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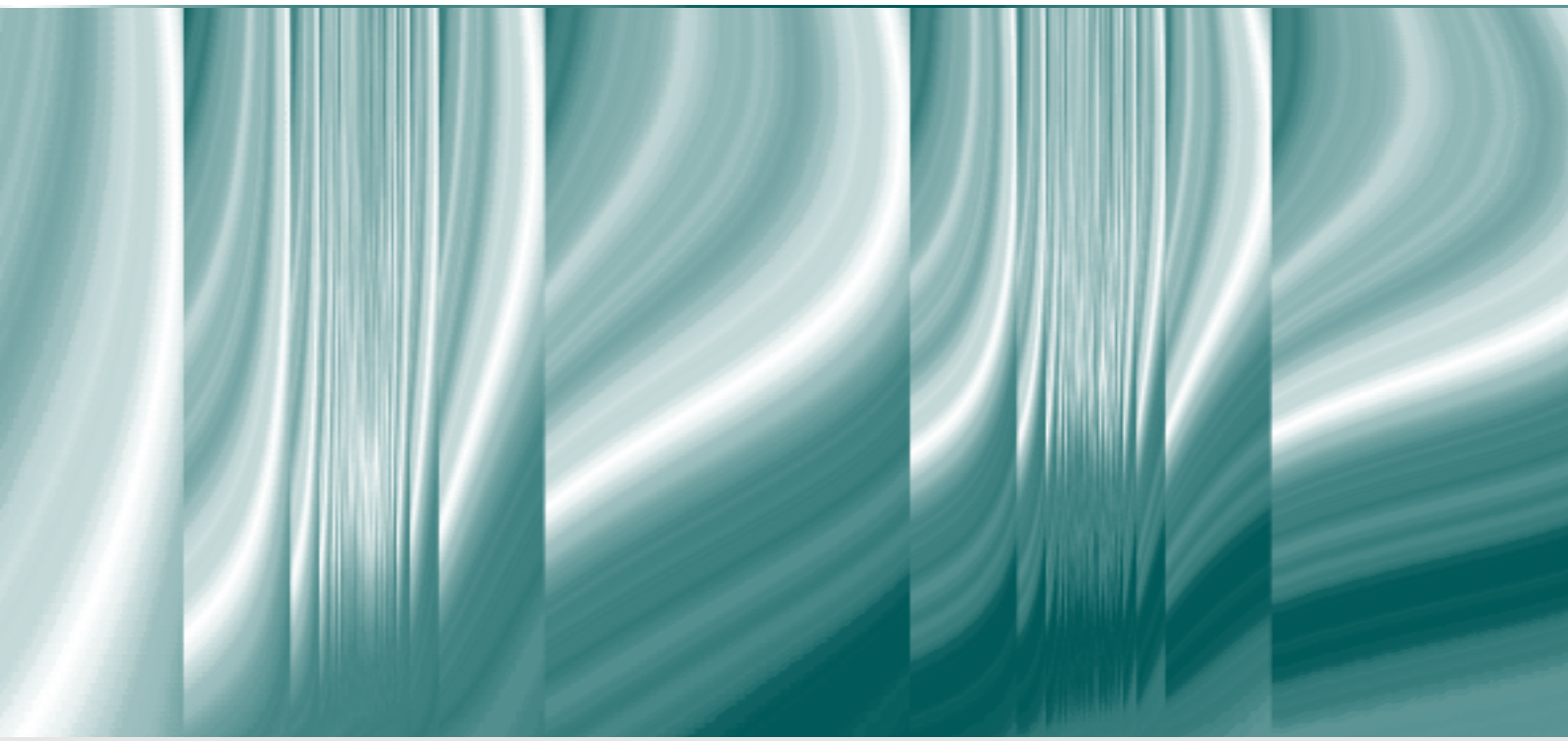

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8/2020

Title/*Naslov*: The transmission of bank liquidity regulation in Slovenia and macroprudential policy implications

No./*Številka*: 8/2020

Published by/*Izdajatelj*: BANKA SLOVENIJE
Slovenska 35
1505 Ljubljana
tel.: 01/+386 1 47 19 000
http://www.bsi.si

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Uporaba in objava podatkov in delov besedila je dovoljena z navedbo vira.

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani
COBISS.SI-ID=22621699
ISBN 978-961-6960-42-7 (pdf)

The transmission of bank liquidity regulation in Slovenia and macroprudential policy implications

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May 18, 2020

Abstract

Since the Nineties, Slovenian banks are required to comply with a minimum ratio between assets and liabilities with residual maturity within thirty days (including liquid assets irrespective of their contractual maturity and liabilities with no-written maturity). For most of the banks in Slovenia, there is evidence of cointegration between numerator and denominator of the liquidity ratio. The existence of cointegration reveals the bank tendency to maintain an equilibrium level of the liquidity ratio. Banks can correct the deviations from the equilibrium either by increasing the liquid assets (asset-based channel) or by extending the maturity of the liabilities (liability-based channel). Results suggest that the relative importance of these two channels varies with the structure of the liabilities. On average, Slovenian banks' adjustments to the liquidity ratio are biased toward the asset-based channel. Therefore, a macroprudential liquidity buffer that could be released in crisis periods would alleviate two mechanisms of liquidity shocks' amplification that relate to the asset-based channel, namely asset fire sale and liquidity hoarding. By counteracting bank liquidity hoarding, a liquidity buffer that is released when a crisis starts should prevent interbank market freeze.

JEL Codes: E44, G21, G28

Keywords: bank liquidity, financial regulation, macroprudential policy, error-correction model

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The author thanks Francesco Corielli and Jan Babecky for valuable suggestions and all participants to the 2017 ECBN conference in Ljubljana. All mistakes are only of the author.

Povzetek

Od devetdesetih let prejšnjega stoletja morajo slovenske banke zagotavljati minimalno razmerje med finančnimi sredstvi in viri sredstev s preostalo zapadlostjo do 30 dni (vključno z likvidnimi sredstvi, ne glede na njihovo pogodbeno zapadlost, in viri sredstev brez določene zapadlosti). Pri večini slovenskih bank obstaja dokaz o kointegraciji med števcem in imenovalcem likvidnostnega količnika. Obstoj kointegracije razkriva nagnjenost banke, da ohrani ravnotežno raven likvidnostnega količnika. Banke lahko popravijo odstopanja od ravnotežja bodisi s povečanjem likvidnih sredstev (pristop na strani aktive) ali podaljšanjem ročnosti virov sredstev (pristop na strani pasive). Rezultati kažejo, da se relativna pomembnost teh dveh pristopov spreminja s sestavo virov sredstev. Slovenske banke se v povprečju raje odločijo za prilagoditve likvidnostnega količnika po pristopu na strani aktive. Zato bi makrobonitetni likvidnostni blažilnik, ki bi se lahko sprostil v kriznih časih, ublažil mehanizma, ki krepita likvidnostne šoke in sta povezana s pristopom na strani aktive, namreč prisilno prodajo sredstev in kopičenje likvidnosti. Likvidnostni blažilnik, ki se sprosti ob začetku krize, bi moral z nevtralizacijo kopičenja likvidnosti bank preprečiti zamrznitev medbančnega trga.

1. Introduction

Liquidity plays a relevant role in financial crises (Bryant (1980), Diamond and Dybvig (1983), Allen and Carletti (2008), Banque de France (2008), Brunnermeier (2009), IMF (2010), Gorton (2010), BIS (2011), Berrospide (2012)). Financial intermediaries not only transfer resources from agents with liquidity surplus to deficient agents. They also operate a maturity transformation. In fact, banks' investment horizon is in general longer than the investment horizon of banks' creditors. The illiquidity of bank assets coupled with the liquidity promised through bank liabilities leaves banks vulnerable to runs and liquidity crises.

Although solvency and liquidity are intertwined, the great financial crisis demonstrated that solvency regulation alone is not enough and using dedicated instruments may best target liquidity-related vulnerabilities. Accordingly, the Basel Committee on Banking Supervision (BCBS) has implemented minimum liquidity standards, namely the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). Since 2015, the LCR has become obligatory in the EU. Given the phasing-in period, the LCR has been fully implemented only since January 2018, while the NSFR will become obligatory in June 2021. However, starting from 2015, banks have to report their NSFR for monitoring reasons.

Specifically, the LCR prescribes banks to hold a bucket of "high-quality liquid assets" (HQLA) sufficient to cope with the estimated cash outflow in thirty days of liquidity stress. HQLA are defined as assets that can be easily and immediately converted into cash at little or no loss of value. HQLA primarily consist of cash, central bank reserves and, to certain extent, marketable securities, sovereign debt and central bank debt.

The introduction of the LCR has prompted increasing interest in the effects of liquidity regulation on bank behaviour. On top of the newly introduced LCR, banks in Slovenia are required to comply with a liquidity requirement (KL1) since the Nineties – they are merely recommended to comply with KL1 since January 2018.[1] Accordingly, the ratio between assets and liabilities with residual maturity within 30 days (including assets easily convertible into cash and sources of funding from which money can be withdrawn with no notice) should be greater than or equal to one: $KL1 \geq 1$. Banks are required to report daily the changes in their liquidity ratio KL1.

[1] Since January 2018, the measure is a recommendation.

The present study exploits the bank-level daily data on KL1 in order to understand how Slovenian banks (adjust their assets and liabilities in order to) comply with the liquidity regulation. In particular, this paper addresses the following research questions:

- are the adjustments to the liquidity ratio biased toward the asset or the liability side of a bank balance sheet?
- do the adjustments depend on the degree of reliance on wholesale funding?
- do the adjustments depend on the degree of reliance on demand deposits?

To my knowledge, this is the first paper that investigates how Slovenian banks comply with the liquidity regulation. Duijm and Wierts (2016) conducted a similar study for the Dutch banking system. In fact, in Netherlands, a measure similar to the LCR was introduced in 2003. The authors document that the adjustments in the liquidity ratio mainly affect the liability side, especially when the ratio is below its long-run equilibrium level. Moreover, they document that, at aggregate level, the considered liquidity measure is not effective in preventing banks' pro-cyclical liquidity risk taking.

