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A liquidity risk index as a regulatory tool for systemically important banks? An empirical assessment across two financial crises

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We provide an empirical assessment of the suggestion, based on Severo (2012), to use a systemic liquidity risk index (SLRI) for estimating liquidity premia that could be charged on large banks as a compensation for the implicit liquidity support obtained from public authorities (Blancher *et al.*, 2013). To this end we compute, over the period January 2004–December 2012, a parsimonious and fully documented SLRI. We also investigate its statistical significance in explaining the level and variability of stock returns for a group of large international banks across the subprime and the Eurozone sovereign debt crises. Main findings are two: our more parsimonious SLRI is close to Severo's but provides a stronger signal of liquidity stress and recovery episodes; we consistently fail to detect, within and across the two crises, a stable group of banks among the global systemically important ones listed by the Financial Stability Board.

Keywords: liquidity premia; systemic risk; banks' stock returns; macroprudential regulation

JEL Classification: C51; G13; G21

1. Introduction

The financial crisis ignited in 2007 in the US subprime mortgage market was magnified and internationally transmitted because of an unprecedented liquidity stress especially in the aftermath of the

mid-September 2008 Lehman's default. This brought to the forefront the manifold features of liquidity, namely the feedbacks between funding and market liquidity (e.g. Brunnermeier and Pedersen, 2009) and the role played by the scarcity of liquidity in compromising banks' and other financial institutions'

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solvency (e.g. Brunnermeier, 2009). As a consequence, policymakers were pushed to take these aspects into account as a crucial component of a macroprudential approach to supervision (de Larosière Report, 2009), thus providing impetus to research for appropriate measures of systemic liquidity risk as a first step to devise regulatory requirements.

In this latter connection, Severo (2012) estimated a coincident index of systemic liquidity shortages (systemic liquidity risk index, SLRI), building on violations of arbitrage relationships in various securities markets, whereby such violations are interpreted as indicators of liquidity stress in global financial markets. In fact, in normal liquidity conditions, arbitrageurs would take advantages through appropriate strategies from misalignments in prices (i.e. price bases). The SLRI was used in Chapter 2 of the April 2011 issue of the Global Financial Stability Report (International Monetary Fund (IMF), 2011), and it is a component of the systemic risk monitoring (SysMo) toolkit employed at the IMF to improve the monitoring of systemic risk (Blancher *et al.*, 2013).

Other systemic liquidity indexes have been constructed based on a similar methodology, namely a set of violations of arbitrage conditions yielding non-null bases and/or of market microstructure measures on turnover and bid-ask spreads to be summarized using different statistical tools, from simple averages of individual indicators to principal component analysis (PCA). An early example, immediately before the 2007 crisis, is the study of Kerry (2008), whose composite indicator of market liquidity has been adopted in the April 2007 Bank of England Financial Stability Report (Bank of England, 2007). Kerry's index of liquidity is computed by averaging nine measures, six of which are microstructural (three different bid-ask spreads representing the gilt repo market, the US dollar foreign exchange market and average of individual stocks in the FTSE100); the remaining three are different return-to-volume measures for the gilt market, the stocks of the FTSE and S&P equity options.¹

The present article builds on Severo's paper contributing along three main lines, which are relevant for the regulatory implications of the SLRI, by providing: (i) a more parsimoniously estimated SLRI,

with a reduced number of arbitrage violations to enhance operational ease of use and replicability, (ii) a test of its usefulness also during the Eurozone sovereign debt crisis in the spirit of an out-of-sample validation exercise, (iii) a check on the selection of a stable set of global systemically important banks (*G-SIBs*), whose market valuations could be impacted by the SLRI. In principle, should the SLRI yield own information, it could be used as an input to price the implicit liquidity support to *G-SIBs* provided by public authorities in order to mitigate potential externalities arising from the individual bank exposure to systemic liquidity risk (Severo, 2012; Blancher *et al.*, 2013). From a macroprudential perspective, detecting a robust association between the SLRI and the evolution of large banks' stock prices would be therefore a promising, though only necessary, condition to pursue the agenda for a more resilient international banking system.

The article is structured as follows. In Section II we examine the main issues connected with the estimation of the index, while in Section III we provide a parsimonious SLRI, illustrate a set of robustness checks on it and discuss the issues arising from the use of a posted interest rate such as the London Interbank Offered Rate (LIBOR). In Section IV, we investigate the impact of the modified SLRI as a determinant of level and variability of stock returns for a group of large international banks, over the two subsamples, 2004–2010 and 2010–2012, and the robustness of the implied selection of *G-SIBs*. Final section concludes.

II. The Estimation of the SLRI

To estimate the SLRI, Severo (2012) uses daily bases, namely price differentials with respect to zero arbitrage profit opportunities, across various geographic locations, and extracts, by means of PCA, statistical factors that drive most of the variation across these bases over time. The proposed index is represented by the first dominant underlying factor explaining most of the temporal evolution of these bases. Specifically, four different types of arbitrage relationships are considered over the period January

¹ Kerry (2008) shows how a simple unweighted average yields an indicator very close to an alternative one using a principal component analysis (PCA) approach. Two notable features are the normalization for each individual series over an assumed 'normal' period, well before the crisis outburst (1999–2004) and a decay factor of 0.94 discount in an exponentially weighted moving average of daily data, in order to privilege more recent information.

2004–October 2010 to find out possible bases: (i) covered interest parity (CIP), (ii) CDS–bond basis for nonbank corporations, (iii) on-the-run versus off-the-run US Treasuries and (iv) (interest rate) swap spread. The series for each basis and of the summarizing indicator are normalized, over the entire sample, at zero mean and unitary SD. As plenty of liquidity allows to exploit arbitrage opportunities, negative and high (in absolute terms) values of the indicator point to systemic liquidity stresses.

Overall, the SLRI fluctuates mildly in periods of normal liquidity in global capital markets (i.e. between 2004 and 2007), signals some stresses around the Bear Stearns bailout (March 2008) and drops sharply (more than five SDs below its mean) at mid-September 2008, after the Lehman bankruptcy. The pattern is roughly similar to the Bank of England Financial market liquidity index in the June 2009 issue of the Financial Stability Report (Bank of England, 2009).

A few remarks are in order on the SLRI. First, Severo (2012) makes use of a very high number of arbitrage relationships (36), including a few which we checked were never violated in practice during the estimation period (swap spread) and others whose violation does not always correspond to the arbitrage rationale (e.g. on-the-run versus off-the-run US Treasuries²). Second, the computation of CDS–bond bases derives from a selection of 11 unidentified nonbank American, European and Japanese corporations. Third, the indicator does not signal clearly a return to good liquidity conditions from the early 2009 and, given the sample period considered, it is not tested around the outburst of the Eurozone sovereign debt crisis (August 2011).

Against this backdrop, the contribution of the article is twofold:

- (i) To provide, over a period that includes also the Eurozone sovereign debt crisis, an estimation of a SLRI that is derived from a more parsimonious set of elementary measures and is fully documented as for data sources;

- (ii) To test the validity of such a revised SLRI over two different financial crises by investigating econometrically the strength of its association with large banks' stock returns evolution, having controlled for market indicators on banks' credit risk and stock market uncertainty and the implied empirical validation of the Financial Stability Board (FSB) list of *G-SIBs*.

The latter contribution has specific policy relevance since, in the Basel 3 framework, *G-SIBs* should be charged with additional capital requirements because of the risk they impose on the resilience of the financial sector (Basel Committee on Banking Supervision, 2013).

III. A Parsimonious Estimate of the SLRI

A well-known issue underlying the rapid transition from the financial to the economic international crisis in the semester following the Lehman bankruptcy is the dollar shortage for most European banks, heavily engaged in trade finance and in the international financial markets and unable to tap the US interbank market because of the counterparty risk for potential lenders (McGuire and von Peter, 2009). On these grounds, we contribute the literature proposing a parsimonious SLRI, fully documented for its elementary data sources, drawn from Thomson Reuters Datastream and Markit and computed out of only two sets of arbitrage conditions that affect mostly US and European headquartered operators. The first set refers to the CIP bases involving the US dollar and three other currencies: the euro, the British pound and the Swiss franc,³ at the 3-, 6- and 12-month horizons. The CIP basis at day t for the \$/€ is computed as:

$$\text{CIP basis}_{t,T} = (1 + i_{t,T}^{\$}) (F_{t,T}/S_t) - (1 + i_{t,T}^{\text{€}}) \quad (1)$$

where F and S are the forward and spot exchange rates, T refers to the 3-, 6- and 12-month maturities,

²The spread between the most recent issue (on-the-run) of Government bonds and the previous ones (off-the-run) is commonly interpreted as a liquidity indicator and can in principle be exploited for arbitrage strategies. However, Krishnamurthy (2002) shows that, considering the costs of shorting the on-the-run bonds, the arbitrage strategies are not profitable, and Vayanos and Weill (2008) show that liquidity and specialness translate into price premia that are consistent with no arbitrage.

