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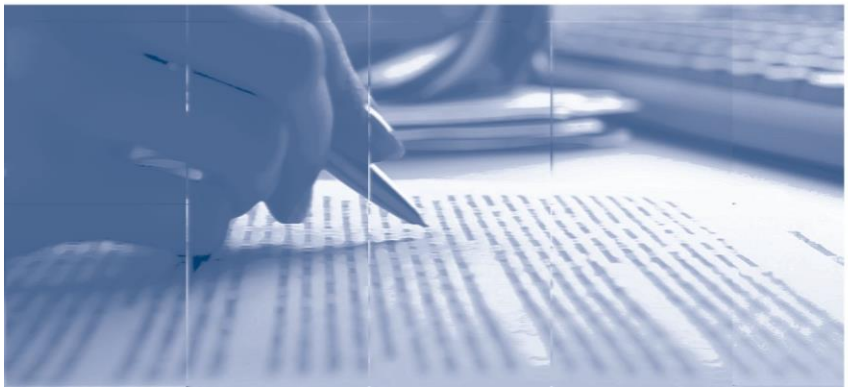

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The Determinants of Structural Liquidity in Brazil: what to expect for the NSFR?

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Abstract

This paper empirically investigates the main determinant factors of the new prudential liquidity requirement, the Net Stable Funding Ratio (NSFR), and assesses the possible impacts of its implementation on the Brazilian banking system. To this end, a dynamic panel of 131 financial institutions was estimated for the period between 2008 and 2014. The results indicate that the cost of adjusting the structural liquidity of Brazilian banks is relatively moderate, requiring about eight quarters for a complete absorption of an exogenous shock. Additionally, the results do not indicate that the NSFR has a negative impact on banks' profitability, as measured by the adjusted return on average assets (ROAA). This suggests a compatibility between lower structural liquidity risk and higher profitability in the long run. Finally, the NSFR presented itself countercyclical, showing its ability to mitigate excessive growth of banking operations during the phase of economic expansion, contributing to the stability of the financial system.

Keywords: Financial System**,** Prudential Regulation, Financial Crisis, Liquidity, Basel III, NSFR.
JEL Classification: G21, G28, E58

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1. Introduction

The recent international financial crisis of 2007-08 revealed that the incentives provided by the financial regulation at the time were not sufficiently appropriate to limit the risks in the maturity transformation process carried out by banks. This fact attracted the attention of banking regulators to the need for new mechanisms to control liquidity risk, considered a key element to the outbreak and rapid spillover of the aforementioned financial crisis [Brunneirmeier (2009), Franklin and Carletti (2008), Booner and Hilbers, (2015)].

In order to overcome this deficiency, the Basel Committee on Banking Supervision (BCBS, 2014) recommended that financial institutions adopt a new measure of liquidity, the Net Stable Funding Ratio (NSFR)[4]. The NSFR is defined as the amount of available stable funding (ASF) relative to the amount of required stable funding (RSF). It is an indicator of structural liquidity that aims to ensure that banks maintain a stable funding profile depending on the composition of their assets and off-balance sheet exposures. According to the timeline established by the G -20 countries, the NSFR will become a minimum requirement by January 1, 2018[5].

According to Berger and Bouwman (2009), the modern theory of financial intermediation explains that liquidity creation exercised by banks (or maturity transformation) is a basic reason that justifies the existence of these institutions in the economies. Banks create liquidity by financing relative illiquid and longer-term assets (e.g. long term loans) with relative liquid and shorter-term liabilities (e.g. demand deposits). As stated by Vazquez and Federico (2015), the notion of maturity transformation is directly related to the concept of structural liquidity mismatch in the banks' balance sheets.

The role of banks in maturity transformation is essential to the real economy since it allows depositors and investors to optimize their resource allocation preferences according to their needs over time. However, in the bank's perspective, this benefit to

[4] Another initiative of the BCBS was the creation of the Liquidity Coverage Ratio (LCR), a short-term liquidity requirement that aims to ensure that banks have an adequate stock of liquid assets that can be readily converted into cash in stressful situations.

[5] Applies to internationally active banks of countries that follow the recommendations of the BCBS (BCBS, 2014).

depositors and investors translates into liquidity risk. Due to the partial illiquidity of its assets and the limited ability to finance itself, meeting its own liquidity demands and that of its many depositors and investors may not be feasible in a certain period of time. Thus, the liquidity risk is an inherent issue involved in the financial intermediation process and can cause bank-runs and contagion effects in the financial system, as discussed by Diamond and Dybvig (1983) and Allen and Gale (2000).

Several empirical studies show that excessive maturity transformation and high dependence on wholesale funding, especially short-term, explain default events of banking firms[6]. Berger and Bouwamn (2008) find that banking crises in the United States were preceded by periods of strong liquidity creation. Yorulmazer (2008) examined the repercussions of the bank run suffered by Northern Rock in 2007. He observed that banks that were more dependent on wholesale funding were severely affected during the adjustment process to that financial shock. According to the author, there is evidence that the liability side and funding characteristics of banks can be a leading source of bank failures and spillover effects.

Vazquez and Federico (2015) point out that banks with weaker structural liquidity and higher leverage, in the period preceding the 2007-08 financial crisis, were more likely to become insolvent. In contrast, banks with more stable funding structures were more resilient and able to remain active during the period of turbulence [(Cornett et. al., 2011), (Bologna, 2011)]. An International Monetary Fund study (IMF, 2013), in turn, found that major mismatches between assets and liabilities, as well as a higher share of short-term debt, are factors correlated to financial instability.

In this sense, the NSFR aims to ensure a greater degree of stability to the financial system. This is done by limiting excesses in the usual maturity transformation process carried out by banks, especially when associated with overreliance on wholesale funding.

[6] Although overreliance on wholesale funding has undermined banks during the 2007-08 financial crisis, Calomiris (1999) draws attention to the fact that the use of these resources allows informed depositors to monitor the management of financial institutions, promoting market discipline. In addition, it allows financial intermediaries to explore investment opportunities beyond what would be possible considering only the retail resources available.

This paper aims to empirically identify the key determinants of the new prudential liquidity requirement, the NSFR, and assess the possible impacts of its implementation on the Brazilian banking system. To do so, it will estimate a dynamic panel with microeconomic data of 131 financial conglomerates and isolated financial institutions in the banking macro-segments I (B1) and II (B2)[7], for 2008-2014, on a quarterly basis. The estimation strategy for the dynamic panel aims to assess the cost of adjustment to banks in relation to the aforementioned liquidity requirement, as recommended by Basel III.

This paper contributes to the banking literature as it calculates a proxy of the new liquidity indicator proposed in Basel III with retroactive effect[8], promoting an initial discussion on the impact of the NSFR on Brazilian banks. To the best of our knowledge, this is the first study that assesses the behavior of the NSFR within the Brazilian banking system. Additionally, we believe this paper contributes to better understand how financial institutions will adjust to the new regulatory environment, even in other jurisdictions.