Similarly to de Haan and van den End (2013a, 2013b) and Duijm and Wierts (2016), the present study uses bank-specific data on assets and liabilities that represent, respectively, the numerator and denominator of the liquidity ratio as defined by the national regulation. However, it differs from de Haan and van den End (2013a, 2013b), who assume that causality runs from liabilities to assets, with banks adjusting their assets in response to a negative funding shock. Instead, as in Duijm and Wierts (2016), this study a) does not make assumption on the direction of causality and b) finds evidence of cointegration between numerator and denominator of the liquidity ratio. Moreover, as Duijm and Wierts (2016), this paper aims to assess the relative importance of asset-based and liability-based adjustments to the liquidity ratio, through the estimation of error correction models.

The contribution of this paper is twofold. First, it is the first study on the effects of the Slovenian measure KL1 on bank behaviour. Second, it extends the methodology in Duijm and Wierts (2016) in order to investigate how the bank liability structure influences the transmission of liquidity shocks. In particular, the paper focuses on the role of wholesale funding and demand deposits (also known as non-maturing deposits). To my knowledge, this

is the first paper that analyses the link between bank liquidity management and bank liability structure.

For most of Slovenian banks, numerator and denominator of the liquidity ratio are cointegrated. The cointegration relationship can be interpreted as the long-run equilibrium level of the liquidity ratio. As expected, results suggest that banks respond to shocks to the liquidity ratio through a combination of asset-based and liability-based adjustments. For instance, a shortfall with respect to the long-run equilibrium level of the liquidity ratio is corrected by increasing the liquid assets and decreasing the short-term liabilities at the same time.

However, the adjustments to the liquidity ratio are biased toward the asset side. Results also suggest that banks adjust the liquidity ratio faster in case of negative shocks that make the liquidity ratio fall below the bank-specific equilibrium level than in case of positive shocks that move the liquidity ratio above that level. Moreover, in case of negative deviations from the equilibrium level of the liquidity ratio, the adjustment is even more biased toward the asset side.

Furthermore, the transmission mechanism of the liquidity regulation is dependent from the bank liability structure. In particular, an increase in bank dependence from wholesale funding is associated with a bigger coefficient of the liability-based adjustment to the liquidity ratio. In contrast, the opposite is true when there is an increase in the dependence from demand deposits. Moreover, banks correct faster the deviations from their long-run equilibrium level of the liquidity ratio when there is a higher dependence from wholesale funding than when there is higher dependence on demand deposits.

The findings seem to suggest that for banks it is easier and cost-efficient to increase the share of liquid assets than increasing the average maturity of their liabilities. However, the results also indicate that it might be easier for banks to extend the maturity of their liabilities when there is abundant wholesale funding with respect to the case when demand deposits represent a relatively high share of bank liabilities. It is worth to mention that, based on KL1 regulation, an outflow rate of 40% is assigned to demand deposits.[2] Therefore, banks experiencing an increase in demand deposits also face a significant increase in the liquidity need in order to comply with KL1.

[2] Initially the outflow rate for demand deposits was set at 100% and it was gradually reduced to 85%, 50% and finally 40%.

On the other hand, KL1 assigns an outflow rate equal to zero to term deposits, unless their residual maturity is shorter than 30 days. In such a case, the outflow rate is 100%. Therefore, a bank can lower the liquidity pressure arising from KL1 by reducing the demand deposits in favor of term deposits with long enough maturity. However, this is possible if the bank can offer to depositors an incentive to switch from non-maturing deposits to term deposits.

By substituting demand deposits with term deposits, depositors expose themselves to liquidity risk, because they cannot withdraw from term deposits before the maturity, unless they accept to pay a predetermined penalty. In fact, the spread between interest rate on term deposits and demand deposits can be seen as a liquidity risk premium.

Let us assume that the liquidity risk premium that the bank should offer in order to get a substitution of demand deposits with term deposits is higher than the opportunity cost of substituting long-term assets with liquid assets. If this is true, when the liquidity ratio falls short of the equilibrium level because of an increase in demand deposits, then the bank will find convenient to resort to the asset-based adjustment to the liquidity ratio instead of offering a higher liquidity risk premium to depositors.

The findings of the present study give valuable insights into the transmission mechanism of liquidity shocks and of liquidity regulation and have important policy implications. Assume, for instance, that the objective of the financial regulator is to reduce the banks' reliance on sources of funding which entail higher funding-liquidity risk. A tightening of the liquidity ratio might be ineffective, in the sense that banks might respond to the tightening of the liquidity ratio through the asset-based channel instead of reducing their dependence on less stable funding.

The asset-based adjustment entails an increase in banks' liquid assets. Therefore, the asset-based channel of the liquidity regulation might be associated with a contraction in credit to the non-banking sector. Moreover, banks may concentrate their pool of liquid investments on few assets. Asset concentration might increase the probability of fire sales in the event that liquidity shocks hit simultaneously many banks and force them to liquidate their position on the same assets.

The rest of the paper is organized as follows. Section 2 offers a literature review. Section 3 gives an overview of bank liquidity regulation in Slovenia. Section 4 describes the data,

models and results. Section 5 discusses the aggregate pattern of liquidity. Section 6 concludes with macroprudential policy implications of the results.

2. Literature review

The available studies relevant for bank liquidity regulation can be divided into three groups. The first group includes papers that mainly try to assess the impact of liquidity measures on bank balance sheet, in particular on lending and lending rates. The second group includes papers on endogenous amplification mechanisms through which even small (liquidity) shocks can lead to systemic banking crises. The third group includes papers that assess whether the existing liquidity measures, in particular the LCR, are enough to curb endogenous amplification mechanisms.

Effects of liquidity policy measures on bank balance sheet

Repullo (2005) provides a theoretical justification for regulatory liquidity requirements in presence of the lender-of-last-resort (LOLR) policy. In fact, his model shows that the support of a LOLR in case of a crisis creates a moral hazard problem, reducing banks' incentive to self-insure by holding liquidity buffers. Aspachs et al. (2005) find evidence of the moral hazard issue pointed by Repullo (2005), i.e. the greater the potential support from the central bank in case of liquidity crises, the lower the liquidity buffer that UK banks hold.[3]

Schertler (2010), using quarterly data for 2,000 German banks from 2000-Q3 to 2008-Q4, examines banks' adjustments of securities holdings, loan repayments and long-term lending, respectively, in response to payment obligations in the coming month. She finds that most banks perform asset-side adjustments by reducing their new long-term loans when they need more liquid assets.

Bonner (2012) analyses the impact of a liquidity requirement similar to the Basel 3 Liquidity Coverage Ratio (LCR) on banks' funding costs and corporate lending rates. Using a dataset of 26 Dutch banks from January 2008 to December 2011, the author finds that banks that are just above/below the liquidity requirement do not charge higher interest rates for

[3] Moreover, they find that banks in their sample pursue a countercyclical liquidity policy. In particular, banks hoard liquidity during periods of economic downturn, when lending opportunities may not be as good, and they run down liquidity buffers during economic expansions when there are more and better lending opportunities. The countercyclical aspect of bank liquidity policy offers a justification for macroprudential liquidity measures that would complement measures addressing merely idiosyncratic liquidity shocks.

corporate lending. This effect is caused by banks being not able to pass on their increased funding costs in the interbank market to private sector clients, implying that banks do not have pricing power.

Bonner *et al.* (2013), using balance sheet data for 7,000 thousands banks from 30 OECD countries in 1998-2007, report that, without liquidity regulation, banks' liquidity buffers are determined by a combination of bank-specific (business model, profitability, deposit holdings, size) and country-specific (disclosure requirements, concentration of the banking sector) factors. As most factors turn insignificant with a liquidity requirement in place, the authors conclude that regulation substitutes most incentives to hold liquid assets.

Banerjee and Mio (2018) study the effect on bank balance sheet of a tightening of liquidity regulation by the UK Financial Services Authority in 2010. The authors finds that banks adjusted the composition of both assets and liabilities, increasing the share of high quality liquid assets and non-financial deposits while reducing intra-financial loans and short-term wholesale funding. They do not find evidence that tightening of liquidity regulation caused banks to shrink their balance sheets, nor reduce the amount of lending to the financial sector.

Endogenous amplification of liquidity shocks

Although the fall in US property prices is the main cause of the 2008 crisis, liquidity also played a crucial role. Allen and Carletti (2008) identify four channels through which shocks related to liquidity provisions propagated in the financial system and on the real economy during the 2008 crisis. First, fall of prices of AAA-rated tranches of securitized products below the fundamental values, for a relatively protracted period. Second, the effect of the crisis on the interbank market for term funding and on collateralised money market. Third, the fear of contagion in case of a major institution's failure[4]. Four, the provision of liquidity to non-financial firms.

With the first signals of the crisis in 2008, haircuts increased and low quality collaterals became more difficult to borrow against. In response, banks started hoarding liquidity. If banks hoard liquidity and, as a result, they are able to cover idiosyncratic shocks from their own liquidity holdings, then their unwillingness to lend to other banks is not an issue. If, on

[4] The controversial use of public funds in the arranged merger of Bear Stearns with J.P. Morgan was justified by the fear that, if the former had failed, its extensive involvement as counterparty in many derivative markets may have caused a string of defaults.

the contrary, the liquidity hoarding prevents the reshuffling of liquidity to deficient but solvent banks, then the badly functioning interbank market warrants the central bank liquidity provision.[5]

Berrospide (2012) finds that liquidity hoarding by U.S. commercial banks explains one-fourth of the reduction in bank lending during the 2007-09 crisis.[6] Malherbe (2014) explains how liquidity hoarding behavior may worsen adverse selection in secondary markets and may results in severe amplification of even small liquidity shocks. The intuition of why holding cash worsens adverse selection is best understood from a buyer's point of view. The more cash a seller is expected to have on hand, the less likely it is that he is trading because of a need to raise cash and the more likely it is that he is trying to pass on a lemon (Akerlof 1970). Therefore, excessive cash holding by some agents imposes a negative externality on others because it reduces future market liquidity.

Nevertheless, holding more cash can be beneficial in presence of another friction known as cash-in-the-market-pricing. A cash-in-the-market-pricing episode is a case in which potential buyers do not have enough cash to clear the market at the "fundamental" value (Allen and Gale, 1994; Allen and Carletti, 2008). In that case, sellers can only obtain a fire sale price for their assets.[7] In that case, holding liquidity has positive externalities and private agents tend to hold too little of it. Liquidity requirements or limits to maturity mismatch can therefore be socially beneficial.

