Bank liquidity, the maturity ladder, and regulation

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Abstract

We investigate 62 Dutch banks' liquidity behaviour from January 2004 till March 2010, subject to liquidity regulation very similar to Basel III's Liquidity Coverage Ratio (LCR). We find that most banks hold more liquid assets against liquid liabilities than strictly required, so that the adoption of the LCR would not have to lead to significant adjustments. More solvent banks hold less liquid assets against their stock of liquid liabilities, suggesting an interaction between capital and liquidity buffers. Most banks do not adjust their liquid assets to cash flows scheduled beyond one year, implying that the Net Stable Funding Ratio (NSFR) would be binding.

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1. Introduction

The crisis that plagues the financial system since 2007 is in essence a banking liquidity crisis (Banque de France, 2008). Wholesale funding has almost completely dried up, in particular long-term funding, leading to an increase of the maturity mismatch on banks' balance sheets. Banks responded to this by hoarding high-quality assets as a buffer against the risk of maturity mismatch and rollover risk of short-term interbank borrowing (Acharya, 2011).

To foster the self-insurance capacity of banks, regulators under Basel III have proposed the Liquidity Coverage Ratio (LCR). The LCR prescribes that banks hold a sufficient level of high-quality assets against the expected net outflow of liquidity. More specifically, a sufficient level of liquid assets should be able to ensure that banks can survive an acute stress scenario lasting for one month (BCBS, 2009).

If accepted, it is foreseen that Basel III's LCR proposal will be implemented in 2015. As of yet, there is little empirical evidence on how banks have responded or will respond to such a LCR requirement. This raises the question how the LCR relates to existing national supervisory liquidity rules, if any, and how the LCR relates to banks' actual liquidity behaviour? The influence of liquidity regulation on bank behaviour may have wider consequences for the financial sector, financial markets and the real economy. Also from that perspective, insight into the interaction between liquidity regulation and bank behaviour is useful.

This paper contributes to the understanding how banks will react to the LCR by investigating banks' actual liquidity behaviour under a framework which resembles the Basel III proposal: the quantitative liquidity requirement as it is in operation in the Netherlands since 2003. In the Dutch supervisory liquidity system, a bank's actual liquidity must exceed required liquidity, at horizons of both one week and one month. Actual liquidity is defined as the stock of liquid assets minus haircuts plus recognised cash inflows weighted by degree of liquidity. Required liquidity is defined as the assumed calls on contingent liquidity lines, assumed withdrawals of deposits, assumed drying up of wholesale funding and derivative funding. The Dutch liquidity requirement, the so-called Liquidity Balance (LB), conceptually resembles Basle III's LCR.

We examine banks' liquidity management under the Dutch regulatory LB rule. Our sample is 62 Dutch banks and our sample period is January 2004 to March 2010. The paper is structured as follows. First, we discuss liquidity regulation as it is operative since 2003 in the Netherlands and compare the Dutch system with the proposed system under Basel III. Next, we present a model of banks' liquidity behaviour, according to which banks hold liquid assets as a buffer against maturity mismatch risk. After discussing the data, we estimate this model and subsequently examine how the empirical model relates to regulation, both Dutch regulation and international regulation as proposed by Basel III. Then, we examine whether liquidity behaviour was different before and after the crisis. Finally, we test how bank characteristics affect liquidity management, after which we conclude.

2. Short literature review

Maturity mismatches are inherent to banks, owing to the transformation of liquid liabilities (e.g. deposits) into illiquid assets (e.g. long-term loans). This gives rise to liquidity risks, as shown by Diamond and Dybvig (1983). Rajan and Bird (2003) show that maturity transformation is inherent to banks and does not depend on implicit safety nets.

Empirically, Aspachs et al. (2005) analyse 57 UK banks' liquidity policy over the period 1985Q1 to 2003Q4 and find that the greater the potential support from the central bank in case of liquidity crises, the lower the liquidity buffer the banks hold. Van Lelyveld and Zymek (2009), using balance sheet data of 7,000 banks from 30 OECD countries in 1998-2007, explain a quarter of the observed variation in liquid reserves by (a dummy variable for) the presence of regulatory liquidity requirements, the extent of deposit insurance, disclosure practices and banking sector concentration.

Our contribution is to empirically estimate a model relating liquid asset holdings by banks to their stock of liquid liabilities and the full maturity ladder of future cash flows, ranging from one month to beyond one year. We confront the estimated empirical relationship with the relationship implied by Dutch and international liquidity rules. Further, we examine the effects of the crisis and bank characteristics on liquidity behaviour.

3. Liquidity regulation

3.1 Dutch regulation

In 2003, the Dutch banking regulator introduced a new quantitative liquidity supervisory system. According to this regulation, banks should have a so-called liquidity balance greater than zero at all times. The liquidity balance is defined for both a one-week and a one-month horizon. For the one month horizon the liquidity balance, LB, is defined as:

$$LB = \frac{Available\ liquidity - Required\ liquidity}{Required\ liquidity} \qquad \text{(R1)}$$

Where:

Available liquidity = Available stock of high-quality liquid assets + Cash inflow scheduled within the coming month (R1a)

And

Required liquidity = Stock of liquid liabilities + Cash outflow scheduled within the coming month (R1b)

Hence, neglecting the denominator of (R1), we can write for LB:

LB = Available stock of high-quality liquid assets - Stock of liquid liabilities + Cash inflow scheduled within the coming month - Cash outflow scheduled within the coming month (R1c)

High-quality liquid assets are assets that can be turned into cash on short notice, such as liquid bonds. Liquid liabilities are debts that can be called upon immediately, such as demand deposits without a fixed term. Cash inflows are receipts of payments due within 1 month, for example one month reverse repo transactions. Cash outflows scheduled within the coming month are payments that are due within one month, for example one-month time deposits.

Liquidity regulation takes into account both market and funding liquidity risks, by applying so-called regulatory haircuts or weights on assets, liabilities, cash inflows and outflows. Liquid assets and cash inflows get haircuts reflecting their liquidity in times of stress. In this way, the regulator accounts for the risk that in case of financial stress, market liquidity may be so low that liquid assets can not be sold immediately or only at a loss. Liquid liabilities and cash outflows are also weighted to reflect the probability of withdrawal. In this way the regulator accounts for differences in funding liquidity risk between, for example, retail deposits and wholesale deposits. The haircuts and weights are dictated by the regulator and have not been altered during the sample period. The regulatory weights are given in Appendix B.[1] The banks thus know their liquidity position according to the regulatory requirements.

LB according to (R1c) can be written as a function of liquid assets, liabilities, cash flows and regulatory weights:

$$LB_{it} = \sum_j a_j \cdot ASSET_{ijt} - \sum_k b_k \cdot LIAB_{ikt} + \sum_l c_l^{M=1} \cdot INFLOW_{ilt}^{M=1} - \sum_m d_m^{M=1} \cdot OUTFLOW_{imt}^{M=1} \quad \text{(R2)}$$

$ASSET_{ijt}$ denotes j liquid asset items and $LIAB_{ikt}$ k liquid liability items for bank i at time t. Both are stock items without an agreed payment schedule. $INFLOW_{ilt}^{M=1}$ denotes l cash inflow items with maturities within one month and $OUTFLOW_{imt}^{M=1}$ m cash outflow items with maturities within one month. Both are payments scheduled to take place in the future, in this case within the coming month. $a_j, b_k, c_l^{M=1}, d_m^{M=1}$ are the respective regulatory weights.

The regulator requires the banks to have a liquidity surplus at all times:

$$LB_{it} \geq 0 \quad \text{(R3)}$$

Combining equations (R2) and (R3), and rearranging, we get the following expression for liquid assets:

$$\sum_j a_j \cdot ASSET_{ijt} \geq \sum_k b_k \cdot LIAB_{ikt} - \sum_l c_l^{M=1} \cdot INFLOW_{ilt}^{M=1} + \sum_m d_m^{M=1} \cdot OUTFLOW_{imt}^{M=1} \quad \text{(R4)}$$

[1] See, e.g., Van de End and Tabbae (2011) for background information on these weights.

Summing up over all *j* assets, *k* liabilities, *l* cash inflows and *m* cash outflows, we get:

$$a_{it} \cdot A_{it} \geq b_{it} \cdot L_{it} - c_{it}^{M=1} \cdot I_{it}^{M=1} + d_{it}^{M=1} \cdot O_{it}^{M=1} \qquad \text{(R5)}$$

where

$$a_{it} = \frac{\sum_j a_j \cdot ASSET_{ijt}}{\sum_j ASSET_{ijt}},\ b_{it} = \frac{\sum_k b_k \cdot LIAB_{ikt}}{\sum_k LIAB_{ikt}},\ c_{it}^{M=1} = \frac{\sum_l c_l^{M=1} \cdot INFLOW_{ilt}^{M=1}}{\sum_l INFLOW_{ilt}^{M=1}},\ d_{it}^{M=1} = \frac{\sum_j d_m^{M=1} \cdot OUTFLOW_{imt}^{M=1}}{\sum_m OUTFLOW_{imt}^{M=1}},$$

$$A_{it} = \sum_j ASSET_{ijt},\ L_{it} = \sum_k LIAB_{ikt},\ I_{it} = \sum_l INFLOW_{ilt}^{M=1},\ O_{it} = \sum_m OUTFLOW_{imt}^{M=1}.$$

Note that coefficients $a_{it}, b_{it}, c_{it}^{M=1}, d_{it}^{M=1}$ are weighted averages of the respective regulatory weights $a_j, b_k, c_l^{M=1}, d_m^{M=1}$, with the relative shares of the different balance sheet and cash flow items as weights. Therefore, as the composition of balance sheet and cash flows may differ between banks and change over time, these coefficients $a_j, b_k, c_l^{M=1}, d_m^{M=1}$ vary over time *t* and across banks *i* as well.

Dividing (R5) by a_{it} yields:

$$A_{it} \geq \frac{b_{it} \cdot L_{it} - c_{it}^{M=1} \cdot I_{it}^{M=1} + d_{it}^{M=1} \cdot O_{it}^{M=1}}{a_{it}} \qquad \text{(R6)}$$

Equation (R6) implies that the minimum required holdings of liquid assets are:

$$A_{it}^R = \beta_{it} L_{it} + \lambda_{it}^{M=1} I_{it}^{M=1} + \mu_{it}^{M=1} O_{it}^{M=1} \qquad \text{(R7)}$$

where

$$\beta_{it} = \frac{b_{it}}{a_{it}}, \lambda_{it}^{M=1} = \frac{c_{it}^{M=1}}{a_{it}},\ \mu_{it}^{M=1} = \frac{d_{it}^{M=1}}{a_{it}}$$

(R7) gives the minimum required liquid asset holdings A_{it}^{R} of bank *i* at time *t*, given the size and composition of liquid liabilities, cash inflows and outflows up to one month, and given the regulatory weights. Coefficients $\beta_{it}, \lambda_{it}^{M=1}, \mu_{it}^{M=1}$ are hypothetical, or theoretical, in that they relate liquid liabilities, cash inflows and cash outflows to the stock of liquid assets under the assumption that banks precisely hold the *minimum required* levels of stock liquid assets at all times; no more, no less. In the remainder of this paper we will denote them as 'regulatory coefficients'.