The paper proceeds as follows. In Section 2, we present stylized facts related to the prudential liquidity regulation, especially the NSFR. Section 3 runs the econometric estimations, including references to data description. In Section 4, we discuss the estimation results. Section 5 is devoted to the conclusions and recommendations for the research agenda.

2. Prudential Liquidity Regulation

In 1975, on the first meeting of the Basel Committee, its chairman stated that the main objective of the Committee was to ensure banks' solvency and liquidity. Despite that, little attention has been given to the debate about liquidity risk. Only recently, with the outbreak of the financial crisis of 2007-08, the matter came to prominence in the prudential regulation discussions (Goodhart, 2011).

[7] The banking segment I (B1) is formed by commercial banks, multiple banks with commercial portfolio or federal savings banks; and by financial conglomerates composed by at least one of the above institutions. The banking segment II (B2) consists of multiple banks without a commercial portfolio; investment banks; and financial conglomerates composed by at least one of the above institutions. Development banks are not included in the sample.

[8] The constructed time series uses quarterly data and comprises the period 2008Q1-2014Q4.

Many risk factors have contributed to the cause of the aforementioned financial crisis. Nevertheless, there is consensus among global academics and regulators that liquidity problems were critical vectors of magnification and transmission of the crisis. In addition, as noted by Booner and Hilbers (2015), the financial crisis has shown that the then current capital regulation was not able to adequately mitigate liquidity risks.

In response to these observations, the BCBS published in December 2010 the document *Basel III: International framework for liquidity risk measurement, standards and monitoring* (BCBS 2010). This document was part of the package of reforms known as Basel III, to address vulnerabilities exposed by the crisis. The document introduced the first two minimum prudential liquidity requirements at international level, the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR).

Regarding the implementation of the LCR in Brazil, the Resolution 4,401 of February 27, 2015, has already established the scope, the minimum requirements for its compliance, as well as the methodology for its calculation and its disclosure requirements (Circular 3,749, of March 5, 2015). Now, the attention turns to the NSFR, which should be regulated by the Central Bank of Brazil in accordance with the timeline established by the BCBS.

According to the Basel Committee (BCBS, 2014), the NSFR was developed to promote a sustainable funding structure for banks. Its objective is to reduce the risk that disruptions to a bank's regular sources of funding will erode its liquidity position in a way that would increase the risk of its failure and potentially lead to a broader systemic stress. In the BCBS´s view, the NSFR limits overreliance on short-term wholesale funding, encourages better assessment of funding risk - across on and off-balance sheet items - and promotes funding stability.

Following the Basel Committee guidelines (BCBS, 2014), the calculation of the NSFR is as follows:

$$NSFR = \frac{ASF}{RSF} \quad (1)$$

where NSFR denotes the structural liquidity ratio[9]. The ASF and RSF represent the available amount of stable funding and the required amount of stable funding, respectively. The ASF is the sum of the institution's funding sources (capital and liabilities) weighted by factors representing the stability of each funding source[10]. The RSF is the weighted sum of exposures (assets and off-balance exposures) weighted according to their liquidity and residual maturity[11]. Therefore, the RSF amount represents the proportion of the institution's exposures that must be supported by stable sources of funding. In this study, we used a comprehensive set of financial, accounting and supervisory data maintained by the BCB, which ensures higher quality and accuracy to the information used in this paper.

The ASF is calculated based on the amount of: (1) capital and capital instruments; liabilities with residual maturity of over one year without the possibility of early redemption, regardless of the counterparty; (2) deposits and other types of funding, without maturity, redeemable or with residual maturity of less than one year provided by retail and small business customers; (3) deposits and other types of funding provided by non-financial corporate customers, government and public sector entities, without maturity, redeemable or with residual maturity of less than one year; trade finance-related funding with residual maturity of less than one year; and other liabilities with residual maturity between six months and one year, including funding provided by financial institutions; and (4) other liabilities without maturity or maturing within six months, including borrowings from financial institutions; clean external funding lines (non-trade finance related); net position in derivative liabilities; provisions; tax and social security liabilities, among others. The weight factor of each type of ASF is shown in Table 1.

The RSF is determined based on the amount of: (1) cash; central bank reserves; sovereign securities (including free positions, excess margins posted on Central Counterparty Clearing Houses (CCP) and securities bought in reverse repo with residual maturity up to six months); quotas of liquid investment funds; and debt issued by other financial institutions maturing within six months; (2) cash flows from performing loans

[9] The time horizon of the NSFR is of one year.
[10] The higher the weighting factor (0% to 100%), the higher the funding stability.
[11] The higher the weighting factor (0% to 100%), the higher the need of the exposure to be funded by stable funding sources.

(those that do not have any overdue payment greater than ninety days) with a residual maturity of less than one year, except those loans that the bank is obligated to roll over to comply with mandatory directions; exchange-traded equities; financial institutions debt issuances with a residual maturity between six months and one year; and other assets with maturity of less than one year, including securities not considered in the previous category; (3) cash flows from performing loans with a residual maturity of over one year, except those loans that the bank is obligated to roll over to comply with mandatory directions; unencumbered securities not considered in the previous categories; commodities (gold); and all margins posted on CCPs; (4) cash flows arising from non-performing loans and those loans that the bank is obligated to roll over to comply with mandatory directions; assets that are encumbered for a period of one year or more; net position in derivative assets; 20% of derivatives liabilities; other assets with residual maturity of more than one year or without maturity, including non-performing loans, fixed assets, and items deducted from regulatory capital, among others; and (5) off-balance sheet exposures: co-obligations, guarantees and letters of credit and irrevocable credit limits provided. The weight factor of each type of RSF is shown in Table 2.

Table 1. ASF weighting factors used in the calculation of the NSFR

Factor	Available amount of stable funding (ASF)
100%	▪ Capital and capital instruments; ▪ Liabilities with residual maturity of over one year without the possibility of early redemption, regardless of the counterparty.
90 or 95%	▪ Deposits and other types of funding, without maturity, redeemable or with residual maturity of less than one year provided by retail and small business customers.
50%	▪ Deposits and other types of funding provided by non-financial corporate customers, government and public sector entities, without maturity, redeemable or with residual maturity of less than one year; ▪ Trade finance-related funding with residual maturity of less than one year; ▪ Other liabilities with residual maturity between six months and one year, including funding provided by financial institutions.
0%	▪ Other liabilities without maturity or maturing within six months, including borrowings from financial institutions, clean external funding lines (non-trade finance related); net position in derivative liabilities; provisions; tax and social security liabilities, among others.