³Differently from Severo (2012), we do not consider, for parsimony, the Japanese yen, the Hong Kong dollar and the Singapore dollar, although we check for robustness when including the first currency (results available upon request).

and i s are the LIBORs at the corresponding maturities. The same holds for the other currencies versus the US dollar.

As for the CDS–bond bases, arising from violations of the arbitrage relations equating CDS prices to credit spreads, we consider the relationship between the yields on 5-year corporate bonds and the 5-year CDS spreads for eight large, publicly traded nonbank corporations in the United States, United Kingdom and Eurozone.⁴ Following the literature, we take the 5-year CDS contract, which represents the conventional maturity and hence is the most liquid one; in addition, the liquidity degree for the selected reference entities is enhanced by the inclusion in the *iTraxx Europe* CDS index for the European corporations and in *CDX.NA.IG* CDS index for the US ones. To compare 5-year CDS spreads and bond yield spreads, the first problem is how to find a corporate bond matching the 5-year constant maturity of the CDS contracts. The second issue concerns the risk-free rate. The bond yield spreads can be calculated by subtracting the risk-free interest rate from the synthetic 5-year constant bond yield. Government bond yields are not however an ideal proxy for risk-free rate, due to taxation treatment, repo specials and legal constraint. An alternative proxy for the risk-free rate is the interest rate swap that has the advantage of being quoted on a constant maturity basis (Blanco *et al.*, 2005). To create a synthetic constant 5-year maturity bond spread, we follow Fontana (2010). For each day in the sample and for each reference entity, we search for a bond with less than 5 years left to maturity and another bond with more than 5 years to maturity; only senior, straight bonds are used. We extract the corporate bond spreads over the swap curve from Datastream using the data type *SWSP*, and by linearly interpolating them we approximate a 5-year maturity bond spread.

Though reducing the arbitrage conditions from 36 to 17, the estimated SLRI, with a first factor in the PCA procedure that accounts for over 60% of the variance,⁵ is very close to Severo's one during the same interval, dropping dramatically in the last quarter of 2008 and recovering only around mid-2009 (Figs 1 and 2).

Fig. 1. Parsimonious and Severo's SLRI. 1 January 2004–31 October 2010 (1804 obs.)

Sources: Dark, own estimates; light line drawn using the publicly available time series provided for Fig. 2.4 in IMF (2011). <http://www.imf.org/external/pubs/ft/gfsr/2011/01/index.htm#c2figure>.

Notes: On the y-axis, the number of SDs is around the zero line. Dates of vertical lines are from left to right: March 2008, Bear Stearns rescue; September 2008, Lehman Brothers failure; April 2010, Greek debt crisis.

Fig. 2. Full sample parsimonious SLRI. 1 January 2004–5 December 2012 (2330 obs.)

Sources: Own estimates; full sample (dark), reduced sample (light).

Notes: On the y-axis, the number of SDs is around the zero line. Dates of vertical lines are from left to right: March 2008, Bear Stearns rescue; September 2008, Lehman Brothers failure; April 2010, Greek debt crisis; July 2011, Eurozone sovereign debt crisis.

⁴ Carrefour for France, Telecom for France, Deutsche Telekom for Germany, Vodafone Group for the UK, Cox Communication, IBM, Dominion Resources and Kinder Morgan Energy for the USA.

⁵ 40% in Severo's paper, as expected given the higher dimensionality of the arbitrage conditions.

Fig. 3. Parsimonious SLRI excluding CDS-bond bases. 1 January 2004–5 December 2012 (2330 obs.)

Source: Own estimates.

Notes: On the y-axis, the number of SDs is around the zero line. For dates of vertical lines see Fig. 2.

Robustness checks

We perform different robustness checks of our estimated SLRI:

- (i) Considering only CIP bases, in order to avoid the subjective choice of corporations for the bond-CDS bases (Fig. 3). Having checked that the inclusion of yen did not change materially the results, we choose, for estimation parsimony, to stick to the SLRI index based on four currencies;
- (ii) Considering only 3-month CIP bases, on the assumption that counterparty risks rise with a lengthened maturity. As expected, the variability of the index increased, but with no material changes in its pattern. We therefore decide, also for ease of comparison, to maintain the three maturities at 3, 6 and 12 months;
- (iii) Substituting in the CIP bases calculations the US Dollar LIBORs with the Eurodollar interest rates at the same maturities.

It is worth discussing the last case, also in the light of the doubts cast on how US LIBORs are computed,

being posted rates that do not reflect effective transactions.⁶ In addition, as shown by the investigations on malpractices on LIBOR determination, some large banks in the respondents' panel could have had the incentive to indicate lower interest rates, especially during the hottest months of the crisis from mid-September 2008 to the first half of 2009, to counteract doubts of their lenders on potential counterparty risks (Edmonds, 2013). An alternative benchmark for the average cost of raising offshore US dollar deposits is the Eurodollar rate downloadable from the US Federal Reserve site under the heading *H.15 Eurodollar deposit rate*. During the peak period of the crisis, the spread of the Eurodollar rate to US dollar LIBOR at corresponding maturities increased sharply, suggesting that average US dollar borrowing costs across the broader range of banks did exceed LIBORs. In contrast, the average rate to borrow euros, measured using EURIBOR, tracked the euro LIBOR closely throughout the crisis. The evidence that US dollar LIBOR was below the actual cost of borrowing US dollars in the market is consistent with the large measured bases in the foreign exchange swap market: the Eurodollar spreads to US dollar LIBOR correspond indeed closely with the premia paid to receive US dollars under swap (Ossolinski and Zurawski, 2010).

The Eurodollar rate has however its own weaknesses: it is in fact an offered broker quote that reflects, by construction, the upper end of rates paid by banks, reported in the Federal Reserve's H.15 report based on data from ICAP (Kuo *et al.*, 2012). In addition, comparing the LIBOR and the Eurodollar interest rate series, the differences concentrate in a very narrow time interval (October 2008/June 2009) and the results for our estimated SLRI turn out to be negligible (results available upon request).

All in all, the robustness checks do not show relevant differences across estimates of an SLRI with a reduced number of arbitrage conditions. Major differences emerge only when considering the January 2010–early December 2012 interval, because the estimated SLRI including only CIP bases signals much more sharply liquidity stresses tied to the euro crisis. Figure 3 shows that,

⁶ A LIBOR is computed as the interquartile trimmed mean of reported interbank offer (ask) rates provided each day by a panel of large banks in the London trading session. Each responding bank estimates the rate at which it could borrow unsecured on the interbank market at different maturities and for 10 currencies.

had we left out the bond–CDS bases, the resulting SLRI is much better to signal liquidity stresses in the Eurozone sovereign debt crisis period, of a somewhat comparable order of magnitude with the period 2008–2009, a finding that is consistent with Allen and Moessner (2012) and Ivashina *et al.* (2012).

IV. Banks' Stock Returns, Liquidity Risk and *G-SIBs*

In this section, following Severo (2012), we investigate the impact of the SLRI on the stock returns of a group of large banks in Australia, Europe, India, Japan, Korea, the United Kingdom and the United States. The underlying hypothesis is that their exposure to foreign financial markets should result in a significant impact of global liquidity stress conditions on their market valuations. A statistically significant coefficient for the SLRI as a determinant of stock returns would therefore lend support to the proposal of estimating, in a contingent claims analysis framework, liquidity premia to be charged, on macroprudential grounds, to systemically important banks, as a compensation for the likely liquidity support from public authorities (Severo, 2012; Blancher *et al.*, 2013). In turn, public authorities' intervention would be justified because of the potential externalities on the global financial system originated by the exposure of large international banks to systemic liquidity risk.