Several studies point to the issue that marking to market of the asset book is an amplification factor of asset fire sales (Cifuentues et al. (2005), Adrian and Shin (2010)). In fact, it can induce a further round of endogenously generated sales of assets, depressing prices further and inducing further sales. This amplification mechanism can lead to contagious failures, that only adequately designed liquidity and capital requirements can forestall. Brunnermeier and Pedersen (2009) coined the term "margin spiral" where increased margins and falling prices reinforce market distress.

[5] Nevertheless, allowing banks to exchange mortgage backed securities for Treasuries is desirable if it improves collateralized lending in the repo market but is not if it simply leads to more window dressing by financial institutions. In this case, such an accommodative measure undermines market discipline.

[6] The precautionary motive to hold liquidity seems to be better captured by unrealized securities losses and loan loss reserves. It follows that these measures of banks' on-balance sheet risks are essential, in addition to off-balance sheet liquidity risk stemming from unused loan commitments.

[7] Fire sales have been pointed as a major amplification factor of the great financial crisis (Acharya *et al.* (2011), Brunnermeier (2009)). See Shleifer and Vishny (2011) for a survey on fire sales.

Moreover, bank liquidity behaviour affects also firms' accumulation of liquidity in response to the risk of disruption of the banking system. Garcia-Macia and Villacorta (2016) models explicitly the role of the banking sector in distributing liquidity across firms. Informational frictions in the banking sector can lead to an interbank market freeze. Firms react to the breakdown of the banking system by inefficiently accumulating liquid assets by themselves. This reduces the demand for bank loans and bank profits, thus triggering a feedback loop, which further disrupts the financial sector and increases the probability of a freeze, inducing firms to hoard even more liquid assets.

Papers on the LCR

In response to the financial crisis of 2007-09, national measures and an internationally agreed set of measures were developed, trying to address to some extent the aforementioned and other issues related to the transmission and amplification of financial shocks. Among such measures, there is the liquidity coverage ratio (LCR).[8]

Several studies have been conducted on the benefits and limits of the LCR. Using a liquidity stress-testing model, van den End and Kruidhof (2012) show that the LCR can have negative externalities, due to banks' liquidity hoarding during stress periods. The authors claim that a flexible approach of the LCR that recognizes less liquid assets in the buffer is a useful macroprudential instrument to mitigate its adverse side-effects during times of stress.

Aldasoro and Faia (2016) build a network model of optimizing banks featuring contagion on both sides of the balance sheet. On the liability side, banks are exposed to rollover risk on short term liabilities. On the asset side, banks' liquidity hoarding might create two types of externalities, namely liquidity freezes in the interbank market and asset fire sales. The authors calibrate the model to European bank data in order to study the effects of the LCR phase-in. They find that LCR might have not contributed to improve the systemic risk profile of the overall banking system and might even cause its deterioration. They also show that an approach that differentiates the liquidity requirements across banks based on their systemic importance might mitigate the aforementioned externalities and increase the stability of the banking system.

[8] Basel Committee on Banking Supervision (2011) has recommended the imposition of a liquidity coverage ratio, while the Dodd-Frank Act in the Unites States stipulated that liquidity requirements should be taken into account for setting prudential standards for systemically important financial institutions.

By using a DSGE model, de Bandt and Chahad (2015) show that the effects of tightening the LCR on interbank market, lending and GDP are a priori unpredictable. An increase in interbank borrowing (in order to increase the cash inflows today) represents additional cash outflows afterwards, which reinforces the burden of the liquidity constraint in the future. Lending might be constrained today by the need to increase the liquid assets in order to meet the minimum required LCR. However, any lending opportunity creates future cash inflows that contribute to comply with the liquidity requirement in the future.

Should lending decrease as a consequence of the liquidity constraint, we can expect a reallocation of production from SMEs to corporate firms which can substitute bank lending with market funding. If bigger companies are more efficient than SMEs, the final effect on GDP would be positive. However, as noticed by de Bandt and Chahad (2015), corporate funding might be crowded out by sovereign bonds, if banks prefer to invest in sovereign bonds rather than corporate bonds. This will cause a negative persistent effect on GDP.

An increase in the LCR might create an incentive for banks to attract more deposits, in order to finance the investment in liquid bonds, as long as the yield on such bonds is higher than the interest rate on deposits. Simulation results from the DSGE model by de Bandt and Chahad (2015) indicate that tightening the LCR is associated with an increase in household deposits and a decrease in consumption.

3. Overview of bank liquidity regulation in Slovenia

Based on Slovenian regulation about banks liquidity position, banks classify financial assets and liabilities by residual maturity into two classes: the first class corresponds to residual maturity of up to 30 days, whereas the second class is relative to residual maturity up to 180 days. The ratio between assets and liabilities in the first class – ratio referred to as KL1 - should be at least equal to one otherwise banks should report the reasons for failing to meet this requirement. The ratio between assets and liabilities in the second class, KL2, is merely informative and no minimal value is required for KL2.

Since its introduction in the Nineties, the KL1 has been subject to modifications that loosened the requirement. The measure was loosened in several occasions through reductions of the weight assigned to the unstable part of demand deposits, in consideration of their

observed stability. The weight was reduced from 100% to 85% in Jan 2006, 50% in January 2007 and 40% in October 2011. The measure was also loosened in December 2008, by allowing banks to include in the numerator of KL1 the pledged part of collaterals eligible for Eurosystem funding. In this way, the liquidity requirement was loosened in order to mitigate the impact of the financial crisis. Such a change has remained in force until December 2017.

In June 2014, Bank of Slovenia introduced a measure targeting the maturity mismatch, the GLTDF (Gross Loan to Deposit Flow). It prescribes banks with positive annual growth of non-banking sector deposits to have a non-negative growth of loans to the same sector. Until December 2017, if banks have failed to meet this requirement, then they had to meet a higher liquidity ratio KL1. Since January 2018, the measure is a recommendation. The rationale of the GLTDF is to boost banks' intermediation activity, support credit to the real economy (in this respect, the GLTDF is a macroprudential measure) and strengthen the ability of banks to repay their depositors.

The LCR was introduced in October 2015, although it is fully implemented since January 2018. The LCR prescribes banks to hold a bucket of "high-quality liquid assets" (HQLA) sufficient to cope with the cash outflow within thirty days of liquidity stress. HQLA are defined as assets that can be easily and immediately converted into cash at little or no loss of value (Bank for International Settlements, 2013). Liquid assets primarily consist of cash, central bank reserves and, to certain extent, marketable securities, sovereign debt and central bank debt.

Despite the introduction of the LCR, in December 2017 the Governing Board of Bank of Slovenia decided to keep in force the KL1 measure, although as a recommendation, for macroprudential purposes. In fact, in light of the current high bank dependence on demand deposits, the outflow rate on deposits prescribed by the LCR might underestimate the outflow rates on demand deposits in case of liquidity stress. Moreover, the monthly reporting frequency prescribed by the LCR seems inappropriate to monitor the evolution of bank exposure to systemic liquidity risk. In contrast, KL1 relies on a more conservative risk assessment for deposits and prescribes daily reporting.

4. Data, models and estimation results

In order to investigate how Slovenian banks manage the liquidity risk and comply with the liquidity regulation, this study uses data on bank assets and liabilities that constitute, respectively, the numerator and denominator of the liquidity ratio known as KL1. The sample includes banks operating in Slovenia between 2002 and 2013.

The sample period starts in July 2002 and ends in Dec 2013, for the following reasons. First, for the period prior to June 2002, data on KL are available at monthly frequency. However, it is not sure whether these are the observations on the last day of the month or monthly averages of daily data[9]. For this reason, the period prior to July 2002 is excluded from the sample. Second, toward the end of 2013 Slovenia experienced a banking crisis, which entailed the default of two domestic banks and the gradual transfer of deposits to other banks. Extending the sample period beyond December 2013 could thus bias the results.

Third, excluding data after December 2013 also means excluding the period following the introduction of the GLTDF measure. The period following the introduction of the GLTDF is excluded because the corrective measure imposed on banks that failed to meet the GLTDF took the form of a tighter KL1. Since this corrective measure might have changed the way in which banks used to comply with KL1, it was decided to exclude the period after the introduction of the GLTDF from this analysis.

The first assumption that I want to test is that banks pursue a long-run equilibrium relationship between numerator (KL1num) and denominator (KL1den) of KL1, which are also referred to as liquid assets and liquid liabilities, in this paper. A long run linear equilibrium relationship between two integrated time series can exist only if the two series are integrated of the same order. Therefore, the first step in the analysis is to test for the existence of unit root in the two variables KL1num and KL1den. The results of the unit root test are reported in the next section.

[9] I use monthly data, obtained from the monthly mean of daily data.

4.1 Unit-root tests and cointegration

Given the expected heterogeneity in bank behavior, in order to test the unit-root assumption, I use Im-Pesaran-Shin panel unit root test (Im et al. (2003)) that allows for different fixed effects in the intercepts and slopes of the cointegration equation. The results in this and the next section are obtained by scaling the liquid assets and liquid liabilities by total assets, in order to control for heterogeneity across banks behavior due to the different size.

For most of the banks in the sample (twelve out of nineteen banks), the numerator and denominator of KL1 are both integrated of order 1 (results in Table 1 and 2), at 10 percent significance level. Therefore, I test the assumption of cointegration only for these banks.[10] I use Pedroni cointegration test (Pedroni (2001)) but, in order to control for cross-sectional dependence, I first subtract from the numerator and denominator of KL1 the cross-sectional means for each period. [11]

The results in Table 3 reject the null hypothesis of no cointegration against the alternative of cointegration for each bank. The cointegration relationship can be interpreted as a long-run equilibrium relationship between numerator and denominator of KL1. In other words, the results in favour of cointegration between KL1num and KL1den for twelve Slovenian banks indicate that these banks pursue in the long-run a target level of the liquidity ratio. The existence of a long-run equilibrium level of KL1 is not a trivial result, given that banks tend to maintain their KL1 above the minimum compulsory regulatory level.[12]

[10] These banks represent more than 70% of the entire banking system as of June 2017 (in terms of total assets) and more than 80% in the first half of the sample period.

