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ΤΙΤΛΟΣ ΔΙΔΑΚΤΟΡΙΚΗΣ ΔΙΑΤΡΙΒΗΣ: DEBT, FINANCIAL INSTITUTIONS AND INSTABILITY

ΟΝΟΜΑΤΕΠΩΝΥΜΟ: ΜΑΡΙΑ ΝΙΚΟΛΑΪΔΗ

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ΔΡΑΣΤΗΡΙΟΤΗΤΑ: BANK LIQUIDITY AND MACROECONOMIC FRAGILITY: EMPIRICAL EVIDENCE FOR THE EMU

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Bank liquidity and macroeconomic fragility: Empirical evidence for the EMU

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Abstract: The supervision of bank liquidity has been one of the core topics in the recently developed regulatory framework of banks (Basel III). This paper investigates two issues that have not been addressed in Basel III and which are of particular importance for the attainment of a more effective liquidity regulation. The first is the need for a dynamic definition of liquidity that takes into account the time-varying liquidity and stability of banks' balance sheet items. The paper develops a new liquidity ratio that explicitly considers this changing nature of liquidity, by assigning weights that depend on financial risks and perceptions. The ratio is estimated and assessed for the EMU-12 countries. The second issue is the need for macro fragility-related liquidity requirements. We provide empirical evidence which suggests that the banking sector does not self-impose such requirements. Based on this evidence, it is argued that the regulatory agents should introduce a positive link between bank liquidity and macroeconomic fragility.

Key words: Banks; liquidity; macroeconomic fragility

JEL classifications: E44; G21; G28

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1. Introduction

The imprudent management of bank liquidity has been one of the core factors that contributed to the 2007-8 financial distress. When the crisis unfolded, various banks exhibited a fragile liquidity position by having a high exposure to short-term funding, even though their capital buffers were at a sufficient level (see e.g. BCBS, 2010a; Ayadi *et al*., 2012; Bonfim and Kim, 2012). The reversal in the liquidity of the interbank market induced them to resort to the fire-sale of assets, transforming their illiquidity problems into insolvency ones. The overall result was the destabilisation of the financial system and the macroeconomy.

These crisis developments have induced important changes in the regulatory framework of banks. Basel III has introduced two liquidity indices, with the aim to better supervise the liquidity of the financial system (see BCBS, 2010a). By imposing certain minimum limits in these indices, the new regulatory framework intends to contribute to the monitoring of both the short-term and the medium- to long-term liquidity of banks.

Even though the explicit consideration of liquidity measures in Basel III is an important step towards a more effective supervision of the banking sector, there are still many issues that remain to be addressed in the field of liquidity regulation. This paper focuses on two of them. The first is the need for a more dynamic definition of liquidity. In the current regulatory framework the weights assigned to banks' assets and liabilities are predetermined and do not adjust according to the conditions in the related financial markets. This is quite problematic since the liquidity and the stability of a balance sheet item is likely to be time-varying as a result of changes in risk perceptions and financial conditions (see e.g. Ayadi *et al*., 2012). A characteristic example is the liquidity of the government bonds. In Basel III government bonds are assigned a static weight equal to 0.05. This implies that in the aftermath of the EMU sovereign crisis all government bonds continue to be treated as highly liquid, despite the substantial deterioration in their liquidity profile. To address the issue of time-varying liquidity this paper puts forward a dynamic liquidity ratio in which the weights of the balance sheet items adjust to their time specific liquidity and stability properties. The suggested ratio is applied to EMU-12 economies and is compared with the static ratio introduced by Basel III.

The second issue refers to the link between bank liquidity and macroeconomic risk. In Basel III, the minimum liquidity requirements are invariant to the fragility of the macro system. From the macroprudential point of view this is problematic: higher (lower) perceived macro risk should be accompanied by a higher (lower) bank liquidity. The reason is twofold. First, higher liquidity requirements in periods of increasing macro fragility restrict banks' liquidity creation; the latter tends to rise in periods of financial euphoria amplifying instability trends.[1] Second, a more liquid banking sector can more adequately absorb the shocks that may stem from a more fragile macroeconomy. In this paper we provide econometric evidence which shows that in most EMU countries the bank liquidity does not increase when the macroeconomic fragility becomes higher. This calls for the imposition of macro fragility-related minimum liquidity requirements.

The paper is organised as follows. Section 2 develops our dynamic liquidity ratio and applies it to EMU-12 countries. Section 3 presents the econometric evidence for the link between bank liquidity and macroeconomic risk. Section 4 concludes and sets out the policy implications of the analysis.

2. The Dynamic Net Stable Funding Ratio: Definition and application

2.1 Definition

The liquidity of a bank expresses its ability to meet contractual liability obligations and to fund asset positions without significant cost.[2] This ability depends positively on (a) the degree of liquidity of its assets and (b) the proportion of stable liabilities in total liabilities. An asset is perceived to be more liquid when it has a low credit and market risk. The credit risk is related with the possibility of borrower's default; a

[1] There is evidence that bank liquidity follows a counter-cyclical pattern, being excessively low when the economy expands and excessively high when the economy shrinks (see Aspachs *et al*., 2004; Acharya *et al*., 2011).

[2] For a detailed definition of the concept of liquidity and its macroeconomic implications see e.g. Minsky (1986), Davidson (2002), BCBS (2008, 2010a) and Nikolaou (2009).

default can lead to the loss of expected inflows that come from loan repayments and interest income. The market risk is associated with the possibility that an asset will be liquidated at an unfavourable price in the related market. A liability is conceived to be stable when it provides a long-term funding and it is not expected to be liquidated by banks' borrowers in financial distress conditions. Overall, the higher the amount of stable liabilities relative to the amount of less liquid assets the better the liquidity position of a bank.

In line with this general framework, in Basel III the liquidity position of banks in the medium to long term is captured by the Net Stable Funding Ratio (*NSFR*), which is given by the ratio of the Available amount of Stable Funding (*ASF*) to the Required amount of Stable Funding (*RSF*). The ratio is written as:

$$NSFR_t = \frac{ASF_t}{RSF_t} = \frac{\sum sw_j \cdot SL_{jt}}{\sum sw_i \cdot SA_{it}} \tag{1}$$

where sw_j is the static weight of liability *j*, sw_i is the static weight of asset i , SL_{jt} is the stock of liability *j* in time *t* and SA_{it} is the stock of asset *i* in time *t*. According to formula (1), the *ASF* is defined as the weighted sum of the stock of liabilities that are deemed stable. The greater the weight assigned to a liability the more stable this liability is conceived. The *RSF* is calculated as the weighted sum of the stock of assets that are less liquid and must be supported with stable funding. The greater the weight applied to an asset the more this asset needs to be supported with stable funding. Given that holding more stable liabilities relative to illiquid assets improves the medium- to long-term liquidity of banks, a higher *NSFR* is desirable.

Table 1 shows how *NSFR* is estimated in this paper. The static weight of each asset and liability is calculated following broadly the approach of BCBS (2010a). Since this ratio is going to be applied to EMU countries, the assets and the liabilities have been categorised according to the classification of balance sheet data provided by the European Central Bank (ECB); see Appendix A for the detailed aggregated balance sheet of euro area monetary financial institutions (MFIs).

On the liability side, capital and reserves are deemed more stable and thereby a weight equal to 1 is assumed. Moreover, deposits with agreed maturity and debt securities issued for longer than one year are classified as equally stable. Deposits of monetary financial institutions, deposits of central government, external liabilities and overnight deposits are regarded less stable than the other deposits. Hence, the former are assigned a weight of 0.8 while the latter are assigned a weight of 0.9. All the other liabilities are given a zero weight. On the asset side, securities other than shares issued by the government in the euro area constitute the most liquid asset, after cash and loans to monetary financial institutions, with a weight equal to 0.05. Loans are classified according to their type. We consider loans for house purchase as more liquid since they are backed by collateral, assigning a weight of 0.65. For other loans to households, for loans to non-financial corporations and for external assets, which tend to be less liquid, a higher weight equal to 0.85 is assigned. The rest of the assets have a weight equal to 1.

Table 1: Balance sheets weighting used to calculate the *NSFR*

Available amount of Stable Funding (*ASF*)		
Basel III category	**Liability**	**Weight**
Tier 1 and 2 capital instruments	Capital and reserves	1
Other liabilities with an effective maturity of one year or greater	Deposits with agreed maturity greater than 1 year	1
	Debt securities issued for longer than 1 year	1
Stable deposits with residual maturity less than a year	Deposits with agreed maturity up to 1 year	0.9
	Deposits redeemable at notice	0.9
	Repurchase agreements	0.9
Less stable deposits with residual maturity less than a year	Overnight deposits	0.8
	Deposits of monetary financial institutions	0.8
	Deposits of the central government	0.8
	External liabilities	0.8
All other liabilities	All other liabilities	0

Required amount of Stable Funding (*RSF*)		
Basel III category	**Asset**	**Weight**
Cash	-	0
Loans to MFIs (e.g. interbank)	Loans to monetary financial institutions	0
Sovereign securities	Holdings of securities other than shares issued by general government in the euro area	0.05
Mortgages	Lending for house purchase	0.65
Retail loans	Loans to non-financial corporations	0.85
	Loans to households *excluding* lending for house purchase	0.85
	External assets	0.85
All other assets	All other assets	1

Source: Based on BCBS (2010a)

One important feature of *NSFR* is that the weights of balance sheet items are static. This is quite problematic since in the real world financial system the liquidity of assets and the stability of liabilities change continuously due to time-varying market conditions, financial perceptions and perceived risks. For example, as Minsky (1986) has pointed out, in tranquil years economic agents' required margins of safety become lower due to the widespread euphoria; hence, the credit and the market risk are perceived to be low (see also Kregel, 1997). The opposite holds in a period that follows a financial episode in which the perceived risks are high and the stability of banks' liabilities declines, due to the generalised increase in economic agents' liquidity preference. Attention should also be drawn to the fact that a market can rapidly turn from a liquid into an illiquid one if, for some reason, many investors try to liquidate their assets at the same time. This is a common feature of financial distress situations.