Table 2. RSF weighting factors used in the calculation of the NSFR

Factor	Required amount of stable funding (RSF)
0% to 15%	▪ Cash; ▪ Central bank reserves; ▪ Sovereign securities (including free positions, excess margins posted on Central Counterparty Clearing House (CCP) and securities bought in reverse repo with residual maturity up to six months); ▪ Quotas of liquid investment funds; and ▪ Debt issued by other financial institutions maturing within six months.
50%	▪ Cash flows from performing loans (those that do not have any overdue payment greater than ninety days) with a residual maturity of less than one year, except those loans that the bank is obligated to roll over to comply with mandatory directions; ▪ Exchange-traded equities; ▪ Financial institutions debt issuances with a residual maturity between six months and one year; and ▪ Other assets with maturity of less than one year, including securities not considered in the previous category.
65% or 85%	▪ Cash flows from performing loans with a residual maturity of over one year, except those loans that the bank is obligated to roll over to comply with mandatory directions; ▪ Unencumbered securities not considered in the previous categories; ▪ Commodities (gold); and ▪ All margins posted on CCPs.
100%	▪ Cash flows arising from non-performing loans and those loans that the bank is obligated to roll over to comply with mandatory directions; ▪ Assets that are encumbered for a period of one year or more; ▪ Net position in derivative assets; ▪ 20% of derivatives liabilities; and ▪ Other assets with residual maturity of more than one year or without maturity, including non-performing loans, fixed assets, and items deducted from regulatory capital, among others.
5%	▪ Off-balance sheet exposures: co-obligations, guarantees and letters of credit and irrevocable credit limits provided.

Table 3 presents descriptive statistics of the NSFR for the Brazilian banking system (BBS), also divided by financial institution size[12]. Table 4 shows the same statistics by ownership and by the economic activity predominantly exploited by the financial institution. The numbers presented represent the relationship between available and required amount of stable funding, expressed as a percentage, as defined in Equation 1. It means that the larger the value of this indicator, the greater the structural liquidity of the bank. For example, a financial institution whose structural liquidity ratio is greater than one indicates that the entity has an amount of stable funding more than sufficient to sustainably finance its assets and off-balance sheet exposures.

[12] Banks are ranked according to their positions in a descending list ordered by banks' total assets. A cumulative distribution function (CDF) is built on the banks' total assets that classify them depending on the region in which they fall in the CDF. It considers as large banks those that fall in the 0% to 75% region. The rest of the banks are considered as non-large.

Table 3. Descriptive statistics: NSFR in the BBS and by bank size (2008-2014)

Statistics	BBS	Large	Non-Large
Minimum	0.28	0.90	0.28
Maximum	23.11	1.90	23.11
Mean	1.83	1.12	1.86
Std. deviation	2.33	0.18	2.38
10th percentile	0.83	0.97	0.82
25th percentile	1.00	1.02	1.00
50th percentile	1.26	1.07	1.29
75th percentile	1.70	1.16	1.73
90th percentile	2.73	1.33	2.83

In the period examined, the median financial institution of the Brazilian banking system has an NSFR of 1.26. Banks located in the 10th and the 90th percentiles have an NSFR of 0.83 and 2.73, respectively. At least a tenth of the banks showed an NSFR of less than one. It means that a portion of the Brazilian banks would have to adjust their structural liquidity to comply with this new operating limit if it were already in place. It should be noted, as well, that the variance of the NSFR is substantially lower in the large banks segment.

Table 4. NSFR by ownership type and by predominantly explored economic activity (2008-2014)

Statistics	State-owned	Privately owned Domestic	Privately owned Foreign	Retail banks[13]	Wholesale banks[14]	Investment banks[15]
Minimum	0.95	0.37	0.28	0.28	0.29	0.41
Maximum	2.59	23.11	22.80	23.11	16.97	22.73
Mean	1.54	1.72	2.00	1.74	1.62	2.36
Std. deviation	0.34	2.14	2.69	2.58	1.34	2.87
10th percentile	1.10	0.85	0.75	0.73	0.90	0.87
25th percentile	1.31	1.03	0.97	0.96	1.06	1.07
50th percentile	1.55	1.25	1.23	1.14	1.36	1.51
75th percentile	1.76	1.60	1.82	1.49	1.68	2.27
90th percentile	1.92	2.47	3.46	2.37	2.27	4.15

As indicated by Table 4, state-owned banks have, on average, better structural liquidity than privately owned banks (domestic and foreign owned). This can be explained, partly, by the relevance of retail funding on these banks and partly by the

[13] For the purposes of this paper, retail banks are those banks or financial conglomerates that focus on loan operations in which there is a predominance of transactions with values up to BRL 100,000.
[14] For the purposes of this paper, wholesale banks are those banks or financial conglomerates that focus on loan operations in which there is a predominance of transactions with values above BRL 500,000.
[15] For the purposes of this paper, investment banks are those banks or financial conglomerates that operate predominantly with marketable securities. This bank category also includes institutions that have relevant investments in subsidiaries and affiliates. This is not the Central Bank of Brazil definition for investment banks.

greater relevance of funding arising from government funds, social funds, judicial deposits and payrolls of state and municipal agencies (in general, long term liabilities). Regarding the business model, the median investment bank showed higher structural liquidity than the banks operating mainly in other segments (retail and investment). This can be explained due to the greater presence of liquid assets in their portfolios (sovereign securities, foreign exchange).

An interesting fact is that the majority part of wholesale banks focused on wholesale lending maintained an adequate structural liquidity, as measured by the NSFR. Despite usually funding their operations also with wholesale investors, those banks often use long-term instruments for it, in general above 12 months.

Figure 1 shows the NSFR level for the Brazilian banking system during 2008-2014, showing also the evolution of the ASF and the RSF portions during the same period. It is noteworthy the reduction of the NSFR by the end of 2008 and early 2009, following the financial crisis of 2007-08, which impacted the liquidity of the Brazilian banking system.

Figure 1. Level of NSFR for the BBS and its respective portions of ASF and RSF)

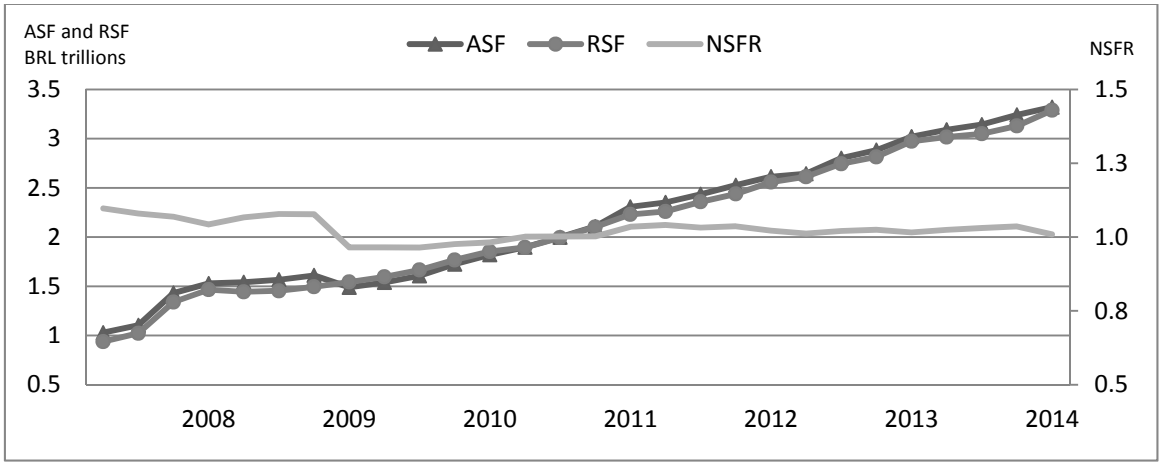


Figure 2 shows the development of the NSFR separately for large and non-large banks. During the analyzed period, there is a significant difference between the level of NSFR in these groups, with smaller banks showing higher and also more volatile NSFR.