[11] Subtracting from the numerator and denominator of KL1 the cross-sectional means for each period is equivalent to controlling for cross-sectional dependence (at least to some extent) via time effects, as suggested by Pedroni 2001.

[12] De Haan and van den End (2013a) also document that banks hold a buffer of liquid assets against liquid liabilities and net cash outflows, above the minimum regulatory requirement.

Table 1. Panel unit-root test

The table shows the results of the panel unit-root test based on the Im-Pesaran-Shin (IPS) method, which assumes the existence of unit root under the null hypothesis. The appropriate number of lags is selected by Schwarz information criterion (SIC). *** denotes 1% significance level. Based on individual unit root tests (Table 2), 7 out of 19 banks are excluded. Banks are not excluded in presence of a unit root in both numerator and denominator of KL1 at 10% significance level (Table 2).

	Assets in liquidity buffer (KL1num)		Liabilities in liquidity buffer (KL1den)	
	Level	First difference	Level	First difference
Full sample (19 banks)				
# obs.	2343	2332	2327	2320
Test statistic	-8.8***	-55.4***	-0.17	-49.39***
p-value	(0.000)	(0.000)	(0.43)	(0.000)
Only banks with unit root in numerator and denominator of KL1 (12 banks)				
# obs.	1578	1568	1567	1558
Test statistic	-0.22	-44.41***	0.91	-39.44***
p-value	(0.41)	(0.000)	(0.82)	(0.000)

Table 2. Intermediate unit-root results

The table shows the individual augmented Dickey-Fuller (ADF) test results for all individual time series. The null hypothesis of a unit root (non-stationarity) is tested against the alternative that there is no unit root. The results in the table show that the null hypothesis cannot be rejected for all nineteen pairs of series. In particular, the results indicate that for most of the banks in the sample, namely twelve out of nineteen, both the series of the numerator and denominator of KL1 are integrated at order 1. The appropriate number of lags is selected by SIC. *, **, *** denote 10, 5 and 1% significance level, respectively.

Bank	assets in KL1		liabilities in KL1		Bank	assets in KL1		liabilities in KL1	
	p-value	lag	p-value	lag		p-value	lag	p-value	lag
1	0.324	3	0.0375**	3	11	0***	0	0.9976	1
2	0.0347**	0	0.8494	2	12	0.0824*	0	0.0699*	3
3	0.5631	0	0.8791	2	13	0.5382	0	0.3238	0
4	0.3095	1	0.7031	1	14	0.5719	0	0.4662	7
5	0.5351	1	0.6341	2	15	0.5364	1	0.7989	0
6	0.2949	4	0.4214	1	16	0.1319	1	0.4274	2
7	0.6443	4	0.4954	4	17	0.3204	0	0.8385	4
8	0.705	0	0.5103	0	18	0.7681	1	0.8006	1
9	0.0411**	3	0.3653	2	19	0.0003***	0	0.0334**	0
10	0.0039***	2	0.0036***	2					

Table 3. Cointegration test results

The table shows the results of Pedroni's cointegration test, after subtracting the cross-sectional means from each observation for the numerator and denominator of KL1, respectively. The null hypothesis of no cointegration is tested against the alternative that a cointegrating vector exists for each bank. The table shows panel statistics (left part) and group statistics (right part). The appropriate number of lags for each time series is selected by SIC. *** denotes 1% significance level.

	within dimension	p-value		between dimension	p-value
Panel v-Statistic	2.67***	0.004	Group rho-Statistic	-9.02***	0.000
Panel rho-Statistic	-9.08***	0.000	Group PP-Statistic	-7.49***	0.000
Panel PP-Statistic	-6.30***	0.000	Group ADF-Statistic	-6.39***	0.000
Panel ADF-Statistic	-6.50***	0.000			

Notes: The panel-statistics approach pools over the "within" dimension. It tests the null hypothesis that the first-order autoregressive coefficient on the residuals is the same for each individual bank. The group statistics approach pools over the "between"dimension. It allows the autoregressive coefficient to differ for each bank.

Given the existence of cointegration, it is possible to estimate an error-correction model and interpret the error-correction coefficients on KL1num and KL1den as the speed of adjustment toward the equilibrium level of the liquidity ratio through the asset-based and liability-based channel of adjustment, respectively.[13] Whether banks are more inclined to adjust their assets or their liabilities in order to converge toward the bank-specific equilibrium level of the liquidity ratio has relevant implications for the transmission of the liquidity regulation on the real economy.

For instance, a tightening of the liquidity ratio can have negative effects on GDP if banks contract lending in order to increase their liquid assets. Section 4.2-4.3 present the estimation results for different error-correction models, which accommodate the possibility that the transmission mechanism of the liquidity ratio varies with the sign of the deviation from the equilibrium (surplus versus deficit) and with the degree of reliance on wholesale funding and demand deposits.

4.2 Vector error-correction model (vecm) and threshold-vecm

In order to predict the impact of a regulatory change addressing the liquidity risk in banking, it is useful to investigate how banks cope with liquidity shocks. A starting point could be to assess the extent to which banks modify their portfolio of assets and their funding structure in order to adjust their liquidity position. Therefore, it is interesting to test the following assumption:

Hp. 1: banks are more inclined to adjust the asset side than the liability side of their balance sheet in case of divergence from the long-run equilibrium level of the liquidity ratio.

Given the presence of cointegration between bank-specific numerator and denominator of KL1 (see the result of cointegration tests in section 4.1), it is possible to estimate a vector error-correction model. Then, the error correction coefficients will provide evidence against or in favor of assumption Hp.1. Therefore, the following model is estimated:

[13] Error correction mechanisms have been widely used in economics. Early versions are Sargan (1964) and Phillips (1957). The idea is that a proportion of the disequilibrium from one period is corrected in the next period. Such models can be derived as optimal behaviour with some types of adjustment costs or incomplete information. The relationship between error correction models and cointegration was first pointed out in Granger (1981). A theorem (known as the Granger representation theorem) showing precisely that cointegrated series can be represented by error correction models was originally stated and proved by Granger (1983).

$$\begin{bmatrix}\Delta LA_{i,t}\\ \Delta LL_{i,t}\end{bmatrix} = \begin{bmatrix}\alpha_i^{LA}\\ \alpha_i^{LL}\end{bmatrix} + \begin{bmatrix}\rho^{LA}\\ \rho^{LL}\end{bmatrix} ED_{i,t-1} + \begin{bmatrix}0 & \gamma_i^{LA}\\ \gamma_i^{LL} & 0\end{bmatrix} \begin{bmatrix}\Delta LA_{i,t-1}\\ \Delta LL_{i,t-1}\end{bmatrix} + \begin{bmatrix}u_{i,t}^{LA}\\ u_{i,t}^{LL}\end{bmatrix} \quad (1)$$

$$ED_{i,t} = LA_{i,t} - \alpha_i^{eq} - \beta_i^{eq} LL_{i,t} \quad (2)$$

where $LA_{i,t}$ and $LL_{i,t}$ denote liquid assets (numerator of KL1) and liquid liabilities (denominator of KL1), respectively, for bank *i*. $ED_{i,t}$ stands for "deviation from the equilibrium for bank *i* at time *t*" and denotes the divergence from the bank-specific long-run equilibrium between liquid assets and liquid liabilities. In other words, $ED_{i,t}$ is defined as the error term in the following cointegration equation

$$LA_{i,t} = \alpha_i^{eq} + \beta_i^{eq} LL_{i,t} + \varepsilon_{i,t} \quad (3)$$

$$ED_{i,t} \equiv \varepsilon_{i,t}$$

In the vector error correction model in equation (1) panel restrictions on the error correction coefficients are imposed. Moreover, the lag of the vector of the dependent variables is included at the right hand side of equation (1) to control for short-term adjustments. The terms $u_{i,t}^{LA}$ and $u_{i,t}^{LL}$ are the residuals. The model in equation (1) can be estimated in different ways. The results reported in this paper are obtained by following the Engle and Granger (1987) two-step procedure.

It might be the case that banks are more sensitive to negative deviations from the equilibrium level of the liquidity ratio than to positive deviations. In other words, banks are expected to intervene faster in case of liquidity deficit than in case of liquidity surplus (deficit and surplus defined with respect to the long-run target level of liquidity). It is also possible that in case of negative deviations from the long-run equilibrium, the adjustment is more biased toward the asset side than in case of positive deviations, or viceversa. In order to investigate this issue, the following threshold–vector error correction model has been estimated:

$$\begin{bmatrix}\Delta LA_{i,t}\\ \Delta LL_{i,t}\end{bmatrix} = \begin{bmatrix}\alpha_i^{LA}\\ \alpha_i^{LL}\end{bmatrix} + \begin{bmatrix}\rho_{deficit}^{LA}\\ \rho_{deficit}^{LL}\end{bmatrix} ED_{i,t-1} * I_{i,t-1} + \begin{bmatrix}\rho_{surplus}^{LA}\\ \rho_{surplus}^{LL}\end{bmatrix} ED_{i,t-1} * (1 - I_{i,t})$$

$$+ \begin{bmatrix}\gamma_i^{LA} & 0\\ 0 & \gamma_i^{LL}\end{bmatrix} \begin{bmatrix}\Delta LL_{i,t-1}\\ \Delta LA_{i,t-1}\end{bmatrix} + \begin{bmatrix}u_{i,t}^{LA}\\ u_{i,t}^{LL}\end{bmatrix} \qquad (4)$$

where $I_{i,t}$ is a dummy variable introduced in the model in order to control for the sign of the deviation from the long-run equilibrium level of the liquidity ratio:

$$I_{i,t} = \begin{cases} 1 & if \quad ED_{i,t} < 0 \\ 0 & otherwise \end{cases}$$

Balke and Fomby (1997) introduced threshold-vector error correction models to accommodate discontinuous changes in the attraction towards the equilibrium characterised by the cointegrating relationships.[14] They find that standard time series methods developed for testing for cointegration in the linear case work reasonably well when threshold cointegration is present.[15]

The implicit assumption behind the cointegration and error correction model is that a tendency to move toward a long-run equilibrium (in expectation) is present every time. However, it is possible that movement toward the long-run equilibrium need not occur in every period. For instance, the presence of fixed costs of adjustment may prevent economic agents from adjusting continuously. Only when the deviation from the equilibrium exceeds a critical threshold, the benefits of adjustment exceed the costs and, hence, economic agents act to move the system back toward the equilibrium.