Our starting point is to compare the estimation results for jointly modelling, in a maximum likelihood setting, daily level and variability in stock returns for a group of 51 (53 in Severo) large international banks, including among the regressors, besides the SLRI, an expanded set of controls for market returns, idiosyncratic and sector banks' credit risk and stock market uncertainty.⁷

The econometric specification to model the impact of the SLRI on the level and the volatility of bank *i*'s stock returns assumes an ARCH(1) process whereby the conditional volatility is directly affected by the SLRI:

$$R_t^i = \beta_0^i + \beta_1^i R_t^M + \beta_2^i \text{SLRI}_t + \beta_Y^i \mathbf{Y}_t + e_t^i \sigma_t^i \quad (2)$$

$$(\sigma_t^i)^2 = \exp(\omega_o^i + \omega_1^i \text{SLRI}_t + \omega_Y^i \mathbf{Y}_t + \gamma^i (e_{t-1}^i)^2); e_t^i \sim N(0, 1) \quad (3)$$

where R^i is the log daily difference of the *i*th bank dollar-denominated stock price and R^M is the return on the market portfolio, proxied by the return on the dollar-denominated MSCI world index covering 24 developed countries. The vector $\mathbf{Y}$ represents controls included in the model – individual and group average bank CDS spreads and the volatility index (VIX),⁸ in order to purge the effects of systemic liquidity stresses on stock returns from idiosyncratic and sector credit risk factors and stock market uncertainty. For ease of comparison, we follow Severo (2012) in the choice of the exponential functional form only for the deterministic component of the conditional variance, in order to avoid negative fitted values for the volatility process. We expect $\beta_2^i > 0$, $\omega_1^i > 0$, because more liquidity should sustain return levels, whereas lower liquidity, being another proxy for market uncertainty, would raise return volatility. The banks used in the econometric investigation include 25 out of 28 *G-SIBs* in the 2012 updated FSB list (FSB, 2012).

Our own contribution is to test the robustness of the coefficient estimates of the parsimonious SLRI regressor with respect to four issues:

- (i) Contemporaneous versus even a mere 1-day-lagged SLRI effects on stock returns (level and variability);
- (ii) Different financial crises, considering the periods 2004–2010 and 2010–2012. The overlap in 2010 allows a comparison with the results in Severo (2012) referring to the first period when using different SLRIs;
- (iii) Selection of *G-SIBs*, to the extent that their market valuations are significantly impacted by the SLRI, in the two sample periods;
- (iv) Implications of a different econometric specification for the volatility of stock returns on issue 2 and issue 3.

⁷ Some tables report results for less than 51 banks when the algorithms implemented in R and EViews fail to converge.

⁸ The SBOE SPX Volatility VIX index, produced by the Chicago Board Options Exchange, estimates the implicit volatility of a synthetic option on the S&P 500 dollar-denominated index over the next 30-day period. It represents one widely adopted measure of expectations of stock market volatility and hence of perceived risk.

Systemic liquidity stress and the 2007/08 crisis

The estimates of the baseline specification, without controls, reported in Table 1 yield a first striking result: in spite of the very close approximation between Severo's and our own estimated liquidity indicator, different banks are singled out when considering the ones with at least a 90% *p*-value for the SLRI in both equations: three (among which only one *G-SIB*) instead of seven (with three other *G-SIBs*).⁹ To take into account that investors may not be able to gather in real time information on global markets to act upon, we replaced contemporaneous with 1-day-lagged SLRI: even such a slight modification yields among the four banks selected only one overlap (Bank of America) with the baseline results (Table 2). It is worth mentioning that this difference emerges although the correlation of contemporaneous and lagged SLRI with other variables is almost identical. We interpret these findings as another hint of the fragility of the SLRI for regulatory use.

A second result emerges when we control for specific bank CDS spreads, in order to take into account idiosyncratic credit risk (Table 3). The SLRI is statistically significant on stock returns (level and variability) for only three banks instead of four and, more interestingly, only three *G-SIBs* are singled out (Credit Suisse, Goldman Sachs and Wells Fargo).

Focusing on the stock returns variance equation, where the SLRI is always highly significant in the baseline specification, a third result is that, controlling for banks' average CDS spread and VIX, the SLRI does not turn significant in 15 (among which Wells Fargo) out of 51 banks, compared to 10 out of 53 in Severo (Table 4). The outcome is not surprising because liquidity stresses are bound to increase market uncertainty, as shown by the negative correlation between SLRI and log VIX (−0.90 over the sample period 2004–2010 and −0.66 over the period 2010–2012).

A fourth result, when all controls are included, namely both specific and bank group average CDS spreads (to consider idiosyncratic and sector credit risk) and VIX, the SLRI becomes insignificant in

Table 1. Baseline specification (1 January 2004–31 October 2010; 1804 obs.)

Bank	β_1^i	β_2^i	ω_1^i	γ^i
National Australia Bank	0.923	−0.077	−0.744	0.461
Commonwealth Bank Australia	0.976	−0.066	−0.681	0.348
Erste Group Bank	1.669	0.030	−0.884	0.483
Dexia	1.454	0.184**	−1.216	0.585
KBC Group	1.505	0.038	−1.354	1.064
BNP Paribas	1.658	0.021	−0.963	0.254
Société Générale	1.764	0.064	−0.905	0.410
Crédit Agricole	1.720	0.097	−0.795	0.468
Deutsche Bank	1.694	−0.029	−0.897	0.177
Commerzbank	1.739	0.091	−0.897	0.384
National Bank of Greece	1.477	0.040	−0.622	0.844
Alpha Bank	1.292	0.090	−0.546	1.035
Bank of Piraeus	1.326	0.124	−0.572	0.967
Unicredit	1.532	0.047	−0.923	0.147
Intesa Sanpaolo	1.401	0.084	−0.692	0.198
Banco Comercial Portugues	1.047	0.105*	−0.452	0.720
Banco Espirito Santo	0.893	0.064	−0.878	0.356
Banco Santander	1.539	−0.004	−0.736	0.189
BBV Argentaria	1.524	0.034	−0.756	0.183
Banco Popular Español	1.349	0.069	−0.764	0.278
UBS	1.529	0.023	−1.008	0.399
Credit Suisse Group	1.521	0.018	−0.789	0.342
Nordea Bank	1.560	0.017	−0.841	0.237
Svenska Handbkn	1.376	−0.040	−0.821	0.245
Swedbank	1.668	−0.003	−0.997	0.405
DNB Nor	1.414	0.028	−0.944	0.510
Danske Bank	1.240	−0.020	−0.814	0.359
State Bank Of India	0.822	0.020	−0.297	1.160
Mizuho Financial Group	0.578	0.128	−0.548	0.892
Sumitomo Mitsui Fin Group	0.541	0.076	−0.606	1.030
Mitsubishi UFJ Fin Group	0.578	0.015	−0.451	0.815

(continued)

⁹ In Table 1, we report also the estimated autoregressive parameters of the ARCH process, which are below unity as required for stationarity, except for 5 cases. As similar results obtain overall, they are not reported in the other tables because of space constraints.

Table 1. Continued

Bank	β_1^i	β_2^i	ω_1^i	γ^i
Shinhan Financial Group	0.880	0.042	-0.605	0.421
Australia & New Zealand Bank	0.950	-0.108	-0.777	0.512
HSBC Holding	1.061	0.014	-1.064	0.178
Barclays	1.527	0.049	-1.391	0.703
Royal Bank of Scotland Group	1.436	0.107	-1.640	0.608
Lloyds Banking Group	1.352	0.075	-1.533	0.587
Standard Chartered	1.579	-0.026	-0.842	0.285
Bank of America	1.075	0.205**	-1.831	0.465
JP Morgan Chase & Co	1.239	0.046	-1.328	0.564
Citigroup	1.364	-0.147	-1.611	0.447
Wells Fargo & Co	1.100	-0.135	-1.567	0.568
Morgan Stanley	1.565	0.061	-1.160	0.756
Goldman Sachs Group	1.358	-0.054	-0.853	0.181
US Bancorp	1.012	-0.057	-1.388	0.411
PNC Financial Services Group	1.032	0.069	-1.448	0.343
SunTrust Banks	1.162	-0.068	-1.611	0.798
BB&T	0.992	0.025	-1.262	0.808
Regions Bank	1.184	0.096	-1.510	1.100
Bank of New York Mellon	1.231	0.009	-0.995	0.274
State Street	1.357	-0.142	-1.553	0.628

Notes: **95% and *90% p -values. p -Values are of at least 99% for β_1^i s, ω_1^i s and γ^i s.