This dynamic nature of financial markets and financial behaviours brings forward the need for a more dynamic definition of liquidity. In this paper this is done by allowing the balance sheet weights in *NSFR* to be a function of the interest rates that correspond to the assets and liabilities under investigation. On the asset side, the interest rates can be used as proxies for the perceived credit and market risk. A higher interest rate is broadly associated with a higher risk premium and, thus, with less liquid assets. On the liability side, a high interest rate implies that banks' lenders are not very willing to provide the required funding. Hence, they are more prone to withdraw their liabilities in a stress event.

In the estimation of the dynamic balance sheet weights the interest rates are compared with a benchmark interest rate. The benchmark interest rate expresses the interest rate that corresponds to the safest and most liquid lending for banks, as this is determined by the monetary policy. The higher the spread between the interest rate of an asset and the benchmark interest rate the less liquid this asset is considered. Furthermore, a high spread between the interest rate of a liability and the benchmark interest rate implies that banks are willing to foregone their profitability in order to obtain funding from this type of liability. Thus, the higher this spread the more banks need to compensate the potential borrowers in order to convince them to become less liquid. This corresponds to cases of less stable funding. In our analysis, the EONIA interest rate has been used as the benchmark interest rate. The EONIA interest rate refers to the interbank lending and is greatly affected by the ECB policy rate.

Adopting this approach, the time-varying weight of asset *i* in time *t* (tw_{it}) is estimated via the following formula:[3]

$$tw_{it} = sw_i + a_i \cdot (r_{it} - rb_{it}) \quad (2)$$

where $a_i \geq 0$ is the responsiveness of the time-varying weight to the interest rate spread of asset *i*; the interest rate spread of asset *i* is defined as the difference between

[3] For simplicity, a linear function has been assumed.

the interest rate of asset i in period t $\left(r_{it}\right)$ and the corresponding benchmark interest rate $\left(rb_{it}\right)$.

Note that $a_i = 0$ when the time-varying weight is not perceived as necessary to be different than the static weight. When the parameter a_i is positive, it is estimated by defining a period maximum value for the time-varying weight:

$$\max(tw_i) = sw_i + d \tag{3}$$

where d is a positive number that is added to the static weight when the dynamic weight takes its maximum value. It holds that:

$$\max(tw_i) = sw_i + a_i \cdot \max(r_i - rb_i) \tag{4}$$

Combining expressions (3) and (4), we get:

$$a_i = \frac{d}{\max(r_i - rb_i)} \tag{5}$$

Following the same logic, the time-varying weight of liability j in time t $\left(tw_{jt}\right)$ is given by:

$$tw_{jt} = sw_j + b_j \cdot (r_{jt} - rb_{jt}) \tag{6}$$

where $b_j \leq 0$ is the responsiveness of the time-varying weight to the interest rate spread of liability j; the interest rate spread of liability j is defined as the difference between the market interest rate of liability j in period t $\left(r_{jt}\right)$ and the corresponding benchmark interest rate $\left(rb_{jt}\right)$. Note that the interest rate spread can be either positive or negative. For instance, in many EMU countries the spread between the deposit interest rates and the EONIA interest rate was negative before the crisis but has become positive after it, as a result of the increasing uncertainty regarding the security of deposit money in the EU banking sector.[4]

The parameter b_j is estimated along the same lines with the parameter a_i. We define a period minimum value:

$$\min(tw_j) = sw_j - e \tag{7}$$

where e is a positive number that is subtracted from the static weight when the dynamic weight takes its minimum value. It holds that:

$$\min(tw_j) = sw_j + b_j \cdot \max(r_j - rb_j) \tag{8}$$

Combining expressions (7) and (8), yields:

$$b_j = \frac{-e}{\max(r_j - rb_j)} \tag{9}$$

The ratio that is based on time-varying balance sheet weights is called Dynamic Net Stable Funding Ratio (*DNSFR*) and is defined as follows:

$$DNSFR_t = \frac{ASF_t}{RSF_t} = \frac{\sum tw_{jt} \cdot SL_{jt}}{\sum tw_{it} \cdot SA_{it}} \tag{10}$$

Table 2 reports the interest rates that have been used for each balance sheet item in the construction of the above ratio. At this point a clarification is in order. The spread between these interest rates and the baseline interest rate should be viewed as a very crude approximation of the time-varying assets' liquidity and liabilities' stability. This spread can be significantly affected by other factors, such as the institutional structures in each country and the financing practices of banks. Moreover, the actual financial risk is also reflected on various macroeconomic factors, such as the

[4] See e.g. ECB (2012b).

unemployment rate of banks' borrowers, the growth rate of the economy, the developments in the housing market etc. However, the advantage of the use of interest rates is that they are available for each balance sheet category and can be easily employed to provide an overall picture of the time-varying liquidity of banks, which is the purpose of our analysis. A more detailed and integrated analysis of bank liquidity can well be the subject of future extension of the present approach.

Table 2: Interest rates used to calculate the balance sheet weighting in *DNSFR*

Available amount of Stable Funding (*ASF*)	
Liability	**Interest rate**
Capital and reserves	-
Deposits with agreed maturity greater than 1 year	Interest rate on deposits with agreed maturity greater than 1 year (to non-financial corporations and households)
Debt securities issued for longer than 1 year	-
Deposits with agreed maturity up to 1 year	Interest rate on deposits with agreed maturity up to 1 year (to non-financial corporations and households)
Deposits redeemable at notice	Interest rate on deposits redeemable at notice (to households)
Repurchase agreements	Interest rate on repurchase agreements (to non-financial corporations and households)
Overnight deposits	Interest rate on overnight deposits (to non-financial corporations and households)
Deposits of monetary financial institutions	Euribor 3 months rate
Deposits of the central government	-
External liabilities	Interest rate on deposits with agreed maturity up to 1 year (to non-financial corporations and households)
All other liabilities	-
Required amount of Stable Funding (*RSF*)	
Asset	**Interest rate**
-	-
Loans to monetary financial institutions	Euribor 3 months rate
Holdings of securities other than shares issued by general government in the euro area	Long-term interest rate for convergence purposes, debt security issued (10 years) for domestic securities
	Euro area 10-year government benchmark bond yield for other than domestic securities
Lending for house purchase	Interest rate for house purchases (to households)
Loans to non-financial corporations	Interest rate on non-financial corporations
Loans to households *excluding* lending for house purchase	Interest on consumer credit and other loans (to households)
External assets	Interest on consumer credit and other loans (to households)
All other assets	-

Notes:
1/ Households include also non-profit institutions serving households (NPISH).
2/ Interest rates on loans and deposits are either annualised agreed rates (AAR) or narrowly defined effective rates (NDER) (see ECB, 2003 for definitions). These interest rates refer to new business indicators.

2.2 Application to EMU-12 countries

In our estimation, aggregated data from the ECB database over the period 2003:01 to 2012:07 have been utilised. The analysis refers to the EMU-12 countries (Belgium, Germany, Ireland, Greece, Spain, France, Italy, Portugal, Finland, the Netherlands, Austria and Luxemburg) for which data are available for a sufficiently long period of time.[5] In the case of government securities on the asset side of banks' balance sheets, we have opted for making a distinction according to the nationality of their issuer: the credit and market risk of these securities is significantly affected by the fiscal position of the country that issues them. For this purpose, the Bruegel database on sovereign bond holding has been employed. This database provides data on the amount of each country's government securities held by the domestic banking sector, allowing us to estimate securities' "home bias". Although these data do not allow us to fully consider the impact of government securities' nationality on the liquidity position of banks, the consideration of the "home bias" permits us to capture, at least partially, some important aspects of this impact.

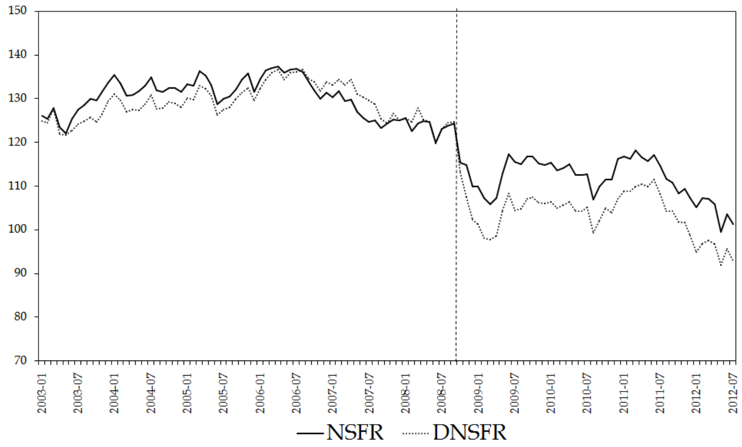
Figure 1 displays the evolution of *NSFR* and *DNSFR* over the period under examination. The vertical dotted line marks the time point in which the collapse of the Lehman Brothers occurred (2008:08). We observe the following: First, in almost all countries *DNSFR* was higher than *NSFR* before the collapse of the Lehman Brothers and lower thereafter.[6] This suggests that the liquidity ratio adopted by Basel III potentially underestimates the liquidity position of banks before the crisis and overestimates it in the after-crisis period. Second, in 7 out of 12 countries (Ireland, Greece, Spain, Italy, Portugal, Austria and Luxembourg) the evolution of liquidity over the last decade seems to be quite different according to the ratio utilised. In particular, while *NSFR* suggests that the bank liquidity in these countries has either remained approximately the same or even improved after the collapse of the Lehman Brothers, *DNSFR* shows a substantial deterioration in liquidity.

[5] The exact data sources of our analysis are reported in Appendix B.