This type of discrete adjustment mechanism has been used to describe economic phenomena like the behaviour of inventories, money balance, consumer durables, prices and employment. Even in efficient financial markets, the presence of transaction costs may create a band in which asset returns are free to diverge and in which arbitrage opportunities exist. Another important field where discrete adjustments can be observed is that of policy

[14] In particular, Balke and Fomby (1997) consider the case of the equilibrium error following a threshold autoregression that is mean reverting outside a given range and has a unit root inside the range. In other words, they examine the case where cointegrating relationship is inactive inside a given range and becomes active once the system gets too far from the equilibrium.

[15] They consider a 'sup-Wald' test of linearity that takes the double-threshold model as the alternative hypothesis.

interventions. For instance, in the case of exchange rate management and commodity price stabilization.[16]

4.3 Results

In order to verify assumption Hp. 1, you need to compare the error-correction coefficient for the liquid assets, ρ^{LA}, with the error-correction coefficient for the liquid liabilities, ρ^{LL}. The first thing to check is that there is convergence toward the long-run equilibrium. Having defined the divergence from the long-run equilibrium as in equation (2), positive (negative) deviation means that there is liquidity surplus (deficit) with respect to the bank-specific long-run equilibrium liquidity ratio.

Therefore, convergence toward the equilibrium requires ρ^{LA} to be negative and ρ^{LL} to be positive. If this holds and ρ^{LA} is bigger than ρ^{LL} in absolute terms, then it is possible to conclude that there is evidence in favor of Hp. 1. Results are presented in Table 4 (symmetric model). The results support the assumption that Slovenian banks are more inclined to adjust the liquid assets than the liabilities in order to keep their equilibrium level of liquidity ratio.

The estimates of the asymmetric error-correction coefficients ($\rho^{LA}_{deficit}$, $\rho^{LA}_{surplus}$, $\rho^{LL}_{deficit}$ and $\rho^{LL}_{surplus}$) are also reported in Table 4 (asymmetric model). The results show that in case of liquidity deficit banks adjust their liquidity position much faster than in case of liquidity surplus. In case of negative shock to liquidity, 39% (|-0.23|+0.16) of the deficit is corrected in the next month. Instead, in case of positive shock, only 18% of the surplus is corrected in the subsequent month. Moreover, in both cases the adjustment is biased toward the asset side.

[16] Another example mentioned in Balke and Fomby (1997) is that of a monetary authority that controls two different interest rates. For instance, the FED controls the Fed Funds rate and the Discount rate. If the spread between the two rates becomes too large, the monetary authority intervenes to change one or both rates to prevent sending conflicting signals about the monetary policy.

Table 4. (Asymmetric) Adjustment Coefficients

The table shows the error correction terms from the GLS results for the (threshold) vector error correction model for twelve banks over the period July 2002 –Dec 2013. ***, **, * denote significance at 1, 5 and 10% significance level, respectively.

	Asset-based adjustment		Liability-based adjustment	
symmetric	ρ^{LA}	-0.20***	ρ^{LL}	0.09*
asymmetric	$\rho^{LA}_{deficit}$	-0.23***	$\rho^{LL}_{deficit}$	0.16***
	$\rho^{LA}_{surplus}$	-0.18***	$\rho^{LL}_{surplus}$	0.01

Note: 633 out of 1178 observations are cases of negative deviations (deficit) from the estimated long run equilibrium level of the liquidity ratio.

The previous results show that banks converge toward the bank-specific long-run equilibrium level of the liquidity ratio through a combination of the asset-based and liability-based channel of adjustment. However, for the given sample of banks and the selected sample period, the asset-based adjustment is predominant. These results are in contrast with the findings relative to Dutch banks in Duijm and Wierts (2016), who document that the adjustment toward a long-run equilibrium in the liquidity ratio mainly affect the liability side, especially when the ratio is below its long-run equilibrium level.

More factors could explain why the results for Slovenia differ from the results for the Netherlands. First, the Dutch market for wholesale funding is more developed than in Slovenia and Dutch banks make more use of it compared to Slovenian banks.[17] This means that it is relatively easier for Dutch banks to raise wholesale funding with long enough maturity (a liability-based adjustment) for the purpose of liquidity management. Another factor justifying the greater recourse of Slovenian banks to the asset-based adjustment, compared to Dutch banks, could be the significant presence of sovereign bonds among liquid assets held by Slovenian banks. Sovereign bonds are generally easy to trade and minimally exposed to the risk of fire sales. Therefore, these securities can flexibly be used to respond to liquidity shocks.

The predominant recourse to the asset-based channel by Slovenian banks can have negative consequences on the real economy. In fact, a tightening of the liquidity regulation as well as a negative liquidity shock might have a contractionary effect on GDP if banks contract

[17] Aggregate data for the Slovenian banking system (Section 5) and for the Dutch banking system (see Duijm and Wierts (2016)) show that the prevailing source of funding for Slovenian banks are deposits from non-banking customers, whereas in Dutch banks wholesale funding pays a more important role.

lending in order to increase their liquid assets.[18] In contrast, imagine that banks respond to a tightening of the liquidity regulation by extending the average maturity of their liabilities. Consequently, banks will have the possibility to finance companies with projects that require longer-term financing. If these companies were also the most productive in the long-run, then the long-run effect on GDP of tightening the liquidity requirement would be positive.

Nevertheless, as pointed by de Bandt and Chahad (2015), the effect of tightening the liquidity requirement (or of liquidity shocks) on GDP is a priori unpredictable. In fact, such effects are determined by a combination of many factors. While this paper studies the bank response to liquidity shocks, which represents the first step of the transmission mechanism of liquidity shocks and of changes in liquidity regulation, studying the entire transmission mechanism including the effects on GDP is left for future research.

Obviously, banks face a trade-off between the costs of increasing the stable funding and the opportunity cost of replacing illiquid and more remunerative assets with liquid assets. We might expect that banks prefer the asset-based adjustment to the liability-based adjustment to the liquidity ratio if the spread between the returns on illiquid and liquid assets is smaller than the spread between the interest rate paid on stable and unstable funding.

Consider, for instance, the current low interest rate environment and the observed preference of depositors for demand deposits. Bank can increase their liquidity ratio by substituting demand deposits, which receive an outflow rate of 40% based on KL1 regulation, with term deposits with maturity longer than 30 days, which receive 0% outflow rate in KL1. In principle, banks could increase the spread between interest rate on term deposits and demand deposits, so to create an incentive for depositors to switch toward term deposits. In order to increase such a spread, banks could either increase the interest rate on term deposits or decrease the interest rate on demand deposits.

However, in the current low interest rate environment, the possibility to increase the return on long-term deposits is constrained by the low profitability on the asset side. At the same time, the possibility to reduce the remuneration on demand deposits is generally constrained by the zero-lower bound. In fact, in the current low interest rate environment, we observe that demand deposits are taking the place of term deposits and banks keep on increasing their liquid assets. Therefore, the monetary policy has an impact on the transmission of liquidity

[18] Actually, many countries experienced a credit contraction during the crisis, although this might be due to other factors (demand factors, binding capital requirements and other supply factors) on top of liquidity issues.

shocks and of liquidity regulation through (although not exclusively) its influence on bank funding structure. The role of the structure of bank funding is investigated in the following subsections.

4.4 Bank compliance with liquidity regulation: the role of the structure of funding

The spread between the return on term deposits and on demand deposits – let us call it deposit spread – that banks should offer to depositors as an incentive to switch from demand deposits to term deposits represents the depositors' liquidity risk premium. The size of the liquidity risk premium that makes depositors indifferent between demand deposit and term deposit depends on depositors' preference for liquidity.

Consider a situation like the current one, in which banks find it difficult to increase the interest rate on term deposits and to bring the deposit spread beyond the level that triggers a switch from demand deposits to term deposits. On top of this situation, if banks cannot raise the stable funding in alternative ways, then the only possibility for banks to meet the liquidity regulation is to increase the liquid assets. Therefore, depositors' preference for liquidity is a factor that influences the transmission mechanism of the liquidity regulation. Following an increase in depositors' preference for liquidity and if the access to stable funding alternative to deposits is limited, banks will rely more on the asset-based adjustment in order to comply with the liquidity regulation.

As mentioned above, another factor affecting the transmission of liquidity shocks and regulation is the availability of wholesale funding. The more difficult and/or costly it is for banks to raise wholesale funding of long enough maturity, the more likely it is that banks react to liquidity shocks (or to a tightening of the liquidity measure) by increasing the liquid assets instead of lengthening the average maturity of wholesale funding. It is plausible that bank reliance on wholesale funding is higher when banks have easier and cheaper access to wholesale funding. Under this assumption, when banks display a higher reliance on wholesale funding they should also be more prone to resort to the liability-based adjustment to the liquidity ratio.

Similarly, it is plausible that bank reliance on demand deposits is higher when depositors manifest higher preference for liquidity and access to wholesale funding is limited and more

costly. In such a case, it becomes more convenient for banks to resort to the asset-based adjustment to the liquidity ratio, as an alternative to increase term deposits and long-term wholesale funding. Therefore, the objective of the subsequent analysis is to test the following assumptions about the dependence of the transmission of liquidity shocks on the bank liability structure:

Hp. 2: the contribution of liability-based adjustments to the liquidity ratio increases with the share of wholesale funding over total assets (WF/TA);

Hp. 3: the contribution of liability-based adjustments to the liquidity ratio decreases with the share of demand deposits over total assets (DD/TA).