Figure 2. NSFR (median) by bank size

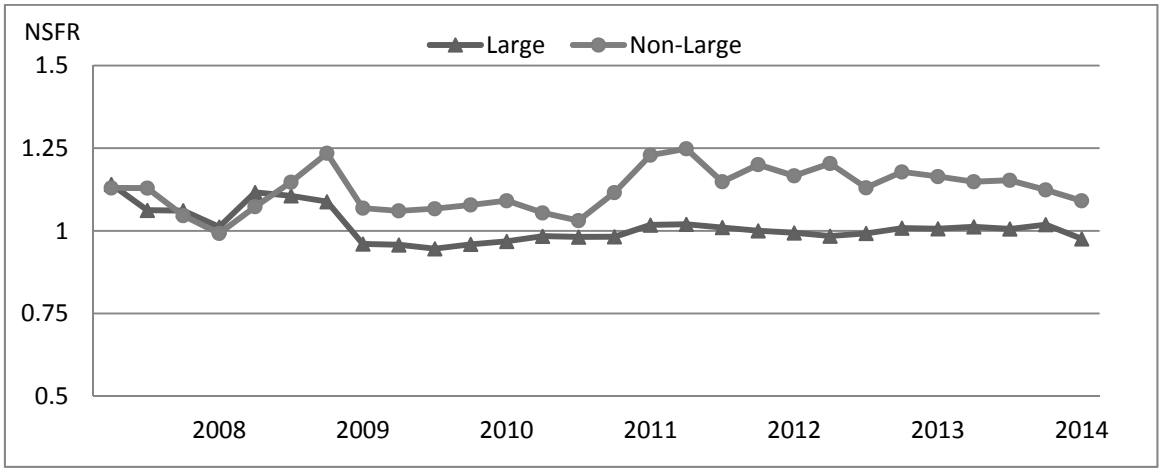


Figure 3 shows the advancement of the NSFR by ownership type, divided between domestic and foreign owned banks. It is worth noting the recovery of the foreign banks structural liquidity in the period, to levels equivalent to those observed for domestic institutions.

Figure 4 also presents the NSFR evolution in the period, but subdividing it between state and privately owned banks. In this case, it is important to observe the reduction in the structural liquidity of state-owned banks. This is associated with a higher rate of growth in the loan portfolio of these institutions during the period. Nevertheless, the structural liquidity of state-owned banks remains above the level held by privately owned banks.

Figure 3. Development of the NSFR (median) by ownership type (domestic vs foreign owned)

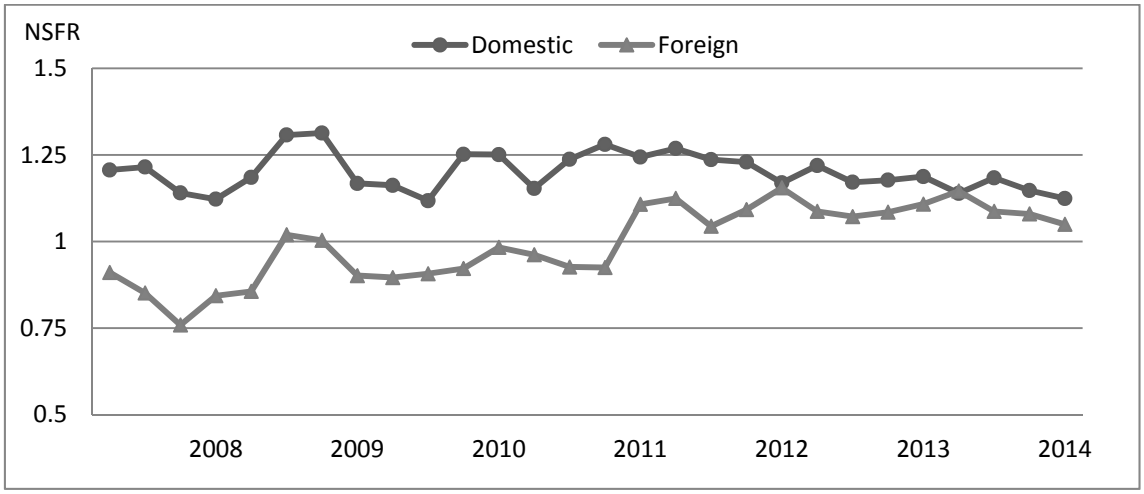
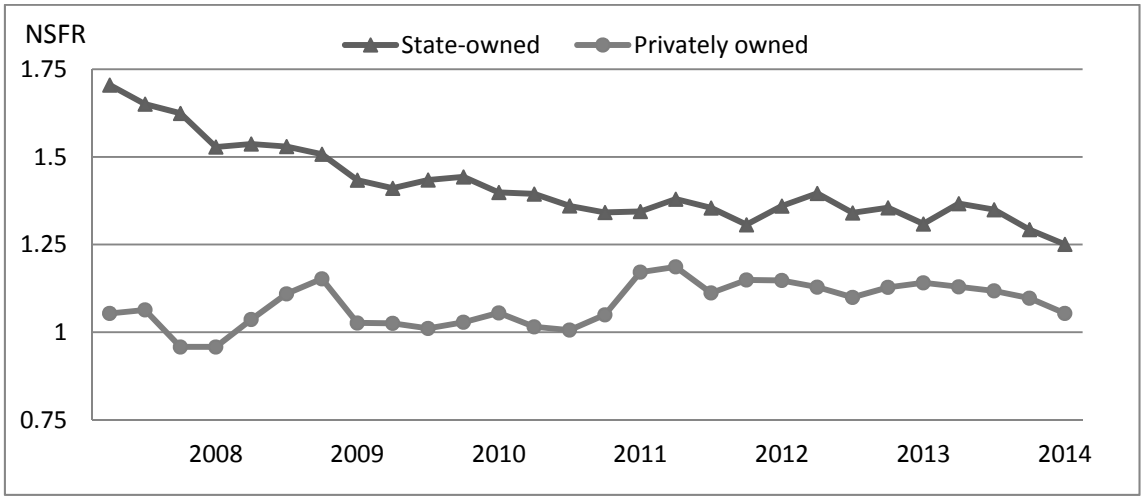
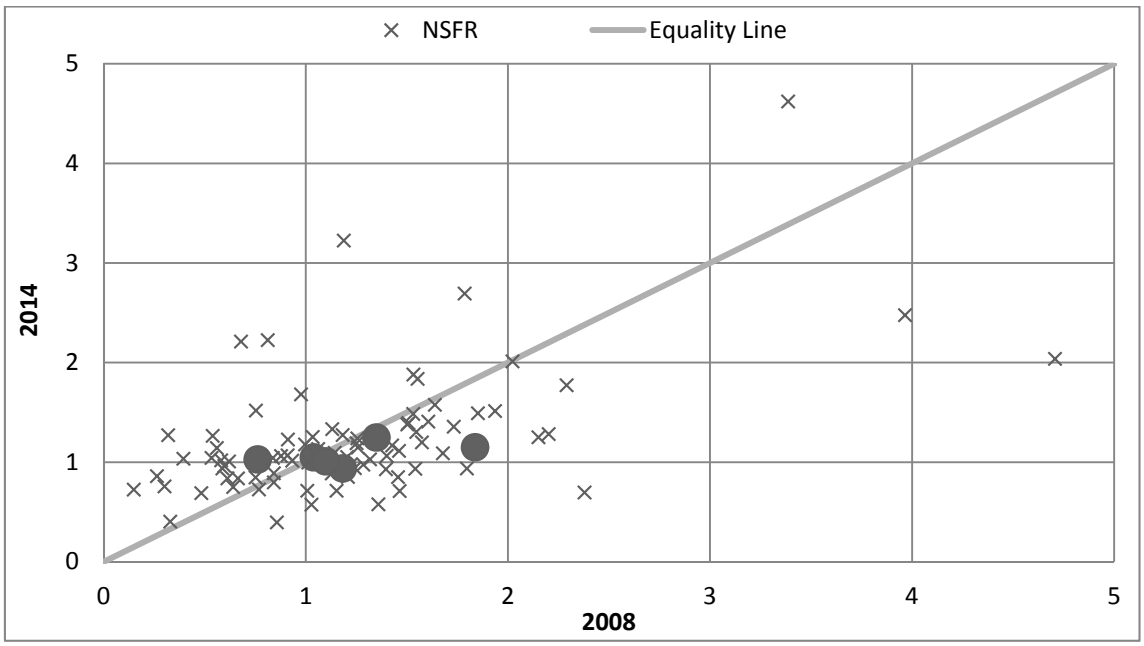


