chile.

Figure 11

Participation of pension funds and other institutional investors in BCP auctions



Source: Central Bank of Chile.

Table A4

Liquid assets' participation in the Chilean bank's balance sheet

	2006	2007	2008	2009	2010	2011	2012	2013
Mean	14.3	13.8	14.4	18.1	18.6	18.0	17.3	15.6
P50	13.8	13.0	13.1	16.2	16.2	15.8	15.2	14.1
P25	10.5	11.7	9.8	12.2	14.0	13.3	13.9	12.0
P75	16.7	15.9	18.7	20.3	20.6	23.1	21.1	18.0
Std. dev.	7.4	5.9	6.7	8.1	7.8	6.5	5.9	5.6

Source: Central Bank of Chile.

Table A5

Central Bank instruments' participation in the liquid assets

	2006	2007	2008	2009	2010	2011	2012	2013
Mean	17.8	23.3	18.0	19.4	17.1	12.4	10.5	8.8
P50	16.6	26.3	18.1	10.2	13.8	9.8	5.5	5.1
P25	4.6	12.2	8.7	7.1	4.6	3.3	2.3	1.6
P75	28.7	31.0	23.8	27.2	24.1	17.1	14.6	13.5
Std. dev.	14.4	14.3	11.3	20.8	16.1	11.5	12.2	9.7

Source: Central Bank of Chile.

APPENDIX B

MAIN FINANCIAL MEASURES TAKEN BY THE CENTRAL BANK OF CHILE: 2005-2011

June 30, 2005: (Repo) The Central Bank authorized the purchase of credit securities using buy-back agreements (Repos) between the Central Bank of Chile and financial institutions at variable interest rates, based on the average value of the MPR during the period the operation is in effect. This measure should deepen the market for these securities.

August 22, 2005: (Bond) The Central Bank announced a change to its policy of issuing its own securities, to offset the monetary effect of bond issues in indexed units of account (Unidades de fomento, UF) maturing in 10 and 20 years (BTU10 and BTU20) from the Treasury as of September.

November 3, 2005: (DER) The Bank empowered financial institutions to operate with local market derivatives based on Chilean Treasury bonds, making the corresponding changes to Chapter III.D.1 in the Compendium of Financial Regulations.

May 18, 2006: (LD) A new way for banks to deposit in the Central Bank was added, called the "Liquidity Deposit in Pesos for Banks and Finance Companies". This type of deposit, which serves the purpose of monetary regulation, operates through electronic communications between commercial banks and the Central Bank, through the open-market operations system, subject to supply and conditions that are set by the Central Bank on each occasion.

December 7, 2006: (EFSMPF) The Central Bank of Chile complemented the definition of the external formal secondary market in which pension funds can trade investment securities internationally, to include securities or other documents issued by foreign firms.

July 31, 2007: (PF1) The Central Bank raised the ceiling on pension fund investment in foreign securities to 35%. Moreover, it increased the ceilings on investment in foreign exchange with no foreign exchange coverage for each type of pension fund, 43% for type A, 28% for type B, 22% for type C and 17% for type D.

April 10, 2008: (INT1) The Central Bank has decided today to intervene in the foreign exchange reinforcing the international liquidity position of the Chilean economy adopting the following measure: increase international reserves by US$8 billion, by purchasing foreign currency, from Monday 14 April and until 12 December 2008. The first reserve purchase program, in force from 14 April to 9 May, will consist of daily purchases for about US$50 million, through competitive auctions.

The monetary effects of this measure will be set off so that the peso liquidity provision in the market is consistent with the monetary policy interest rate. During the period corresponding to the first aforementioned program, this will be implemented through short-term operations.

October 10, 2008: (Flap) The Board of the Central Bank of Chile informs that new measures were adopted today, which are intended to make liquidity management more flexible in the domestic financial system, in response to a further deterioration of international financial markets. These measures, which will be implemented next week, include:

- To extend from one to six months the U.S. dollar swap purchase program. These swaps will be offered at 60 and 90 days, alternately each week for US$500 million at each auction. This measure implies offering a maximum amount of up to US$5 billion.
- As a complement to the aforesaid program, to offer Repo operations aimed at injecting liquidity in pesos at similar terms.
- To offer, every week and during the same six-month term, renewable 7-day Repo operations, which may have bank deposits as collateral. This measure allows expanding the universe of eligible collaterals for financing transactions.

June 15, 2009: (MD) The Central Bank modified its debt schedule by suspending the issue of five year peso bonds (BCP5), five year UF bonds (BCU5), and BCU10 in the primary market. At the same time, the Central Bank announced that it would buy back up to US$1.0 billion of its five and ten-year Central Bank UF bonds. It further communicated that the measures described above are necessary to offset the impact on the fixed income market of the Finance Ministry announcement, on the same day, of a new issue of Treasury bonds for approximately US$1.7 billion and a new program of foreign exchange sales totaling US$4.0 billion, in the form of competitive auctions of US$40 million a day.

January 3, 2010: (MD2) BCP5 are reinstated.

November 4, 2010: (PF2) Chapter III.F.4, Pension fund investments of the Compendium of Financial Regulations was modified to raise the upper limit on total overseas investment by the pension funds from 60% to 80%. At the same time, the upper limit on overseas investment by type of fund was raised to 100% for type A funds, 90% for type B funds, 75% for type C funds, 45% for type D funds, and 35% for type E funds.

