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Contents

Introduction

One of the fastest growing areas in the economic sciences is broadly defined area of finance, with particular emphasis on the financial markets, financial institutions and risk management. Real world challenges stimulate the development of new theories and methods. A large part of the theoretical research concerns the analysis of the risk of not only economic entities, but also households.

The first Wrocław Conference in Finance WROFIN was held in Wrocław between 22nd and 24th of September 2015. The participants of the conference were the leading representatives of academia, practitioners at corporate finance, financial and insurance markets. The conference is a continuation of the two long-standing conferences: INVEST (Financial Investments and Insurance) and ZAFIN (Financial Management – Theory and Practice).

The Conference constitutes a vibrant forum for presenting scientific ideas and results of new research in the areas of investment theory, financial markets, banking, corporate finance, insurance and risk management. Much emphasis is put on practical issues within the fields of finance and insurance. The conference was organized by Finance Management Institute of the Wrocław University of Economics. Scientific Committee of the conference consisted of prof. Diarmuid Bradley, prof. dr hab. Jan Czekaj, prof. dr hab. Andrzej Gospodarowicz, prof. dr hab. Krzysztof Jajuga, prof. dr hab. Adam Kopiński, prof. dr. Hermann Locarek-Junge, prof. dr hab. Monika Marcinkowska, prof. dr hab. Paweł Miłobędzki, prof. dr hab. Jan Monkiewicz, prof. dr Lucjan T. Orłowski, prof. dr hab. Stanisław Owsiak, prof. dr hab. Wanda Ronka-Chmielowiec, prof. dr hab. Jerzy Różański, prof. dr hab. Andrzej Sławiński, dr hab. Tomasz Słoński, prof. Karsten Staehr, prof. dr hab. Jerzy Węcławski, prof. dr hab. Małgorzata Zaleska and prof. dr hab. Dariusz Zarzecki. The Committee on Financial Sciences of Polish Academy of Sciences held the patronage of content and the Rector of the University of Economics in Wroclaw, Prof. Andrzej Gospodarowicz, held the honorary patronage.

The conference was attended by about 120 persons representing the academic, financial and insurance sector, including several people from abroad. During the conference 45 papers on finance and insurance, all in English, were presented. There were also 26 posters.

This publication contains 27 articles. They are listed in alphabetical order. The editors of the book on behalf of the authors and themselves express their deep gratitude to the reviewers of articles – Professors: Jacek Batóg, Joanna Bruzda, Katarzyna Byrka-Kita, Jerzy Dzieża, Teresa Famulska, Piotr Fiszeder, Jerzy Gajdka, Marek Gruszczyński, Magdalena Jerzemowska, Jarosław Kubiak, Tadeusz Kufel, Jacek Li-

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Wanda Ronka-Chmielowiec, Krzysztof Jajuga

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BANK SOLVENCY AND LIQUIDITY RISK IN DIFFERENT BANKING PROFILES – THE STUDY OF EUROPEAN BANKING SECTORS

RYZYKO NIEWYPŁACALNOŚCI I PŁYNNOŚCI W RÓŻNYCH PROFILACH DZIAŁALNOŚCI BANKÓW – BADANIE DLA EUROPEJSKIEGO SEKTORA BANKOWEGO

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JEL Classification: F36, F65, G21, G32, G33

Abstract: The goal of this study is to identify empirically how the banking size and activities affect directly the bank solvency and liquidity risk in different banking profiles. Through a dataset that covers 4250 European banks, spanning the period of 1996-2011, and the methodology of panel regression, I examine the implications of banks' size (in terms of assets and equity) and the nature of the business activity on the stability of European banking sector. The research questions are: whether the biggest banks, included in the SIFIs group are the most unstable link of systemic risk, and whether they manifest themselves as spreading and growing instability in the banking sector. To show the heterogeneity of risk determinants, the sample of banks was divided as follows: large/small assets and large/small equity. The findings have implications for both bank risk management and regulators. This paper advances the agenda of making macroprudential policy operational.

Keywords: banking, liquidity, bank solvency, systemic risk, instability.