Figure 4. Development of the NSFR (median) by ownership type (state vs privately owned)



In Figure 5, we present a scatter diagram of the NSFR, comparing the NSFR level for all banks included in this study between the first quarter of 2008 and the last quarter of 2014. The diagonal line shows the situation in which the banks have not changed their NSFR between the two specified periods. Banks located above (below) the diagonal line increased (decreased) their level of structural liquidity (NSFR). Examination of this figure shows that about 60% of banks reduced their NSFR in the period and that approximately 2/3 of the banks operate with NSFR above 1. Most large banks, represented by the solid circles, also reduced their NSFR between the two periods.

Figure 5. Scatter diagram of the NSFR (2008-2014)



3. Econometric model specification and data

The estimation carried out in this study is done through the use of Arellano and Bover (1995), and Blundell and Bond (1998) estimator. This estimator allows the use of conditions of additional moments in relation to the original estimator of Arellano and Bond (1991), in order to correct the problem of weak instruments. Similar estimation strategy was adopted by Athanasoglou et al. (2008), Garcia- Herrero et al. (2009), Delis and Kouretas (2011), and Dietrich et al. (2014).

In order to identify the determinants of the NSFR for Brazilian banks, the following econometric specification was estimated:

$$\ln(NSFR_{it}) = \gamma \ln\left(NSFR_{i,t-1}\right) + \sum_{j=1}^{J} \beta_j X_{it}^{j} + \sum_{m=1}^{M} \varphi_m Z_{it}^{m} + \beta_4 D_t + \alpha + \nu_i + \varepsilon_{it} \quad (2)$$

where $NSFR_{it}$ represents the structural liquidity indicator (NSFR) of bank i at time t, as defined in section 2 of this paper; X_{it}^{j} is a vector of variables that characterizes each bank; Z_{it}^{m} is a vector of variables that capture the macroeconomic conditions of the country; D_t is a time dummy variable used to control potential effects of economic changes; ν_i represents the non-observable individual factors; and ε_{it} is the error term that, by hypothesis, is identically and independently distributed with zero mean and constant variance [$\varepsilon_{i,t} \sim \text{IID}(0, \sigma_\varepsilon^2)$].

To control for the effects of the economic environment conditions, the following variables were used: (1) prevailing domestic policy rate – Selic[16] - at the end of the quarter; (2) volatility of the benchmark rate for existing swaps[17] at the end of the quarter. With this, we expected to capture the process of adjustments in the interest rate expectations; and (3) real growth of gross domestic product at market prices (GDP) [18],

[16] Selic rate - Over - (% p.m.) – Central Bank of Brazil, Bulletin, Financial and Capital Markets Section (BCB Bulletin/M. Finan.) - BM12_TJOVER12.
[17] Benchmark rate – Fixed-rate Swaps - 180 days – average of the period - (% p.a.) – Foreign Exchange Clearinghouse (BM&FBovespa) - BMF12_SWAPDI18012.
[18] GDP – Market prices – quarterly real variation - ref. 2010 - (%) – Brazilian Institute of Geography and Statistics (IBGE), System of National Accounts – 2010 Reference - (IBGE/SCN 2010 Quarterly) - SCN104_PIBPMG104.

in order to assess the effects of business cycles in the process of adjustments in the level of banks' structural liquidity.

To capture bank-specific characteristics, we used the following indicators: (1) Probability of Default (PD); (2) Cost of Funding (CP), represented by the average funding rate of interest-bearing liabilities; (3) Growth Rate of Assets; (4) Size, measured by the logarithm of adjusted total assets; (5); Capital Ratio; (6) Financial Intermediation Margin, which represents the ratio between the financial intermediation income and total operating income of the institution; (7) Adjusted Return on Average Assets (ROAA). The latter performance indicator is the ratio between the cumulative balance of operating income and the average adjusted total assets of the last six months from the reporting date, taking into consideration the following adjustments: prepaid expenses; securities available for sale; and cash flow hedge.

The following variables were used to control the financial institutions by ownership type and by predominantly explored economic activity: (1) State-owned; (2) Foreign owned; (3) Wholesale banks; and (4) Investment banks.