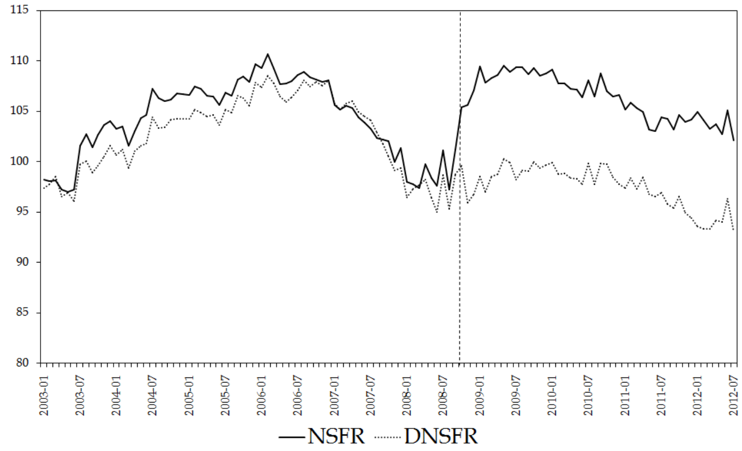
[6] There are only some exceptions in the case of Germany, Ireland, Austria and Luxemburg for which in some time periods before the crisis the *DNSFR* was lower than the *NSFR*.

Figure 1: Net Stable Funding Ratio *(NSFR)* and Dynamic Stable Funding Ratio (*DNSFR*) in percentage points, EMU-12 countries, 2003:01 to 2012:07

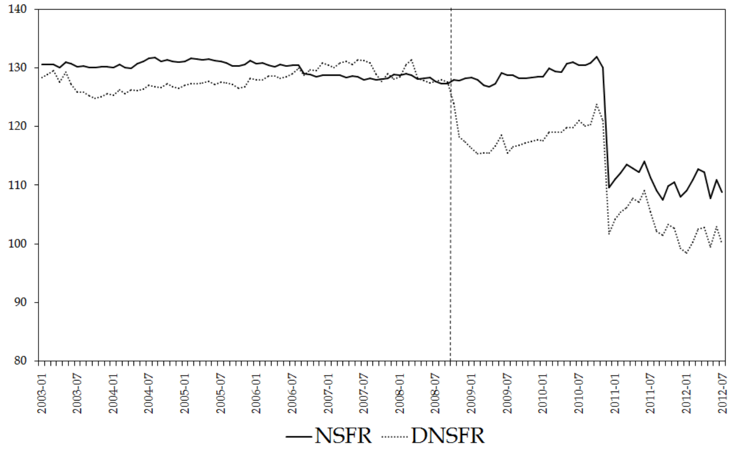
a) Belgium



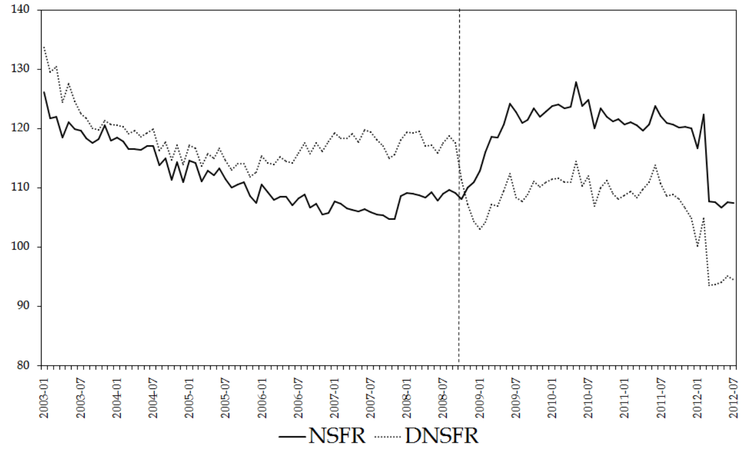
c) Ireland



b) Germany



d) Greece



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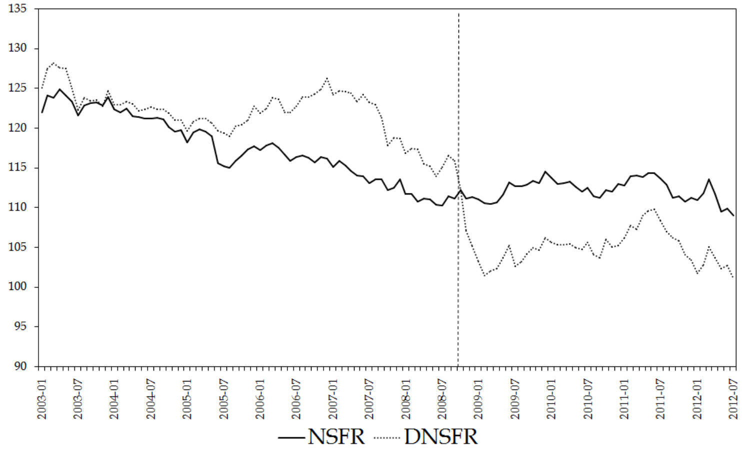
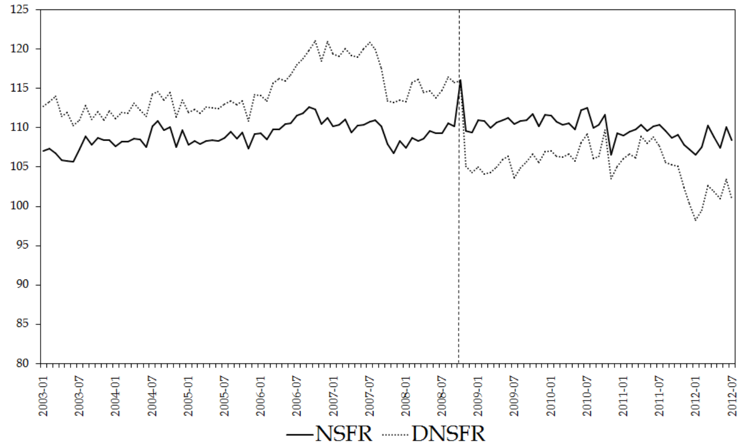
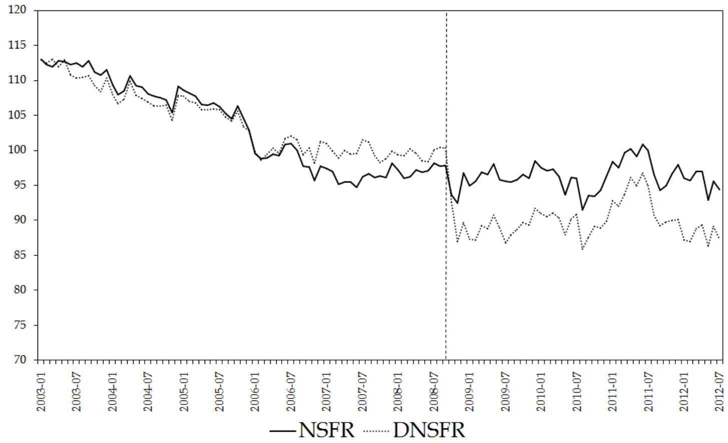
e) Spain



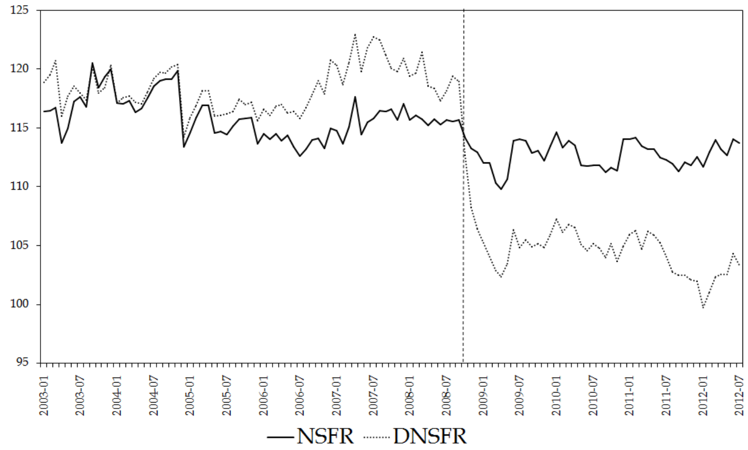
g) Italy



f) France



h) Portugal



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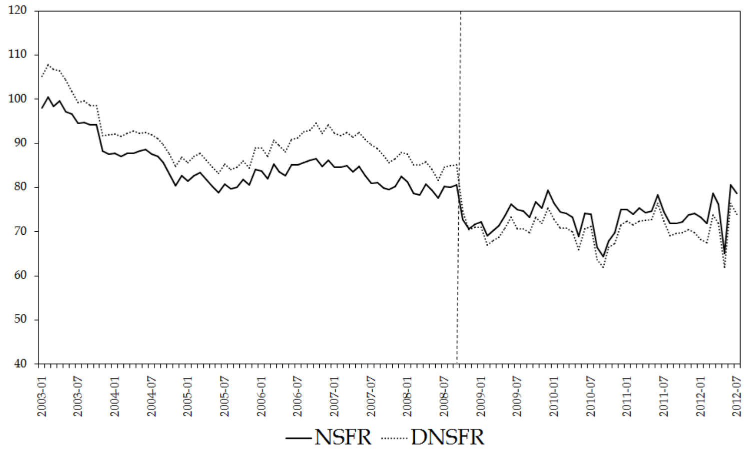
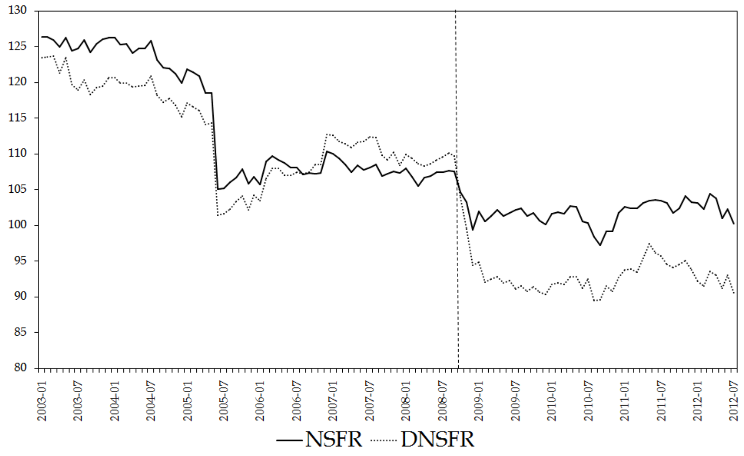
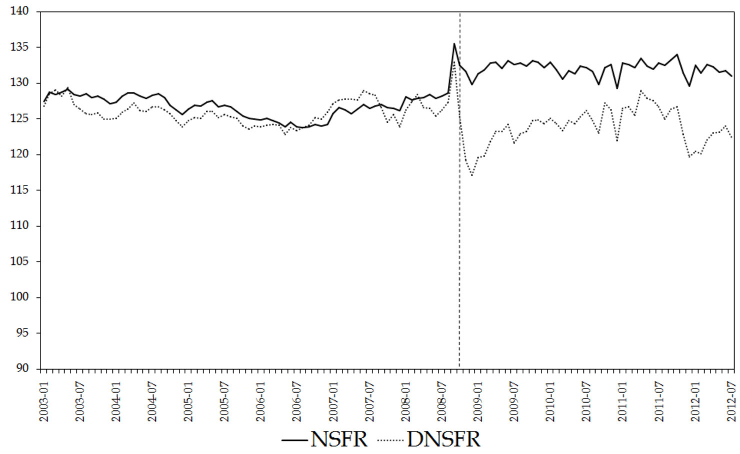
i) Finland