Streszczenie: Celem badania jest weryfikacja empiryczna wpływu wielkości i działalności bankowej na ryzyko niewypłacalności oraz utraty płynności w różnych profilach banków. Wykorzystując bazę 4250 banków europejskich obejmującą okres 1996-2011 oraz metodykę regresji panelowej, podjęto próbę odpowiedzi min. na pytanie badawcze: czy największe banki, wchodzące w skład grupy SIFI, są najbardziej niestabilnym sektora bankowego? Aby pokazać różnorodność uwarunkowań ryzyka systemowego, próba banków została podzielona w następujący sposób: duże/małe aktywa i duży/mały kapitał własny. Wyniki mają znaczenie zarówno dla zarządzania ryzykiem bankowym jak i władz regulacyjnych. Artykuł powinien stanowić wytyczne dla kształtowania polityki makroostrożnościowej.

Słowa kluczowe: bankowość, płynność, wypłacalność banku, ryzyko systemowe, niestabilność.

1. Introduction and motivation

The global financial crisis has intensified the financial regulation debate on the macroprudential approach to supervision of systemic risk. On the one hand, regulators led to identify of the so-called Systemically Important Financial Institutions (SIFI's), but on the other, they wonder if such actions are adequate and sufficient for the whole banking system. The Basel Committee on Banking Supervision [2010] defined the SIFI's as financial institutions "whose disorderly failure, because of their size, complexity and systemic interconnectedness, would cause significant disruption to the wider financial system and economic activity", however, it remains interesting, what kind of banks (considering assets/equity size) take the biggest risk. In the literature, the mainstream discussion of SIFI's focused on the largest financial institutions (Bongini et al. [2014]; Greenwood et al. [2012]; Gouriéroux et al. [2012]), apart from the fact whether the small banks afford to raise enough capital to protect both, themselves and the financial system, against severe adverse scenarios.

The main bank's activity is the liquidity mismatch, which means providing liquidity by obtaining funding that is more liquid than their assets. The traditional business model of many banks is based on maturity transformation – funding through shorter term deposits into longer term investments. The first sign of a systemic crisis influencing the banking system is mainly manifested by a lack of liquidity in the bank's balance sheet. It makes banks vulnerable to creditor runs and consequently, the loss of solvency.

Bank's stability depends on the combination of its capital levels and funding position. In this case the aim of this paper is looking at liquidity-solvency nexus of banks and reflecting on the accuracy of Basel III regulation, whether solvency and liquidity risks are treated separately, or they strengthen mutually. The goal of the paper is to fill the gap in the literature and empirically test the solvency-liquidity interaction of banks examining the short-term balance sheets of nearly 4250 banks in Europe over the period of 1996-2011. I also investigate the size and vulnerability of the liquidity and solvency risks in the European banking system and their determinants (specific, macroeconomic or financial market). This paper addresses the need for a better understanding of the determinants of solvency-liquidity risk taking by banks in Europe. To the best of the authors' knowledge, this is the first study that seeks to present leverage and liquidity gap distribution in different bank profiles and identify which factors can explain the risk variation in individual banks.

The results suggest that there are strong interactions between solvency and liquidity risks of banks that make them particularly vulnerable to systemic crisis. Following this statement, the systematic importance may occur not only in large, levered banks, but also in small ones. These solvency-liquidity interactions should be accounted for in designing he liquidity and capital regulation.

The paper is organized as follows. In Section 2, I present the literature review of solvency and liquidity in the banking system. In Section 3, I describe the data and methodology of the research study. Finally, Section 4 is devoted to the presentation of the results and implications for managing and supervision of the solvency-liquidity risk.

2. Literature review and hypothesis

Literature discusses the problem of defining financial entities which effect systemic risk and threaten real economy and the whole financial system. The key question, for implementing macroprudential regulation, is: How can these SIFI's be identified?

From a quantitative viewpoint, systemic risk refers to small probability events in the financial system that result in high losses [Drehmann, Tarashev 2011]. Also, the theory provides conflicting predictions about optimal systemic risk measures. It suggests that measurement tools should support the understanding of linkages between the financial institutions and macroeconomics. The European Central Bank categorized three forms of systemic risk in the banking sector: first, as a slow build-up of vulnerabilities in the banking sector that may drive a financial crisis; second, as a result of an idiosyncratic risk to a particular financial institution that is transmitted to other entities; third, as a common shock that affects the whole system and is propagated to the real sectors [ECB 2009].