The proposed estimator of Arellano and Bover (1995) and of Blundell and Bond (1998) requires stationary data to produce accurate estimates. To verify this condition, we performed the unit root tests proposed by Levin et al. (2002), Im et al. (2003) and Maddala and Wu (1999), which are abbreviated as LLC, IPS and Fisher, respectively. At the 5% level of significance, the hypothesis that the panel series have a unit root is rejected. The results are shown in Table 5. Additional details about these tests can be found in the annex.

Table 5. Unit root tests for a panel of financial conglomerates

Variable	LLC			IPS			Fisher		
	t-valor	TD	Lag	t-valor	TD	Lag	t-valor	TD	Lag
NSFR	-5.4***	0	0	-5.2***	0	0	-6.4***	0	0
GDP	-19.1***	1	1	-6.0***	1	0	-4.7***	1	0
Selic rate	-18.7***	1	1	-16.8***	1	1	-19.8***	1	0
Swaps	-23.1***	1	1	-13.4***	1	0	-8.2***	1	0
Probility of Default	-7.6***	1	1	-4.8***	1	0	-8.2***	1	0
Cost of Funding	-15.1***	0	1	-8.9***	1	0	-4.1***	1	0
Growth of Assets	-5.2***	1	3	-4.6**	1	2	-5.6***	1	2
Regulatory Capital	-13.3***	1	2	-6.2***	1	0	-4.3***	1	4
Intermadiation Margin	-8.6***	1	2	-8.3***	1	0	-5.8***	1	4
Adjusted ROAA	-5.0***	1	0	-13.3***	1	0	-8.3***	1	4

Note: * p < 0.10; ** p < 0.05; *** p < 0.01.

4. Results

Equation 2 was estimated using the Generalized Method of Moments (GMM) system in one stage of Blundell and Bond (1998). The set of instruments used in the estimation process consists of the first lagged differences of the series considered in each model specification, on the level equations; and the lagged levels of these series, on the equations in first difference.

In the determination of the number of lags of instrumental variables, we worked around the following problems: (1) avoid correlation with the error term; (2) control the excessive use of available instruments. Accordingly, the matrix of instruments was collapsed, so that only the second, third and fourth lags of the regressors were used as instrumental variables.

The Hansen's overidentification test showed no correlation between the instruments used and the error term of the regression. In all specifications of the estimated model the null hypothesis is not rejected, which ensures the validity of the instruments used.

The Arellano and Bond (1991) autocorrelation test of residuals indicates that there is first-order autocorrelation and rejects the hypothesis of second order autocorrelation for the equations in first difference in all specifications estimated at a significance level of 5%. Therefore, the following hypotheses are fulfilled: 1) non-correlation of lags (above the second) of regressors in level with the first-difference of the errors; 2) non-correlation of the first-differences of the regressors with the error in level.

Table 6 shows the results from three model specifications. The specification (1) is an autoregressive process of order 1, for the entire sample, including controls for bank-specific factors that do not vary over time, such as ownership type and economic activity predominantly explored by the financial institution. The specification (2) adds macroeconomic variables as regressors, while the specification (3) extends the model through the inclusion of bank's microeconomic variables.

It is worth noting that the value of the autoregressive coefficient in specification (3), which includes a broader set of information, indicates that the cost of adjusting the structural liquidity indicator (NSFR) of the Brazilian banks can be classified as relatively moderate. This means that, on average, an aggregate shock would have 99% of its initial impact dispelled in only seven quarters.

Tighter monetary policy has unfavorable effects on the structural liquidity of banks. This can be associated with both increases in funding costs and the adjustment process of the financial margins. The results show a negative and significant correlation between the increase in interest rates and the NSFR. The elasticity of the NSFR was estimated at 0.32 percentage point for each 1 percentage point increase in the Selic rate. The reference rate swaps also has a negative association with the NSFR, with an estimated elasticity of 0.05 percentage point for every 1 percentage point in the volatility of such rate.

In the examined period, the structural liquidity indicator (NSFR) presents itself counter-cyclical. This can be explained because during periods of economic growth there is an increase in investment opportunities, causing banks to increase the search for additional yields in the maturity transformation process (for example, raising the share of risky and less liquid assets in their portfolio). Dietrich et al (2014) found a similar result in a study applied to Western European banks. Thus, the NSFR acts limiting the structural maturity mismatch of banks in times of economic expansion, moments in which optimism can lead to excessive risk taking.

Table 6. Regression results of the determinants of the NSFR for the Brazilian banking industry, in the period between 2008-2014

Explanatory Variables	(1)	(2)	(3)
$NSFR_{(t-1)}$	0.5206***	0.5220***	0.5263***
	(0.0909)	(0.0107)	(0.0145)
Selic		-0.3680***	-0.4352***
		(0.0983)	(0.0971)
Swap		-0.0567***	-0.0687***
		(0.0261)	(0.0262)
GDP		-0.0102***	-0.0120***
		(0.0037)	(0.0036)
Probability of Default			0.5800***
			(0.1457)
Funding Cost			-0.0120***
			(0.0099)
Growth $Assets_{(t-1)}$			-0.1389***
			(0.0380)
Size (ln assets)			-0.3509***
			(0.0243)
Capital Ratio			0.0310**
			(0.0123)
Financial Margin			-0.9666***
			(0.1944)
Adjusted ROAA			0.0141***
			(0.0035)
State-owned Banks	0.2323	0.5455	7.2394***
	(1.0554)	(1.0644)	(1.0520)
Foreign owned Banks	1.7759***	1.7658***	1.3422***
	(0.1071)	(0.1074)	(0.1041)
Wholesale Banks	0.2174***	0.2186***	0.1568***
	(0.0450)	(0.0749)	(0.0801)
Investment Banks	0.0240	0.0360	0.2281***
	(0.0863)	(0.0862)	(0.0848)
Constant	0.2857***	0.2754***	2.4361***
	(0.0746)	(0.1669)	(0.2942)
Time dummy	Sim	Sim	Sim
Seasonal dummy	Sim	Sim	Sim
Fixed effects	Sim	Sim	Sim
Order 2 Abond	0.2167	0.2124	0.3100
Sargan (p-value)	0.2454	0.2296	0.3008
Wald test (p-value)	0.0000	0.0000	0.0000
Number of samples	3,447	3,447	3,447

Note: $* p < 0.10$; $** p < 0.05$; $*** p < 0.01$. Standard deviation in parentheses. The specification (1) is an autoregressive model of the NSFR, with the inclusion of control variables by bank category. The specification (2) includes macroeconomic variables, while the specification (3) is an extended version of the model with the inclusion of microeconomic variables within the banking firm.

The probability of default (PD) increases with the level of NSFR, which also occurs in relation to the capital ratio. This result seems to indicate signaling strategies, through which institutions perceived as riskier need to maintain a superior level of liquidity and capitalization to ensure the confidence of their creditors.