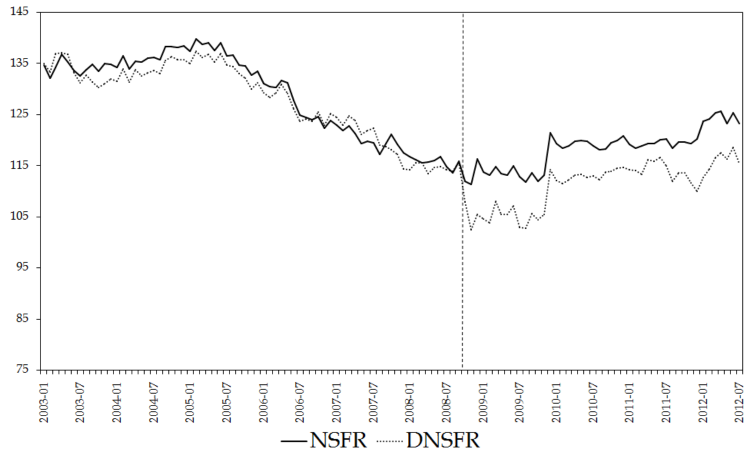
j) Netherlands



k) Austria



l) Luxembourg



The difference between the two indices in the aftermath of the crisis has basically to do with the developments in the government bond market as well as in the deposit market. The crisis has substantially modified the liquidity of bonds that have been issued by countries with fiscal problems. Hence, banks that hold government bonds of these countries have seen a deterioration in their liquidity position. Due to the "home bias" in the holding of government bonds, this implies that the banking sector in Greece, Ireland, Portugal and Spain has most greatly been affected by the distress in the bond market. Furthermore, the crisis has influenced the behaviour of depositors especially in economies in which a banking crisis coexists with a severe fiscal crisis and a generalised uncertainty regarding the macroeconomic prospects. In these economies the interest rate on deposits has increased, reflecting the decline in the stability of deposit liabilities. Again, the countries that have been more importantly been affected by this development are Greece, Ireland, Portugal and Spain. This explains why the highest divergence between the dynamic and the static ratio is reported for the banking sector of these countries.

On the basis of the above estimates, it can be overall argued that the *NSFR* does not successfully gauge the decline in the liquidity of banks that seems to have occurred in various EMU countries as a result of the recent financial distress. By assigning static weighs in banks' balance sheet items, this ratio ignores the changing nature of liquidity, which is particularly important in periods of financial distress. On the contrary, the dynamic liquidity ratio suggested in this paper reflects the effects of financial distress on the liquidity of assets and the stability of liabilities, depicting more accurately the fragility of banks over periods of high volatility and uncertainty, as the current one.

3. The link between bank liquidity and macroeconomic fragility in the EMU: An econometric analysis

In Basel III, the imposed minimum liquidity requirements are invariant to macroeconomic conditions. For example, the minimum *NSFR* is equal to 100% irrespective of the degree of financial fragility in the macroeconomy (see BCBS 2010a). However, from a macroprudential point of view the bank liquidity should, arguably, increase when the macro system seems to be more prone to financial instability. The rational is twofold. First, excessive financial expansion is commonly one of the underlying reasons behind the build-up of financial fragility structures. A rise in bank liquidity (which, practically, implies lower debt expansion for both financial and non-financial corporations) can slow down the financial instability tendencies of the macro system. Second, a more liquid financial system can more successfully absorb the shocks that stem from the real economy. For instance, a better liquidity position allows banks to more successfully face the problems arising from an unexpected rise in the loan default rate of households and firms.

In this section we explore whether the banking sector in EMU countries increases its liquidity when the macro system becomes more fragile. Failure to find a positive link between bank liquidity and macro fragility implies that banks do not self-impose macro fragility-liquidity requirements. This would suggest the need for the regulatory agents in the EMU to impose such requirements in order to decrease the system-wide risk.

In our empirical investigation bank liquidity is captured both by the static and the dynamic liquidity ratio developed in the previous section. Following Tymoigne (2011), the macroeconomic fragility is viewed "as the propensity of financial problems to generate financial instability". In this paper, the macroeconomic fragility is proxied by the credit-to-GDP ratio. Although this measure cannot provide a detailed view of the macroeconomic fragility (see Tymoigne, 2011 for sector-specific indices), it can be used to give an overall picture of some financial instability tendencies. Empirical evidence has shown that the credit-to-GDP ratio can quite successfully signal periods of financial distress (see Drehmann *et al.*, 2010). An additional advantage is that it is available for most of the countries under investigation.[7]

3.1 Econometric methodology

The econometric exploration of the link between bank liquidity and macro fragility is conducted by utilising time-series techniques and making the analysis distinctively for

[7] Note also that credit-to-GDP ratio has been used by Basel III as the main guide for determining the appropriate amount of countercyclical capital buffer (see BCBS, 2010b).

each country with the use of aggregated data for the banking sector.[8] Time-series techniques have been chosen instead of panel data ones for two reasons. First, we wish to avoid the heterogeneity bias which basically stems from the diversification of macroeconomic fragility within the EMU. Second, the purpose of the econometric investigation is to examine how each national banking sector responds to the macroeconomic fragility of its country. Thus, a panel investigation of this issue would not be illuminating for our purposes.

The econometric analysis is conducted by utilising the ARDL-bounds testing procedure, developed by Pesaran and Shin (1999) and Pesaran *et al*. (2001). The main advantage of this approach, relative to the more traditional Johansen (1988) maximum likelihood method, is twofold. First, it allows us to check for cointegration when the variables of the econometric analysis are either I(0) or I(1). On the contrary, Johansen's cointegration technique prerequisites the existence of only I(1) series. As will be shown below, in our sample the possibility of I(0) series cannot be excluded, implying that the ARDL-bounds testing approach is more appropriate. Second, the ARDL-bounds testing procedure is more suitable for small sample data sizes, as our own one. The Johansen method relies on a VAR system of equations and, thus, the degrees of freedom may decline significantly when the size of the sample is small.

The following econometric specification is used:

$$LIQ_t = \gamma_0 + \gamma_1 \cdot CREDIT_t + u_t \tag{11}$$

where *LIQ* is the liquidity ratio (either the *NSFR* or the *DNSFR*, see section 2) and *CREDIT* is the credit-to-GDP ratio obtained from the ECB database. The credit-to-GDP ratio is available on a quarterly basis. For the purposes of our analysis the quarterly data have been transformed to monthly ones, using the cubic-spline function. All variables in the econometric analysis are expressed in percentage points. The analysis refers to the period 2003:01 to 2012:07.[9]

[8] Recent empirical literature has investigated the relationship between banks' liquidity and micro characteristics using micro panel datasets (see e.g. Berger and Bouwman, 2009; Fungacova *et al*., 2010; Distinguin *et al*., 2012; Horvath *et al*., 2012).
[9] For the Netherlands and Luxemburg the data start from 2005:01 while for Austria they start from 2006:01.

Following Pesaran *et al*. (2001), the econometric analysis is conducted in three steps. First, we conduct unit root tests. At this stage it is important to rule out the possibility of I(2) series. We initially apply the Phillips-Perron unit root test. However, the existence of a structural break in our series could reduce the ability of this test to properly identify the order of integration. The financial crisis has potentially caused such a structural break in our series. To examine whether a break could change the order of integration in our series we use the Zivot and Andrews (1992) test with one structural break. This break point is endogenously determined by the data using as a criterion the minimisation of the ADF *t*-test statistic. We estimate two models of the Zivot and Andrews (1992) test: model A with a change in intercept and model C with a change in both intercept and slope. The null hypothesis is that the time series has a unit root without a structural break; the alternative hypothesis suggests that there is a trend stationary series with a structural break.