Systemic risk measures such as the Marginal Expected Shortfall (MES) [Acharya et al. 2010; Brownlees, Engle 2011], and the CoVaR [Adrian, Brunnermeier 2008] estimate the domino channels in the banking system. However, they require testing of crisis scenarios. An alternative approach is based on more informative data sets, corresponding to clearing and large interbank payment systems [Elsinger et al. 2004, 2006a,b].

Another research focuses on structural modelling of bank's balance-sheet positions in terms of assets and liabilities [Greenwood et al. 2012; Gouriéroux et al. 2012]. However, these balance sheets give no information on the existing exogenous and contagion effects, they are characterized by relatively simple and publicly accessible data. Major consequences in terms of SIFI's identification follow from the fact, that small, unlevered banks can appear more systemically risky than the large and levered ones. More specifically, our testable hypotheses about the systemic importance of banks are the following:

H1. Capital-constrained and small assets banks have a larger average exposure to liquidity risk than adequately capitalized and big banks.

Based on this approach, I compared the distribution of liquidity and solvency risk in different assets/equity size banks. I used two risk measures: firstly – leverage, as the financial institutions can improve their own solvency by higher equity

and corresponding lower leverage, that reduce the probability of insolvency; and secondly – short term liquidity gap, as short-term deposits can be quickly withdrawn by customers. The effective method to manage the liquidity risk and prevent the banking crisis is holding short-term assets ready for sale. These methods are very popular, simple to calculate and interpret.

The problem of complementarity of solvency and liquidity risk is broadly described by Goodhart [2008] and International Monetary Fund [2008]. They indicate that an illiquid bank can progress to insolvency, and vice versa: an insolvent bank cannot find financing in the market. Diamond and Rajan [2005, 2011] describe the interaction between solvency and liquidity banks' fundamentals as the base of the systemic crisis. Rochet and Vives [2004] and Morris and Shin [2008] empirically emphasize that higher capital levels of banks give the confidence to creditors in providing funds and liquidity to them.

While the solvency-liquidity risk management has been well studied theoretically in the literature, the interplay between liquidity and solvency risks in banks tends to be neglected in the new regulatory standards. The Basel III liquidity requirements[1] impose that banks hold an appropriate amount of liquid and high-quality assets to cover their liquidity perforce. However, the liquidity perforce is substantially an effect of the bank's mix funding policy and does not depend on other counterparty's fundamentals (especially on its assets' risk and capital adequacy).

Similarly, increasing capitalization will force banks to carefully consider how much of and to which businesses and clients they allocate capital, but it is not associated with bank's exposure to liquidity risk. On the other hand, the new liquidity measure will prolong the duration of financing, which will reduce the rollover risk, but will increase the funding cost. The solvency-liquidity interactions have been empirically measured by Das and Sy [2012], Pierret [2013] and Gorton and Metrick [2012] on a sample of the U.S. banks. They highlight the empirical interaction between solvency and liquidity risks of banks that make them particularly vulnerable to the aggregate crisis. In this paper, I fill gap in the literature and test the solvency-liquidity risk problem in big/small banks. I study whether the following hypothesis holds in the European banking system:

H2. Banks' liquidity shortfall and solvency risk interactions are much more visible in small banks then in large ones.

The determinants and the causes of the recent global financial crisis have been largely described in the finance literature. The key indicated factors of leverage and liquidity risk in banks include the malfunctioning of the financial market, monetary policy, or the transmission mechanism through the interest rate channel. Surprisingly,

[1] The new liquidity measures: Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR).

while there are several analyses dealing with the effect of monetary policy actions on bank stability [Fiordelisi et al. 2014; Madura and Schnusenberg 2000; Yin and Yang 2013; Adrian and Shin 2008; Kim et al. 2013], there are no empirical studies including the solvency and liquidity risk in the European market. My work is related to different strands of literature. Studies on the link between leverage and liquidity risk in the banking and financial market factors find that investors' risk appetite is an important determinant of banks stability [Acharya et al. 2010; Beltratti and Stulz 2012].