Table 2. Baseline specification with 1-day-lagged SLRI (2004–2010; 1803 obs.)

Bank	β_1^i	β_2^i	ω_1^i
National Australia Bank	0.926	-0.075	-0.743
Commonwealth Bank Australia	0.987	-0.095	-0.693
Erste Group Bank	1.675	0.035	-0.874
Dexia	1.469	0.142	-1.237
KBC Group	1.521	0.000	-1.333
BNP Paribas	1.655	0.008	-0.980
Société Générale	1.777	0.022	-0.910
Crédit Agricole	1.725	0.101	-0.785
Deutsche Bank	1.706	-0.009	-0.902
Commerzbank	1.741	0.106	-0.903
National Bank of Greece	1.470	0.034	-0.620

(continued)

Table 2. Continued

Bank	β_1^i	β_2^i	ω_1^i
Alpha Bank	1.277	0.064	-0.548
Bank of Piraeus	1.312	0.101	-0.575
Unicredit	1.531	0.047	-0.924
Intesa Sanpaolo	1.393	0.054	-0.703
Banco Comercial Portugues	1.032	0.102	-0.456
Banco Espirito Santo	0.881	0.035	-0.893
Banco Santander	1.532	-0.022	-0.761
BBV Argentaria	1.515	0.030	-0.776
Banco Popular Español	1.341	0.062	-0.771
UBS	1.522	0.087	-1.027
Credit Suisse Group	1.527	0.022	-0.768
Nordea Bank	1.557	0.013	-0.843
Svenska Handbkn	1.386	-0.037	-0.824
Swedbank	1.670	-0.023	-0.999
DNB Nor	1.419	-0.020	-0.937
Danske Bank	1.249	-0.016	-0.815
State Bank Of India	0.824	0.033	-0.292
Mizuho Financial Group	0.588	0.145	-0.563
Sumitomo Mitsui Fin Group	0.553	0.097	-0.615
Mitsubishi UFJ Fin Group	0.586	0.023	-0.454
Shinhan Financial Group	0.869	0.063	-0.614
Australia & New Zealand Bank	0.967	-0.081	-0.782
HSBC Holding	1.053	0.051	-1.059
Barclays	1.537	0.013	-1.367
Royal Bank of Scotland Group	1.488	0.005	-1.633
Lloyds Banking Group	1.399	0.001	-1.524
Standard Chartered	1.584	-0.025	-0.829
Bank of America	1.036	0.189**	-1.852
JP Morgan Chase & Co	1.196	0.050	-1.278
Citigroup	1.321	0.006	-1.670
Wells Fargo & Co	1.084	-0.241***	-1.591
Morgan Stanley	1.542	0.109	-1.144
Goldman Sachs Group	1.364	-0.006	-0.831
US Bancorp	1.032	-0.025	-1.335
PNC Financial Services Group	1.023	0.139	-1.360
SunTrust Banks	1.189	-0.088	-1.592
BB&T	0.957	0.059	-1.278
Regions Bank	1.019	0.432***	-1.549
Bank of New York Mellon	1.213	0.102	-0.999
State Street	1.358	-0.109	-1.551

Notes: ***99% and **95% p -values. β_2^i and ω_1^i refer to $SLRI_{t-1}$. p -Values are of at least 99% for β_1^i s and ω_1^i s. 2010 stands for 31 October 2010.

Table 3. Baseline specification augmented for bank-specific CDS spread (2004–2010)

Bank	β_1^i	β_2^i	β_{CDS}^i	ω_1^i	ω_{CDS}^i	Obs.
National Australia Bank	0.896	−0.253**	−0.0035**	−0.265***	0.014	1804
Commonwealth Bank Australia	0.936	−0.085	−0.0012	−0.269***	0.013	1804
Erste Group Bank	1.589	0.217*	0.0014	−0.548***	0.005	1804
Dexia	1.357	0.087	−0.0006	−0.517***	0.007	1804
KBC Group	1.444	0.206	0.0012	−0.399***	0.012	1804
BNP Paribas	1.599	0.060	0.0008	−0.730***	0.011	1804
Crédit Agricole	1.613	0.067	0.0001	−0.544***	0.011	1804
Deutsche Bank	1.671	−0.097	−0.0013	−0.545***	0.010	1804
Commerzbank	1.748	0.079	−0.0008	−0.683***	0.009	1804
Unicredit	1.397	−0.003	−0.0010	−0.569***	0.009	1804
Intesa Sanpaolo	1.291	0.024	−0.0010	−0.457***	0.009	1804
Banco Santander	1.445	−0.035	−0.0005	−0.386***	0.011	1804
BBV Argentaria	1.438	−0.014	−0.0007	−0.483***	0.009	1804
Banco Popular Español	1.206	0.079	−0.0003	−0.307***	0.006	1804
UBS	1.397	0.090	−0.0002	−0.218***	0.014	1804
Credit Suisse Group	1.496	−0.076	−0.0014	−0.474***	0.009	1804
Nordea Bank	1.480	0.033	0.0002	−0.305***	0.015	1804
Svenska Handbkn	1.343	−0.021	0.0001	−0.345***	0.015	1804
Swedbank	1.610	0.223**	0.0022*	−0.429***	0.007	1804
DNB Nor	1.844	0.119	0.0038	−0.405***	0.018	718
Danske Bank	1.189	0.116	0.0016	−0.261***	0.013	1804
Mizuho Financial Group	0.588	0.092	−0.0008	−0.401***	0.006	1804
Sumitomo Mitsui Fin Group	0.568	0.111	0.0010	−0.385***	0.009	1761
Mitsubishi UFJ Financial Group	0.587	0.046	0.0008	−0.300***	0.006	1761
Australia & New Zealand Banking	0.927	−0.183*	−0.0021	−0.384***	0.012	1804
HSBC Holding	0.982	0.145**	0.0022**	−0.485***	0.017	1804
Barclays	1.464	0.151	0.0003	−0.452***	0.016	1804
Royal Bank of Scotland Group	1.331	0.096	−0.0003	−1.219***	0.010	1804
Lloyds Banking Group	1.275	0.211	0.0010	−1.005***	0.012	1804
Standard Chartered	1.674	0.066	0.0011	−0.553***	0.005	1447
Bank of America	0.953	0.291***	0.0009	−0.582***	0.018	1804
JP Morgan Chase & Co	1.196	0.079	0.0007	−0.323***	0.023	1804
Citigroup	1.210	0.104	−0.0003	−0.620***	0.009	1804
Wells Fargo & Co	0.898	0.260**	0.0027*	−0.296***	0.024	1804
Goldman Sachs Group	1.338	−0.231*	−0.0021*	−0.106	0.009	1804
PNC Financial Services Group	1.388	0.301	−0.0021	−0.820***	0.004	718

Notes: ***99%, **95% and *90% *p*-values. *p*-Values are of at least 99% for β_1^i s and ω_{CDS}^i s. 2010 stands for 31 October 2010.

the variance equation for almost three-fifths of banks; it is highly significant in only 11 out of 25 *G-SIBs* (Table 5).