Second, we estimate an error correction form of function (11) using the OLS estimation technique:

$$\Delta LIQ_t = c_0 + c_1 \cdot LIQ_{t-1} + c_2 \cdot CREDIT_{t-1} + \sum_{i=1}^{p} c_{3p} \cdot \Delta LIQ_{t-i} + \sum_{i=1}^{p} c_{4p} \cdot \Delta CREDIT_{t-i} + e_t \qquad (12)$$

The ARDL-bounds testing procedure requires the estimation of the *F*-test statistic that tests the null hypothesis that $\hat{c}_1 = \hat{c}_2 = 0$, as well as of the *t*-test statistic that checks the null hypothesis that $\hat{c}_1 = 0$. These statistics are then compared with the critical values provided by Pesaran *et al*. (2001). The existence of a long-run relationship between *LIQ* and *CREDIT* requires that the null hypothesis is rejected. If the *t*-test and *F*-test statistics are higher than the upper bound of the respective critical values then the null hypothesis is rejected. If the *t*-test and *F*-test statistics are below the lower bound of the respective critical values then the null hypothesis cannot be rejected and no long-run relationship exists. When the computed *t*-test and *F*-test statistics falls within the bounds of the critical values, it is not possible to arrive at a conclusive decision.

Before estimating equation (12) we need to control for the existence of a possible structural breakpoint. In particular, we test whether such a break exists in September 2008, when Lehman Brothers collapsed.[10] To this end, the Chow test is conducted in which the null hypothesis suggests that no break exists. The rejection of the null hypothesis implies that a dummy variable must be included in equation (12). Additionally, it is essential to choose the optimal lag structure of equation (12). In this procedure, our criterion is the minimisation of the Akaike (AIC) and Schwartz (SBC) Bayesian Information Criteria as well as the existence of no autocorrelation.

Third, if cointegration has been found, we proceed to estimate the optimal ARDL specification which is specified using the AIC. Note, though, that in our analysis we have chosen the ARDL models to be estimated even if no cointegration is found. This allows us to further check that the result of the cointegration analysis is correct. From the estimation of the optimal ARDL we obtain the long-run coefficient for *CREDIT* and the error correction term. Moreover, the estimations are also conducted for the sub-periods 2003:01 to 2008:08 and 2008:09 to 2012:07 to further examine whether the crisis has prompted a change in the relationship between *CREDIT* and *LIQ*.

Overall, the existence of a positive long-run relationship between the liquidity ratios and the credit-to-GDP requires that: (i) the F and t statistics indicate cointegration; (ii) there is a statistically significant long-run coefficient for *CREDIT* and (iii) the (lagged) equilibrium correction term is negative and statistically significant. If any of these conditions is not satisfied for a specific country, then it can be argued that the liquidity of this country's banking sector does not react positively to a rise in the credit-to-GDP ratio, supporting the view for the imposition of macro fragility-related liquidity requirements.

3.2 Results

In Appendix C the results from the Phillips-Perron unit root test are reported. It turns out that the variables are a mixture of I(0) and I(1). When the Zivot and Andrews is used to control for the existence of a structural break (see Appendix D), some of the

[10] ECB (2012b) has reported a break in bank financing patterns in the third quarter of 2008.

I(1) series according to the Phillips-Perron test appear to be I(0) with one structural break. The existence of stationary series in our sample indicates the need for the use of the ARDL-bounds testing approach to cointegration, which is valid for both I(0) and I(1) variables.

Table 3 and Table 4 display the various *F* and *t* statistics for *NSFR* and *DNSFR* respectively, over the whole period of the analysis. The Chow test, presented in Appendix E, indicates the existence of a structural break in most EMU countries. AIC and SBC criteria have been used to determine the appropriate lag order *p* for each country with or without deterministic trend (see Appendix F). In Table 5 and Table 6 the estimation results for the optimal ARDL specification over the whole period and the two sub-periods are presented (both for *NSFR* and *DNSFR*).

Table 3: *F* and *t* statistics for testing the existence of long-run relationship of equation (11) for the dependent variable *NSFR*, EMU-12 countries, 2003:01 to 2012:07

		Without trends			With trends		
	p	t_{III}	F_{II}	F_{III}	t_v	F_{IV}	F_V
BE	3	-3.94[c]	5.20[c]	7.79[c]	-3.20[a]	5.75[c]	7.63[c]
GE	1	-1.14[a]	1.44[a]	1.39[a]	-0.42[a]	1.39[a]	1.98[a]
IR	3	- 2.61[a]	10.33[c]	14.44[c]	-2.22[a]	9.65[c]	6.62[b]
GR	3	-1.71[a]	1.53[a]	1.55[a]	-1.58[a]	7.73[c]	10.35[c]
SP	3	-1.88[a]	2.64[a]	2.26[a]	-2.22[a]	2.50[a]	3.73[a]
FR	2	-2.06[a]	2.19[a]	2.53[a]	-1.98[a]	1.69[a]	2.30[a]
IT	3	-3.00[b]	3.36[a]	5.02[b]	-3.42[b]	4.32[a]	5.86[a]
PT	3	-3.53[c]	12.29[c]	6.23[c]	-3.64[b]	4.41[a]	6.62[b]
FI	1	-3.8[c]	5.94[c]	8.58[c]	-3.76[c]	5.66[c]	7.12[c]
NL	3	-6.04[c]	14.71[c]	21.8[c]	-6.09[c]	14.73[c]	20.85[c]
AT	2	-4.22[c]	6.95[c]	9.39[c]	-4.01[c]	6.67[c]	8.24[c]
LU	3	-0.97[a]	4.29[c]	1.17[a]	-0.82[a]	0.87[a]	0.75[a]

Note: [a] indicates that the statistic lies below the 0.05 lower bound, [b] that it falls within the 0.05 bounds and [c] that the statistic lies above the 0.05 upper value; t_{III} and t_V are the *t*-test statistics for the *t*-tests of Pesaran *et al*. (2001) for cases III and V respectively; F_{II}, F_{III}, F_{IV} and F_V are the *F*-test statistics for the *F*-tests of Pesaran *et al*. (2001) for the cases II, III, IV and V respectively (see Pesaran *et al*., 2001 for the critical values of the *t*-tests and *F*-tests); *p* is the selected lag order for equation (12).

The results presented in Tables 3 and 4 show that when *NSFR* is used as a dependent variable there is evidence in favour of a long-run relationship for Belgium, Portugal, Finland, the Netherlands and Austria. When *DNSFR* is used as a liquidity ratio, cointegration also exists for Spain, France and Italy.

In the case of Belgium and Portugal, the estimation results for the ARDL model illustrate that there is an inverse statistically significant relationship between *NSFR* and the credit-to-GDP ratio. This relationship is not, though, robust for the two sub-periods. For instance, in Belgium the statistical significant coefficient of *CREDIT* is negative for the period 2003:01 to 2008:08, but it turns positive for the period 2008:09 to 2012:07. In France there is also a negative relationship between credit-to-GDP and *DNSFR*, but this is insignificant for the subperiods. For Finland, the Netherlands and Spain no statistically significant effect of *CREDIT* on the liquidity ratios is reported. In the case of Austria a statistically important positive effect of *CREDIT* on *NSFR* turns out to exist for the whole period. The same holds for Italy when *DNSFR* is used as a liquidity ratio, although in the subperiods this effect ceases to exist. Overall, these results show very little evidence of a long-run positive relationship between bank liquidity and macroeconomic fragility in the EMU.

Table 4: *F* and *t* statistics for testing the existence of long-run relationship of equation (11) for the dependent variable *DNSFR*, EMU-12 countries, 2003:01 to 2012:07

		Without trends			With trends		
	p	t_{III}	F_{II}	F_{III}	t_v	F_{IV}	F_V
BE	2	-4.33[c]	6.47[c]	9.61[c]	-4.16[c]	6.46[c]	9.67[c]
GE	1	-2.14[a]	2.16[a]	2.97[a]	-0.15[a]	3.93[a]	5.88[a]
IR	3	-0.59[a]	5.26[c]	7.61[c]	-0.65[a]	5.06[b]	0.77[a]
GR	3	-2.12[a]	1.86[a]	2.70[a]	-3.38[a]	4.61[a]	6.75[c]
SP	2	-4.57[c]	7.39[c]	10.56[c]	-4.31[c]	7.09[c]	9.89[c]
FR	3	-4.04[c]	6.53[c]	9.66[c]	-3.94[c]	6.44[c]	8.65[c]
IT	3	- 3.87[c]	5.05[c]	7.51[c]	-3.93[c]	5.31[c]	7.94[c]
PT	3	- 5.37[c]	10.76[c]	15.48[c]	-5.55[c]	10.96[c]	15.69[c]
FI	1	-4.33[c]	8.12[c]	11.87[c]	-4.31[c]	7.85[c]	9.7[c]
NL	3	-3.71[c]	10.12[c]	15.17[c]	-3.65[b]	10.09[c]	13.15[c]
AT	3	-3.54[c]	4.43[c]	6.29[c]	-3.50[b]	4.21[a]	6.27[c]
LU	1	-0.76[a]	2.66[a]	1.20[a]	-0.74[a]	0.90[a]	0.82[a]

Note: [a] indicates that the statistic lies below the 0.05 lower bound, [b] that it falls within the 0.05 bounds and [c] that the statistic lies above the 0.05 upper value; t_{III} and t_V are the *t*-test statistics for the *t*-tests of Pesaran *et al*. (2001) for cases III and V respectively; F_{II}, F_{III}, F_{IV} and F_V are the *F*-test statistics for the *F*-tests of Pesaran *et al*. (2001) for the cases II, III, IV and V respectively (see Pesaran *et al*., 2001 for the critical values of the *t*-tests and *F*-tests); *p* is the selected lag order for equation (12).

In the countries in which no cointegration is found, the results from the estimation of the ARDL models (see Tables 5 and 6) show that only in two of them (Germany and Greece) there may be a possibility for a positive relationship between *CREDIT* and the liquidity ratios. For the other countries the coefficient of *CREDIT* is either insignificant or negative. Therefore, even if someone doubts the inference of the Pesaran *et al.* (2001) test, the overall conclusion for little evidence of a positive link between macroeconomic fragility and bank liquidity in the EMU does not alter.