I believe that the recent global financial crisis has clearly shown the negative consequences of wholesale funding on bank solvency-liquidity interactions, and I test if this hypothesis is true for Europe over the 1996-2011 period:

H3. Banks that are assets/equity small are more vulnerable to financial market factors than big banks.

3. Research design and identification of the banking risk measures

Testing for the interactions between solvency risk and short liquidity gap, I use leverage as the solvency risk measure, calculated as:

$$LEVERAGE_{n,i,t} = \frac{TA_{n,i,t}}{E_{n,i,t}} \tag{1}$$

where: $LEVERAGE_{it}$ is the leverage ratio measure; E – total bank's equity, TA – total assets, i – the cross-sectional dimension across banks, n – country; t denotes the time dimension.

The credible leverage ratio is the one that ensures adequate capture of both the on- and off-balance sheet leverage of banks. As a liquidity measure, I used the gap between bank's liquid assets and short term deposits, calculated as ratio:

$$LIQSHORT_{n,i,t} = \frac{\left(Assets\_short_{n,i,t} - Deposit\_short_{n,i,t}\right)}{Assets\_short_{n,i,t}} \tag{2}$$

where: $LIQSHORT_{it}$ is the liquidity gap covering only short term periods, $Assets\_short_{it}$ – short-term, liquid banks assets, $Deposit\_short_{it}$ – short-term deposits of bank i in period t term debt, and short-term assets.

Liquidity risk ratio will increase as the short-term debt will be invested in long-term profitable assets. The gap between the short-term assets and short-term debt – the liquid asset shortfall – represents the amount of liquid assets that would be left, if the bank completely lost its access to short-term funding.

As liquidity risk concerns both sides of the balance sheet, I test for the interaction between the solvency risk and short-term liquidity. Therefore, the solvency-liquidity risk is tested using a panel regression model presented as (Eq. 3):

$$Y_{n,i,t} = \beta_1 + \beta_2 Y_{n,i,t-l} + \beta_3 LEVERAGE_{n,i,t} + \beta_4 LIQSHORT_{n,i,t} + \beta_4 VIX_{index} + \sum_{j=1}^{k} \gamma_j z_{n,i,t-j} + \sum_{j=1}^{k} \vartheta_j s_{n,i,t-j} + \mu_{ji} + \varepsilon_{i,t} \quad (3)$$

where: $Y_{n,i,t}$ is the bank risk measure, calculated as $LEVERAGE_{n,i,t}$ (Eq. 1) for bank solvency risk and calculated as $LIQSHORT_{n,i,t}$ (Eq. 2), for bank liquidity risk, in *i-th* country, observed in period *t*, *l* – number of lags for dependent variable, β – the regression coefficient (the measure of sensitivity of stability risk), VIX_index_t – index of implied market volatility in period *t* (a financial market factor), $z_{n,i,t}$ – a vector of independent variables that are specific to the bank, *z* = [*SIZE*, *LOAN_TA*],

where: *SIZE* – the logarithm of total banks assets, *LOAN_TA* – the ratio of bank's loans to total assets; $s_{n,i,t}$ – a vector of the independent macroeconomic variables, *s* = [*GDP_GROWTH, INFLATION, LT_IR_RATE, MM_RATE*],

where: *GDP_GROWTH* – annual growth rate of real GDP, *INFLATION* – inflation rate, *LT_IR_RATE* – long term interest rate, *MM_RATE* – short term money market interest rate; μ_j – a group effect, $\varepsilon_{j,t}$ – a random component.

To test our hypotheses, I apply two-step GMM robust estimator for data spanning the years 1996–2011 on individual banks [Arellano, Bond 1991; Blundell, Bond 1998]. To test the validity of the instruments, I implemented the Hansen specification test, which, under the null hypothesis of valid moment conditions, is asymptotically distributed as chi-square [Arellano, Bond 1991; Blundell, Bond 1998]. All regression parameters are provided with the level of significance, which should facilitate interpretation of results.