The model in the previous section can be easily modified in order to capture the dependence of the transmission of liquidity shocks on the bank liability structure. In particular, in order to test Assumption 2, the model in equation (4) – section 4.2 - is modified as follows:

$$\begin{bmatrix}\Delta LA_{i,t}\\ \Delta LL_{i,t}\end{bmatrix} = \begin{bmatrix}\alpha_i^{LA}\\ \alpha_i^{LL}\end{bmatrix} + \begin{bmatrix}\rho_{low\_w}^{LA}\\ \rho_{low\_w}^{LL}\end{bmatrix} ED_{i,t-1} * I_{i,t-1}^{low\_w} + \begin{bmatrix}\rho_{high_w}^{LA}\\ \rho_{high_w}^{LL}\end{bmatrix} ED_{i,t-1} * (1 - I_{i,t}^{low\_w})$$

$$+ \begin{bmatrix}\gamma_i^{LA} & 0\\ 0 & \gamma_i^{LL}\end{bmatrix} \begin{bmatrix}\Delta LL_{i,t-1}\\ \Delta LA_{i,t-1}\end{bmatrix} + \begin{bmatrix}u_{i,t}^{LA}\\ u_{i,t}^{LL}\end{bmatrix} \quad (5)$$

where $I_{i,t}^{low\_w}$ is a dummy variable introduced in the model in order to control for the degree of dependence on wholesale funding:

$$I_{i,t}^{low\_w} = \begin{cases} 1 & if\ \dfrac{WF}{TA} < bank\ specific\ mean\ ratio\left(\overline{\dfrac{WF}{TA}}\right) \\ 0 & otherwise. \end{cases}$$

Similarly, in order to test Assumption 3, the dummy variable in the model in equation (5) is replaced with an appropriate dummy variable, $I_{i,t}^{low\_dd}$, that controls for the degree of dependence on demand deposits:

$$I_{i,t}^{low\_dd} = \begin{cases} 1 & if\ \frac{DD}{TA} < bank\ specific\ mean\ ratio\ \left(\overline{\frac{DD}{TA}}\right) \\ 0 & otherwise. \end{cases} \quad (6)$$

4.4.1 The role of wholesale funding

Two versions of the model in equation (5) are estimated. In the first version, the overall wholesale funding is considered, irrespective of the maturity. Wholesale funding is defined as the amount of funding obtained from domestic and foreign banks plus the issued securities. In the second version of the model, only wholesale funding with residual maturity within 30 days is accounted for (this is the part of wholesale funding that contributes to the denominator of KL1). Wholesale funding is scaled by total assets, so to capture the relative importance of this source of funding relative to the size of the bank. The estimated coefficients of the error correction term in the two versions of the model in equation (5) are reported in Table 5.

Table 5. Adjustment Coefficients in the model that controls for wholesale funding

The table shows the error correction terms from the GLS estimation of the threshold vector error correction model where the variable responsible for the discontinuity in the error correction coefficient is wholesale funding. Estimation period July 2002 –Dec 2013. ***, **, * denote significance at 1, 5 and 10% significance level, respectively. Big (small) volume means above (below) the average volume over the sample period.

Dependence on wholesale funding (relative to total assets)	Total wholesale funding		Wholesale funding maturing in 30 days	
	Adjustment		Adjustment	
	asset-based	liability-based	asset-based	liability-based
small	-0.07**	0.10***	-0.11***	0.08***
Big	-0.14***	0.13***	-0.09**	0.19***

The estimated coefficients of error correction show an increase in the liability-based adjustment to the liquidity ratio when the dependence on wholesale funding is higher. In the first version of the model (when the total amount of wholesale funding is considered), the speed of adjustment to the liquidity ratio driven by a liability-based adjustment increases from 10% to 13% when moving from low to high dependence on wholesale funding. In the second version of the model (when only the part of wholesale funding that contributes to the denominator of the liquidity ratio KL1 is considered) the speed of adjustment of liabilities increases significantly from 8% to 19% when moving from low to high dependence on wholesale funding. These findings suggest that a possible reason why the liability-based adjustment to the liquidity buffer is more important for Dutch banks than for Slovenian ones

is the more developed market for wholesale funding in the Netherlands than in Slovenia, as already mentioned while discussing the results in the previous section.

Moreover, the overall adjustment of the liquidity position (through both the asset and liability channel) is faster when the bank relies more on wholesale funding. In particular, according to the model where total wholesale funding is considered, any divergence from a target level of liquidity are corrected in the next month for an amount corresponding to 17% (=|-7%|+10%) when the bank relies less on wholesale funding. Instead, a much higher percentage equivalent to 27% (=|-14%|+13%) of the deviation from the equilibrium level of liquidity is corrected in the subsequent month when the banks relies more on wholesale funding. Similar results are obtained from the model that considers only the wholesale funding with residual maturity within 30 days: 19% (=|-11%|+8%) of a liquidity shock is corrected within a month in case of low dependence on wholesale funding, whereas 28% of a liquidity shock is corrected in 30 days when wholesale funding represents a higher share of total assets.

4.4.2 The role of demand deposits

Consider now the effect of an increase in the dependence on demand deposits. In particular, it is interesting to assess the impact of the different degree of dependence on demand deposits on the liability-based adjustment to the liquidity ratio. The estimated error correction coefficients in the model that controls for the level of dependence on demand deposits are reported in Table 6. The estimated coefficient of error correction associated with the liability-based adjustment to the liquidity ratio is lower when the dependence on demand deposits is bigger. The explanation for this result is that retail demand deposits are notoriously sluggish and cannot easily be manipulated by the bank in the short run. This result is consistent with the results in Table 5, indicating that when wholesale funding becomes scarce, banks tend to resort more to the asset-based channel and less to the liability-based channel of adjustment to the liquidity ratio.

The results in the third column of Table 6 seem quite strong, with the coefficient of the liability-based adjustment decreasing from 13% to 0%, given that the coefficient is statistically non-significant, when moving from small to big reliance on demand deposits. However, during the sample period the Bank of Slovenia lowered the risk weight assigned to demand deposits three times. This could explain why this result is striking.

In fact, a reduction in the risk weight (outflow rate) on demand deposits means that banks need to invest a smaller fraction of demand deposits in liquid assets, thus implying a lower opportunity cost for banks from collecting demand deposits instead of more stable funding. Consequently, the decreases in the risk weight on demand deposits might have contributed to weaken further the already weak incentives of banks to resort to the liability channel compared to the asset-based adjustment to the liquidity ratio, especially in presence of big reliance on demand deposits.[19]

Therefore, as a robustness check the model is also estimated over a shorter period, namely January 2007 – September 2011, which represents the longer sub-sample period during which regulatory changes affecting the risk weight of demand deposits did not occur.[20] If the intuition above is correct, then the reduction in the coefficient of the liability-based adjustment associated with an increase in bank dependence from demand deposits should be smaller in the sub-sample compared to the entire sample period.

Table 6. Adjustment Coefficients in the model that controls for demand deposits

The table shows the error correction terms from the GLS results for the (threshold) vector error correction model where the variable responsible for the discontinuity in the error correction coefficient is the volume of demand deposits. ***, **, * denote significance at 1, 5 and 10% significance level, respectively. Big (small) volume means above (below) the average volume over the sample period.

Dependence on demand deposits (relative to total assets)	Estimation period July 2002-Dec 2013		Estimation period Jan 2007-Sep 2011	
	Adjustment		Adjustment	
	asset-based	liability-based	asset-based	liability-based
small	-0.13***	0.13***	-0.22***	0.14***
Big	-0.19**	0.07	-0.16***	0.10**

As expected, the reduction in the liability-based adjustment associated with the increase in bank dependence from demand deposits is bigger when the model is estimated over the entire sample period than over the selected sub-sample (column 3 versus column 5 in Table 6). In particular, in the former case (i.e. entire sample period) the coefficient of the liability-based adjustment decreases from 13% to basically 0, given that the coefficient is statistically non-

[19] While it is not realistic to think that banks refuse the money that a customer intend to keep in a demand deposit, they can persuade that customer in favor of a term deposit with relatively long maturity, by offering a higher remuneration on this latter. This operation would result into a liability-based adjustment to the liquidity ratio.

[20] In both cases, i.e. when the model is estimated over the full sample and the sub-sample, the amount of demand deposits is scaled by total assets, so to capture the relative importance of this source of funding relative to the size of the bank.

significant, while it decreases from 14% to 10% in the second case (i.e. subsample estimation).

On top of the aforementioned decreases in the risk weight on demand deposits, a further reason that could explain why the reduction in the liability-based adjustment associated with bigger reliance on demand deposits is stronger on average over the entire sample period than in the sub-sample is the following. Compared to the subsample period, on average over the entire sample period it was likely more costly for banks to substitute stable funding for unstable funding, that is to resort to the liability-based adjustment.

In fact, the subsample period mainly coincides with the great financial crisis and the European sovereign debt crisis. Both crises triggered a reduction in Euribor rates and in deposit rates and a flattening of the term structure of interest rates. Due to a flatter term structure of interest rates, the difference between the cost for banks of long-term funding and the cost of unstable funding was smaller over the sub-sample compared with the entire sample period. Therefore, the aversion of banks to resort to the liability-based channel was weaker over the sub-sample period.

What is more interesting is to compare the liability-based adjustment coefficients in Table 6 with those in Table 5. These results overall indicate that the liability-based adjustment to the liquidity ratio is bigger when there is higher dependence on wholesale funding, whereas it is smaller when there is higher dependence on demand deposits. In particular, these results could suggest that it is more difficult and costly for banks, or it takes longer, to convince depositors to switch from demand deposits to term deposits rather than lengthening the maturity of wholesale funding, with the purpose of increasing the liquidity ratio.[21]

Further insights can be obtained by comparing the change in the total adjustment to the liquidity ratio (asset-based plus liability-based adjustment) in the case of increased dependence on wholesale funding as opposed to the case of increased dependence on demand deposits. An increase in the dependence on wholesale funding is associated with a faster

[21] However, this last consideration is true if we assume that when there is an increase in the bank dependence from a specific source of funding, then the liability-based adjustment to the liquidity ratio is mainly implemented by lengthening the maturity of that specific source of funding. This requires that bank dependence on wholesale funding and liquidity of the market for wholesale funding are highly correlated, which seems realistic.

overall adjustment to the liquidity ratio (liability-based plus asset-based adjustment)[22]: from 17% (19%) to 27% (28%) in the first (second) version of the model.

Instead, an increase in the dependence from demand deposits is associated with slower adjustment to the liquidity ratio: from 26% (36%) to 19% (26%) in the model estimated over the entire sample (sub-sample) period. A possible interpretation of this result is that an increase in wholesale funding is considered to entail higher liquidity risk than a similar increase in demand deposits and, therefore, in the first case banks adjust faster their liquidity position. This interpretation is in line with the observed stability of demand deposits and instability of wholesale funding (the latter especially observed during the 2007-2009 crisis).