Table 5: Estimation results for the ARDL model, dependent variable: *NSFR*, EMU-12 countries

(a) Period: 2003:01 to 2012:07

	CREDIT	EC_{-1}	R^2-Adjusted	$X^2_{SC}(12)$	X^2_{FF}	X^2_{H}	Trend	Dummy	ARDL
BE	-0.37**	-0.19***	0.95	15.21 [0.23]	0.001 [0.97]	4.41 [0.03]	No	Yes	ARDL(1,0)
GE	1.44	-0.02	0.93	28.14 [0.005]	1.69 [0.19]	2.62 [0.10]	No	Yes	ARDL(3,4)
IR	-0.32**	-0.09**	0.86	7.97 [0.78]	0.40 [0.84]	17.23 [0.00]	No	Yes	ARDL(3,3)
GR	2.23	-0.08*	0.90	30.43 [0.002]	0.001 [0.97]	0.84 [0.35]	Yes	Yes	ARDL(2,1)
SP	-0.06*	-0.17***	0.95	9.66 [0.64]	0.18 [0.67]	0.03 [0.84]	Yes	Yes	ARDL(1,0)
FR	-0.51***	-0.14***	0.93	16.50 [0.16]	9.65 [0.002]	2.61 [0.10]	No	Yes	ARDL(1,0)
IT	0.14**	-0.41***	0.39	13.23 [0.35]	2.88 [0.08]	1.80 [0.17]	Yes	No	ARDL(2,0)
PT	-4.91***	-0.32***	0.73	5.85 [0.92]	0.80 [0.36]	7.61 [0.006]	No	No	ARDL(1,0)
FI	-0.11	-0.24***	0.85	8.10 [0.77]	6.73 [0.009]	9.14 [0.002]	No	Yes	ARDL(3,0)
NL	0.008	-0.48***	0.80	9.05 [0.69]	3.02 [0.08]	10.12 [0.001]	No	Yes	ARDL(1,0)
AT	0.16***	-0.73***	0.88	16.38 [0.17]	8.96 [0.003]	0.95 [0.32]	No	Yes	ARDL(1,2)
LU	0.27	-0.02	0.93	13.73 [0.31]	0.03 [0.84]	0.75 [0.38]	No	Yes	ARDL(3,0)

(continued from the previous page)

(b) Period: 2003:01 to 2008:08

	CREDIT	EC_{-1}	R^2-Adjusted	$X^2_{SC}(12)$	X^2_{FF}	X^2_{H}	Trend	ARDL
BE	-0.56***	-0.26***	0.85	7.64 [0.81]	0.55 [0.45]	0.32 [0.56]	No	ARDL(1,4)
GE	0.26***	-0.13**	0.90	14.68 [0.25]	0.004 [0.94]	0.23 [0.62]	No	ARDL(1,0)
IR	-0.24	-0.07*	0.87	13.94 [0.30]	3.67 [0.05]	11.87 [0.001]	No	ARDL(2,0)
GR	1.42***	-0.51***	0.92	7.93 [0.79]	0.12 [0.72]	0.42 [0.51]	Yes	ARDL(2,2)
SP	0.08	-0.40***	0.96	9.42 [0.66]	3.80 [0.05]	0.05 [0.82]	Yes	ARDL(1,1)
FR	0.68	-0.16**	0.96	9.59 [0.65]	0.07 [0.77]	0.04 [0.83]	Yes	ARDL(1,0)
IT	-0.62**	-0.40***	0.58	14.96 [0.24]	2.01 [0.15]	0.01 [0.89]	Yes	ARDL(2,0)
PT	0.24***	-0.56***	0.57	4.96 [0.95]	0.19 [0.66]	3.90 [0.04]	Yes	ARDL(1,0)
FI	-0.15	-0.15***	0.88	9.68 [0.64]	1.05 [0.30]	0.02 [0.87]	No	ARDL(1,0)
NL	0.25	-0.55***	0.27	14.09 [0.29]	0.04 [0.83]	24.55 [0.00]	No	ARDL(1,0)
AT	-	-	-	-	-	-	-	-
LU	0.09***	-0.74***	0.97	17.23 [0.14]	0.02 [0.86]	0.55 [0.45]	Yes	ARDL(1,0)

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(c) Period: 2008:09 to 2012:07

	CREDIT	**EC_{-1}**	**R^2-Adjusted**	**$X^2_{SC}(12)$**	**X^2_{FF}**	**X^2_H**	**Trend**	**ARDL**
BE	1.81*	-0.21**	0.73	9.15 [0.68]	-0.04 [0.94]	0.007 [0.93]	Yes	ARDL(1,0)
GE	1.60**	-0.36***	0.92	20.92 [0.05]	10.86 [0.001]	0.57 [0.44]	Yes	ARDL(1,4)
IR	-0.05	-0.35***	0.83	16.21 [0.18]	0.001 [0.97]	3.93 [0.04]	Yes	ARDL(3,0)
GR	-5.45	-0.03	0.77	10.42 [0.57]	0.56 [0.45]	0.01 [0.90]	No	ARDL(2,0)
SP	0.31***	-0.39***	0.67	13.42 [0.33]	0.02 [0.86]	0.29 [0.58]	No	ARDL(1,4)
FR	0.02	-0.44***	0.27	8.27 [0.76]	1.90 [0.16]	0.30 [0.57]	No	ARDL(1,0)
IT	0.05	-1	0.35	11.11 [0.51]	0.17 [0.67]	0.43 [0.50]	Yes	ARDL(0,1)
PT	0.07	-0.33***	0.44	13.90 [0.30]	0.47 [0.48]	3.86 [0.04]	No	ARDL(1,0)
FI	0.009	-0.63***	0.09	15.90 [0.19]	0.54 [0.46]	2.11 [0.14]	No	ARDL(1,0)
NL	-0.23**	-0.55***	0.53	6.43 [0.89]	0.05 [0.82]	0.10 [0.74]	Yes	ARDL(4,0)
AT	-	-	-	-	-	-	-	-
LU	-0.0006	-0.52***	0.81	19.26 [0.08]	0.37 [0.54]	0.64 [0.42]	Yes	ARDL(4,0)

Note: The symbols ***, **, and * denote statistical significance at 0.01, 0.05 and 0.10 levels, respectively. R^2- *Adjusted* is the adjusted squared multiple correlation coefficient. $x^2_{SC}(12)$, x^2_{FF} and x^2_H are maximum-likelihood test statistics for the null hypothesis of no serial correlation, for no functional form mis-specification and of no heteroskedasticity, respectively*;* *p*-values are reported in brackets.

Table 6: Estimation results for the ARDL model, dependent variable: *DNSFR*, EMU-12 countries

(a) Period: 2003:01 to 2012:07

	CREDIT	EC_{-1}	R^2-Adjusted	$X^2_{SC}(12)$	X^2_{FF}	X^2_{H}	Trend	Dummy	ARDL
BE	-0.20	-0.22***	0.97	25.27 [0.01]	0.17 [0.67]	6.94 [0.008]	No	Yes	ARDL(3,4)
GE	0.49	-0.07**	0.95	14.84 [0.25]	1.78 [0.18]	4.16 [0.04]	No	Yes	ARDL(4,4)
IR	-0.66	-0.03	0.91	4.81 [0.96]	3.11 [0.07]	3.91 [0.04]	No	Yes	ARDL(3,0)
GR	0.90**	-0.17***	0.89	17.99 [0.11]	1.11 [0.29]	8.17 [0.004]	Yes	Yes	ARDL(2,1)
SP	-0.03	-0.21***	0.98	20.90 [0.05]	1.06 [0.30]	0.65 [0.418]	No	Yes	ARDL(4,1)
FR	-0.32***	-0.25***	0.95	12.72 [0.38]	6.74 [0.009]	2.34 [0.12]	No	Yes	ARDL(1,0)
IT	0.17*	-0.24***	0.89	14.91 [0.24]	0.35 [0.55]	0.005 [0.94]	No	Yes	ARDL(1,0)
PT	0.05	-0.28***	0.96	9.26 [0.68]	1.31 [0.25]	2.84 [0.09]	No	Yes	ARDL(1,0)
FI	-0.06	-0.26***	0.93	16.41 [0.17]	9.17 [0.002]	7.68 [0.006]	No	Yes	ARDL(3,0)
NL	0.5	-0.21***	0.95	5.78 [0.92]	1.55 [0.21]	2.46 [0.11]	No	Yes	ARDL(1,0)
AT	0.28	-0.41***	0.57	8.80 [0.72]	2.00 [0.15]	0.04 [0.83]	No	Yes	ARDL(1,3)
LU	0.45	-0.03	0.95	18.59 [0.09]	0.001 [0.97]	0.90 [0.34]	No	Yes	ARDL(4,4)

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(b) Period: 2003:01 to 2008:08

	CREDIT	EC_{-1}	R^2-Adjusted	$X^2_{SC}(12)$	X^2_{FF}	X^2_{H}	Trend	ARDL
BE	-0.55**	-0.19***	0.82	13.98 [0.30]	1.63 [0.20]	0.003 [0.95]	No	ARDL(1,4)
GE	-0.23***	-0.26***	0.77	13.38 [0.34]	1.20 [0.27]	7.12 [0.008]	No	ARDL(1,0)
IR	-1.41*	0.07	0.90	19.05 [0.08]	2.29 [0.12]	7.84 [0.005]	Yes	ARDL(4,0)
GR	0.11	-0.16**	0.74	12.19 [0.43]	0.92 [0.37]	0.50 [0.47]	No	ARDL(2,1)
SP	0.48***	-0.48***	0.88	14.40 [0.27]	3.56 [0.05]	0.34 [0.55]	Yes	ARDL(1,3)
FR	0.44	-0.36***	0.91	11.67 [0.47]	0.27 [0.60]	0.06 [0.79]	Yes	ARDL(1,0)
IT	-1.38*	-0.20*	0.80	14.10 [0.29]	3.31 [0.06]	1.61 [0.20]	Yes	ARDL(2,0)
PT	0.05	-0.26**	0.48	9.45 [0.66]	0.15 [0.69]	2.81 [0.09]	No	ARDL(3,0)
FI	-0.05	-0.14***	0.86	7.30 [0.83]	0.05 [0.81]	0.13 [0.71]	No	ARDL(1,0)
NL	1.29***	-0.45***	0.66	10.10 [0.60]	2.27 [0.13]	0.14 [0.70]	No	ARDL(1,0)
AT	-	-	-	-	-	-	-	-
LU	0.01	-0.54***	0.96	9.12 [0.69]	0.39 [0.53]	0.01 [0.91]	Yes	ARDL(1,0)