We check for possible cross-sectional effects, as priced by markets through CDS spreads, owing to the different policies pursued by the central banks as

Table 4. Variance equation augmented for logs of average CDS spread and VIX (2004–2010)

Bank	ω_1^i	$\omega_{\log AVCDs}$	$\omega_{\log VIX}$
National Australia Bank	-0.102*	0.181***	1.641***
Commonwealth Bank Australia	0.025	0.081	2.019***
Erste Group Bank	-0.156**	-0.041	1.941***
Dexia	-0.288***	0.437***	1.744***
KBC Group	-0.218***	0.362***	1.940***
BNP Paribas	-0.244***	0.001	1.935***
Société Générale	-0.110*	0.198***	1.897***
Crédit Agricole	-0.267***	0.378***	0.764***
Deutsche Bank	-0.162***	0.133**	1.724***
Commerzbank	-0.324***	0.024	1.493***
National Bank of Greece	-0.102*	0.541***	0.462**
Alpha Bank	-0.105	0.780***	-0.235
Bank of Piraeus	-0.083	0.725***	0.082
Unicredit	-0.328***	0.217***	1.220***
Intesa Sanpaolo	-0.218***	0.090	1.074***
Banco Comercial Portugues	0.172***	0.118*	1.603***
Banco Espirito Santo	-0.222***	0.740***	0.306
Banco Santander	0.042	0.259***	1.635***
BBV Argentaria	-0.117*	0.318***	1.148***
Banco Popular Español	-0.010	0.666***	0.881***
UBS	-0.181***	0.391***	1.496***
Credit Suisse Group	-0.251***	0.051	1.503***
Nordea Bank	-0.219***	-0.078	1.781***
Svenska Handbkn	-0.276***	-0.151**	1.682***
Swedbank	-0.230***	0.123*	1.631***
DNB Nor	-0.235***	-0.127*	2.005***
Danske Bank	-0.147**	0.292***	1.250***
State Bank Of India	0.065	-0.302***	1.653***
Mizuho Financial Group	0.109*	-0.127*	2.265***
Sumitomo Mitsui Fin Group	-0.096	-0.168**	1.789***
Mitsubishi UFJ Fin Group	0.060	-0.320***	2.121***
Shinhan Financial Group	-0.080	-0.348***	2.139***
Australia & New Zealand Bank	-0.075	0.053	1.956***
HSBC Holding	-0.058	0.346**	2.001***
Barclays	-0.164**	0.084	2.758***
Royal Bank of Scotland Group	-0.358***	0.444***	2.207***
Lloyds Banking Group	-0.425***	0.586***	1.471***
Standard Chartered	-0.292***	-0.020	1.537***
Bank of America	-0.339***	0.771***	1.915***
JP Morgan Chase & Co	-0.231***	0.243***	2.282***
Citigroup	-0.423***	0.660***	1.751***
Wells Fargo & Co	-0.081	0.509***	2.627***
Morgan Stanley	-0.340***	0.077	2.052***
Goldman Sachs Group	-0.245***	0.194***	1.253***
US Bancorp	-0.009	0.463***	2.291***
PNC Financial Services Group	-0.118	0.295***	2.472***
SunTrust Banks	-0.139**	0.681***	2.104***
BB&T	-0.038	0.540***	2.054***
Regions Bank	-0.210***	0.589***	2.203***
Bank of New York Mellon	-0.463***	0.106	1.309***
State Street	-0.465***	-0.085	2.481***

Notes: ***99%, **95% and *90% *p*-values. 2010 stands for 31 October 2010.

Table 5. Variance equation augmented for specific bank CDS and logs of average CDS spreads and VIX (2004–2010)

Bank	ω_I^i	ω_{CDS}^i	$\omega_{\log AVCDS}$	$\omega_{\log VIX}$	Obs.
National Australia Bank	-0.049	0.006**	-0.009	1.590	1804
Commonwealth Bank Australia	0.044	0.003	-0.051	2.003	1804
Erste Group Bank	-0.097	0.003***	-0.258***	1.938	1804
Dexia	-0.088	0.005***	-0.059	2.000	1804
KBC Group	-0.094	0.009***	-0.056	1.469	1804
BNP Paribas	-0.260***	0.004	-0.152	1.962	1804
Société Générale	-0.133**	0.009**	-0.205	1.935	1804
Crédit Agricole	-0.279***	0.003	0.217	0.834	1804
Deutsche Bank	-0.239***	-0.012**	0.600***	1.752	1804
Commerzbank	-0.346***	0.004	-0.121	1.462	1804
Unicredit	-0.329***	0.007***	-0.137	1.166	1804
Intesa Sanpaolo	-0.244***	0.011***	-0.330***	1.057	1804
Banco Santander	0.040	0.012***	-0.471***	2.030	1804
BBV Argentaria	-0.146**	0.008***	-0.287**	1.505	1804
Banco Popular Español	0.070	0.002***	0.339***	1.224	1804
UBS	0.007	0.011***	-0.081	1.270	1804
Credit Suisse Group	-0.239***	0.004**	-0.083	1.330	1804
Nordea Bank	0.047	0.019***	-0.579***	1.805	1804
Svenska Handbkn	-0.010	0.021***	-0.599***	1.563	1804
Swedbank	-0.026	0.006***	-0.160**	1.694	1804
DNB Nor	0.164	0.019***	-1.415***	2.720	718
Danske Bank	-0.070	0.004**	0.159*	1.213	1804
Mizuho Financial Group	0.103	-0.001	-0.104	2.258	1804
Sumitomo Mitsui Fin Group	-0.082	0.002	-0.162	1.655	1761
Mitsubishi UFJ Financial Group	0.072	0.002	-0.328***	2.047	1761
Australia & New Zealand Banking	-0.046	0.004	-0.093	1.951	1804
HSBC Holding	0.082	0.010***	-0.038	2.222	1804
Barclays	0.067	0.015***	-0.560***	2.538	1804
Royal Bank of Scotland Group	-0.434***	-0.008***	0.997***	1.913	1804
Lloyds Banking Group	-0.421***	0.001	0.519***	1.513	1804
Standard Chartered	-0.210***	0.002	-0.162**	1.649	1447
Bank of America	-0.204***	0.011***	0.136	1.800	1804
JP Morgan Chase & Co	-0.028	0.022***	-0.369***	1.708	1804
Citigroup	-0.284***	0.004***	0.358***	1.601	1804
Wells Fargo & Co	0.107*	0.017***	-0.127	2.121	1804
Goldman Sachs Group	-0.003	0.006***	-0.026	1.040	1804
PNC Financial Services Group	0.110	0.003***	-0.210	3.183	718

Notes: ***99%, **95% and *90% *p*-values. *p*-Values are of at least 99% for $\omega_{\log VIX}$. 2010 stands for 31 October 2010.

providers of liquidity in domestic currency. To this end, we divide the sample into four groups, according to the country where a bank is headquartered (13 US banks, 18 Eurozone ones, 7 other European ones, 8 remaining ones) and replace the log of overall average CDS spread with four similar variables, computed for each group. The results are fairly robust with respect to the SLRI effects; among the 11 *G-SIBs* the only, though not irrelevant, change is the inclusion of Sumitomo Mitsui and the exclusion of Wells Fargo.

The Eurozone sovereign debt crisis

The pattern of econometric findings for the period 2010–2012 is similar to the one for the previous crisis, though with some interesting differences when considering Eurozone headquartered banks. First, the SLRI is highly significant almost always in the stock returns' variance equation and hardly so for the level one. Experimenting with a 1-day-lagged SLRI yields again that the regressor is more often significant, at least at the 10% confidence, and that

there is lack of robustness in identifying specific banks when allowing even for such a small timing change (Tables 6 and 7).

An interesting feature that emerges when inserting all controls – bank-specific and average CDS spreads and VIX, all in logs – is the following. Within the small group of banks (less than one-fifth) where the SLRI is statistically significant there is a neat split between four Eurozone banks headquartered in sovereign-risk hit countries (Greece, Portugal, Spain) or having received a public capital infusion (Commerzbank, in 2008, only partially refunded in 2012) and four other ones, among which three US *G-SIBs*. Whereas for the latter group the negative sign in the variance equation can be intuitively explained because a larger SLRI, meaning a lack of liquidity, increases uncertainty and therefore the volatility in stock returns, the opposite sign for the former group is *prima facie* rather puzzling.