To sum up, these results of the present study signal that the liquidity management strategy of a bank and, therefore, the transmission of liquidity shocks and regulation are dependent from the bank liability structure. The structure of funding of a bank likely reflects some features of the financial markets where the bank mainly operates, in particular where it mainly raises funds. For instance, the degree of development of the market for wholesale funding and the preferences of savers-investors (for instance, propensity for deposits rather than bonds or shares). The results in this paper, combined with those in Duijm and Wierts (2016), suggest that the structure of bank funding and the aforementioned country-specific features of financial market are relevant factors explaining cross-country differences in the transmission of bank liquidity shocks and of liquidity regulation, as in the case of Slovenia versus the Netherlands.

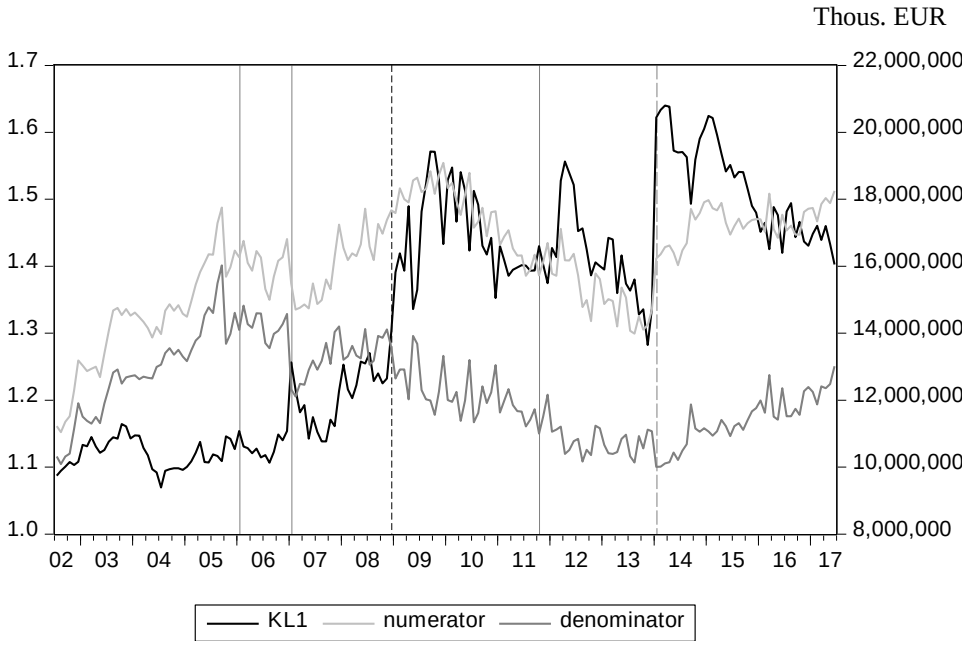
5. Exposure to funding liquidity risk at banking system level

5.1 Pattern of the liquidity ratio around the crisis

At aggregate level, available liquidity always lies above the required liquidity (Figure 1), so the minimum regulatory requirement is maintained, similarly to the Dutch case (de Hann and van den End (2013) and Duijm and Wierts (2016)). However, there is not a strong evidence of comovement between numerator and denominator of the liquidity ratio at aggregate level, so cointegration is not found in data at banking system level.

[22] The coefficient of error correction can be interpreted as the speed of adjustment toward the long-run equilibrium existing between cointegrated variables. A coefficient of error correction equal to 10% means that 10% of the deviation from the equilibrium that occurs in a month is eliminated in the next month.

Figure 1. KL1 (left axis) and its components (right axis) for the Slovenian banking system.



The three vertical gray lines identify the dates on which the risk weigth for sight deposits was decreased (Jan 2006, Jan 2007 and Oct 2011). The black dashed line pins down Dec 2008, when the KL1 requirement was released, by allowing the assets pledged for ECB funding to enter the numerator of KL1. The dashed gray line identifies Dec 2013, when non-performing loans were transferred to the Bad Asset Managing Company.

Moreover, both numerator and denominator of the liquidity ratio increased in the run-up to the financial crisis, in particular in the first three quarters of 2007 (Figure 1). However, the increase in required liquidity (denominator of KL1) outweighed the rise in liquid assets, resulting in a lowering of the liquidity ratio.

During the crisis, the liquidity ratio increased, as banks increased their exposure to liquid assets while decreasing their reliance on short-term and unstable wholesale funding. These data are consistent with a procyclical pattern of risk taking, that is increasing risk taking in good times (characterised by credit expansion and economic growth) and derisking in bad times. A somehow similar cyclical pattern in the liquidity ratio was observed in Slovenia prior to and after the European sovereign debt crisis, although the liquidity ratio did not go down to the level prior to the great financial crisis.

5.2 Balance sheet composition

The dynamics of the composition of numerator and denominator of the liquidity ratio and of the composition of the whole balance sheet (Figure 2-5) show how banks fulfilled their strategy of increasing risk taking prior to the crisis and derisking during the crisis.[23] On the asset side (Figure 2 and 4), prior to the crisis banks increased their exposure to wholesale lending - to banks and other financial institutions (OFIs)[24] - and riskier securities than domestic sovereign bonds, which instead were decreasing. Moreover, lending to non-financial customers expanded as well as off-balance sheet exposures (these latter especially in 2007). On the liability side (Figure 3 and 5), interbank borrowing followed an upward path until 2008, at a faster pace between the second half of 2006 and the first half of 2007. Off-balance sheet liabilities exhibited an upward trend in 2007 second and third quarters.

During the crisis, such dynamics changed significantly. In 2008, wholesale lending – in particular interbank lending - started decreasing and the negative trend remained for quite some year (in particular, until toward the end of 2012, for interbank lending with residual maturity within thirty days). Gradually, lending to non-financial customers decreased. At the same time, banks increased remarkably their reserves at the central bank and the assets eligible to be collaterals for Eurosystem funding. In particular, banks switched from riskier securities to domestic sovereign bonds.

Indeed, banks used the eligible assets in order to receive funding from the central bank. This is visible from KL from the amount of pledged asset for Eurosystem funding (Figure 2). Similarly, balance sheet data (Figure 5) confirm that bank increased the funds raised from the central bank during the financial crisis (2008-09), as well as during the European sovereign debt crisis (more precisely, over 2011-2013). In 2008, interbank borrowing switched from a prolonged positive trend to a prolonged negative trend (Figure 3 and 5).

To sum up, balance sheet data confirm a) the steady increase in wholesale lending from 2004 until 2009 included and its gradual decrease afterwards, and b) the exuberant expansion of credit to the non-financial sector before the crisis (2004-2007) and its contraction

[23] Notice the difference between balance sheet data and KL reporting. The former show the total amount of balance sheet items at the considered date. The latter show the amount of cash flows that these items are expected to generate or are able to generate (for instance, in the case of securities that can be sold on the market to raise cash, if needed) in the coming thirty days.

[24] There is high correlation between total interbank lending and the interbank lending that shows up in the numerator of KL1 (Figure 2 and 4), given that interbank operations mostly have very short maturity.

afterwards. At the same time, total assets of the Slovenian banking system expanded faster in the run up to the financial crisis than previously. Finally, balance sheet data confirm that the crisis made banks switch from unstable wholesale funding toward more stable funding, namely equity and non-financial customers' deposits.

Overall, these data tell us that in the run up to the financial crisis banks in Slovenia, as in many other countries, expanded their activity, including loans, by financing it with cheaper but unstable wholesale funding, thus increasing their 'liquidity leverage'[25]. Afterwards, banks shifted from unstable to stable funding (mainly from interbank borrowing to non-financial customers' deposits), thus reducing their exposure to funding liquidity risk. Despite roll-over issues with wholesale funding, the funds raised through deposits from non-banking customers allowed the Slovenian banking system to continue expanding, although at a lower pace in 2008-9 than in the two preceding years. The total assets of the Slovenian banking system start shrinking in 2010, when the European sovereign debt crisis put further pressures on banks, followed by the default of two Slovenian banks.

[25] 'Liquidity leverage' is a concept that reflects maturity mismatch and liquidity characteristics of assets and liabilities without a contractual maturity. Thus, the 'liquidity leverage' indicates bank exposure to funding liquidity risk.

Figure 2. Components of the numerator of KL1 (thous. EUR).

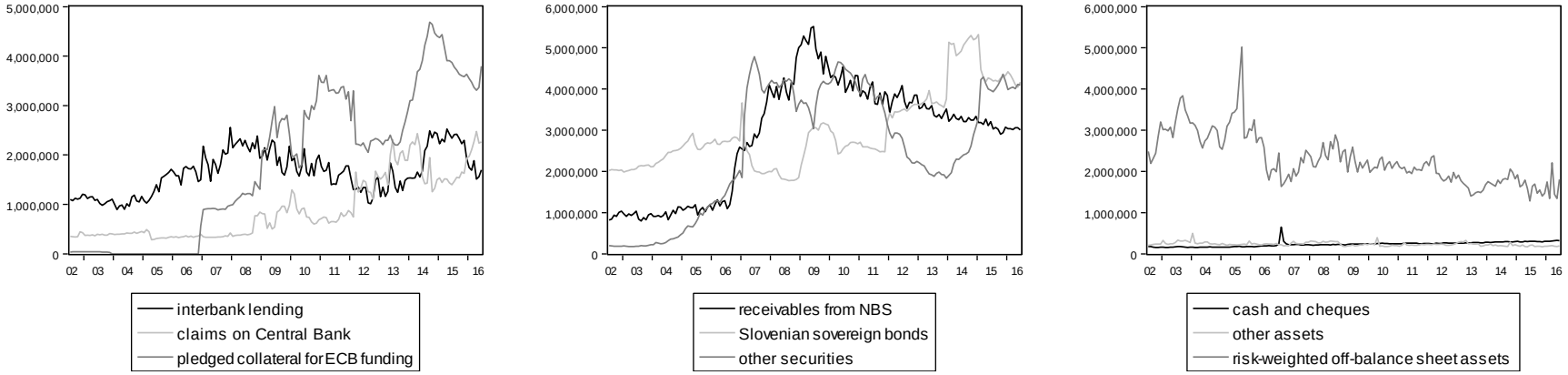


Figure 3. Components of the denominator of KL1 (thous. EUR).