3.2 Basel III

Basel III has proposed two ratios for monitoring bank liquidity: the Liquidity Coverage Ratio (LCR) and the Net Stable Funding Ratio (NSFR). The LCR is defined as:

$$LCR = \frac{Stock\ of\ \ high\text{-}quality\ liquid\ \ assets}{Net\ \ cash\ outflows\ scheduled\ \ within\ 1\ month} \tag{R8}$$

LCR is very similar to LB. Both consider a horizon of one month for the cash flows. Like the LB, regulatory weighting is applied, but the weights may have different values since they are formulated by a different regulator. In particular, the composition of the stock of high-quality liquid assets is defined more narrowly for the LCR than for the LB (compare the tables in Annex B). Using the same notation as for LB, LCR can be written as:

$$LCR_{it} = \frac{\sum_{j} e_j \cdot ASSET_{ijt}}{\sum_{k} f_k \cdot LIAB_{ikt} - \sum_{m} g_l^{M=1} \cdot INFLOW_{ilt}^{M=1} + \sum_{m} h_m^{M=1} \cdot OUTFLOW_{imt}^{M=1}} \tag{R9}$$

As mentioned in Section 3.1, $LIAB_{ikt}$ are stock items without an agreed payment schedule, for instance demand deposits. By applying assumed run-off rates f_k to such items they are *de facto* transformed into cash outflows. The regulator requires the banks to have an LCR greater than 1 at all times:

$$LCR_{it} \geq 1 \tag{R10}$$

Combining equations (R9) and (R10) and rearranging, we get the following expression for liquid assets:

$$\sum_j e_j \cdot ASSET_{ijt} \geq \sum_k f_k \cdot LIAB_{ikt} - \sum_l g_l^{M=1} \cdot INFLOW_{ilt}^{M=1} + \sum_m h_m^{M=1} \cdot OUTFLOW_{imt}^{M=1} \qquad \text{(R11)}$$

Note that (R11) is very similar to (R4), except for the regulatory weights. These may differ from the weights used by the Dutch regulator for LB. This implies that (R11) can also be rewritten in terms of the *minimum required* holdings of liquid assets, as we did in (R7):[2]

$$A_{it}^R = \beta_{it} L_{it} + \lambda_{it}^{M=1} I_{it}^{M=1} + \mu_{it}^{M=1} O_{it}^{M=1} \qquad \text{(R12)}$$

The second liquidity indicator of Basel III, the Net Stable Funding Ratio (NSFR), is defined as:

$$NSFR = \frac{Available\ amount\ of\ \ stable\ funding}{Required\ \ amount\ of\ \ stable\ funding} \qquad \text{(R13)}$$

This ratio is the proportion of *long-term* assets which are funded by *long term*, stable funding. NSFR is different from both LB and LCR in that it focuses on the long term. Cash flows shorter than one month are not considered. Therefore, in the remainder of this study, we will focus on LB and LCR.

4. Model

Maturity transformation is risky, because it implies a maturity mismatch between the assets and the liabilities on the bank's balance sheet. This is the reason for a bank to hold a buffer stock of liquidity, i.e. high quality assets which can be sold or pledged immediately or at short notice. This is also the reason for a regulator to prescribe minimum liquidity holdings to banks under supervision. The regulatory buffer requirements may be greater since the social

[2] For ease of notation, we do not differentiate the parameters between (R7) and (R12), although these may differ due to differences in regulatory weights.

optimum for bank liquidity usually lies higher than the private optimum (Acharya et al., 2009), as banks' liquidity buffers may prevent a systemic crisis or mitigate its effects on the real economy.

In principle, the capacity for maturity transformation is greater when a bank holds a larger stock of liquid assets, since the funding risk can be met by selling or pledging these assets. As Goodhart (2008, p. 43) states: "There is a trade of between stock liquidity and maturity transformation. What, perhaps, we need is a menu of relationships between stock liquidity and maturity transformation, such as if maturity transformation is measured from 0 (no transformation) to infinite, and stock liquidity is measured as a percentage of assets (…)". He illustrates this with Table 1.

[insert Table 1 about here]

However, Goodhart (*op. cit.*) notes that there is an immediate problem with Table 1: "this assumes that there is a single accepted scale of measurement, whether cardinal or ordinal, for both maturity transformation and stock liquidity, and this is not so." He mentions that one way to look at maturity transformation is by means of maturity ladders, where one looks at the net liquidity positions of banks over differing horizons (see his Table 2). He also sees some problems with this, though. To name one (Goodhart, *op. cit.*): "What does one do about retail deposits, demandable on sight but normally the most stable and reliable of all liabilities"?

[insert Table 2 about here]

Yet, in the real world, banks do link their stock of liquid assets to maturity ladders. According to a survey conducted by the ECB (2002, pp 23-24), "some banks tie their cash flow limits to their stock of liquid assets, for example by imposing a minimum ratio between the two elements. Volume limits for individual maturity buckets are often interrelated: lower for short-term maturities and higher for long-term maturities." This approach is also discussed among several accepted bank liquidity management techniques by Van Greuning and Brajovic Bratanovic (2000, p. 167): "Liquid assets actually held can then be compared to the local currency value of the short-term mismatch in order to assess how much of the latter is in fact covered by a buffer stock of high-quality liquid assets."

Following the above line of reasoning, we postulate the following benchmark model for the *actual* liquid asset holdings by banks:

$$A_{it} = \beta_i L_{it} + \sum_{s=1}^{5} \delta_i^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \alpha_i \qquad \text{(M1)}$$

where suffix *i* denotes the bank, *t* the time period. A_{it} is the stock of liquid assets, L_{it} the stock of liquid liabilities, $I_{it}^{M=s}$ the future cash inflow with maturity *s*, and $O_{it}^{M=s}$ the future cash outflow with maturity s. Hence, $(I_{it}^{M=s} - O_{it}^{M=s})$ stands for future *net* cash flow with maturity *s*. Maturity *s* has the following values: 1: less than one month, 2: between one month and three months, 3: between three and six months, 4: between six and twelve months, and 5: longer than one year. $\alpha_i, \beta_i, \delta_i^{M=s}$ are bank-specific parameters. α_i is a bank-specific intercept. Because we expect a bank to be willing to hold more liquid assets the more obligations it has, we assume $\beta_i \geq 0$, $\delta_i^{M=s} \leq 0$. As banks' liquidity management may diverge between banks or bank groups, all parameters have a suffix *i*.

We also postulate an alternative specification, where net cash flow up to one month ($M = 1$) is split into cash inflow and cash outflow. The reason to do this is that, as we have seen in Section 3.1, both Dutch and Basel III's liquidity regulation weigh future expected cash inflows and outflows (with a maturities within one month) separately. Hence, we write:

$$A_{it} = \beta_i L_{it} + \lambda_i^{M=1} I_{it}^{M=1} + \mu_i^{M=1} O_{it}^{M=1} + \sum_{s=2}^{5} \delta_i^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \alpha_i \qquad \text{(M2)}$$

where $\lambda_i^{M=1} \leq 0, \mu_i^{M=1} \geq 0$

5. Data

We use monthly consolidated data on liquid assets, liabilities, cash inflows and outflows of Dutch banks over the period January 2004 to March 2010. This period encompasses both the

pre-crisis and the crisis period. Our variables of interest are summed up and defined in Appendix A. All balance sheet variables have been scaled by total assets.

The data source is De Nederlandsche Bank's (DNB) prudential liquidity report (DNB, 2003). This data source contains end-of-month data on liquid assets, liabilities and cash flows for all Dutch banks (including branches and foreign branches) under supervision, with a detailed break-down per balance sheet item. These data are unique for two reasons. One, there is information on the maturities of the expected cash inflows and outflows in case there is an underlying payment schedule. The maturity buckets are as defined in Section 4: 1) less than one month, 2) between one month and three months, 3) between three and six months, 4) between six and twelve months, and 5) longer than one year. Second, there is detailed information on the regulatory weights of all asset, liability and cash flow items.

Not every item is reported by all banks, since some banks do not have exposures in all categories. Also, the data is very unbalanced. For that reason we use data of 62 banks out of a total of 107, for which data is available for the whole sample period.

Figure 1 shows, for the aggregate of our sample, the stocks of liquid assets and liabilities, together with the expected future net cash flows of different maturities. The top panel shows the stocks of liquid assets and liabilities. The stock of liquid assets comprises mostly bonds eligible as collateral at the central bank. The stock of liquid liabilities comprises mostly (retail and wholesale) demand deposits without a fixed term. This is the balance sheet item Goodhart (2008) did not know how to deal with (see above). As it is demandable on sight and has no fixed maturity, it consequently can not be categorized into one of the maturity buckets. Therefore, we consider it to be stock liquidity on the liability side. An option could be to subtract the stock of liquid liabilities from the stock of liquid assets, so that a sort of 'net stock liquidity position' is obtained. However, we prefer to consider the stocks of liquidity assets and liabilities separately in our analysis, as this is also done by the regulator.

[insert Fig. 1 about here]

The bottom panel of Figure 1 shows the maturity ladder, i.e. the expected future net cash flow positions for different maturities. Net cash flows for maturities until one year are mostly negative (however, note that this is for the aggregate), while the maturity bucket beyond one

year is positive. This asymmetric distribution over short-term and long-term maturity buckets reflects the earlier mentioned banks' business model of maturity transformation (funding short-term, lending long-term). Negative mismatches appear to be greatest for maturities until one week and between one and three months.

Figure 2 shows the LB, aggregated for the population of Dutch banks. Following the practice of the Dutch regulator, it is expressed as a ratio of required liquidity. For the aggregate, there was a surplus during the whole sample period. The surplus declined during 2004-2007 from 0.15 to 0.06 after which it increased sharply during 2008-2009, levelling off around the end of 2009 and the beginning of 2010.

[insert Fig. 2 about here]

The change in LB can be decomposed into four components:

Change in liquidity balance = Change in stock volume + Change in stock composition + Change in flow volume + Change in flow composition (D1)

Figure 3 shows this decomposition.[3] The strong increase of LB during 2008-2009 appears to be achieved primarily by the change in flow volume and secondary by the change in stock volume. These two components of the change in LB to a large extent reflect liquidity hoarding and a cut in wholesale lending (De Haan and Van den End, 2011).

[insert Figure 3 about here]

Figure 4 shows the Dutch regulatory *minimum required* liquid assets holdings, A^R, aggregated for our sample of Dutch banks, and scaled by total assets. This ratio has been calculated using equation (R7). We also include *actual* liquidity holdings into this figure, which is identical to the series depicted in the top panel of Figure 1. The difference between the minimum required and actual liquidity holdings is also shown in the figure.[4] It shows how it is possible that

[3] The four components (within brackets) have been calculated according to the following identity, using the notation as in (R5):
$[a_{it-1} \cdot \Delta A_{it} - b_{it-1} \cdot \Delta L_{it}] + [\Delta a_{it} \cdot A_{it-1} - \Delta b_{it} \cdot L_{it-1}] + [c_{it-1}^{M=1} \cdot \Delta I_{it}^{M=1} + d_{it-1}^{M=1} \cdot \Delta O_{it}^{M=1}] + [\Delta c_{it}^{M=1} \cdot I_{it-1}^{M=1} + \Delta d_{it}^{M=1} \cdot O_{it-1}^{M=1}]$

[4] Its shape is similar to but different from that of the liquidity balance as shown in Figure 2. Their difference in shape has two reasons: (1) Scaling: Fig. 2 shows ratios of required liquidity, while Fig. 4 shows ratios of total

banks managed to fulfil the regulatory liquidity requirements during the crisis that hit in the fall of 2007. *Actual* liquidity dropped during the first part of the crisis (August 2007 – February 2009), but recovered after that. *Required* stock liquidity also dropped during the first part of the crisis, but even more quickly than actual stock liquidity, and moreover stayed on this lower level thereafter. As a result, the difference between actual and required liquidity improved during the crisis. The sharp decrease in required stock liquidity was mostly obtained by a cut in wholesale lending and a flight into more liquid assets (De Haan and Van den End, 2011).