Our interpretation is that for these banks, mostly depending on public support for their viability, a lack of liquidity may strengthen the belief, based on *too-big-to-fail* considerations, of a further infusion of public resources, thus inducing to bet for a less

Table 6. Baseline specification (1 January 2010–5 December 2012; obs. 764)

Bank	β_1^i	β_2^i	ω_1^i
National Australia Bank	0.954	0.047	−0.862***
Erste Group Bank	2.051	0.495***	−1.199***
Dexia	2.087	−0.038	−0.750***
KBC Group	2.409	0.388	−0.911***
BNP Paribas	2.340	0.303*	−1.327***
Société Générale	2.636	0.375*	−1.078***
Crédit Agricole	2.492	0.357*	−0.765***
Deutsche Bank	2.136	0.300**	−0.846***
Commerzbank	2.129	0.146	−0.605***
National Bank of Greece	1.805	0.280	−0.342**
Alpha Bank	1.810	0.529	−0.404***
Bank of Piraeus	1.512	0.191	−0.122
Unicredit	2.409	0.356	−0.898***
Intesa Sanpaolo	2.506	0.115	−0.665***
Banco Comercial Portugues	1.507	0.576***	−0.460***

(continued)

Table 6. Continued

Bank	β_1^i	β_2^i	ω_1^i
Banco Espirito Santo	1.682	0.404*	−0.971***
Banco Santander	2.043	0.100	−0.580***
BBV Argentaria	2.123	0.097	−0.529***
Banco Popular Español	1.711	−0.098	0.107
UBS	1.599	0.327**	−0.625***
Credit Suisse Group	1.653	0.279*	−0.843***
Nordea Bank	1.815	−0.080	−0.596***
Svenska Handbkn	1.524	−0.087	−0.536***
Swedbank	1.889	0.021	−0.683***
DNB Nor	1.777	0.143	−0.555***
Danske Bank	1.550	0.017	−0.528***
State Bank Of India	0.677	0.044	−0.312**
Mizuho Financial Group	0.288	−0.065	0.238*
Sumitomo Mitsui Fin Group	0.327	−0.027	0.018
Mitsubishi UFJ Fin Group	0.351	−0.003	−0.113
Shinhan Financial Group	0.704	0.026	−0.878***
Australia & New Zealand Bank	1.038	−0.092	−0.866***
HSBC Holding	1.224	0.090	−0.624***
Barclays	2.213	0.168	−0.917***
Royal Bank of Scotland Group	1.958	0.231	−0.971***
Lloyds Banking Group	1.948	0.203	−0.624***
Standard Chartered	1.433	0.000	−0.637***
Bank of America	1.493	−0.100	−1.241***
JP Morgan Chase & Co	1.312	−0.031	−1.080***
Citigroup	1.666	0.034	−0.779***
Wells Fargo & Co	1.292	−0.170	−0.456***
Morgan Stanley	1.514	0.055	−1.340***
Goldman Sachs Group	1.107	0.076	−0.740***
US Bancorp	1.069	−0.150	−0.871***
PNC Financial Services Group	1.153	−0.166	−0.522***
SunTrust Banks	1.590	−0.072	−0.775***
BB&T	1.127	−0.230*	−0.465***
Regions Bank	1.732	−0.158	−0.668***
Bank of New York Mellon	1.239	−0.009	−0.573***
State Street	1.223	0.087	−0.761***

Notes: ***99%, **95% and *90% *p*-values. *p*-Values are of at least 99% for β_1^i s. 2012 stands for 5 December 2012.

Table 7. Baseline specification with 1-day-lagged SLRI (2010–2012; obs. 763)

Bank	β_1^i	β_2^i	ω_1^i
National Australia Bank	0.952	0.051	−0.871***
Erste Group Bank	2.050	0.503***	−1.161***
Dexia	2.093	−0.026	−0.802***
KBC Group	2.395	0.418*	−0.910***
BNP Paribas	2.298	0.389**	−1.311***
Société Générale	2.627	0.425**	−1.131***
Crédit Agricole	2.478	0.408**	−0.776***
Deutsche Bank	2.137	0.319**	−0.862***
Commerzbank	2.135	0.151	−0.638***
National Bank of Greece	1.809	0.260	−0.421***
Alpha Bank	1.820	0.590	−0.456***
Bank of Piraeus	1.544	0.120	−0.242
Unicredit	2.403	0.410*	−0.910***
Intesa Sanpaolo	2.504	0.136	−0.714***
Banco Comercial Portugues	1.510	0.541***	−0.525***
Banco Espírito Santo	1.666	0.358	−0.988***
Banco Santander	2.029	0.116	−0.616***
BBV Argentaria	2.108	0.110	−0.557***
Banco Popular Español	1.713	−0.084	0.051
UBS	1.594	0.332**	−0.639***
Credit Suisse Group	1.638	0.329**	−0.849***
Nordea Bank	1.805	−0.063	−0.605***
Svenska Handbkn	1.517	−0.088	−0.575***
Swedbank	1.880	0.017	−0.711***
DNB Nor	1.773	0.142	−0.620***
Danske Bank	1.538	−0.049	−0.519***
State Bank of India	0.676	0.072	−0.271**
Mizuho Financial Group	0.290	−0.082	0.162
Sumitomo Mitsui Fin Group	0.328	−0.055	−0.033
Mitsubishi UFJ Fin Group	0.353	−0.013	−0.174
Shinhan Financial Group	0.701	0.035	−0.873***
Australia & New Zealand Bank	1.035	−0.075	−0.878***
HSBC Holding	1.221	0.090	−0.639***
Barclays	2.198	0.217	−0.918***

(continued)

Table 7. Continued

Bank	β_1^i	β_2^i	ω_1^i
Royal Bank of Scotland Group	1.932	0.263	−0.985***
Lloyds Banking Group	1.938	0.208	−0.537***
Standard Chartered	1.424	−0.007	−0.697***
Bank of America	1.495	−0.100	−1.231***
JP Morgan Chase & Co	1.318	−0.021	−1.052***
Citigroup	1.683	0.041	−0.732***
Wells Fargo & Co	1.292	−0.160	−0.408***
Morgan Stanley	1.528	0.081	−1.323***
Goldman Sachs Group	1.110	0.094	−0.745***
US Bancorp	1.072	−0.146	−0.772***
PNC Financial Services Group	1.153	−0.181	−0.498***
SunTrust Banks	1.604	−0.071	−0.690***
BB&T	1.133	−0.233*	−0.369***
Regions Bank	1.738	−0.164	−0.610***
Bank of New York Mellon	1.243	−0.005	−0.548***
State Street	1.228	0.093	−0.751***

Notes: ***99%, **95% and *90% p -values. β_2^i and ω_1^i refer to $SLRI_{t-1}$. p -Values are of at least 99% for β_1^i s. 2012 stands for 5 December 2012.

bumpy stock returns evolution (Table 8).¹⁰ We find some supporting evidence to the hypothesis when substituting the log of overall average CDS spreads with the log of regional average CDS spreads, which are computed on four groups according to the country where a bank is headquartered. Table 9 highlights two results that contrast to the pre-Euro crisis case, where the main outcomes are almost unaffected by this change: first, there is a modification in the selection within the three US G -SIBs (in BOFA and out JPMorgan); second, the estimated autoregressive parameters for the ARCH process are significantly above unity only for banks of Eurozone countries most hit by the crisis (three Greek and two Portuguese banks). The breach of the stationarity requirement for the stochastic process may be interpreted as a hint that for these banks, highly

¹⁰ The results on the split between Euro-based banks and US ones are qualitatively robust to lagged instead of contemporaneous SLRI or to logs instead of levels of individual CDS spreads (though in this latter case the set of banks where the algorithm convergence is attained and is associated with a statistical significant SLRI coefficient is modified).

Table 8. Variance equation augmented for logs of bank-specific CDS, average CDS and VIX (2010–2012)