Through a dataset that covers 4250 European banks spanning the period 1996–2011 and the methodology of panel regression, the empirical findings document the solvency-liquidity nexus in the banking sector. The full range of banks from 31 countries in Europe (Austria, Belgium, Cyprus, Greece, Finland, France, Denmark, Germany, Spain, the Netherlands, Luxembourg, Ireland, Iceland, Norway, Portugal, Sweden, Switzerland, Great Britain, Italy, Bulgaria, the Czech Republic, Estonia, Latvia, Lithuania, Poland, Romania, Slovenia, Slovakia, Ukraine, Hungary, Turkey[2]) divided into four groups: i/ large asset banks defined as the 30% of the largest in terms of total assets of the banking system, and ii/ small asset banks, defined as the 30% of smallest in terms of total assets of the banking system, iii/ large equity banks defined as the 30% of the largest in terms of total equity of the banking system, and iv/ small equity banks, defined as the 30% of smallest in terms of total equity of the banking system. Then I try to identify the sensitivity of solvency-liquidity risk

[2] Turkey and Ukraine have been classified for testing due to the significantly expanded banking sector and aspirations of these countries to join the European Union.

indicators to a number of variables. The study should indicate the general outline of dependency and diversification of sources of risk in the indicated groups.

I compute the measure of bank's risk using the Bankscope database, which reports bank balance sheet data. I use unconsolidated statements since they are preferred to avoid relevant differences in balance sheets of headquarters and subsidiaries compensating each other. The international sample of banks is restricted to banks with availability of no less than 75 per cent of data. Macroeconomic variables are obtained from the database: OECD Statistics, and the World Bank. VIX index is obtained from Thomson Reuters Eikon. I relate the data to risk models, as well as descriptive statistics of the selected variables for large/small assets, as provided in Table 1 and Table 2 for large/small equity banks.

Table 1. Descriptive statistics of selected variables for group of samples: large and small assets banks

Group of banks:	Large assets	Small assets	Large assets	Small assets	Large assets	Small assets	Large assets	Small assets	Large assets	Small assets
Variable	Observation		Mean		Std. Dev.		Min		Max	
LIQSHORT	1 647	13 386	**–2.79**	**–3.45**	**0.86**	**0.60**	–4.42	–5.88	1.00	1.00
LEVERAGE	17 006	15 652	**21.15**	**13.30**	**19.24**	**11.50**	4.62	9.53	291.11	269.76
LOAN_TA	17 006	15 652	0.57	0.56	0.23	0.24	–0.13	0.00	1.00	1.00
CAP_TA	15 017	1 167	8.43	12.80	7.21	13.70	0.66	0.56	99.84	99.89

Note 1: **large assets banks**, defined as 30% of the largest in terms of total assets of the banking system; **small assets banks**, defined as 30% of the smallest in terms of total assets of the banking system. The sample includes observations from 31 European countries, spanning the period 1996–2011.

Note 2: as *LEVERAGE* (Eq. 1) – for bank solvency risk, *LIQSHORT* (Eq. 2) – liquidity gap, *SIZE* – logarithm of total banks assets, *LOAN_TA* – as the ratio of bank's loans to total assets, *CAP_TA* – as the ratio of banks capital to total assets.

Source: Author's own study.

Table 2. Descriptive statistics of all the variables used in the regression and for group of samples

Group of banks:	Large equity	Small equity	Large equity	Small equity	Large equity	Small equity	Large equity	Small equity	Large equity	Small equity
Variable	Observation		Mean		Std. Dev.		Min		Max	
LIQSHORT	15 994	14 114	**–2.10**	**–3.32**	**0.85**	**0.62**	–4.42	–5.03	1.00	1.00
LEVERAGE	16 672	16 195	**19.80**	**12.79**	**14.04**	**20.94**	1.00	4.62	264.97	291.11
LOAN_TA	16 672	16 195	0.56	0.59	0.23	0.23	0.13	0.00	1.00	1.00
CAP_TA	14 504	12 352	10.27	8.98	10.74	9.09	0.66	–100.00	100.00	98.80

Note 1: **large assets banks**, defined as 30% of the largest in terms of total assets of the banking system; **small assets banks**, defined as 30% of the smallest in terms of total assets of the banking system. The sample includes observations from 31 European countries, spanning the period 1996–2011.