[insert Figure 4 about here]

Figure 5 shows approximations of the LCR and the NSFR for the aggregate of our sample of Dutch banks. Because the Dutch regulatory despatches are not yet fully compatible with Basel III, the mapping of the Dutch data is not perfect. Therefore, the figure must be interpreted with reservation. This especially holds for LCR, which is below 1 during the whole sample period. This is due to the fact that some items, such as covered bonds, being part of liquid assets in LCR, are not specified separately in the Dutch liquidity report. Nevertheless, aggregate LCR for our sample declined from 0.8 in 2004 to 0.4 at the end of 2007, after which it recovered to 0.7 beginning of 2010. Aggregate NSFR was greater than 1 during the whole sample period, but very close to 1 at the end of 2007.

[insert Fig. 5 about here]

Our sample of 62 banks consists of four types of banks. First, there is the 'top-5' group consisting of the five largest Dutch banks: ABN Amro, ING, Fortis, Rabo and SNS.[5] These five banks make out 85% of the Dutch banking sector's total assets. The second is 19 'other Dutch banks', comprising a diverse group of medium-sized institutions. The third is 19 'foreign subsidiaries', and the fourth 19 'foreign branches. Panel A of Table 3 presents medians and standard deviations for the variables used in models (M1) and (M2). Median stocks of liquid assets are of similar magnitude for the different bank types: around 0.2 to 0.3 of total assets. Median stocks of liquid liabilities are around 0.4 for all banks except other

assets; (2) Regulatory weighting of assets: Fig. 2 is after regulatory weighting, Fig. 4 before regulatory weighting.

[5] In 2008, Fortis was merged into ABN Amro and ceased to exist as a separate bank.

Dutch banks (0.3). Standard deviations are relatively large for both liquid assets and liabilities. Median cash inflow and outflow scheduled within the coming month are larger for the top-5 banks than for the other Dutch banks. Median net cash flows for maturities beyond one month are around zero, except for the maturity beyond one year which is positive especially for the top-5 banks and the other Dutch banks.

[insert Table 3 about here]

6. Estimation results

In this Section we estimate the models presented in Section 4. The empirical specifications of (M1) and (M2) are, respectively:

$$A_{it} = \beta L_{it} + \sum_{s=1}^{5} \delta^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \alpha_i + \tau_t + \varepsilon_{it} \qquad \text{(E1)}$$

$$A_{it} = \beta L_{it} + \lambda^{M=1} I_{it}^{M=1} + \mu^{M=1} O_{it}^{M=1} + \sum_{s=2}^{5} \delta^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \alpha_i + \tau_t + \varepsilon_{it} \qquad \text{(E2)}$$

where α_i are fixed bank effects, τ_t time effects and ε_{it} residuals, which we allow to be clustered. The inclusion of both bank and time effects make (E1) and (E2) so-called two-way fixed effects panel models. The inclusion of fixed bank effects α_i implies the use of the so-called within estimator, which only considers the time variation *within* banks and disregards all time-invariant variation *between* banks.

There are two econometric issues. One issue is whether there is an endogeneity problem. This problem may arise when the independent variables are not exogenous but endogenous. In econometric terms, this problem would cause the independent variables to be correlated with the error term and lead to a bias in the estimated coefficients. There are economic arguments suggesting that our independent variables are exogenous. The stock of liquid liabilities consists mostly of retail demand deposits, which are notoriously sluggish and cannot easily be manipulated by the bank in the short term. The future cash inflows and outflows scheduled

within the coming month are contractually fixed obligations with the bank's debtors and creditors, respectively, and as such cannot be easily breached by the bank. The same holds for the future net cash flows scheduled beyond one month. Hence, our independent variables seem to be exogenous to the bank, in contrast to the dependent variable, the stock of liquid assets, which consists mostly of liquid bonds and as such is easily adjustable by the bank itself by purchase or sale on the market.

Still, we did two robustness checks with respect to the endogeneity problem. First, we experimented with lagging the independent variables one period, to mitigate the problem of simultaneity. The results showed that the coefficient for liquid liabilities is robust for lagging, but that the coefficients for the 1 month-cash flows are not. However, lagging future cash flows scheduled within the coming month by one period (month) implies the assumption that cash flows scheduled for the past month are relevant for the decision on liquid asset holdings today. This does not seem realistic. Therefore, we prefer the model without lags. Second, we ran an instrumental variables regression, instrumenting the 1-month cash inflow and outflow by their lagged values plus all other model variables. The magnitudes of the coefficient estimates remained more or less the same, indicating that the original estimates do not suffer from simultaneity bias.

The other potential issue is multicollinearity, i.e. high correlation between independent variables. The correlation between the stock of liquid liabilities on the one hand and the cash flow variables on the other is low (around 0.3). However, there is high correlation between the cash inflow and cash outflow within one month (around 0.9). An explanation for this is that banks try to match those cash flows, being by far the largest in gross terms, as part of their liquidity management and in order to meet the LB requirement. Therefore, as a robustness check, we also estimate (E1), where *net* cash flow for one month is included instead of *gross* cash inflow and outflow (1-month net cash flow has a low correlation with net cash flows beyond one month). This way, we can check whether the coefficients of the stock of liquid liabilities and net cash flows beyond one month are robust to the separate inclusion of the correlated 1-month cash inflow and outflow.

In the empirical equations (E1) and (E2), all coefficients are assumed to be equal across banks. However, as mentioned in Section 4, liquidity management may differ between banks or bank groups. Therefore, we will proceed in two steps. First, we will estimate the models

using the standard assumption of equal coefficients across all banks. Second, we will estimate the models for the different bank groups to be distinguished by bank type and bank characteristics.

Table 4 presents the estimation results for (E1) and (E2), respectively. These models explain the within variation of stock liquid asset holdings well, according to the within-R^2 of around 0.79 and 0.84 for the whole sample. The model fit is best for other Dutch banks (0.99) and weakest for foreign affiliations (0.55). Many coefficients are significant and when they are, have the expected signs. The coefficients of liquid liabilities and net cash flows for maturities longer than one month turn out to be robust to the inclusion of gross cash inflow and outflow within one month (E2) instead of net cash flow within one month (E1). Therefore, in the remainder of this paper, we focus on (E2), because this relates more closely to regulation which also looks at gross cash flows within one month.

[insert Table 4 about here]

For the whole sample, none of the coefficients for net cash inflows beyond one month are statistically different from zero at conventional significance levels. However, several maturities longer than one month are significant for several banks types. The top-5 banks seem to manage their stock liquidity with an eye on maturities between 3 and 12 months. Other Dutch banks seem to look at maturities between 3 and 6 months and beyond one year. For foreign subsidiaries maturities between 1 and 3 and beyond 6 months are significant. For foreign branches it is the maturity between 6 and 12 months. Hence, only the other Dutch banks and foreign subsidiaries seem to look further than one year ahead. We note that for both bank types the standard deviation of net cash inflow beyond one year happens to be relatively high (Table 3), so that this result may be driven by outliers. We conclude that our findings are consistent with a survey finding of ECB (2002), that banks seldom look further ahead than one year for liquidity management purposes.[6]

From these results we draw two main conclusions. First, banks tend to adjust their assets by taking into account their short-term future cash flows. This reflects the liquidity channel of

[6] ECB (2002, p. 24): "Operational liquidity management typically focuses on periods from one day to between one and three months. (…) Strategic liquidity management focuses on periods up to one year (…). It is uncommon for banks to look further than one year ahead (…)."

financial transmission through which the funding liquidity position of banks affects bank lending (BIS, 2011). Second, the results suggest that the Net Stable Funding Ratio (NSFR) would be binding since it requires that banks match maturities of assets and liabilities in the longer term.

7. How does liquidity behaviour relate to liquidity regulation?

In this section we investigate how banks' liquidity management relates to bank liquidity regulation, both Dutch and Basel III. To understand how, note the similarity between (R7), or (R12), on the one hand, and (E2) on the other. Regulatory models (R7) and (R12) describe how liquid liabilities and cash flows are weighted using regulatory weights in order to get a measure of the *minimum required* stock of liquid assets according to LB and LCR, respectively. In contrast, (E2) is an *empirical* representation of the relationship between the *actual* stock of liquid assets on the one hand and liquid liabilities and cash flows on the other. (E2) has been fitted to the data in the previous section, and the estimates have been presented in Table 4. In other words, the empirical estimates of the coefficients in (E2) reflect *actual* liquidity behaviour, while the regulatory coefficients in (R7) and (R12) represent hypothetical liquidity behaviour as if banks exactly fulfil the *minimum requirements* at all times.

Using (R7) and (R12) and the actual regulatory weights, we calculate the *regulatory* coefficients for LB and LCR and present these in Table 5, under the headings 'LB' and 'LCR', respectively. In the same table, we include the *empirical* estimates of the coefficients of (E2), which are taken from Table 4. A comparison between the empirical coefficients and the regulatory coefficients may give insight into the way banks' liquidity management deviates from regulatory minimum standards.

[insert Table 5 about here]

Let us first compare the empirical coefficients with the regulatory coefficients based on LB. The LB coefficient for stock liquid liabilities is lower than the empirical one for all banks and all bank types except foreign branches. This means that banks, on average, hold more liquid assets against liquid liabilities than strictly required according to LB. This is especially the case for other Dutch banks and foreign subsidiaries. The LB coefficient of 1-month cash

inflow is, in absolute terms, greater than its empirical counterpart for the top-5 banks and the foreign banks. Regulatory and empirical coefficients are similar for other Dutch banks. This result implies that most banks, on average, do not fully reduce their liquid asset holdings when there is an inflow of cash scheduled within the coming month. This may reflect prudent behaviour, but may also relate to our earlier finding that most banks look further ahead than one month, unlike the liquidity requirement. The LB coefficient for cash outflow scheduled within one month does not deviate much from the empirical counterpart for most banks, except for foreign banks.

Next, we compare the empirical coefficients with the regulatory coefficients based on LCR. While interpreting these coefficients, two things should be kept in mind. First, LCR is not in operation yet. Therefore, the comparison with LCR coefficients is even more hypothetical because banks did not have to meet this rule at the time. The goal of the exercise is to assess whether and how actual liquidity behaviour of Dutch banks deviated from the new Basel III liquidity standard. Second, the mapping of the regulatory weights from LCR on the Dutch regulatory despatches is imperfect, as mentioned in Section 5. Therefore, the LCR coefficients should be interpreted with reservation. With these two caveats in mind, we observe that the empirical coefficient of the stock of liquid liabilities is greater than the LCR coefficient for both top-5 banks and other Dutch banks, which suggests that these types of banks already met the LCR rule in the sample period and that the implementation of the LCR would not lead to significant adjustments of banks' assets. This is not the case for foreign banks, especially foreign branches. The LCR coefficients of 1-month cash inflows and outflows are not statistically different from their empirical counterparts for the top-5 and other Dutch banks, in contrast to those of the foreign banks. The magnitudes of the LCR cash flow coefficients for foreign subsidiaries seem out of line, which may be due to the imperfect mapping of LB despatches to LCR rules. For that reason, we abstain from an economic interpretation of these differences.

Finally, we compare the regulatory coefficients of the LCR with those of the LB. The LCR coefficient of stock liquid liabilities is greater than the LB coefficient. Hence, under the LCR standard, banks have to maintain a greater buffer of liquid assets against their stock of liquid liabilities. This can be explained by the stricter definition in the LCR of the stock of liquid assets that should cover the expected liquidity outflow. For the top-5 banks, this difference is relatively small, though.