January 3, 2011: (INT2) The Central Bank of Chile has decided to initiate a foreign exchange purchase program to strengthen its international liquidity position. The foreign exchange purchase program will be sterilized through the issue of short-term instruments and the use of facilities for a total of US$2.0 billion dollars, together with bond issues in pesos and UFs (unidad de fomento, an inflation-indexed unit of account) for US$10.0 billion. The structure of this plan has been designed to soften the effects of the measure on prices in the debt market.

December 22, 2011: (Flap2) The Central Bank of Chile will implement a temporary program to facilitate the financial system liquidity management in pesos. The Bank will offer a floating rate repo program, for terms of up to 91 days.

APPENDIX C

LIQUIDITY (PS) AND CREDIT GROWTH

Table C1

Liquidity (PS spread) and credit growth

	Consumer	Commercial	Housing	Total
PS30	0.05	0.04	0.02	0.03
	(0.03)	(0.03)	(0.02)	(0.03)
	[0.01]	[0.01]	[0.00]	[0.00]
PS90	-0.04	-0.02	-0.050*	-0.055*
	(0.03)	(0.02)	(0.02)	(0.03)
	[0.01]	[0.00]	[0.06]	[0.04]
PS180	-0.066**	-0.047*	-0.077***	-0.073***
	(0.02)	(0.02)	(0.02)	(0.02)
	[0.07]	[0.06]	[0.23]	[0.13]
PS360	-0.068***	-0.044**	-0.074***	-0.066***
	(0.02)	(0.02)	(0.01)	(0.02)
	[0.12]	[0.09]	[0.31]	[0.16]

Coefficients, standard errors and *R*-squared of individual univariate regression between the PS spread and credit growth (by type of credit). Monthly data, 2005-2013. Standard errors in parentheses. In brackets, adjusted *R*-squared. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table C2

Liquidity (PS spread) and NPL

	Consumer	Commercial	Housing	Total
PS30	0.001	0	-0.006**	-0.002*
	(0.001)	(0.001)	(0.002)	(0.001)
	[0.03]	[-0.006]	[0.112]	[0.048]
PS90	0	0.001	0	0.001
	(0.001)	(0.001)	(0.002)	(0.001)
	[-0.011]	[0.023]	[-0.012]	[-0.003]
PS180	0	0.001**	0.004**	0.002**
	(0)	(0)	(0.001)	(0.001)
	[-0.003]	[0.076]	[0.085]	[0.096]
PS360	0	0.001*	0.004***	0.002**
	(0)	(0)	(0.001)	(0)
	[-0.007]	[0.049]	[0.136]	[0.112]

Coefficients, standard errors and *R*-squared of individual univariate regression between the PS spread and credit growth (by type of credit). Monthly data, 2005-2013. Standard errors in parentheses. In brackets, adjusted *R*-squared. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

APPENDIX D

DEALING WITH SELECTION BIAS

To address a potential the selection bias problem in the determination of a void auction, we set the specification in two steps, using a Heckman (1979) probit correction. In the first stage, we estimate the participation of banks in an auction as a function of an alternative liquidity indicator (Spread Prime Swap 30 days, and the Libor-OIS spread, for short- and long-maturity auctioned instruments, respectively). This explanatory variable is used since it reasonably correlates with the participation, and as an aggregated macro variable is available for all instruments' maturities, for all dates. In a second stage we estimate the probability that an auction is declared void, depending on the CALRP indicator, and correcting for the participation already estimated in the first stage.

Tables 21 and 22 show that the correction is necessary. The p value is different from zero and the results of the biased regression differ from the corrected one. However, given the signs of coefficients are not altered, we find that the corrected results do not alter the conclusions of the original specification.

Table D1

Heckman probit (two steps) for PDBC: 30, 90, 180 and 360 days

Probit Void Auctions (,): 2nd step								
	(1)	M.E. (1)	(2)	M.E. (2)	(3)	M.E. (3)	(4)	M.E. (4)
CALRP PDBC30	0.0058	0.0004						
	(0.0034)	(0.0002)						
CALRP PDBC90			0.0516***	0.0062***				
			(0.0099)	(0.0008)				
CALRP PDBC180					0.0125***	0.0132***		
					(0.003)	(0.0029)		
CALRP PDBC360							0.0053	0.0050*
							(0.0033)	(0.0024)
Auction Participation (participation =1,: =0): 1st step								
Prime spread swap 30 days	-0.0010*							
	0.0004							
Prime spread swap 90 days			-0.0022***					
			0.0004					
Prime spread swap 180 days					-0.0024***			
					0.0004			
Prime spread swap 360 days							-0.0011	
							0.0007	
Rho	0.7859		0.6337		-0.9935		-0.9926	

Coefficients and standard errors of individual univariate regression between *Auction participation* ∈ {0,1}and the corresponding CALRP for each instrument maturity. Daily data, 2005-2013. Standard errors in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

Table D2

Heckman probit (two steps) for BCP: 2, 5 and 10 years

Probit Void Auctions (,): 2nd step						
	(5)	M.E. (5)	(6)	M.E. (6)	(7)	M.E.(7)
CALRP BCP2	0.0092***	0.0102***				
	(0.0026)	(0.0028)				
CALRP BCP5			0.0197	0.0109***		
			(0.0106)	(0.0022)		
CALRP BCP10					0.0085	0.0023
					(0.0212)	(0.0053)
Prime spread swap 360	-0.0008**		-0.0004		0.0013*	
	(0.0003)		(0.0004)		(0.0006)	
Rho	-1		-0.9855		-0.8678	

Coefficients and standard errors of individual univariate regression between *Auction participation* $\in \{0,1\}$ and the corresponding CALRP for each instrument maturity. Daily data, 2005-2013. Standard errors in parentheses. ***$p<0.01$, **$p<0.05$, *$p<0.1$.

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