Bank	ω_1^i	$\omega_{\log CDS}^i$	$\omega_{\log AVCDS}$	$\omega_{\log VIX}$	Obs.
Commonwealth Bank Australia	0.245	−0.054	−0.472	2.644***	764
Erste Group Bank	−0.018	1.872***	−0.500	1.001***	764
Dexia	0.294	2.762***	−1.067*	1.153***	764
KBC Group	0.024	1.270**	0.042	1.201***	764
BNP Paribas	0.261	0.119	1.058	2.433***	764
Société Générale	−0.088	0.794	0.021	1.177***	764
Crédit Agricole	0.290	0.067	1.081**	1.331***	764
Deutsche Bank	0.087	−0.332	1.067***	1.293***	764
Commerzbank	0.523**	−0.983**	2.637***	0.783**	764
National Bank of Greece	0.348*	0.935*	0.122	0.976***	764
Alpha Bank	0.041	0.074	1.410	−0.185	764
Bank of Piraeus	1.725***	0.608	−1.010	−0.184	195
Unicredit	−0.230	0.589	0.721	0.564*	764
Intesa Sanpaolo	0.263	0.842	−0.041	1.351***	764
Banco Comercial Portugues	0.519*	0.023	1.715***	0.442	764
Banco Espirito Santo	−0.110	0.124	1.651***	−0.173	764
Banco Santander	−0.100	2.659***	−2.412***	1.977***	764
BBV Argentaria	−0.090	1.705***	−1.252***	1.299***	764
Banco Popular Español	0.538**	1.320***	−0.932*	0.763***	764
UBS	0.075	−0.272	0.343	1.607***	764
Credit Suisse Group	−0.252	−0.142	0.751**	0.656**	764
Nordea Bank	0.277	0.934*	−0.579	1.513***	764
Svenska Handbkn	0.192	0.227	0.240	1.195***	764
Swedbank	0.183	0.080	−0.050	1.869***	764
DNB Nor	0.255	0.252	0.319	1.517***	764
Danske Bank	0.291	0.297	−0.202	1.671***	764
State Bank of India	0.109	−0.872*	1.396***	0.338	764
Mizuho Financial Group	0.124	−0.007	−0.521**	0.310	764
Mitsubishi UFJ Financial Group	0.092	−0.300	−0.916**	0.655	195
Shinhan Financial Group	0.167	1.140***	−0.234	1.335***	764
Australia & New Zealand Banking	0.070	0.515	−0.763**	2.150***	764
HSBC Holding	−0.243	2.352***	−1.379***	0.822***	764
Barclays	−0.181	−0.349	0.802*	1.015***	764
Royal Bank of Scotland Group	−1.042***	−1.621*	0.869	0.604*	764
Lloyds Banking Group	0.024	−0.268	0.542	1.307***	764
Standard Chartered	−0.043	0.816	−0.811	1.366***	764
Bank of America	−0.450	1.355**	−0.647	0.397	764
JP Morgan Chase & Co	−0.545***	1.228**	−0.341	0.543	764
Citigroup	−0.484**	0.431	−0.295	0.528*	764
Wells Fargo & Co	−0.145	0.896**	−1.219***	1.034***	764
Morgan Stanley	−0.209	0.313	0.432	1.485***	764
Goldman Sachs Group	−0.334*	1.958***	−2.096***	0.841***	764
US Bancorp	0.201	0.864**	0.034	1.809***	195
PNC Financial Services Group	−0.227	0.208	−0.887***	1.404***	764

Notes: ***99%, **95% and *90% *p*-values. 2012 stands for 5 December 2012.

Table 9. Variance equation augmented for logs of bank-specific and regional average CDS spreads and VIX (2010–2012)

Bank	ω_1^i	$\omega_{\log CDS}^i$	$\omega_{\log AVCDS}^j$	$\omega_{\log VIX}$	γ^i	Obs.
Commonwealth Bank Australia	0.245	−0.040	−0.783	−0.783	−0.002	764
Erste Group Bank	−0.012	1.806***	−0.372	−0.372	0.184	764
Dexia	0.292	2.931***	−1.113**	−1.113**	0.596*	764
KBC Group	0.030	1.375***	−0.064	−0.064	0.846**	764
BNP Paribas	0.228	0.375	0.633	0.633	0.364**	764
Société Générale	−0.075	1.026*	−0.212	−0.212	0.568**	764
Credit Agricole	0.245	0.148	0.826**	0.826**	0.362	764
Deutsche Bank	0.036	−0.155	0.765***	0.765***	0.160	764
Commerzbank	0.454**	−1.050**	2.305***	2.305***	0.819***	764
National Bank of Greece	0.250	2.225***	−1.511**	−1.511*	1.741**	764
Alpha Bank	−0.132	1.504**	−0.569	−0.569	2.587**	764
Bank of Piraeus	1.761***	0.537	−0.558	−0.558	2.276***	195
Unicredit	−0.265	0.610	0.571	0.571	0.551*	764
Intesa Sanpaolo	0.309	0.481	0.477	0.477	0.472**	764
Banco Comercial Portugues	0.333	−0.158	1.602***	1.602***	2.191**	764
Banco Espirito Santo	−0.205	−0.049	1.540***	1.540***	1.370***	764
Banco Santander	0.013	2.824***	−2.126***	−2.126***	0.262**	764
BBV Argentaria	−0.040	1.885***	−1.187***	−1.187***	0.372**	764
Banco Popular Español	0.558***	1.492***	−0.959**	−0.959**	0.486**	764
UBS	0.188	−1.033	1.248*	1.248*	0.070	764
Credit Suisse Group	−0.143	−0.558	1.472***	1.472***	0.055	764
Nordea Bank	0.243	1.439*	−1.319	−1.319	0.0260.019	764
Svenska Handbkn	0.280	−0.861*	1.566***	1.566***		764
Swedbank	0.181	0.014	0.013	0.013	−0.036	764
DNB Nor	0.304	0.910	−0.347	−0.347	0.442***	764
Danske Bank	0.157	1.454***	−2.461***	−2.461***	0.298**	764
State Bank of India	0.039	−0.149	1.244*	1.244*	0.285*	764
Mizuho Financial Group	0.198	−0.093	−0.628	−0.628	0.233***	764
Shinhan Financial Group	0.190	0.972**	−0.175	−0.175	−0.001	764
Australia & New Zealand Banking	0.084	0.283	−0.982	−0.982	−0.034	764
HSBC Holding	−0.374	3.043***	−2.290***	−2.290***	0.140**	764
Barclays	−0.107	−0.167	0.872	0.872	0.239	764
Royal Bank of Scotland Group	−0.908***	−2.269***	1.863**	1.863**	0.410*	764
Lloyds Banking Group	0.093	−0.967	1.420**	1.420**	0.270	764
Standard Chartered	0.014	−0.121	−0.138	−0.138	0.474***	764
Bank of America	−0.609**	1.645***	−1.478*	−1.478*	0.880***	764
JP Morgan Chase & Co	−0.190	−0.707	1.709**	1.709**	0.123	764
Citigroup	−0.469**	0.054	0.058	0.058	0.274**	764
Wells Fargo & Co	−0.268	0.623	−1.670***	−1.670***	0.211***	764
Morgan Stanley	−0.014	−1.179	3.081***	3.081***	0.619***	764
Goldman Sachs Group	−0.718***	2.511***	−4.145***	−4.145***	0.182	764
US Bancorp	0.241	0.886**	0.846	0.846	−0.028	195
PNC Financial Services Group	−0.369*	0.633	−1.484***	−1.484***	0.015	764

Notes: ***99%, **95% and *90% *p*-values. Region *j*: the USA, Eurozone, other European countries, other. 2012 stands for 5 December 2012.

depending on public support for their viability, a market-based view of their stock prices is not warranted.

A different econometric specification for returns volatility

For ease of comparison, the specification adopted so far for the stock returns volatility is the one, admittedly idiosyncratic, adopted by Severo (2012). In order to test the robustness of our results, we re-estimated the final specification for the variance equation with all controls in a more conventional EGARCH (1,0) setting, thus replacing Equation 3 with Equation 4:

$$\sigma_t^2 = \exp(\omega_0^i + \omega_1^i \text{SLRI}_t + \omega_Y^i \mathbf{Y}_t + \gamma^i e_{t-1}^i) \quad (4)$$

where $\mathbf{Y}_t$ is the vector of all controls, including the four group average CDS spreads instead of the overall average one.