8. Liquidity management in the crisis

For Dutch banks, De Haan and Van den End (2011) find that banks reduced wholesale lending, hoarded liquidity and conducted fire sales of equity investments in response to the funding liquidity shock during the crisis of 2007. In this section, we examine how the crisis affected their liquidity management in terms of their stock of liquidity holdings. For this, we re-specify (E2) as follows:

$$A_{it} = \beta_1 L_{it} + \beta_2 L_{it} C_t + \lambda_1^{M=1} I_{it}^{M=1} + \lambda_2^{M=1} I_{it}^{M=1} C_t + \mu_1^{M=1} O_{it}^{M=1} + \mu_2^{M=1} O_{it}^{M=1} C_t + \sum_{s=2}^{5} \delta^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \gamma C_t + \alpha_i + \tau_t + \varepsilon_{it} \quad \text{(E3)}$$

where C_t is a dummy variable 'Crisis', which has value 1 from August 2007 to the end of the sample (March 2010) and 0 before. This dating is based on the sudden rise of CDS and Euribor spreads for Dutch banks since August 2007 (Figure 6).

[insert Figure 6 about here]

Table 6 presents the estimation results. Our interest especially concerns the significance and magnitude of the interaction term coefficients, $\beta_2, \lambda_2, \mu_2$.[7] For all banks and the top-5 banks the coefficient of the stock of liquid liabilities interacted with Crisis, β_2, is -0.149 and -0.139, respectively. For foreign branches it is statistically different from zero but small in economic terms (-0.043). For other Dutch banks and foreign affiliates it is not significant. The estimated coefficients of the cash flows with Crisis, λ_2 and μ_2, are not significant for most banks, except λ_2 for foreign affiliates. Hence, the crisis thus seems to have affected liquidity management for the majority of banks, in particular with regard to the stock of liabilities. Banks hold less liquid assets against the stock of liquid liabilities during the crisis than before.

[insert Table 6 about here]

[7] Coefficient γ is not interesting in itself, for C_t has only been added to facilitate sensible interpretation of the coefficients $\beta_2, \lambda_2, \mu_2$ (Brambor et al, 2006).

9. Liquidity management and bank characteristics

In this Section we examine whether liquidity management depends on bank characteristics, other than bank type. To limit the number of variables characterising banks, we apply factor analysis. From a larger set of variables we selected four variables that are available for all banks in our sample and for the whole sample period. Applying factor analysis on these four variables, we obtained two 'common factors' contributing substantially to the variance of these four variables, and having economically interpretable and significant factor loadings. The first factor has high loadings on retail deposits and retail demand deposits, both scaled by total assets (Table 7). Therefore, we label factor 1 'Retail funding'. The second factor has high loadings on the equity ratio and the Z-score, a measure of distance to default. Hence, we label factor 2 'Safe'. Panel B of Table 3 gives their medians and standard deviations.

[insert Table 7 about here]

Tables 8 and 9 present the estimation results for our model (E2) including interaction terms with the two factor variables, R_t for 'Retail funding', and S_t for 'Safe', respectively:

$$A_{it} = \beta_1 L_{it} + \beta_2 L_{it} R_t + \lambda_1^{M=1} I_{it}^{M=1} + \lambda_2^{M=1} I_{it}^{M=1} R_t + \mu_1^{M=1} O_{it}^{M=1} + \mu_2^{M=1} O_{it}^{M=1} R_t + \sum_{s=2}^{5} \delta^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \gamma R_t + \alpha_i + \tau_t + \varepsilon_{it} \quad \text{(E4)}$$

$$A_{it} = \beta_1 L_{it} + \beta_2 L_{it} S_t + \lambda_1^{M=1} I_{it}^{M=1} + \lambda_2^{M=1} I_{it}^{M=1} S_t + \mu_1^{M=1} O_{it}^{M=1} + \mu_2^{M=1} O_{it}^{M=1} S_t + \sum_{s=2}^{5} \delta^{M=s} (I_{it}^{M=s} - O_{it}^{M=s}) + \gamma S_t + \alpha_i + \tau_t + \varepsilon_{it} \quad \text{(E5)}$$

The interaction terms with 'Retail funding' are not statistically significant at conventional levels (disregarding the puzzling interaction with 1-month cash outflow for the whole sample which is not found in the underlying groups of bank types; Table 8). The interaction with the second factor, 'Safe', yields more significant results (Table 9). The negative sign of the coefficient of stock liquid liabilities interacted with this factor (for all banks: -0.314) suggests that banks that are safer keep less liquid assets as a buffer against the stock of liquid

liabilities. This holds for all bank groups, except the top-5 and the foreign branches where the interaction term is insignificant. On the other hand, safer banks reduce their liquid asset holdings by less against 1-month cash inflows (as implied by the positive sign of the interaction coefficient). This is not significant for foreign branches. The top-5 banks are an exception again: safer banks reduce their liquid assets by more, instead of less, against 1-month cash inflows. Finally, the interaction with 1-month cash outflow is only significant for the top-5 banks and foreign subsidiaries; the interaction term is positive for the top-5 banks while it is negative for the foreign subsidiaries.

[insert Table 8 and 9 about here]

For the purpose of illustration, Figure 7 shows, for the whole sample, the coefficients of liquid liabilities, 1-month cash inflow and 1-month cash outflow by degree of bank safety. As one moves from left to right on the horizontal axis, i.e. from banks with lower degrees of safety towards banks with higher degrees of safety, liquid liabilities have lower positive marginal effects on liquid asset holdings while 1-month cash inflows have less negative marginal effects. On the coefficient of the 1-month cash outflow, safety has no significant influence. From this we conclude that banks that are more 'safe' are less inclined to keep liquidity buffers against their liquid liabilities (possibly because safe banks are less vulnerable to demand deposit run-offs), but are less inclined to reduce their buffers when expected inflows increase (possibly indicating more conservative liquidity management). These results suggest an interaction between capital and liquidity buffers, which should be taken into account by regulators which set both capital and liquidity standards.

[insert Figure 7 about here]

10. Conclusion

This paper examines liquidity management of 62 Dutch banks, subject to the Dutch liquidity supervisory framework, in operation since 2003. The sample period is January 2004 to March 2010. The Dutch quantitative liquidity requirement, the so-called Liquidity Balance (LB), resembles the Liquidity Coverage Ratio (LCR) proposed by Basel III.

We find an empirical relationship between the stock of liquid assets and maturity transformation, measured by a maturity ladder. Banks keep liquid assets, mostly bonds, as a buffer against both the stock of liquid liabilities, mostly demand deposits without a fixed term, and against net cash outflows of different maturities. This relationship is strongest for Dutch banks and weakest for foreign banks, especially foreign branches. We find that only smaller Dutch banks (i.e. excluding the top-5) and foreign subsidiaries manage their liquid assets with an eye on net cash flows beyond one year, which is consistent with the earlier survey finding of ECB (2002) that banks seldom look further ahead than one year for liquidity management purposes. This suggests that the Net Stable Funding Ratio (NSFR) would be binding.

Confronting liquidity behaviour with regulation, we find that banks, on average, hold more liquid assets against liquid liabilities than strictly required according to the Dutch LB. This is especially the case for smaller Dutch banks and foreign subsidiaries. Also banks, on average, do not fully reduce their liquid asset holdings when there is an inflow of cash within the coming month.

For Dutch banks, the empirical coefficient of stock liquid liabilities is greater than the LCR coefficient, which suggests that most of these banks already fulfil Basel III's LCR rule. This is not the case for foreign banks, especially foreign branches. Hence, the evidence suggests that the LCR would not lead to significant asset adjustments by Dutch banks, since they have prepared to the Basel III requirements by meeting domestic regulatory rules. Of course, this could be different for banks in countries where no quantitative liquidity requirements have been in place.

We find that the crisis has negatively affected liquid asset holdings against liquid liabilities, especially for the top-5 banks.

Further, we find that safer banks, in terms of higher capitalization and greater distance to default, hold less liquid assets against their stocks of liquid liabilities. This holds for all banks except foreign branches. These results suggest an interaction between capital and liquidity buffers, which should be taken into account by regulators which set both capital and liquidity standards.

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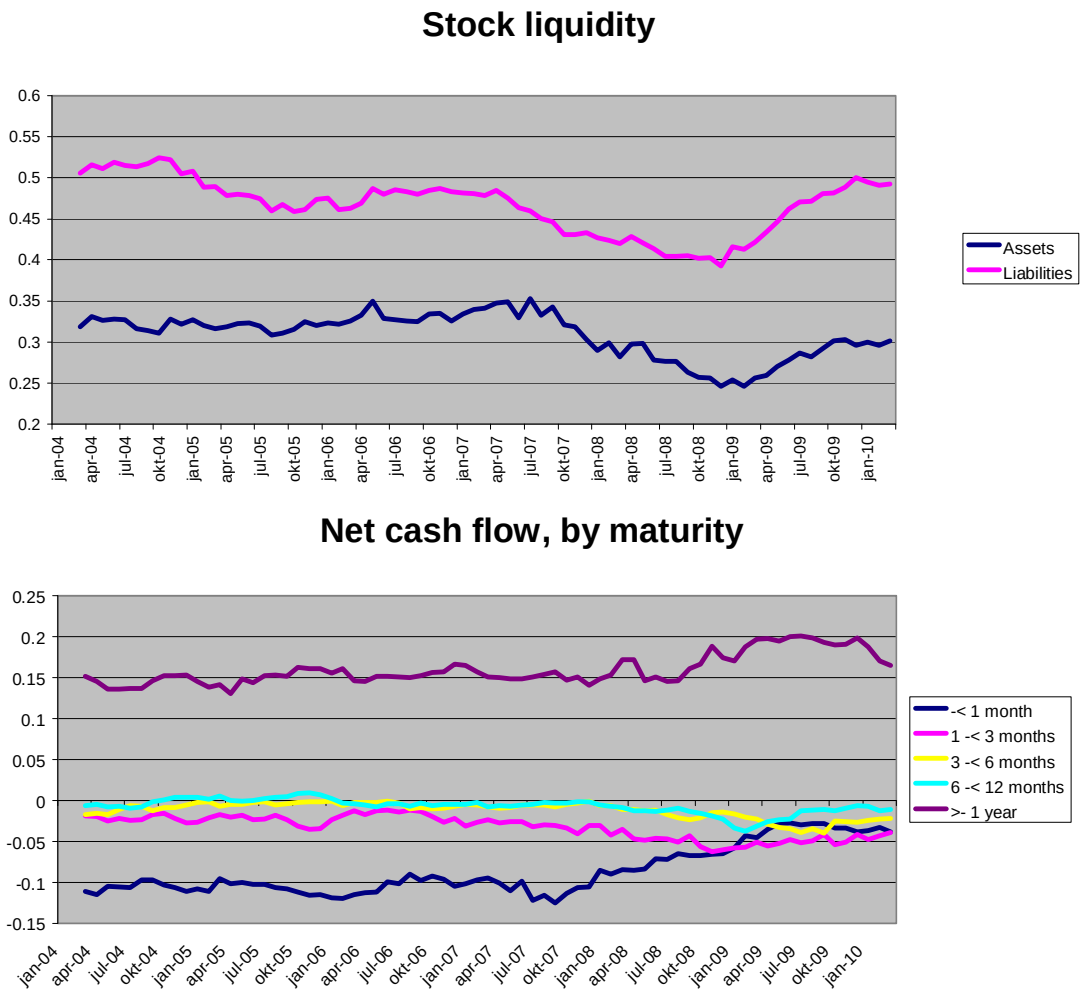
Figures

Fig. 1 - Stock liquidity and net cash flows

(Scaled by total assets)