Note 2: as *LEVERAGE* (Eq. 1) – for bank solvency risk, *LIQSHORT* (Eq. 2) – liquidity gap, *SIZE* – logarithm of total banks assets, *LOAN_TA* – as the ratio of bank's loans to total assets, *CAP_TA* – as the ratio of banks capital to total assets.

Source: Author's own study.

The information given in Table 1 emphasizes the differences in both, the mean ratio of liquidity gap and leverage. Negative value of liquidity gap means a greater risk of losing liquidity by a bank. The comparison of the leverage between the large (21,15) and small banks (13,30) shows that large banks use the external capital financing much more expansively than the small banks. On the other hand, the short term liquidity gap is smaller in the big banks (–2,79 vs. –3,45). The similar situation can be observed in the sample of large/small equity banks (Table 2). It can be assumed that large banks benefit from the economies of scale. The size allows for better diversification, which reduces risks and allows banks to operate with lower capital and less-stable funding. Also large banks may use wide spectrum of funding for market-based sources, which facilitates the financing in the case of crisis situations. Small banks may be more volatile during financial market changes and lose relying only on traditional business. It confirms the H1 that the capital-constrained and small banks have a larger average exposure to liquidity risk than adequately capitalized and big banks.

4. Results

Results on the changes in the liquidity-solvency measures of risk (LEVERAGE and LIQSHORT) are presented in Tables 3 and 4, respectively. Having seen the key features and implications of the model (Eq. 3), let us now have a look at the implications for the effects of the leverage ratio sensitivity. The simulation results presented in Table 3 show clear evidence of significant interactions between liquidity-solvency nexus in small banks. The increase in the liquidity gap limits the use of leverage in small banks (–2,277; –1,016 – respectively), as opposed to large banks, where these changes are positive but insignificant (0,063; 0,764 – respectively). I find similar interactions in small banks for the liquidity gap sensitivity with changes in leverage risk. The increase in the leverage ratio decreases liquidity short gap in small banks (–0,902; –0,801 – respectively) much more then in large banks (Table 4).

This last result could indicate that banks did indeed experience differential changes in liquidity-solvency risk depending on the assets/equity size. I explicitly follow the related study by Pierret [2013] and Perotti and Suarez [2011]. It is surprising that I find no significant liquidity-solvency risk interactions for our large banks sub-samples. However, the problem is important because small but illiquid bank can progress to insolvency, and cause the contagion process of systemic risk in all the banking system. It is proof of the hypothesis H2: Bank's liquidity shortfall and solvency risk interactions are much more visible in small banks then in large ones.

The size of loans LOAN_TA does not constitute incentive for applying higher leverage in large banks (impact is not statistically significant), but significantly increases the use of leverage at small banks. On the other hand, it should be noted that in both types of banks the cost of money factor (LT_IR_RATE – long-term

Table 3. The relationship between **banking leverage** and liquidity gap, specific and macroeconomic determinants