Higher rates of asset growth negatively impact the level of banks' NSFR. This suggests the hypothesis that banks tend to finance rapid growth through less stable sources of funding.

With respect to size, larger banks have lower NSFR. Larger institutions tend to benefit from the "too big to fail" status and from the "flight to quality" effects. By itself, these conditions reduce the liquidity risk of these institutions, which can also attract funding more quickly due to the scale of their operations. So, large banks would not need to maintain high levels of liquidity because they have more ways to adjust it to the necessary levels.

The financial intermediation margin, that is, the relative importance of income from financial intermediation in the composition of the banks' operating revenues, proved to be negatively correlated to the NSFR. Thus, the higher the relevance of the financial intermediation result to the bank, the lower its NSFR level. This result is consistent with the objective of the NSFR to limit excesses in the financial intermediation process. This occurs because the calibration of the NSFR ratio tends to be more restrictive for institutions that are mainly focused on financial intermediation in relation to other types of activities, such as the provision of services.

In normal yield curve situations (the longer the term, the more the interest), the trade-off between stability of long-term funding (usually more expensive and more stable) and financial results is expected. Therefore, the expectation was that higher NSFR levels would increase borrowing costs. Interestingly, however, is that funding costs have proven to be inversely related to the NSFR level. That is, operating with greater structural liquidity does not necessarily mean higher costs of funding.

It is also worth noting that the overall profitability, as measured by adjusted ROAA, was positively correlated with the level of the NSFR. Bearing in mind that the NSFR aims to reduce excesses in the maturity transformation process, considered positively correlated with banks' profitability (the higher the maturity transformation, the greater the profitability), we were expecting a negative correlation between the NSFR and the banks' profitability. There are, therefore, offsetting effects, such as increased operational efficiency, which neutralize the possible negative impacts of the NSFR on the profitability of banks.

5. Conclusion

In this study, our goal was to identify the main determinant factors of the NSFR and assess the possible impacts of its introduction as a minimum requirement in the Brazilian banking system. Accordingly, we constructed an NSFR proxy to measure the structural liquidity of Brazilian banks during the period of 2008-2014, following the guidelines of the Basel III for the NSFR. This measure incorporates a broad set of financial, accounting and supervisory data maintained by the BCB, needed for the calculation of the NSFR.

Empirical evidence suggests that the adoption of the NSFR as an operational limit, in a complementary manner to the limits of capital and leverage, would contribute to mitigate excessive growth of banking operations during the phase of economic growth. This result corroborates the study of Dietrich et al. (2014), for banks in Western Europe, that also found that the NSFR is marginally countercyclical.

During the study period (2008-2014), on average, 24.25% of banks would not be compliant if there was a minimum limit in place for the NSFR equal to one. At the end of 2014, 21.37% of banks considered in the sample would not be compliant if there was such a limit, though half of these entities are only marginally below that limit. However, 6% of the banks, all of them non-large, presented an NSFR below 0.80, which could give rise to a greater effort of financial structure reorganization.

The good news, however, lies in the fact that the liquidity adjustment cost for banks in the first quartile (NSFR < 0.875) is relatively small. On average, these banks would need only four quarters to adjust for changes in the regulatory environment. This

process could involve a higher cost course of action, represented by an increase in capital, or a reorientation of the business plan. Alternatively, banks could opt for a combination of a lower volume of illiquid assets in their portfolio and a modification of their funding profile[19].

In addition, the results do not indicate that the NSFR has a negative impact on the banks' profitability, as measured by the adjusted ROAA. This suggests a compatibility between lower structural liquidity risk and higher profitability in the long run.

The introduction of the NSFR requirement can change the risk acceptance policy of the banking firm, affecting the stability of the financial system. Also important is to examine how the banks' liquidity components behave in economic cycles and the potential unintended consequences due to this new minimum liquidity requirement. The empirical verification of these issues is left as a research suggestion.

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[19] According to King (2013), the most cost effective strategies to meet the NSFR are to increase holdings of higher-rated securities and to extend the maturity of wholesale funding.

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Table 7. Regression results of the determinants of the NSFR (quartile 75), for the Brazilian banking industry, in the period between 2008-2014

Explanatory Variables	(4)	(5)	(6)
$NSFR_{(t-1)}$	0.5227***	0.5232***	0.5700***
	(0.0244)	(0.0244)	(0.0350)
Selic		-0.7140*	-0.6664*
		(0.3702)	(0.3786)
Swap		-0.2100**	-0.2307**
		(0.0996)	(0.1018)
GDP		-0.0165	-0.0133
		(0.0149)	(0.0152)
Probability of Default			0.9204
			(0.6990)
Funding Costs			-0.0799***
			(0.0252)
Growth of $Assets_{(t-1)}$			-0.0795*
			(0.1326)
Size (ln assets)			-0.3105***
			(0.0819)
Regulatory Capital			0.0568
			(0.0499)
Financial Margin			-0.4736
			(0.9419)
Adjusted ROAA			0.0137
			(0.0118)
State-owned Banks	2.9345	2.4830	10.0939**
	(4.1294)	(4.1489)	(4.4266)
Foreign owned Banks	1.3070***	1.3220***	1.4719***
	(0.2432)	(0.2444)	(0.2788)
Wholesale Banks	-0.1220	0.1404	0.6592**
	(0.2317)	(0.2324)	(0.2927)
Investment Banks	0.2340	0.2599	0.1469
	(0.2492)	(0.2491)	(0.2650)
Constant	0.7485**	1.8844***	2.5133**
	(0.3006)	(0.6571)	(1.0884)
Time Dummy	Sim	Sim	Sim
Seasonal dummy	Sim	Sim	Sim
Fixed effects	Sim	Sim	Sim
Order 2 Abond	0.2973	0.2934	0.4723
Sargan (p-value)	0.5452	0.5387	0.3409
Wald test (p-value)	0.0000	0.0000	0.0000
Number of samples	819	819	819

Note: $* p < 0.10$; $** p < 0.05$; $*** p < 0.01$. Standard deviation in parentheses. The specification (1) is an autoregressive model of the NSFR, with the inclusion of control variables by bank category. The specification (2) includes macroeconomic variables, while the specification (3) is an extended version of the model with the inclusion of microeconomic variables within the banking firm.