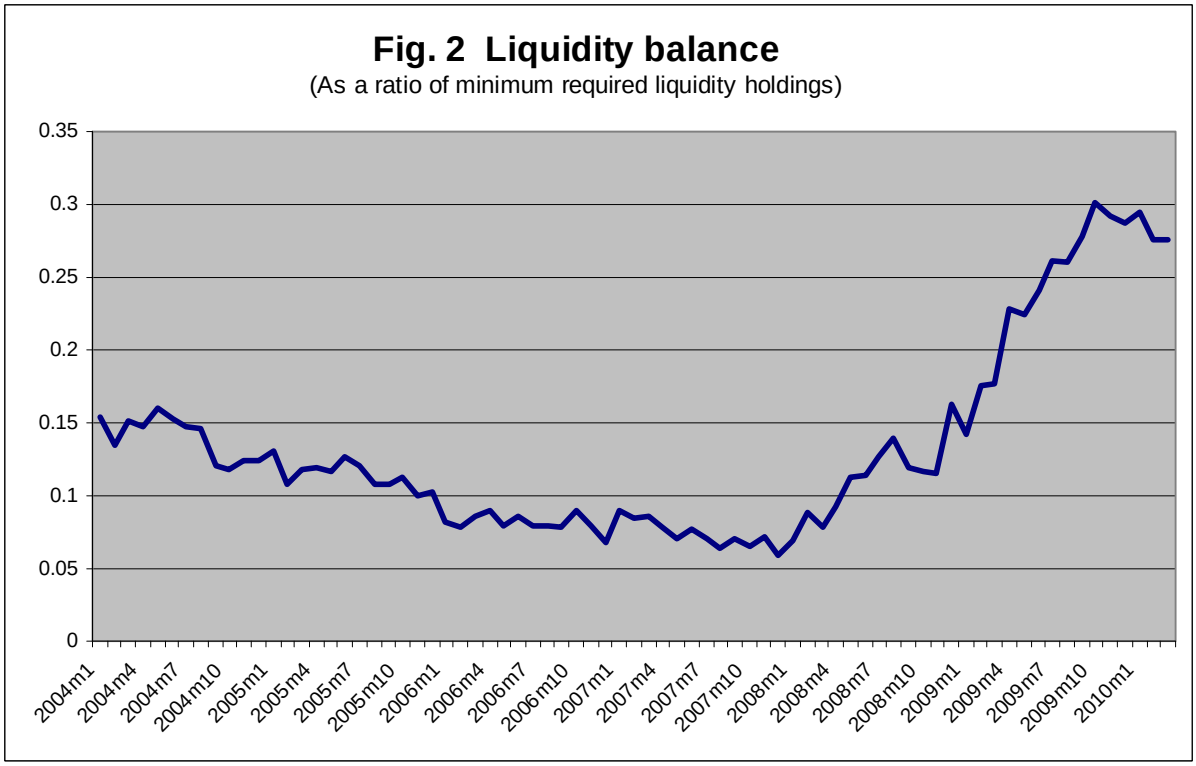
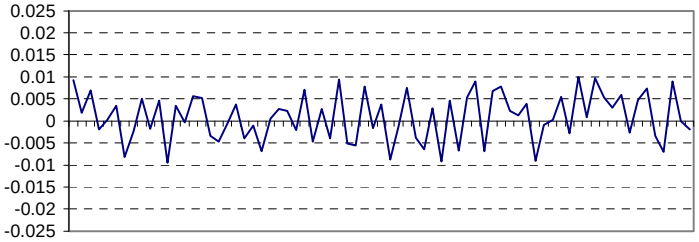


Fig. 2 Liquidity balance
(As a ratio of minimum required liquidity holdings)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2004m1
2004m4
2004m7
2004m10
2005m1
2005m4
2005m7
2005m10
2006m1
2006m4
2006m7
2006m10
2007m1
2007m4
2007m7
2007m10
2008m1
2008m4
2008m7
2008m10
2009m1
2009m4
2009m7
2009m10
2010m1

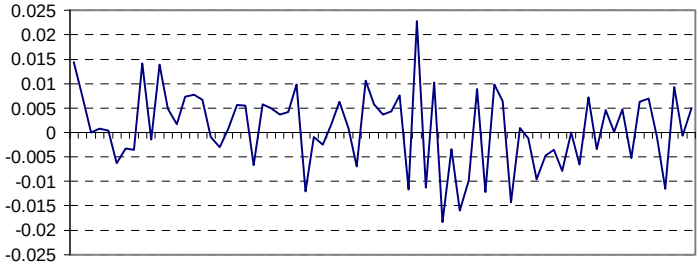
Fig. 3. Decomposition of change in liquidity balance

(Ratio of total assets)

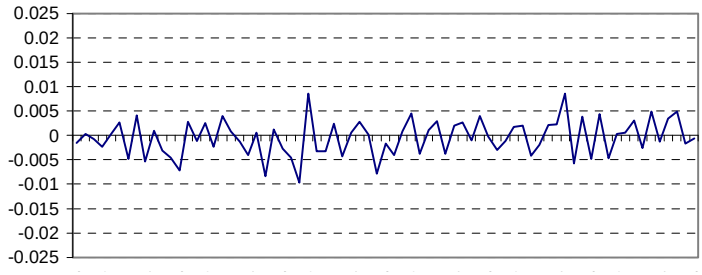
1. Change in liquidity balance
(= 2 + 3 + 4 + 5)



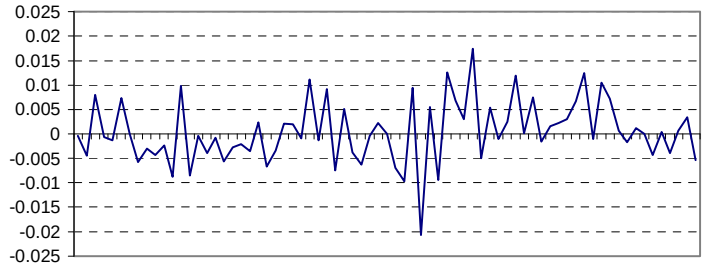
2. Change in stock volume



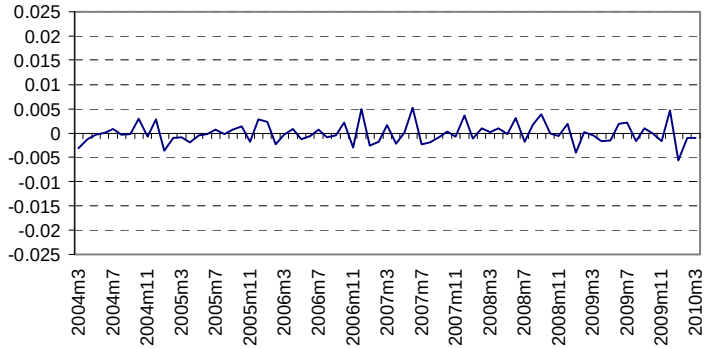
3. Change in stock composition



4. Change in flow volume



5. Change in flow composition



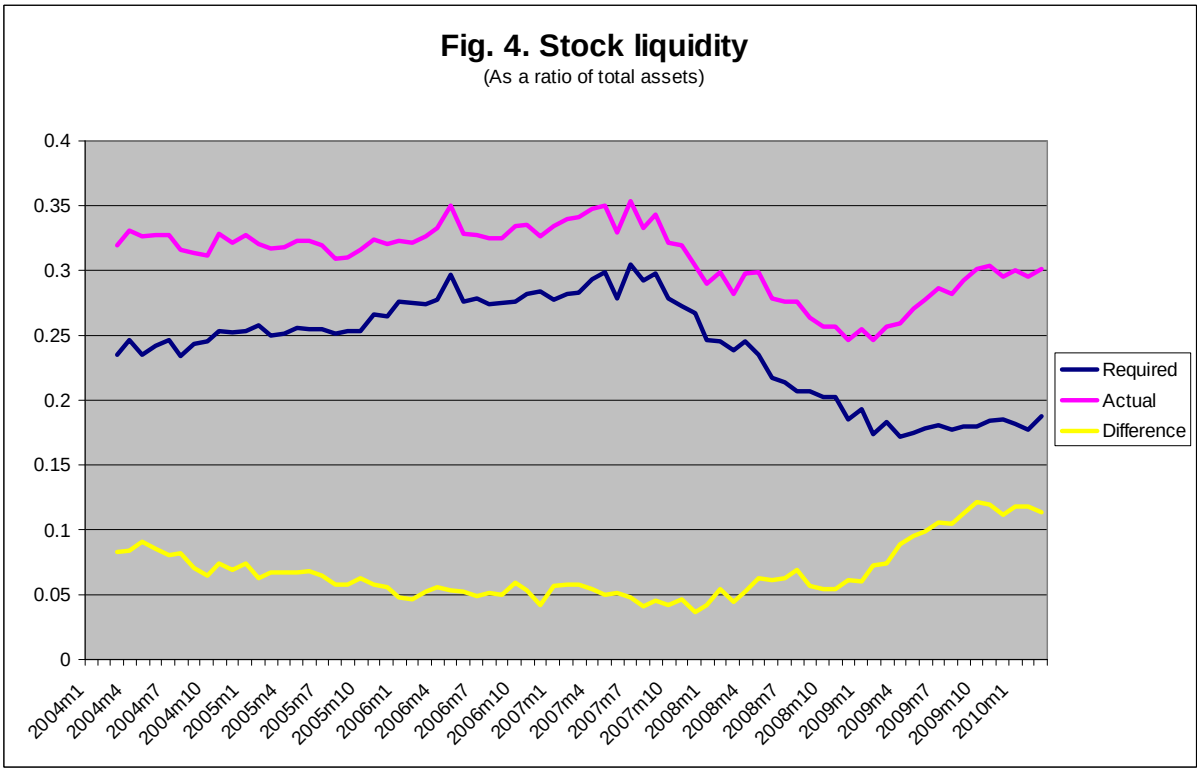
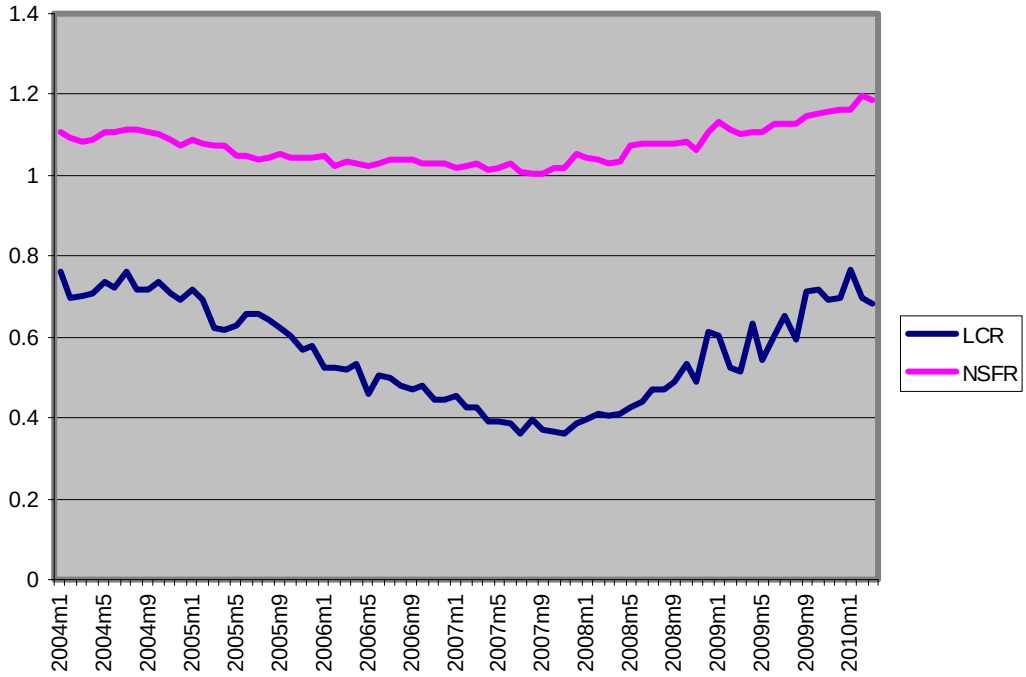