Group of banks:	Full sample		Large assets		Small assets		Large equity		Small equity	
Y=LEVERAGE	coef.	p -value	coef.	p -value	coef.	p -value	coef.	p -value	coef.	p -value
Y(-1)	0.838	0.000	0.732	0.000	0.868	0.000	0.564	0.000	0.797	0.000
	0.044		0.081		0.073		0.064		0.069	
Y(-2)	0.043	0.264	0.124	0.039	–0.008	0.859	0.291	0.000	0.209	0.005
	0.038		0.060		0.047		0.055		0.074	
LIQSHORT	–0.876	0.041	0.063	0.344	–2.277	0.001	0.764	0.051	–1.016	0.098
	0.429		0.820		0.319		0.763		0.747	
SIZE	0.002	0.886	0.002	0.963	0.016	0.541	–0.013	0.629	0.031	0.471
	0.015		0.033		0.025		0.026		0.043	
LOAN_TA	–0.061	0.903	–2.100	0.137	2.076	0.009	–0.113	0.911	2.082	0.039
	0.501		1.414		0.800		1.016		1.009	
GDP_GROWTH	0.010	0.348	0.061	0.231	0.024	0.314	0.007	0.674	–0.039	0.177
	0.010		0.027		0.024		0.018		0.029	
INFLATION	–0.116	0.020	–0.003	0.379	–0.071	0.106	–0.099	0.318	0.026	0.032
	0.050		0.117		0.167		0.099		0.152	
LT_IR_RATE	–0.379	0.000	–0.022	0.002	–0.941	0.002	–0.059	0.013	–0.859	0.013
	0.064		0.136		0.142		0.105		0.159	
MM_RATE	0.213	0.000	0.363	0.000	0.165	0.057	0.354	0.000	–0.125	0.175
	0.035		0.087		0.087		0.082		0.092	
VIX_INDEX	–0.021	0.000	–0.021	0.004	–0.023	0.004	–0.013	0.018	0.020	0.003
	0.003		0.007		0.008		0.006		0.007	
CONSTANT	1.605	0.265	1.499	0.596	–0.229	0.906	0.436	0.831	–11.238	0.007
	1.439		2.828		1.945		2.044		4.147	
Tests and observations:										
Arellano-Bond test for AR(1):	–4.69	0.00	–3.31	0.00	–4.16	0.00	–3.10	0.00	–2.88	0.00
Arellano-Bond test for AR(2):	1.65	0.10	0.60	0.05	-0.09	0.09	-2.13	0.03	-1.66	0.09
Hansen test:	842.18	0.00	637.00	0.00	671.85	0.00	675.69	0.00	638.60	0.00
Number of instruments:	392		392		392		392		392	
Number of obs:	36 529		12 965		7 824		12 577		8 491	
Number of banks:	4 251		1 543		1 562		1 511		1 641	

Note 1: The sample of all banks from 31 European countries and in divisions of large/small assets and large/small equity.

Note 2: The model is given by Eq. (3). The symbols have the following meaning: *LEVERAGE* (Eq. 1) – for bank solvency risk, *LIQSHORT* (Eq. 2) – liquidity gap, *SIZE* – logarithm of total banks assets, *LOAN_TA* – as the ratio of bank's loans to total assets, *GDP_growth* – real GDP growth rate, *INFLATION* – inflation rate, *LT_IR_RATE* – long term interest rate, *MM_RATE* – short term money market interest rate, *VIX_index* – index of implied volatility. The models have been estimated using the GMM estimator with robust standard errors. Standard Error are given in Italic. The p-value denotes significance levels. Data range 1996-2011.

Source: Author's own study.

Table 4. The relationship between **banking short liquidity gap** and leverage, specific and macroeconomic determinants