Table 8. Regression results of the determinants of the NSFR (quartile 25), for the Brazilian banking industry, in the period between 2008-2014

Explanatory Variables	(7)	(8)	(9)
$NSFR_{(t-1)}$	0,4182***	0,4321***	0,3878***
	(0,0389)	(0,0392)	(0,0426)
Selic		-0,1701*	-0,1138
		(0,0992)	(0,0985)
Swap		-0,0467**	-0,0070
		(0,0246)	(0,0262)
GDP		-0,0099***	-0,0093***
		(0,0030)	(0,0029)
Probability of Default			0,1046
			(0,1105)
Funding Costs			0,0119
			(0,0076)
Growth of $Assets_{(t-1)}$			0,0957***
			(0,0316)
Size (ln assets)			-0,0147
			(0,0129)
Regulatory Capital			-0,0322***
			(0,0115)
Financial Margin			0,0657
			(0,0997)
Adjusted ROAA			0,0087***
			(0,0026)
Foreign owned Banks	0,0699	0,0559*	0,1264**
	(0,0480)	(0,0484)	(0,0543)
Wholesale Banks	0,0680	0,0734	0,0726
	(0,0573)	(0,0531)	(0,0557)
Investment Banks	-0,0258	0,0288	-0,0731
	(0,0537)	(0,0534)	(0,0541)
Constants	0,3092***	0,6628***	1,1345***
	(0,0572)	(0,1630)	(0,2245)
Time Dummy	Sim	Sim	Sim
Seasonal dummy	Sim	Sim	Sim
Fixed effects	Sim	Sim	Sim
Order 2 Abond	0,2078	0,1125	0,0628
Sargan (p-value)	0,5607	0,6005	0,7240
Wald test (p-value)	0,0000	0,0000	0,0000
Number of samples	844	844	844

Note: $* p < 0.10$; $** p < 0.05$; $*** p < 0.01$. Standard deviation in parentheses. The specification (1) is an autoregressive model of the NSFR, with the inclusion of control variables by bank category. The specification (2) includes macroeconomic variables, while the specification (3) is an extended version of the model with the inclusion of microeconomic variables within the banking firm.

Annex

As explained, the proposed estimator of Arellano and Bover (1995) and of Blundell and Bond (1998) requires stationary data to produce consistent estimates. To verify this condition, we performed the unit root tests proposed by Levin et al. (2002), Im et al. (2003), and Maddala and Wu (1999). These tests are abbreviated as LLC, IPS and Fisher, respectively.

The LLC test assumes that there is independence between the individuals who compose the panel. The null hypothesis is that each series individually is non-stationary, against the alternative hypothesis that the series are stationary. The test is given by the following equation:

$$\Delta y_{it} = \rho y_{i,t-1} + \sum_{L=1}^{k_i} \theta_{iL} \Delta y_{i,t-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \quad (3)$$

where d_{mt} indicates the vector of deterministic variables and α_{mi} corresponds to the coefficient vector for the model $m = 1, 2$ and 3. Specifically, $d_{1t} = \{\emptyset\}$, $d_{2t} = \{1\}$ and $d_{3t} = \{1, t\}$ represent, respectively, the equation test without the inclusion of deterministic terms, with the inclusion of a constant term and with the inclusion of a drift and a trend. The choice of m e k_i should be made so that ε_{it} do not present a serial autocorrelation.

The implementation of the test is done in three steps. First, we estimate a regression for each cross-section separately in order to identify the optimal number of lags. For a given T, a $k_{máx}$ is chosen and then we examine through the t statistic if a lower lag order is more appropriate. Once set the k_i, we regress Δy_{it} on $\Delta y_{i,t-L}$ and d_{mt} in order to obtain $\hat{e}_{it}$; and regress y_{it-1} on $\Delta y_{i,t-L}$ and d_{mt} to obtain $\hat{v}_{it}$, in which $L = 1, \dots, k_i$. To control for heterogeneity among individuals, these errors should be normalized. The second step is to estimate the long-term variance under the unit root null hypothesis. This statistic is used to calculate the adjusted t statistic of the unit root test equation. In the last step we regress $\tilde{e}_{it} = \rho \tilde{v}_{it} + \tilde{\xi}_{it}$, in which $\tilde{e}_{it}$ and $\tilde{v}_{it}$ are the standardized residuals obtained in the first step and $\tilde{\xi}_{it}$ is a white noise. This last

regression has $N\tilde{T}$observations, in which $\tilde{T} = T - \bar{k} - 1$ and $\bar{k} = \sum_{i=1}^{N} k_i/N$. The statistic test for the null hypothesis H_0: $\rho = 0$ is given by $t_\sigma = \hat{\rho}/\sigma(\hat{\rho})$.

The IPS test is less restrictive because it allows heterogeneity in the autoregressive parameter of first order under the alternative hypothesis. The null hypothesis of the test is that all series is non-stationary, that is, H_0: $\rho_i = 0$ for all i. The alternative hypothesis allows for the existence of unit root for some (but not all) individuals of the panel:

$$H_1: \ \rho_i < 0 \text{ for } i = 1, 2, \ldots N_1; \text{ e } \rho_i = 0 \text{ for } i = N_1 + 1, \ldots N \tag{4}$$

the fraction of the individuals series that is stationary should not be zero, that is, $\lim_{N\to\infty}(N_1/N) = \delta$, in which $0 < \delta \leq 1$. The test is given by the equation:

$$\Delta y_{it} = \alpha_i + \rho_i y_{i,t-1} + \sum_{L=1}^{k_i} \theta_{iL} \Delta y_{i,t-L} + \varepsilon_{it} \tag{5}$$

The statistical t-bar of the IPS test is defined as the average of individual augmented Dickey-Fuller tests (ADF).

The Fisher test is a multivariate version of the Dickey-Fuller and Phillips-Perron tests proposed by Maddala and Wu (1999). This test consists of making N unit root tests for each individual panel. The test statistic is given by $P_\lambda = -2\sum \ln(p_i)$, and p_i is the p- value for each individual panel. P_λ has χ^2 distribution with 2N degrees of freedom. The null hypothesis and the alternative hypothesis are the same considered for IPS test. The test equation may include deterministic terms and lagged terms in the specification and should be determined so as to produce uncorrelated residuals. Fisher's unit root test can be applied also to unbalanced panel.

Choi (2001 apud Baltagi, 2008) proposed the following statistic for the Fischer test:

$$Z = \frac{1}{\sqrt{T}} \sum_{i=1}^{T} \Phi^{-1}(p_i) \tag{6}$$

where Φ is the normal cumulative distribution function. As $0 \leq p_i \leq 1$, then $\Phi^{-1}(p_i)$ follows the standard normal probability distribution $N(0, 1)$. The author showed that when T goes to infinity, Z converges to $N(0, 1)$.

The cases of serial correlation presence in the residuals were treated with the inclusion of augmented terms in the unit root test equation. To define the maximum number of lags, we used the rule $L_{max} = T^{1/4} + 2$, as recommended by Hayashi (2000) for small samples, in which $T = 28$ is the number of time periods of the panel.

Thus, $L_{max} = 4$ was determined as the maximum number of lags in the test equation of each country. The choice of k_i in each individual equation was defined by using the Schwarz information criterion. For the purposes of completing the LLC test, the estimation of the long-term variance was performed based on the kernel method of Bartlett, while the selection of the bandwidth follows the Newey-West method.