Fig. 4. Stock liquidity
(As a ratio of total assets)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2004m1
2004m4
2004m7
2004m10
2005m1
2005m4
2005m7
2005m10
2006m1
2006m4
2006m7
2006m10
2007m1
2007m4
2007m7
2007m10
2008m1
2008m4
2008m7
2008m10
2009m1
2009m4
2009m7
2009m10
2010m1
Required
Actual
Difference

Fig. 5. Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR)



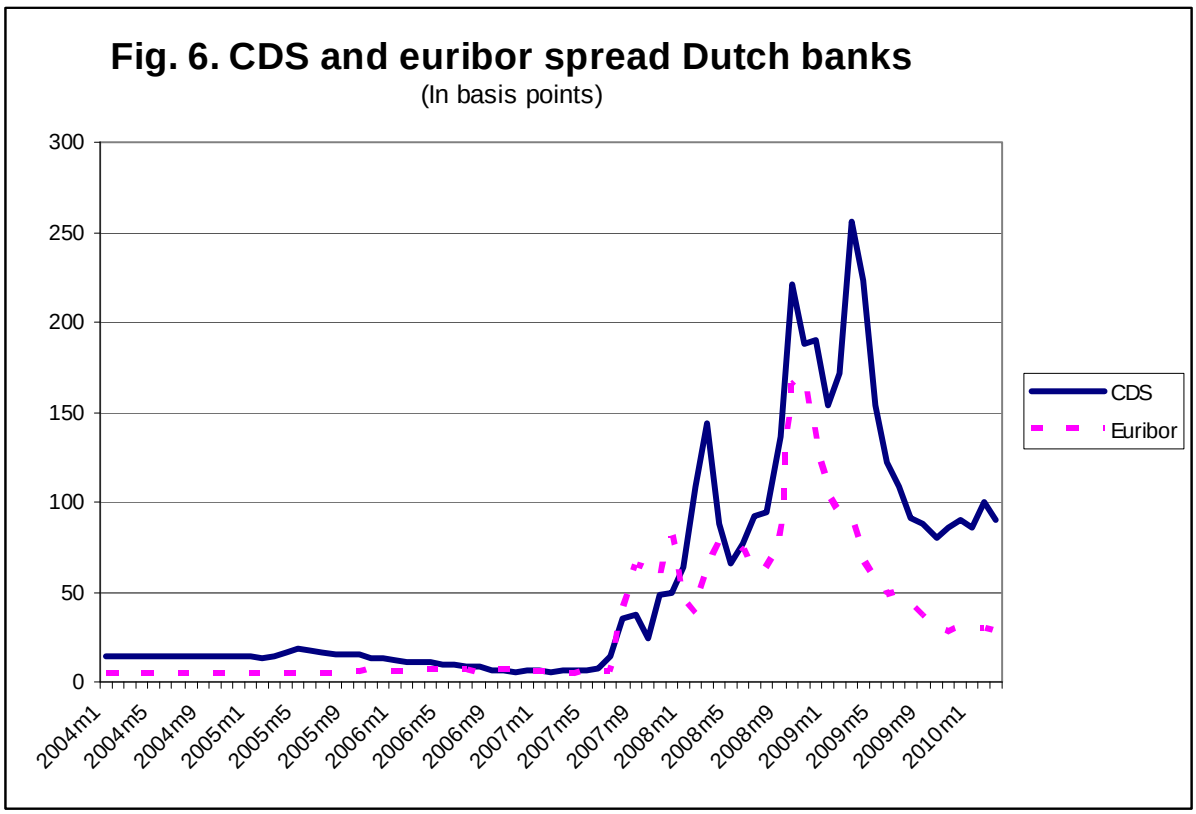
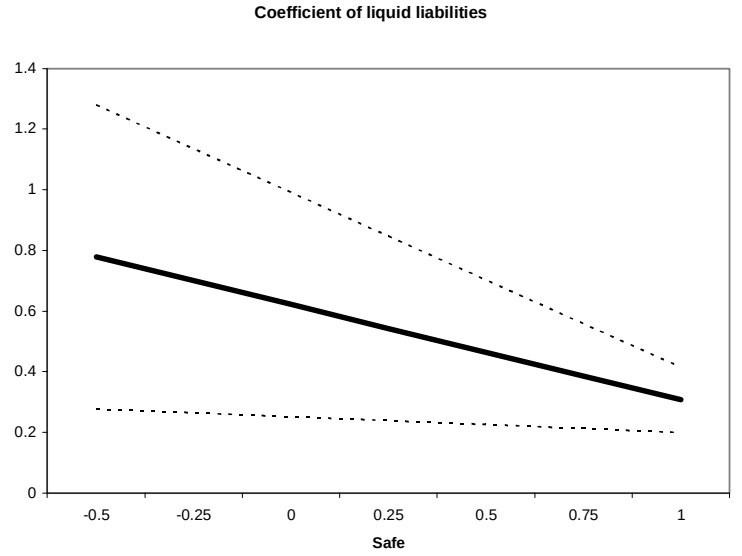
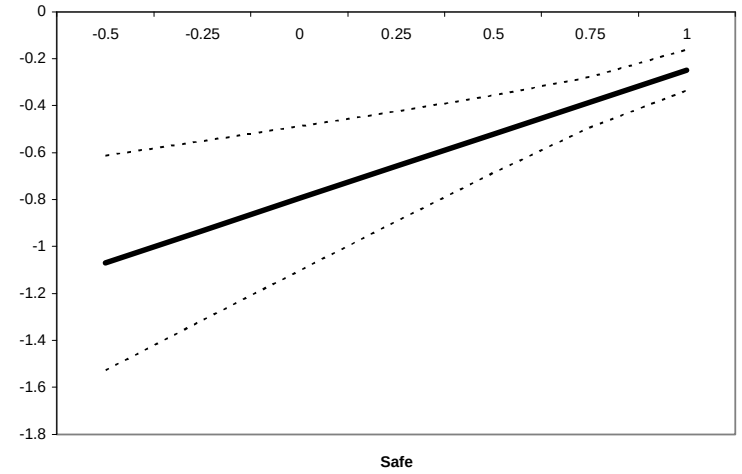
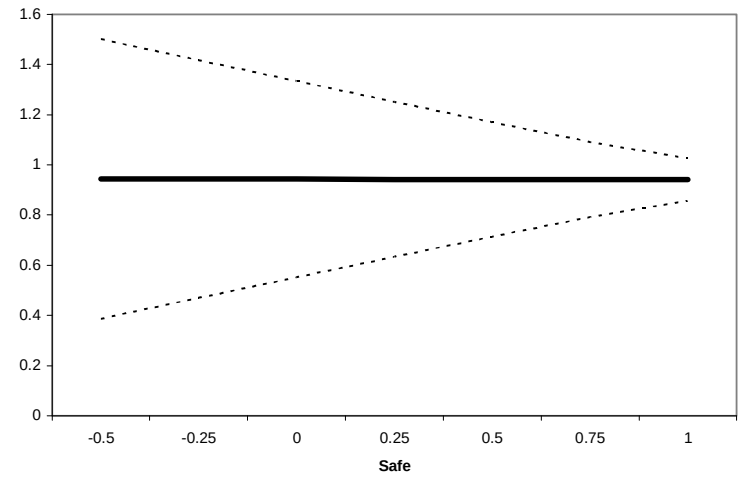


Fig. 6. CDS and euribor spread Dutch banks
(In basis points)
300
250
200
150
100
50
0
2004m1
2004m5
2004m9
2005m1
2005m5
2005m9
2006m1
2006m5
2006m9
2007m1
2007m5
2007m9
2008m1
2008m5
2008m9
2009m1
2009m5
2009m9
2010m1
CDS
Euribor

Fig. 7. Coefficient of liquid liabilities, 1-month cash inflow and 1-month cash outflow, by degree of bank safety
(Whole sample)







Tables

Table 1. Maturity transformation and stock liquidity

Actual maturity transformation	0	30	60	100	Infinite
Appropriate stock liquidity	0	5	10	30	100

Taken from: Goodhart (2002), p. 43

Table 2. Net future cash flows by maturity

	Up to 1 week	1-4 weeks	Up to 3 months	3-6 months	6 months >
Bank A	+20	-40	-50	+10	+60
Bank B	-30	+20	-10	--	+20

Taken from: Goodhart (2002), p. 43

Table 3. Summary statistics

	Whole sample		Of which: Top-5 banks		Other Dutch banks		Foreign subsidiaries		Foreign branches	
	Median	Standard deviation	Median	Standard deviation	Median	Standard deviation	Median	Standard deviation	Median	Standard deviation
Panel A										
Stock liquid assets	0.246	1.317	0.298	0.145	0.215	2.088	0.255	0.991	0.224	0.534
Stock liquid liabilities	0.398	1.542	0.392	0.176	0.291	1.316	0.441	0.950	0.411	2.245
Cash inflow < 1 month	0.167	0.773	0.255	0.146	0.108	1.337	0.240	0.269	0.127	0.273
Cash outflow < 1 month	0.143	1.133	0.350	0.186	0.063	2.006	0.231	0.252	0.102	0.250
Net cash inflow < 1 month	0.000	0.477	-0.060	0.081	0.006	0.832	0.001	0.150	0.000	0.152
Net cash inflow 1 -< 3 months	0.006	0.162	-0.035	0.029	0.000	0.169	0.035	0.151	0.010	0.178
Net cash inflow 3 -< 6 months	0.000	0.064	-0.015	0.019	0.000	0.069	0.010	0.071	0.000	0.055
Net cash inflow 6 -< 12 months	0.000	0.068	-0.010	0.025	0.000	0.071	0.014	0.071	0.000	0.065
Net cash inflow > 12 months	0.059	0.204	0.218	0.093	0.126	0.178	0.070	0.279	0.001	0.125
Panel B										
Equity ratio	0.061	0.166	0.031	0.012	0.067	0.205	0.078	0.113	0.031	0.180
Z-score	49.490	112.314	119.595	94.571	61.019	161.572	52.162	72.678	19.121	70.172
Retail deposits	0.297	0.299	0.373	0.203	0.438	0.295	0.280	0.249	0.135	0.349
Retail demand deposits	0.000	0.215	0.147	0.084	0.037	0.303	0.000	0.149	0.000	0.138

Note: All variables have been scaled by total assets. Variable definitions are given in Appendix A.

Table 4. Estimation results, for equations (E1) and (E2), respectively.
Dependent variable is stock of liquid assets.