(continued from the previous page)

(c) Period: 2008:09 to 2012:07

	CREDIT	EC_{-1}	R^2-Adjusted	$X^2_{SC}(12)$	X^2_{FF}	X^2_H	Trend	ARDL
BE	0.24	-0.17**	0.75	11.58 [0.48]	0.84 [0.35]	3.71 [0.05]	No	ARDL(1,0)
GE	4.04***	-0.19***	0.91	17.92 [0.11]	2.65 [0.10]	0.05 [0.81]	No	ARDL(3,3)
IR	-0.004	-0.28	0.71	19.82 [0.07]	0.02 [0.87]	0.66 [0.41]	Yes	ARDL(3,0)
GR	3.20***	-0.32***	0.77	11.12 [0.51]	0.02 [0.86]	0.54 [0.45]	Yes	ARDL(1,2)
SP	0.53**	-0.26***	0.82	24.45 [0.01]	12.27 [0.00]	2.65 [0.10]	No	ARDL(2,4)
FR	0.09	-0.34***	0.50	8.30 [0.76]	1.40 [0.23]	11.17 [0.001]	No	ARDL(1,0)
IT	0.51	-0.37***	0.60	13.05 [0.36]	0.05 [0.80]	10.24 [0.001]	Yes	ARDL(1,1)
PT	0.16	-0.22***	0.83	20.40 [0.06]	0.71 [0.39]	14.64 [0.00]	No	ARDL(2,0)
FI	-0.16	-0.59***	0.25	22.38 [0.03]	3.29 [0.06]	0.32 [0.56]	No	ARDL(1,0)
NL	0.27	-0.19***	0.83	4.58 [0.97]	3.42 [0.06]	12.01 [0.001]	No	ARDL(1,0)
AT	-	-	-	-	-	-	-	-
LU	-0.0007	-0.34**	0.80	22.28 [0.03]	0.92 [0.33]	0.001 [0.98]	Yes	ARDL(4,4)

Note: The symbols ***, **, and * denote statistical significance at 0.01, 0.05 and 0.10 levels, respectively. R^2- *Adjusted* is the adjusted squared multiple correlation coefficient. $x^2_{SC}(12)$, x^2_{FF} and x^2_H are maximum-likelihood test statistics for the null hypothesis of no serial correlation, for no functional form mis-specification and of no heteroskedasticity, respectively; *p*-values are reported in brackets.

4. Conclusion

This paper has centered on the issue of liquidity regulation. This issue has been at the core of the innovations of Basel III. The paper has put forward a dynamic liquidity ratio that, contrary to the ratios used in Basel III, allows for a time-varying definition of bank balance sheet items' liquidity and stability. The implementation of this ratio in the EMU-12 countries has shown that it can more successfully portray the actual liquidity problems of banks, especially in the aftermath of the crisis. This implies that a more dynamic view of liquidity needs to be adopted in the current regulatory framework.

Using the ARDL bounds-testing approach, the paper has also indicated that in most EMU countries bank liquidity is not positively related with macroeconomic fragility. Based on this evidence, it has been argued that bank liquidity requirements should increase when the macroeconomic risk becomes higher. This will allow liquidity regulation to play a more substantial role in preventing the financial instability in the macroeconomy.

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Appendix A: Aggregated balance sheet of euro area monetary financial institutions (MFIs) excluding European System of Central Banks (ESCB)

1. Assets		**2. Liabilities**	
1.1. Loans to euro area residents		2.1. Currency in circulation (Not available)	
	1.1.1. Monetary financial institutions	2.2. Deposits of euro area residents	
	1.1.2. General government		2.2.1. Monetary financial institutions
	1.1.3. Other euro area residents		2.2.2. Central government
	1.1.3.1. Non-financial corporations		2.2.3. Other general government/other euro area residents
	1.1.3.2. Households		2.2.3.1. Overnight
	1.1.3.2.1. Consumer credit		2.2.3.2. With agreed maturity
	1.1.3.2.2. Lending for house purchase		*2.2.3.2.1. Up to 1 year*
	1.1.3.2.3. Other lending		*2.2.3.2.2. Over 1 year and up to 2 years*
	1.1.3.3. Non-monetary financial intermediaries other than insurance corporations and pension funds		*2.2.3.2.3. Over 2 years*
	1.1.3.4. Insurance corporations and pension funds		2.2.3.3. Redeemable at notice
1.2. Holdings of securities other than shares issued by euro area residents			*2.2.3.3.1. Up to 3 months*
	1.2.1. Monetary financial institutions		*2.2.3.3.2. Over 3 months*
	1.2.1.1. Up to 1 year		2.2.3.4. Repurchase agreements
	1.2.1.2. Over 1 year and up to 2 years	2.3. Money market fund shares/units	
	1.2.1.3. Over 2 years	2.4. Debt securities issued	
	1.2.2. General government		2.4.1. Up to 1 year
	1.2.3. Other euro area residents		2.4.2. Over 1 year and up to 2 years
1.3. Money market fund shares/units			2.4.3. Over 2 years
1.4. Holdings of shares/other equity issued by euro area residents		2.5. Capital and reserves	
	1.4.1. Monetary financial institutions	2.6. External liabilities	
	1.4.2. Other euro area residents	2.7. Remaining liabilities	
1.5. External assets			
1.6. Fixed assets			
1.7. Remaining assets			

Note: See Colangelo and Lenza (2012) and ECB (2012a) for the definitions of the data.

Appendix B: Description of the data sources

Variable name	**Data sources**
Net Stable Funding Ratio (*NSFR*)	ECB, monetary statistics, MFI balance sheets
Credit-to-GDP ratio (*CREDIT*)	ECB, Euro area accounts, main indicators
Sovereign bond holding by resident banks	Bruegel (see Merler and Pisani-Ferry, 2012)
Long-term interest rate for convergence purposes, debt security issued (10 years)	ECB, monetary statistics, long term interest rates
Euro area 10-year government benchmark bond yield for other than domestic securities	ECB, monetary statistics, market indices
EONIA interest rate (*rb*)	ECB, money banking and financial markets, market indices
Euribor 3 months rate	European Bank Federation
Interest rate on deposits	ECB, money banking and financial markets, market interest rates, deposits
Interest rate on loans	ECB, money banking and financial markets, market interest rates, loans

Appendix C: Philips-Perron unit root tests

		Levels		First differences	
		Without trends	**With trends**	**Without trends**	**With trends**
BE	*NSFR*	-0.247	-2.571	-11.031***	-11.180***
	DNSFR	-0.203	-2.035	-10.042***	-10.136***
	CREDIT	0.066	-1.433	-4.627***	-4.701***
GE	*NSFR*	-0.422	-1.845	-10.909***	-11.002***
	DNSFR	-0.111	-1.744	-10.636***	-10.721***
	CREDIT	-1.701	-1.390	-3.117**	-3.211*
IR	*NSFR*	-2.476	-2.243	-12.954***	-13.095***
	DNSFR	-0.842	-2.159	-15.310***	-15.886***
	CREDIT	-1.029	-0.820	-3.399**	-3.470**
GR	*NSFR*	-2.015	-2.138	-15.102***	-15.033***
	DNSFR	-1.764	-3.186*	-13.840***	-13.788***
	CREDIT	-1.888	0.918	-3.096**	-3.504**
SP	*NSFR*	-1.010	-2.202	-11.693***	-11.674***
	DNSFR	-0.534	-2.036	-9.206 ***	-9.167***
	CREDIT	-3.510***	2.348	-1.270	-2.687
FR	*NSFR*	-1.863	-2.251	-12.848***	-12.902***
	DNSFR	-1.401	-3.317*	-11.505***	-11.462***
	CREDIT	0.343	-2.261	-3.729***	-3.730**
IT	*NSFR*	-5.276***	-5.579***	-18.902***	-18.958***
	DNSFR	-1.167	-2.215	-12.618***	-12.642***
	CREDIT	-2.074	0.477	-3.867***	-3.904**
PT	*NSFR*	-2.956**	-4.725***	-13.907***	-13.837***
	DNSFR	-0.892	-2.172	-11.408***	-11.368***
	CREDIT	-0.895	-0.508	-3.319**	-3.382*
FI	*NSFR*	2.536	-3.558**	-14.746***	-15.132***
	DNSFR	-1.939	-2.630	-13.339***	-13.501***
	CREDIT	-0.620	-1.711	-3.972***	-3.953**
NL	*NSFR*	-3.530***	-3.981**	-10.008***	-10.110***
	DNSFR	-1.666	-2.157	-8.987***	-8.959***
	CREDIT	-1.530	-1.974	-3.840***	-3.804**
AT	*NSFR*	-1.800	-2.923	-13.537***	-13.618***
	DNSFR	-3.574***	-3.692**	-9.056***	-9.002***
	CREDIT	-1.380	-1.120	-3.352**	-3.486**
LU	*NSFR*	-2.167	-1.048	-11.342***	-12.538***
	DNSFR	-1.885	-1.233	-10.603***	-10.975***
	CREDIT	-1.287	-1.876	-4.303***	-4.324***

Note: The table reports Z_t statistics. The symbols ***, **, and * denote statistical significance at 0.01, 0.05 and 0.10 levels, respectively.