Groups of banks:	Full sample		Large assets		Small Assets		Large equity		Small equity	
Y=LIQSHORT	coef.	p -value	coef.	p -value	coef.	p -value	coef.	p -value	coef.	p -value
Y(-1)	0.432	0.000	0.463	0.000	0.529	0.000	0.449	0.000	0.554	0.000
	0.070		0.059		0.104		0.050		0.098	
Y(-2)	0.085	0.002	0.035	0.206	0.164	0.004	0.068	0.039	0.071	0.005
	0.027		0.028		0.056		0.033		0.025	
LEVERAGE	–0.001	0.017	0.002	0.005	–0.902	0.075	–0.003	0.000	–0.801	0.016
	0.001		0.001		0.001		0.001		0.000	
SIZE	0.000	0.543	–0.001	0.418	0.000	0.936	0.000	0.978	0.001	0.373
	0.001		0.001		0.001		0.001		0.001	
LOAN_TA	0.099	0.000	0.042	0.458	0.055	0.078	0.021	0.729	0.051	0.092
	0.025		0.057		0.031		0.060		0.030	
GDP_GROWTH	0.000	0.239	–0.001	0.149	-0.001	0.067	–0.002	0.105	-0.001	0.172
	0.000		0.001		0.001		0.001		0.001	
INFLATION	0.009	0.000	0.029	0.000	0.019	0.000	0.022	0.000	0.027	0.000
	0.002		0.005		0.005		0.006		0.007	
LT_IR_RATE	0.005	0.030	0.015	0.003	0.014	0.001	0.020	0.000	0.021	0.001
	0.002		0.005		0.004		0.005		0.006	
MM_RATE	0.001	0.488	–0.034	0.026	–0.865	0.010	–0.478	0.183	–0.972	0.002
	0.001		0.003		0.003		0.003		0.004	
VIX_INDEX	–0.001	0.000	–0.001	0.005	–0.001	0.004	–0.001	0.001	–0.001	0.006
	0.000		0.000		0.000		0.000		0.000	
CONSTANT	0.853	0.000	0.433	0.045	0.444	0.076	0.325	0.093	0.486	0.097
	0.171		0.215		0.250		0.193		0.293	
Tests and observations:										
Arellano-Bond test for AR(1):	–4.85	0.00	–5.62	0.00	–2.32	0.02	–5.86	0.00	–5.17	0.00
Arellano-Bond test for AR(2):	–1.65	0.09	–1.30	0.02	–1.21	0.02	–1.77	0.07	0.51	0.06
Hansen test:	952.15	0.00	706.33	0.00	583.05	0.00	670.69	0.00	660.73	0.00
Number of instruments:	394		394		394		394		394	
Number of obs:	36110		12850		7684		12469		8376	
Number of banks:	4200		1526		1541		1497		1617	

Note 1: The sample of all banks from 31 European countries and in divisions of large/small assets and large/small equity.

Note 2: The model is given by Eq. (3). The symbols have the following meaning: *LEVERAGE* (Eq. 1) – for bank solvency risk, *LIQSHORT* (Eq. 2) – liquidity gap, SIZE – logarithm of total banks assets, *LOAN_TA* – as the ratio of bank's loans to total assets, GDP_growth – real GDP growth rate, *INFLATION* – inflation rate, *LT_IR_RATE* – long term interest rate, *MM_RATE* – short term money market interest rate, VIX_index – index of implied volatility. The models have been estimated using the GMM estimator with robust standard errors. Standard Error are given in Italic. The p-value denotes significance levels. Data range 1996-2011.

Source: Author's own study.

and MM_RATE – short-term) significantly influences the risk undertaken by banks. Leverage ratio is reduced by the increases of long term interest rates in small banks much more then in big ones. Also, the changes in money market rate influence negatively the liquidity short gap in small banks. I also note the negative coefficient of the VIX index as banks' exposure to liquidity risk decreases during high volatility in the market. Finally, solvency-liquidity risk is not sensitive to the considered macroeconomic factors (GDP and inflation rate).

Summing up the implications of solvency-liquidity risk interaction and its determinants confirms positively three hypotheses following from the theoretical discussion.

5. Conclusion

This paper reveals the empirical solvency-liquidity risk problem. The interaction between solvency and liquidity risks of banks should not be treated separately because they strengthen each other, and make them particularly vulnerable to the aggregate crisis. In this paper, I tested the solvency-liquidity risk by examining the short-term balance sheet and the solvency risk measures of a sample of European banks in years 1996-2011. Firstly, I found that capital-constrained and small assets banks have a larger average exposure to liquidity risk than adequately capitalized and big banks.

Surprisingly, the study also presented that the leverage affects negatively and significantly the funding gap of small banks, but such influence is not found in the large banks sample. This suggests that large banks may have a more flexible business model (with higher leverage and more market-based funding activities) than small banks. The size allows for better diversification, which reduces the risks and allows banks to operate with lower capital and wide spectrum of funding. When the bank holds more short-term liquidity gap, its risk of insolvency in a crisis increases. Small banks may be more volatile during financial market changes and lose relying only on traditional business. The problem is important because small but illiquid bank can progress to insolvency, and cause the contagion process of systemic risk in the whole banking system.

This results appear to be strong under many robustness checks and support the theoretical models of the interaction between solvency and liquidity risks and its amplification to systemic risk. The findings may inform the current debate on changes in the international regulation of the banking sector and definition of systematically important financial institutions.

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