As for the *G-SIBs* singled out because of the highly statistical significance of the SLRI regressor, we have to draw, as before, different conclusions in the two sample periods. While results are robust in the period 2004–2010,¹¹ what we obtain for the period 2010–2012 strengthens our concerns on the possibility to use the SLRI to calibrate on a stable set of *G-SIBs* a price for the expected liquidity support provided by public authorities. The positive sign of the (statistically significant) SLRI regressor results is in line with those of the previous specification in Tables 5 and 9 only for some European banks, but differs for the estimated autoregressive parameters, which are now consistent with the stationarity requirement also for banks of Eurozone crisis-hit countries (Table 10). What is more interesting, only three non-Euro *G-SIBs* (RBS, Citi and GS) keep to be singled out

Table 10. Variance equation augmented for logs of bank-specific and regional average CDS spreads and VIX (2010–2012); EGARCH(1,0) process

Bank	ω_I^i	$\omega_{\log \text{CDS}}^i$	$\omega_{\log \text{AVCDS}}^j$	$\omega_{\log \text{VIX}}$	γ^i	Obs.
Commonwealth Bank Australia	0.253	−0.045	−0.753	2.741***	0.051	764
Erste Group Bank	0.007	1.747***	−0.340*	0.943***	0.126*	764
Dexia	0.311**	2.733***	−0.980**	1.144***	0.291***	764
KBC Group	0.006	0.924***	0.243	1.172***	0.218**	764
BNP Paribas	0.207	0.221	0.712	2.311***	0.317**	764
Société Générale	−0.104	0.703*	0.052	1.116***	0.270***	764
Credit Agricole	0.218	0.158	0.759**	1.285***	0.176*	764
Deutsche Bank	0.022	0.035	0.627***	1.167***	0.134*	764
Commerzbank	0.302*	−0.837**	1.797***	0.775***	0.331***	764
National Bank of Greece	0.235*	1.917***	−1.261*	0.969***	0.249***	764
Alpha Bank	−0.151	1.273***	−0.427	−0.093	0.211***	764
Bank of Piraeus	0.920	−0.128	0.105	−0.694	0.252	195
Unicredit	−0.279	0.630*	0.478	0.529**	0.271***	764
Intesa Sanpaolo	0.340*	0.455	0.493	1.257***	0.270***	764
Banco Comercial Portugues	0.312**	−0.283	1.669***	0.290	0.559***	764
Banco Espírito Santo	−0.192	−0.231	1.533***	−0.078	0.404***	764
Banco Santander	−0.048	2.672***	−2.001***	1.806***	0.153**	764
BBV Argentaria	−0.021	1.918***	−1.200***	1.279***	0.244***	764

(continued)

¹¹ The autoregressive parameter estimates are below unity for all banks but one (results not reported for space constraints).

Table 10. Continued

Bank	ω_I^i	$\omega_{\log CDS}^i$	$\omega_{\log AVCDS}^j$	$\omega_{\log VIX}$	γ^j	Obs.
Banco Popular Español	0.516***	1.512***	-0.980***	0.640***	0.197***	764
UBS	0.271**	-0.961	1.240*	1.761***	0.034	764
Credit Suisse Group	-0.126	-0.527	1.455***	0.614**	0.049	764
Nordea Bank	0.247	1.448**	-1.324*	1.554***	0.069	764
Svenska Handbkn	0.274	-0.864**	1.576***	1.137***	0.038	764
Swedbank	0.187	0.000	0.021	1.909***	-0.039	764
DNB Nor	0.223	0.737	-0.008	1.224***	0.272***	764
Danske Bank	0.116	1.426***	-2.366***	2.111***	0.185***	764
State Bank of India	0.036	-0.157	1.234**	0.026	0.167**	764
Mizuho Financial Group	0.261	-0.082	-0.587	0.491*	0.214***	764
Sumitomo Mitsui Fin Group	0.198	0.791	-4.293***	1.471	-0.096	195
Mitsubishi UFJ Fin Group	0.293	0.500	-3.188*	1.509	0.214	195
Shinhan Financial Group	0.195	0.976**	-0.166	1.420***	-0.015	764
Australia & New Zealand Banking	0.080	0.308	-0.988	2.340***	-0.020	764
HSBC Holding	-0.398**	2.482***	-1.962***	0.793***	0.221***	764
Barclays	-0.127	-0.140	0.831	0.856***	0.173**	764
Royal Bank of Scotland Group	-0.861***	-2.188***	1.795***	0.583**	0.178**	764
Lloyds Banking Group	0.073	-1.002	1.402**	1.331***	0.159**	764
Standard Chartered	-0.188	2.306	-2.170***	0.996***	0.475***	764
Bank of America	-0.276	1.522***	-1.131*	0.663***	0.410***	764
JP Morgan Chase & Co	-0.185	-0.663	1.709**	0.932***	0.095	764
Citigroup	-0.497***	0.039	0.015	0.477**	0.184***	764
Wells Fargo & Co	-0.299	0.673**	-1.625***	1.362***	0.273***	764
Morgan Stanley	0.062	-1.385**	3.404***	1.019***	0.310***	764
Goldman Sachs Group	-0.728***	2.567***	-4.194***	1.270***	0.234***	764
US Bancorp	0.188	0.752**	0.769	1.516	0.019	195
PNC Financial Services Group	-0.371**	0.667	-1.479***	1.539***	0.024	764
BB&T	-0.151	1.061**	-1.415***	1.941***	0.052	472

Notes: ***99%, **95% and *90% p -values. Region j : the USA, Eurozone, other European countries, others. 2012 stands for 5 December 2012.

when comparing the estimates under different specifications of the final variance equation.

V. Conclusions

We provide estimates of an SLRI comparable to the one proposed in Severo (2012) but derived from a more parsimonious, and fully documented, set of elementary indicators of market liquidity stress, extending the period to 2012, in order to include also the Eurozone sovereign debt crisis. We then perform an econometric investigation of the

association between the SLRI and a group of large banks' stock prices, with particular reference to robustness issues (i.e. for which banks the indicator turns out to be statistically significant) and to an empirical validation of the systemically important banks (*G-SIBs*) list proposed by the FSB. We assess the issues across the subprime financial crisis and its developments up to 2010 in the first time interval and the Eurozone sovereign debt crisis in the second one.

Main findings are that the indicator is close to Severo's but provides a stronger signal of liquidity stress and recovery episodes over the same period. Moreover, robustness checks do not

show relevant differences across estimates built on a reduced number of arbitrage conditions, except when considering the 2010–2012 interval. In fact, a SLRI including only CIP bases signals more sharply liquidity stresses in the Eurozone sovereign debt crisis period, comparable with the period 2008–2009, a finding that is consistent with Allen and Moessner (2012) and Ivashina et al. (2012).

As for the econometric investigation on banks' exposure to liquidity risk in the period 2004–2010, results for the baseline specification with no controls are *prima facie* consistent with Severo (2012) and show that liquidity stresses in practice do not affect stock returns levels, whereas they enhance return volatility. However, different banks are singled out when considering the ones with significant *p*-values for the SLRI in both equations: three (among which only one *G-SIB*) instead of seven (with three other *G-SIBs*) in Severo (2012). When introducing controls for bank-specific and group credit risk and stock market uncertainty, the statistical significance of the SLRI is reduced and varies across banks. Moreover, the empirical selection of banks further differs when using another econometric specification for stock returns volatility.

The pattern of findings during the period 2010–2012 is similar, but for the intriguing result of a neat split between two groups of banks: four Eurozone banks that are headquartered in sovereign-risk hit countries or have received a public capital infusion, and four other ones, among which three US *G-SIBs*. In the first group, liquidity stresses are associated with a reduced rather than a larger volatility of stock returns, possibly on grounds of moral hazard, because the expectations of a further infusion of public resources could induce to bet for a less bumpy stock returns evolution.

We investigated possible cross-sectional effects by country of banks' headquarters, as priced by markets through banks' CDS spreads, owing to the different policies pursued by the central banks, as providers of liquidity in domestic currency. While leaving almost unaffected the main results in the period 2004–2010, we found a relevant modification in the set of the three US *G-SIBs* in the Euro crisis period.

These results motivate a sceptical assessment of policy suggestions to use a SLRI as an input to compute liquidity premia to be charged on a stable

set of large banks as a compensation for the TBTF-driven liquidity support from public authorities. We rather support the Basel 3 approach that relies on supervisors' assessment for required liquidity prudential ratios and for additional loss absorbency capital requirements for supervisors' selected *G-SIBs*. The recent financial crisis has indeed confirmed that financial assets market valuation, among which banks' stock prices, is too prone to herding and other fads to be relied upon to devise robust macro-prudential tools.

We envisage two main themes for future research. First, the ambiguous implications of our results on the issue of systemic liquidity risk and stock performance of differently headquartered *G-SIBs*, and hence of their resilience against such a risk, call for a deeper investigation of their (expected) dependence on home and foreign central banks as providers of their domestic and foreign liquidity in case of an aggregate shortage of liquidity (Baglioni, 2012). Second, elementary measures of market liquidity stresses can yield different signals of systemic liquidity risk across financial crises and/or financial markets. An investigation on how to incorporate thresholds – time-/country-dependent – effects when using a SLRI could help to shed some light on why such a type of indicator has so little effects on stock returns levels.

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