	Whole sample		*Of which:* Top-5 banks		Other Dutch banks		Foreign subsidiaries		Foreign branches	
	(E1)	(E2)	(E1)	(E2)	(E1)	(E2)	(E1)	(E2)	(E1)	(E2)
Stock liquid liabilities	0.546** (0.230)	0.465** (0.197)	0.561** (0.115)	0.558*** (0.097)	0.982*** (0.007)	0.890*** (0.090)	0.830*** (0.029)	0.817*** (0.035)	0.198*** (0.034)	0.191*** (0.036)
Cash inflow < 1 month		-0.432** (0.168)		-0.887** (0.241)		-0.904*** (0.099)		-0.063 (0.338)		-0.336* (0.189)
Cash outflow < 1 month		0.924*** (0.075)		0.906*** (0.119)		1.004*** (0.008)		-0.073 (0.412)		0.174 (0.155)
Net cash inflow < 1 month	-1.260*** (0.156)		-0.910*** (0.117)		-1.013*** (0.009)		0.035 (0.401)		-0.189 (0.173)	
Net cash inflow 1 -< 3 months	-0.188 (0.798)	-1.105 (0.729)	-0.152 (0.199)	-0.155 (0.227)	0.280 (0.198)	0.217 (0.191)	-1.423** (0.611)	-1.349** (0.530)	-0.544 (0.361)	-0.418 (0.325)
Net cash inflow 3 -< 6 months	-0.271 (0.387)	0.188 (0.394)	-0.769** (0.178)	-0.774*** (0.154)	-1.113*** (0.122)	-1.102*** (0.132)	0.131 (0.388)	0.072 (0.341)	-0.066 (0.119)	-0.090 (0.104)
Net cash inflow 6 -< 12 months	-0.251 (0.198)	-0.324* (0.189)	-1.009** (0.244)	-1.013** (0.225)	-0.053 (0.117)	-0.041 (0.104)	-0.710*** (0.249)	-0.725** (0.258)	-0.132 (0.133)	-0.087 (0.128)
Net cash inflow > 12 months	0.049 (0.324)	-0.101 (0.219)	-0.117 (0.079)	-0.122 (0.127)	-0.614*** (0.067)	-0.593*** (0.067)	-0.447*** (0.103)	-0.335*** (0.112)	-0.224 (0.227)	-0.204 (0.201)
R^2 -within	0.797	0.846	0.831	0.831	0.994	0.994	0.860	0.861	0.578	0.587
Number of obs.	4511	4511	365	365	1372	1372	1387	1387	1387	1387
Number of banks	62	62	5	5	19	19	19	19	19	19

Note: Two-way fixed effects (within) regression. Time dummies have been included but are not reported. Robust standard errors, adjusted for clustering, are given within parentheses; ***, **, * denote that their p-values are less than or equal to 1%, 5% and 10%, respectively. All variables have been scaled by total assets. Variable definitions are given in Appendix A.

Table 5. Comparison of empirical coefficients (from Table 4, model 2) with regulatory coefficients based on the Liquidity Balance (LB) and the Liquidity Coverage Ratio (LCR)

	Whole sample			*Of which:* Top-5 banks			Other Dutch banks		
	Empirical	LB	LCR	Empirical	LB	LCR	Empirical	LB	LCR
Stock liquid liabilities	0.465** (0.202)	0.236*** (0.002)	0.904*** (0.061)	0.558*** (0.097)	0.316*** (0.010)	0.471*** (0.012)	0.890*** (0.090)	0.236*** (0.005)	0.604*** (0.035)
Cash inflow < 1 month	-0.432** (0.168)	-0.839*** (0.003)	-2.612*** (0.285)	-0.887** (0.241)	-0.994*** (0.002)	-0.641*** (0.013)	-0.904*** (0.099)	-0.899*** (0.006)	-1.405*** (0.117)
Cash outflow < 1 month	0.924*** (0.075)	0.785*** (0.004)	3.057*** (0.445)	0.906*** (0.119)	0.974*** (0.005)	0.696*** (0.009)	1.004*** (0.008)	0.819*** (0.009)	1.191*** (0.040)
Number of obs.	4511	4146	4146	365	375	375	1372	1225	1225
Number of banks	62	62	62	5	5	5	19	19	19

	Foreign subsidiaries			Foreign branches		
	Empirical	LB	LCR	Empirical	LB	LCR
Stock liquid liabilities	0.817*** (0.035)	0.196*** (0.003)	1.241*** (0.169)	0.191*** (0.036)	0.296*** (0.006)	0.980*** (0.096)
Cash inflow < 1 month	-0.063 (0.338)	-0.831*** (0.005)	-5.246*** (0.876)	-0.336* (0.189)	-0.779*** (0.006)	-1.545*** (0.095)
Cash outflow < 1 month	-0.073 (0.412)	0.749*** (0.006)	7.046*** (1.339)	0.174 (0.155)	0.734*** (0.007)	1.104*** (0.037)
Number of obs.	1387	1375	1375	1387	1171	1171
Number of banks	19	19	19	19	19	19

Note: Empirical coefficients and standard errors (within parentheses) have been copied from Table 4, model 2. Regulatory coefficients have been calculated using (R7) for LB and (R12) for LCR; the coefficients are the sample means and the standard errors are the standard deviations of the sample means. ***, **, * denote significance levels of 1%, 5% and 10%, respectively.

Table 6. Estimation results, by pre-crisis and crisis period. Dependent variable is stock of liquid assets.

	Whole sample	*Of which:* Top-5 banks	Other Dutch banks	Foreign subsidiaries	Foreign branches
Stock liquid liabilities	0.529** (0.208)	0.652*** (0.067)	0.897*** (0.083)	0.817*** (0.044)	0.223*** (0.037)
Stock liquid liabilities x Crisis	-0.149** (0.072)	-0.139*** (0.015)	0.020 (0.036)	0.054 (0.160)	-0.043*** (0.004)
Cash inflow < 1 month	-0.495** (0.188)	-0.949** (0.240)	-0.925*** (0.098)	0.029 (0.376)	-0.404** (0.192)
Cash inflow < 1 month x Crisis	-0.055 (0.172)	0.213 (0.171)	0.142 (0.108)	-0.266 (0.195)	0.226* (0.127)
Cash outflow < 1 month	0.934*** (0.067)	0.965*** (0.112)	1.013*** (0.012)	-0.164 (0.405)	0.241 (0.168)
Cash outflow < 1 month x Crisis	0.086 (0.111)	-0.083 (0.133)	-0.094 (0.073)	0.293 (0.209)	-0.053 (0.119)
Net cash inflow 1 -< 3 months	-1.002 (0.650)	-0.223 (0.118)	0.195 (0.143)	-1.372** (0.536)	-0.484 (0.303)
Net cash inflow 3 -< 6 months	0.086 (0.350)	-0.718*** (0.142)	-1.009*** (0.108)	0.049 (0.326)	-0.166* (0.095)
Net cash inflow 6 -< 12 months	-0.336* (0.175)	-0.769** (0.214)	-0.065 (0.081)	-0.741** (0.270)	-0.119 (0.113)
Net cash inflow > 12 months	-0.124 (0.211)	-0.128 (0.099)	-0.590*** (0.064)	-0.339*** (0.111)	-0.202 (0.166)
R^2 –within	0.859	0.850	0.995	0.861	0.617
Number of obs.	4511	365	1372	1387	1387
Number of banks	62	5	19	19	19

Note: Two-way fixed effects (within) regression. Time dummies have been included but are not reported. Robust standard errors, adjusted for clustering, are given within parentheses; ***, **, * denote that their p-values are less than or equal to 1%, 5% and 10%, respectively. All variables have been scaled by total assets. Variable definitions are given in Appendix A. Crisis is a dummy variable with value 1 in the period August 2007 to end of sample (March 2010) and 0 in the pre-crisis period January 2004 to July 2007.

Table 7. Factors and factor loadings

	Factor 1: 'Retail funding'	Factor 2: 'Safe'
Equity ratio	-0.119	**0.400**
Z-score	0.081	**0.409**
Retail deposits	**0.956**	0.027
Retail demand deposits	**0.954**	-0.042
Eigenvalue	1.846	0.329
Cumulative proportion of variance explained	0.953	1.123

Variable definitions are given in Appendix A. Factor loadings have been rotated using orthogonal Varimax. Factor loadings equal to or higher than 0.4 have been printed in bold.

Table 8. Estimation results for interaction with Retail funding
Dependent variable is stock of liquid assets.

	Whole sample	*Of which:* Top-5 banks	Other Dutch banks	Foreign subsidiaries	Foreign branches
Stock liquid liabilities	0.295 (0.188)	0.493*** (0.109)	0.934*** (0.086)	0.805*** (0.043)	-0.529 (0.549)
Stock liquid liabilities x Retail funding	-0.295* (0.167)	-0.267 (0.247)	-0.061* (0.034)	-0.030 (0.145)	-1.305 (1.047)
Cash inflow < 1 month	-0.217 (0.218)	-0.730** (0.246)	-0.968*** (0.093)	-0.100 (0.324)	-0.302 (0.238)
Cash inflow < 1 month x Retail funding	0.275 (0.252)	0.025 (0.434)	-0.038 (0.056)	0.127 (0.176)	0.288 (0.200)
Cash outflow < 1 month	0.507** (0.243)	0.812*** (0.122)	0.991*** (0.047)	-0.048 (0.396)	-0.632 (0.543)
Cash outflow < 1 month x Retail funding	-0.683** (0.293)	-0.002 (0.274)	-0.063 (0.070)	-0.049 (0.206)	-1.242 (0.972)
Net cash inflow 1 -< 3 months	-1.322 (0.866)	-0.104 (0.106)	0.276 (0.239)	-1.360** (0.649)	-0.228 (0.300)
Net cash inflow 3 -< 6 months	0.106 (0.415)	-0.726** (0.184)	-1.030*** (0.131)	-0.019 (0.259)	-0.163 (0.152)
Net cash inflow 6 -< 12 months	-0.307* (0.179)	-0.683** (0.246)	-0.052 (0.158)	-0.668** (0.280)	0.071 (0.213)
Net cash inflow > 12 months	-0.165 (0.230)	-0.247* (0.101)	-0.609*** (0.084)	-0.471*** (0.064)	-0.454 (0.290)
R^2 –within	0.763	0.777	0.992	0.855	0.594
Number of obs.	4119	365	1300	1288	1166
Number of banks	62	5	19	19	19

Note: Two-way fixed effects (within) regression. Time dummies have been included but are not reported. Robust standard errors, adjusted for clustering, are given within parentheses; ***, **, * denote that their p-values are less than or equal to 1%, 5% and 10%, respectively. All variables have been scaled by total assets. Variable definitions are given in Appendix A. Retail funding is an unobserved summary variable obtained by factor analysis; it has also been included separately but is not reported.

Table 9. Estimation results for interaction with Safe
Dependent variable is stock of liquid assets.

	Whole sample	*Of which:* Top-5 banks	Other Dutch banks	Foreign subsidiaries	Foreign branches
Stock liquid liabilities	0.621*** (0.189)	0.551** (0.147)	0.890*** (0.032)	0.715*** (0.043)	0.201* (0.102)
Stock liquid liabilities x Safe	-0.314** (0.134)	-0.041 (0.108)	-0.264** (0.094)	-1.200*** (0.115)	-0.084 (0.127)
Cash inflow < 1 month	-0.796*** (0.156)	-0.636*** (0.115)	-0.933*** (0.042)	-0.219 (0.268)	-0.528*** (0.104)
Cash inflow < 1 month x Safe	0.547*** (0.157)	-0.388*** (0.072)	0.339*** (0.101)	1.104*** (0.194)	0.249 (0.306)
Cash outflow < 1 month	0.942*** (0.199)	0.772*** (0.043)	1.028*** (0.020)	0.177 (0.270)	-0.003 (0.174)
Cash outflow < 1 month x Safe	-0.001 (0.171)	0.509*** (0.090)	-0.021 (0.025)	-0.779** (0.355)	-0.286 (0.217)
Net cash inflow 1 -< 3 months	-0.708* (0.410)	-0.224 (0.114)	0.045 (0.102)	-1.071*** (0.378)	-0.287 (0.224)
Net cash inflow 3 -< 6 months	-0.199 (0.254)	-0.725*** (0.164)	-0.928*** (0.161)	-0.008 (0.231)	-0.286 (0.193)
Net cash inflow 6 -< 12 months	-0.215* (0.129)	-0.853** (0.204)	-0.040 (0.125)	-0.481*** (0.167)	-0.106 (0.179)
Net cash inflow > 12 months	-0.360*** (0.108)	-0.211 (0.130)	-0.653*** (0.092)	-0.418*** (0.084)	-0.435 (0.277)
R^2 –within	0.858	0.800	0.994	0.885	0.629
Number of obs.	4119	365	1300	1288	1166
Number of banks	62	5	19	19	19

Note: Two-way fixed effects (within) regression. Time dummies have been included but are not reported. Robust standard errors, adjusted for clustering, are given within parentheses; ***, **, * denote that their p-values are less than or equal to 1%, 5% and 10%, respectively. All variables have been scaled by total assets. Variable definitions are given in Appendix A. Safe is an unobserved summary variable obtained by factor analysis; it has also been included separately but is not reported.