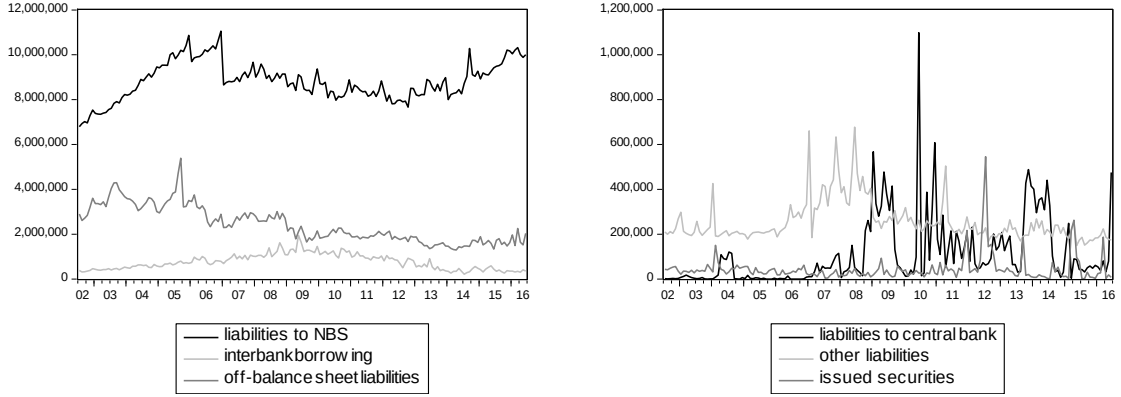


Figure 4. Breakdown of total assets (thous. EUR).

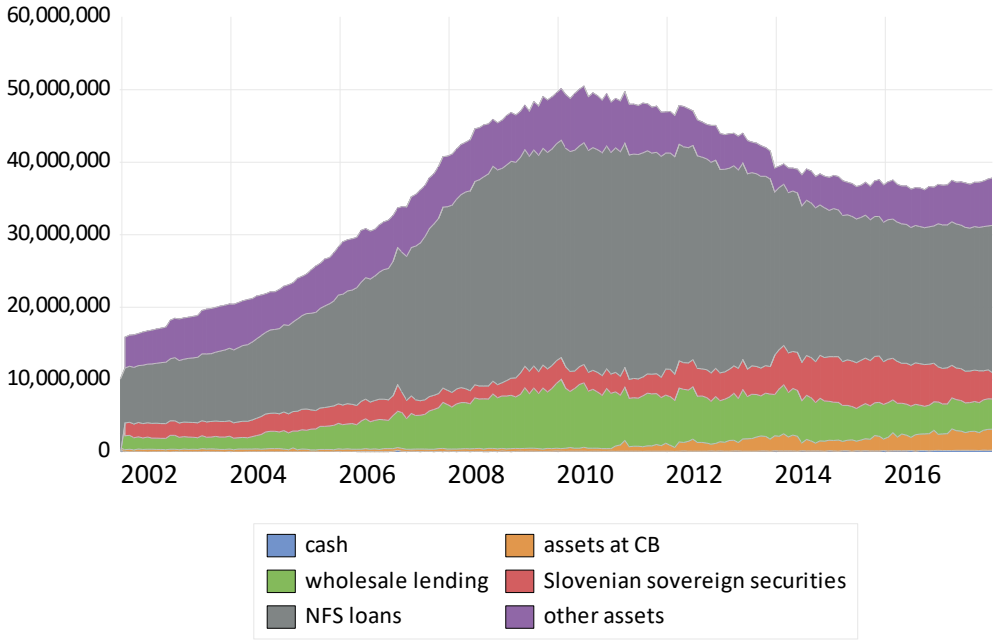
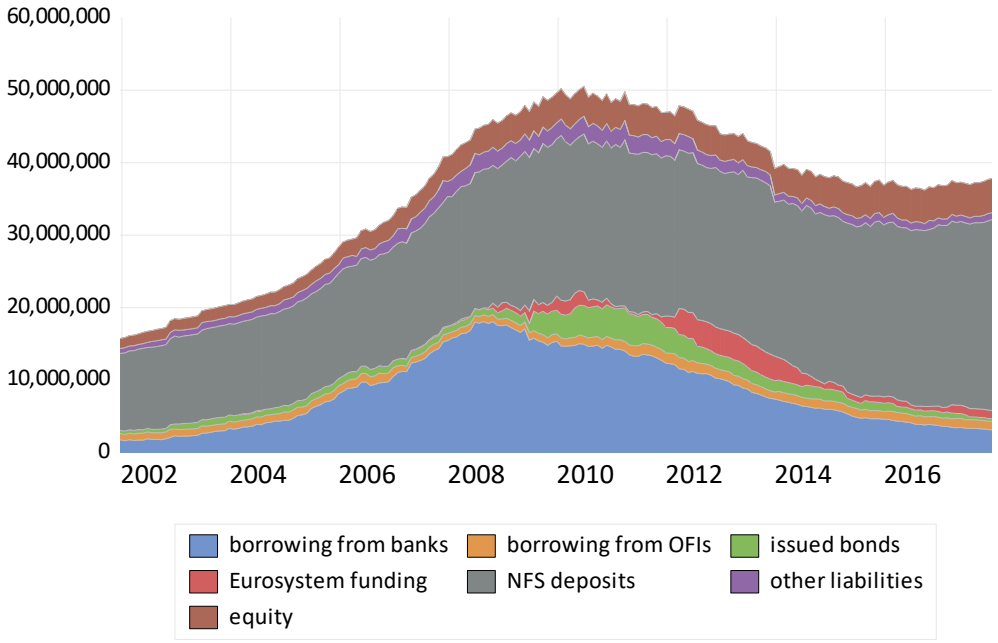


Figure 5. Breakdown of total liabilities (thous. EUR).



6. Conclusions

This paper investigates bank response to liquidity shocks as a preliminary step toward the study of the transmission of bank liquidity regulation in Slovenia. More precisely, it tries to quantify the relative importance of asset-based and liability-based adjustments to the liquidity ratio. The results signal that, in the case of banks operating in Slovenia, the asset-based adjustments are in general more pronounced than liability-based adjustments, in contrast with the findings in Duijm and Wierts (2016) for the case of the Netherlands.

There are two main possible explanations for this difference between Slovenian and Dutch banks. First, the significant presence of sovereign bonds among the liquidity assets held by Slovenian banks gives these latter a strong incentive to resort to the asset-based adjustment. In fact, sovereign bonds are usually very liquid assets and the risk of fire sale is very low. Second, the market for wholesale funding is more developed in the Netherlands than in Slovenia, thus making easier for Dutch banks to raise wholesale funding for the purpose of liquidity management.

It follows that structural characteristics of the financial system in a country, like the availability of wholesale funding, influence the structure of bank funding as well as the bank response to liquidity shocks, as captured by the second set of results in this paper. In particular, the liability-based adjustment to the liquidity ratio becomes smaller when there is higher bank dependence on demand deposits, whereas it becomes bigger when there is higher bank dependence on wholesale funding. These results suggest that it might be easier and/or cost efficient for banks to lengthen the maturity of their liabilities when there is abundant wholesale funding with respect to the case when demand deposits represent a relatively high share of total liabilities. Moreover, since demand deposits increase when interest rate are low, these results also point to the influence of monetary policy on bank response to liquidity shocks.

The predominance of the asset-based adjustment to the liquidity ratio has relevant macroprudential policy implications. First, a negative systemic liquidity shock can have negative effects on credit and on GDP if banks contract lending in order to increase their liquid assets. Therefore, the macroprudential policy maker should evaluate the possibility to release the liquidity requirement or adopt other macroprudential policy measures, such as a

release of the countercyclical capital buffer, in case of materialization of systemic liquidity risk.

The second macroprudential policy implication relates to the possible frictions in the markets for securities that banks hold among their assets. In fact, as explained in Section 2, when banks hit by a liquidity shock need to sell the securities in their portfolio, two types of frictions may make banks only obtain a price below the fundamental value. The first friction is the cash-in-the-market-pricing and occur when potential buyers do not have enough cash to clear the market. Moreover, since the securities are marked-to-market, an initial price drop may force other banks to sell the same securities and reinvest in more liquid assets (in order to meet the liquidity requirement). This amplification mechanism leads to asset fire sale. In order to smooth such amplification mechanism, the macroprudential policy maker should consider releasing the liquidity requirement when a systemic liquidity shock materializes.

The second type of friction relates to adverse selection and is more likely to kick in presence of liquidity hoarding, as explained by Malherbe (2014). In fact, the more cash a seller is expected to have on hand, the less likely it is that he is trading because of a need to raise cash and the more likely it is that he is trying to pass on a lemon (Akerlof 1970). Therefore, excessive cash holding by some banks imposes a negative externality on others because it reduces future market liquidity, thus pushing the price of traded securities below their fundamental value. Also this second type of friction can be an amplification mechanism of liquidity shocks. Given the current high amount of excess reserves in banks in Europe, regulators should not overlook this mechanism.

To alleviate this friction, the macroprudential policy maker should consider measures to counteract banks' incentives for liquidity hoarding. Also in this case, one possibility is a countercyclical liquidity buffer. In fact, banks may tend to hoard liquidity if they are afraid not to be able to meet the liquidity requirement in case of a systemic liquidity crisis. Allowing banks to go below the liquidity requirement during a crisis can reduce banks' incentive for liquidity hoarding ex-ante as well as ex-post, thus reducing also another negative externality represented by interbank market freeze.

By alleviating bank liquidity hoarding and the frictions that can lead to asset fire sale, a countercyclical liquidity buffer may help increasing the effectiveness of monetary policy and of macroprudential policies addressing the credit cycle. In fact, as discussed in Berrospide

(2012), liquidity hoarding by banks may constrain the effectiveness of monetary policy that is aimed at restoring the stability of funding markets. Moreover, the considerable fear associated with the riskiness of banks' portfolios further limits the ability of policy actions to revamp credit growth and stimulate the real economy.

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