Appendix D: Zivot and Andrews (1992) unit root tests with one structural break

		Model A		Model C	
		t	**Break point**	***t***	**Break point**
BE	*NSFR*	-3.303	2008-10	-3.609	2006-09
	DNSFR	-4.275	2008-10	-4.065	2008-10
	CREDIT	-5.278**	2008-03	-4.049	2010-12
GE	*NSFR*	-15.144***	2010-12	-14.201***	2010-12
	DNSFR	-4.810**	2010-12	-4.320	2010-12
	CREDIT	-5.335**	2008-07	-6.359***	2008-07
IR	*NSFR*	-3.663	2008-10	-3.907	2008-10
	DNSFR	-2.966	2007-05	-3.482	2007-01
	CREDIT	-1.925	2008-01	-2.996	2008-06
GR	*NSFR*	-3.691	2008-11	-2.524	2009-01
	DNSFR	-3.066	2006-07	-3.629	2011-02
	CREDIT	-0.132	2011-01	-1.802	2010-09
SP	*NSFR*	-4.552	2009-05	-4.789	2009-05
	DNSFR	-4.181	2008-09	-4.388	2008-10
	CREDIT	-2.432	2010-05	-3.597	2009-01
FR	*NSFR*	-3.998	2005-11	-4.826	2005-12
	DNSFR	-4.443	2010-09	-6.019***	2008-10
	CREDIT	-5.188**	2010-09	-5.387**	2009-06
IT	*NSFR*	-4.153	2010-11	-4.006	2010-11
	DNSFR	-4.531	2008-11	-4.699	2008-11
	CREDIT	-3.216	2010-06	-6.141***	2008-11
PT	*NSFR*	-5.408**	2004-12	-5.817***	2004-12
	DNSFR	-7.086***	2008-10	-7.000***	2008-10
	CREDIT	-3.134	2007-04	-3.360	2008-04
FI	*NSFR*	-3.368	2010-12	-3.619	2008-10
	DNSFR	-4.118	2008-10	-4.534	2008-10
	CREDIT	-4.070	2007-12	-4.695	2009-06
NL	*NSFR*	-4.704	2006-10	-4.710	2006-10
	DNSFR	-5.723***	2006-10	-5.714***	2006-10
	CREDIT	-4.795	2007-01	-4.522	2007-01
AT	*NSFR*	-3.590	2005-09	-7.713***	2005-09
	DNSFR	-4.913**	2005-10	-5.022	2005-10
	CREDIT	-2.718	2007-10	-3.629	2007-10
LU	*NSFR*	-2.717	2004-06	-3.382	2006-01
	DNSFR	-3.135	2007-12	-5.921***	2006-10
	CREDIT	-6.276***	2006-09	-7.626***	2006-09

Note: The table reports the *t*-test statistics. Critical values for model A (model C) are equal to -5.43 (-5.57) and -4.80 (-5.08) at 0.01 and 0.05 significant levels, respectively. The symbols *** and ** denote statistical significance at 0.01 and 0.05 levels, respectively.

Appendix E: Chow tests results for equation (11)

	NSFR and *CREDIT*	*DNSFR* and *CREDIT*
	F	***F***
BE	2.81 (0.065)	25.2 (0.000)
GE	80.5 (0.000)	175.7 (0.000)
IR	6.85 (0.002)	3.21 (0.044)
GR	62.41 (0.000)	16.88 (0.000)
SP	22.72 (0.000)	206.8 (0.000)
FR	69.75 (0.000)	13.84 (0.000)
IT	0.33 (0.714)	97.2 (0.000)
PT	2.02 (0.137)	141.1 (0.000)
FI	3.68 (0.028)	10.56 (0.000)
NL	23.68 (0.000)	100.1 (0.000)
AT	51.16 (0.000)	5.71 (0.005)
LU	21.4 (0.000)	19.2 (0.000)

Note: The table shows the *F*-test statistics; *p*-values are reported in the parentheses.

Appendix F: Statistics for selecting the lag order of equation (12)

		NSFR and *CREDIT*								*DNSFR* and *CREDIT*					
		Without trends			**With trends**					**Without trends**			**With trends**		
	p	*AIC*	*SBC*	X^2_{SC}	*AIC*	*SBC*	X^2_{SC}		*p*	*AIC*	*SBC*	X^2_{SC}	*AIC*	*SBC*	X^2_{SC}
BE	1	-249.7	-259.2	23.7**	-250.2	-261	23.1**	**BE**	1	-254.2	-263.7	31.2***	-255.2	-266	31.9
	2	-250.7	-262.9	23.8**	-251.4	-265	23.1**		2	-254.8	-267	33.3***	-255.6	-269.2	34.7
	3	-250	-264.9	18.3	-250.1	-266.3	16.9		3	-254.2	-269.1	27.3***	-255.2	-271.4	27.8***
GE	1	-241.1	-250.6	19.8*	-241.4	-252.2	21.2**	**GE**	1	-250.5	-259.9	14.1	-248.5	-259.4	21**
	2	-235.9	-248.1	38***	-235.9	-249.5	33.9***		2	-242.8	-255	22.4*	-238	-251.5	15
	3	-229.7	-244.6	33.2***	-230.7	-247	33.4***		3	-239.6	-254.5	14.8	-238.1	-254.4	17.8
IR	1	-181.4	-190.8	10.5	-182.2	-193	10.6	**IR**	1	-180.9	-190.3	10.4	-181.6	-192.4	10.4
	2	-180	-192.2	7.9	-180.8	-194.3	8.1		2	-180.3	-192.5	5.4	-181.2	-194.8	5.6
	3	-181.8	-196.7	8.9	-182.7	-198.9	8.9		3	-182.2	-197.1	8.18	-183.1	-199.4	8.2
GR	1	-245.2	-254.7	17.6	-236.6	-247.5	28.8***	**GR**	1	-247.7	-257.2	19.7*	-244.4	-255.2	18
	2	-246.3	-258.5	12.1	-237.7	-251.2	27.8***		2	-248.7	-260.9	16	-245.6	-259.2	21.5**
	3	-247.9	-262.8	14.7	-238.9	-255.1	29.3***		3	-250.7	-265.6	18	-247.3	-263.6	19.7*
SP	1	-138.5	-148	7.8	-138.6	-149.4	8.6	**SP**	1	-179.7	-189.1	29.4***	-180.5	-191.3	30.5***
	2	-140.2	-152.4	9.4	-139.8	-153.3	11.1		2	-181	-193.2	29.4***	-181.9	-195.4	29.8***
	3	-141.9	-156.8	16.8	-141.3	-157.6	18.2		3	-179.3	-194.28	-194.24**	-180.3	-196.6	25.6**
FR	1	-206.2	-215.7	17.7	-207.2	-199.2	17.7	**FR**	1	-219.8	-229.2	19.7*	-220.8	-231.6	20*
	2	-206.9	-219.1	15.5	-207.8	-221.4	15.6		2	-220.8	-233	20.9**	-221.8	-235.3	21**
	3	-207.8	-222.7	19.0*	-208.7	-224.9	19.4*		3	-220.9	-235.8	22.2**	-221.8	-238	22.5
IT	1	-185.6	-193.7	11.1	-184.3	-193.8	12.5	**IT**	1	-223.2	-232.7	14.1	-223.4	-234.3	14.2
	2	-186.1	-196.9	12.8	-185.3	-197.5	13		2	-224.5	-236.7	32***	-225.1	-238.6	32***
	3	-187.6	-201.2	13	-187.1	-202	15		3	-225.6	-240.5	30.1***	-226.1	-242.4	30.9***
PT	1	-178.2	-186.3	7.4	-178.7	-188.2	7.8	**PT**	1	-194.2	-203.7	12.7	-194.4	-205.2	14
	2	-180	-190.9	9.2	-180.7	-192.9	8.5		2	-196.1	-208.3	14.3	-196.4	-209.9	15.7
	3	-181.8	-195.3	9.5	-182.3	-197.2	8.3		3	-196.6	-211.5	13.7	-196.6	-212.9	16.2
FI	1	-270.2	-279.7	17.1	-271.2	-282.1	17	**FI**	1	-269.3	-278.8	19.3*	-270.3	-281.1	19.1*
	2	-267.2	-279.4	9.6	-268.2	-281.8	9.8		2	-267.6	-279.8	14.8	-268.6	-282.1	15.2
	3	-268.6	-283.5	8.2	-269.5	-285.8	8.7		3	-268.9	-283.8	13	-269.9	-286.1	13.8
NL	1	-166.3	-175	44.6***	-166.8	-176.6	43***	**NL**	1	-179.7	-188.4	21.3*	-180.1	-190	22.1**
	2	-166.5	-177.6	44.1***	-167.1	-179.5	42.9***		2	-179.4	-190.5	26.1***	-180.1	-192.4	26.5***
	3	-167.4	-181	38.7***	-168	-182.8	36.3***		3	-180.5	-194.1	28.7***	-181.4	-196.2	28.3***
AT	1	-116.1	-124.2	15.7	-116.9	-126.2	14.7	**AT**	1	-153.4	-161.6	21.8**	-154.4	-163.7	21.5**
	2	-117.2	-127.7	15.8	-117.5	-129.1	13.3		2	-153.7	-164.1	16.3	-154.2	-165.8	14.3
	3	-117	-129.7	15.7	-117.8	-131.7	14.5		3	-153.7	-166.5	8.75	-154.6	-168.5	9.33
LU	1	-173.8	-182.4	20.28	-174.7	-184.5	20.9*	**LU**	1	-189.6	-198.2	19.7*	-190.4	-200.3	19.7*
	2	-171.1	-182.2	13	-171.8	-184.1	12.3		2	-185.4	-196.5	16.7	-186.3	-198.7	16.4
	3	-172.1	-185.7	15.6	-172.9	-187.7	16.7		3	-183.2	-196.8	18.5*	-184.2	-199	18.8*

Note: *p* is the lag order for the error correction model in equation (12); AIC and SBC denote Akaike's and Schwarz's Bayesian Information Criteria, respectively; x^2_{SC} is the maximum-likelihood test statistic for the null hypothesis of no serial correlation. The symbols ***, **, and * denote statistical significance at 0.01, 0.05 and 0.10 levels, respectively.