Appendix A. Definition of variables.

Variable	Definition
Cash inflow, different maturities	(Claims with fixed maturities + Claims on behalf of security transactions + Retail loans + Secured wholesale loans + Illiquid bonds + Claims on behalf of derivatives)/Total assets
Cash outflow, different maturities	(Liabilities to Central Bank due beyond one week + Issued securities + Wholesale fixed term deposits + Retail fixed term deposits + Secured wholesale borrowing + Liabilities on behalf of derivates)/Total assets
Crisis	Dummy variable with value 1 for August 2007 to end of sample (March 2010), and value 0 before August 2007
Equity ratio	Equity/Total assets
Retail deposits	(Retail demand deposits + Retail fixed term deposits)/Total assets
Retail demand deposits	Retail demand deposits/Total assets
Retail funding	Unobserved summary variable obtained by factor analysis, with high factor loadings on Retail deposits and Retail demand deposits
Safe	Unobserved summary variable obtained by factor analysis, with high factor loadings on Equity ratio and Z-score
Stock of liquid assets	(Cash + Claims demandable on short notice + Liquid debt instruments eligible as ECB collateral + Other liquid debt instruments + Securities + Liquid stocks)/Total assets
Stock of liquid liabilities	(Liabilities to Central Bank due within one week + Wholesale demand deposits + Retail demand deposits + OBS liabilities)/Total assets
Z-score	Distance to default, measured as (Return on assets + Equity ratio)/Standard deviation of Return on assets over previous 36 months

Appendix B

Dutch LB regulatory weights

The values in columns WEEK and MONTH represent haircuts on assets and run-off rates of liabilities.

For the liquidity test for the full month, a distinction is made between non-scheduled items and scheduled items. In contrast to non-scheduled items, scheduled items are included on the basis of their possible or probable due dates. For the liquidity test for the first week, scheduled items are only included if they are explicitly taken into account in day-to-day liquidity management (treasury operations). In the following table, scheduled items are indicated by the letter M.

GROUP	ASSETS	M	WEEK	MONTH
	Banknotes/coins		100	100
	Receivables from central banks (including ECB)			
1	Demand deposits		100	100
1	Amounts receivable	M	100	100
1	Receivables in respect of reverse repos	M	100	100
1	Receivables in the form of securities or tier 2 eligible assets	M	d*	d*
	Collection documents			
	Available on demand		100	100
	Receivable	M	100	100
	Readily marketable debt instruments/ECB eligible assets			
	Issued by public authorities and central banks			
2	ECB tier 1 and tier 2 eligible assets		95**	95**
2	ECB tier 2 eligible assets, deposited		85**	85**
2	ECB tier 2 eligible assets, not deposited		85	85
2	Other readily marketable debt instruments, Zone A		95	95
2	Other readily marketable debt instruments, Zone B		70	70
	Issued by credit institutions			
2	ECB tier 1 eligible assets		90**	90**
2	ECB tier 2 eligible assets, deposited		80**	80**
2	Other debt instruments qualifying under the CAD (Capital Adequacy Directive)		90	90
2	Other liquid debt instruments		70	70
	Issued by other institutions			
2	ECB tier 1 eligible assets		90**	90**
2	ECB tier 2 eligible assets, deposited		80**	80**
2	Other debt instruments qualifying under the CAD (Capital Adequacy Directive)		90	90
2	Other liquid debt instruments		70	70
	Amounts receivable			
	Branches and banking subsidiaries not included in the report			
3	Demand deposits		50	100
3	Amounts receivable in respect of securities transactions	M)	100	100
	Other amounts receivable	M	100	90
	Other credit institutions			
3	Demand deposits		50	100
3	Amounts receivable in respect of securities transactions	M)	100	100
3	Other amounts receivable	M	100	90
	Public authorities			
3	Demand deposits		50	100
3	Amounts receivable in respect of securities transactions	M)	100	100
3	Other amounts receivable	M	100	90
	Other professional money market players			
3	Demand deposits		50	100
3	Amounts receivable in respect of securities transactions	M)	100	100
3	Other amounts receivable	M	100	90
	Other counterparties			
	Demand deposits		0	0
	Amounts receivable in respect of securities transactions	M)	100	90

4	Other amounts receivable, including premature redemptions	M	50	40
	Receivables in respect of repo and reverse repo transactions			
	Reverse repo transactions (other than with central banks)			
5	Receivables in respect of bonds	M	100	100
5	Receivables in respect of shares	M	100	100
	Repo transactions (other than with central banks)			
5	Receivables in the form of bonds	M	90/d*/**	90/d*/**
5	Receivables in the form of shares	M	70	70
	Securities lending/borrowing transactions			
5	Securities stock on account of securities lending/borrrowing transactions		100	100
5	Securities receivable on account of securities lending/borrowing transactions	M	100	100
	Other securities and gold			
6	Other liquid shares		70	70
6	Unmarketable shares		0	0
2	Unmarketable bonds	M	100	100
	Gold		90	90
	Official standby facilities			
14	Official standby facilities received		100	100
14	Receivables in respect of derivatives	M	***	***
	Total			

	LIABILITIES	M	WEEK	MONTH
	Moneys borrowed from central banks			
7	Overdrafts (payable within one week)		100	100
7	Other amounts owed	M	100	100
	Debt instruments issued by the bank itself			
8	Issued debt securities	M	100	100
8	Subordinated liabilities	M	100	100
	Deposits and fixed-term loans			
	Branches and banking subsidiaries not included in the report			
9	Amounts owed in respect of securities transactions	M)	100	100
9	Deposits and other funding – fixed maturity	M	100	90
	Other credit institutions			
9	Amounts owed in respect of securities transactions	M)	100	100
9	Deposits and other funding – fixed maturity	M	100	90
	Other professional money market players			
9	Amounts owed in respect of securities transactions	M)	100	100
9	Deposits and other funding – fixed maturity – plus interest payable	M	100	90
	Other counterparties			
	Amounts owed in respect of securities transactions	M)	100	100
10	Deposits and other funding – fixed maturity – plus interest	M	50	40
10	payable	M	20	20
	Fixed-term savings deposits			
	Liabilities in respect of repo and reverse repo transactions			
	Repo transactions other than with central banks			
11	Amounts owed in respect of bonds	M	100	100
11	Amounts owed in respect of shares	M	100	100
	Reverse repo transactions other than with central banks			
11	Amounts owed in the form of bonds	M	100	100
11	Amounts owed in the form of shares	M	100	100
	Securities lending/borrowing transactions			
11	Negative securities stock on account of securities lending/borrowing transactions		100	100
11	Securities to be delivered on account of securities lending/borrowing transactions	M	100	100
	Credit balances and other moneys borrowed with an indefinite effective term			

	Branches and banking subsidiaries not included in the report			
12	Current account balances and other demand deposits		50	100
12	*Other credit institutions*			
12	Balances on vostro accounts of banks		50	50
12	Other demand deposits		50	100
	Other professional money market players			
12	Demand deposits		50	100
	LIABILITIES (continued)	M	WEEK	MONTH
	Savings accounts			
13	Savings accounts without a fixed-term		2.5	10
	Other			
13	Demand deposits and other liabilities		5	20
13	Other amounts due and to be accounted for, including the balance of forward transactions and amounts due in respect of social and provident funds		5	20
	Official standby facilities			
14	Official standby facilities granted		100	100
	Liabilities in respect of derivatives			
14	Known liabilities in respect of derivatives	M	***	***
14	Unknown liabilities in respect of derivatives		***	***
	Other contingent liabilities and irrevocable credit facilities			
14	Unused irrevocable credit facilities, including underwriting of issues		2.5	10
14	Bills accepted	M	100	100
14	Credit-substitute guarantees		2.5	10
14	Non-credit-substitute guarantees		1.25	5
14	Other off-balance-sheet liabilities		1.25	5
	Total			

M = Scheduled item.
M) = Settlement due within one week or open-ended, including first week or as scheduled.
* = Less applicable discount.
** = Either at stated percentage or at percentages applicable for ECB/ESCB collateral purposes.
*** = Calculated amount for the period concerned.
90/d*/** = 90% OR: less applicable discount (provided the method is consistently applied).

Basel III LCR regulatory weights

Illustrative Template for the Liquidity Coverage Ratio

Item	Factor (to be multiplied against total amount)	Total amount	With factor applied
Stock of high quality liquid assets			
Cash	100%		
Qualifying marketable securities from sovereigns, central banks, public sector entities, and multi-lateral development banks	100%		
Qualifying central bank receivables	100%		
Domestic sovereign or central bank debt in domestic currency	100%		
In addition, the Committee will gather data on the following instruments to analyse the impact of this standard on the financial sector: *Qualifying corporate bonds rated AA or higher* *Qualifying corporate bonds rated A- to AA-* *Qualifying covered bonds rated AA or higher* *Qualifying covered bonds rated A- to AA-*	 80% 60% 80% 60%		
Total value of stock of highly liquid assets			
Cash Outflows			
Retail deposits:			
- stable deposits	minimum 7.5%		
- less stable retail deposits [additional categories to be determined by jurisdiction]	minimum 15%		
Unsecured wholesale funding:			
- Stable, small business customers	minimum 7.5%		
- Less stable, small business customers [additional categories to be determined by jurisdiction]	minimum 15%		
- non-financial corporates, no operational relationship	75%		
- non-financial corporates, sovereigns, central banks and public sector entities with operational relationships	25% of deposits needed for operational purposes		
- other legal entity customers and sovereigns, central banks, and PSEs without operational relationships	100%		

Source: BCBS, 2009b

Secured funding:			
Funding from repo of illiquid assets and securities lending/borrowing transactions illiquid assets are lent out	100%		
Additional requirements			
Liabilities related to derivative collateral calls related to a downgrade of up to 3-notches	100% of collateral that would be required to cover the contracts in case of up to a 3-notch downgrade		
Market valuation changes on derivatives transactions	Amount should be nationally determined [as relevant to specific banks]		
Valuation changes on posted non-cash or non-high quality sovereign debt collateral securing derivative transactions	20%		
ABCP, SIVs, Conduits, etc:			
- Liabilities from maturing ABCP, SIVs, SPVs, etc	100% of maturing amounts and 100% of returnable assets		
Term Asset Backed Securities (including covered bonds)	100% of maturing amounts		
Currently undrawn portion of committed credit and liquidity facilities to:			
- retail clients	10% of outstanding lines		
- non-financial corporates; credit facilities	10% of outstanding lines		
- non-financial corporates; liquidity facilities	100% of outstanding lines		
-- other legal entity customers	100% of outstanding lines		
Other contingent funding liabilities (such as guarantees, letters of credit, revocable credit and liquidity facilities etc)	Determined by supervisors, specific to needs at certain banks.		
Planned outflows related to renewal or extension of new loans (retail or wholesale)	100%		
Any other cash outflows (including planned derivative payables)			
Total cash outflows			
Cash Inflows			
Amounts receivable from retail counterparties	100% of planned inflows from performing assets		
Amounts receivable from wholesale counterparties	100% of planned inflows from performing wholesale customers		
Receivables in respect of repo and reverse repo transactions backed by illiquid assets and securities lending/borrowing transactions where illiquid assets are borrowed.	100%		
Other cash inflows			
Total cash inflows			
Net cash outflows (= Total cash outflows minus Total cash inflows)			
Liquidity coverage ratio (= Total value of stock of high quality liquid assets / Net cash outflows)			