PRACE NAUKOWE UNIWERSYTETU EKONOMICZNEGO WE WROCŁAWIU
RESEARCH PAPERS OF WROCŁAW UNIVERSITY OF ECONOMICS nr 482 • 2017

Wrocław Conference in Finance: Contemporary Trends and Challenges ISSN 1899-3192
e-ISSN 2392-0041

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MACRO- AND MICROPRUDENTIAL REGULATIONS AND THEIR EFFECTS ON PROCYCLICALITY OF SOLVENCY AND LIQUIDITY RISK

INSTRUMENTY MAKRO- I MIKROOSTROŻNOŚCIOWE I ICH WPŁYW NA PROCYKLICZNOŚĆ RYZYKA WYPŁACALNOŚCI I PŁYNNOŚCI BANKU

DOI: 10.15611/pn.2017.482.16
JEL Classification: E32, G21, G28, G32

Summary: This paper aims to identify the effect of macroprudential policies and microprudential regulations and their interactions on the sensitivity of leverage and liquidity funding risk to the business cycle. Analysing the sample of 782 banks we find that both macroprudential and microprudential instruments have insignificant impact on the procyclicality of leverage in the non-crisis period. Macroprudential instruments decrease the procyclicality of liquidity risk during the non-crisis period and increase the procyclicality of leverage during the crisis. Restrictions on the range of activities conducted by banks reduce the procyclicality of liquidity risk during the non-crisis period. Interaction between the macroprudential instruments targeted at risk-taking by borrowers and restrictions on the range of activities taken by banks has been found to be effective in reducing the procyclicality of leverage during the crisis period.

Keywords: leverage, liquidity, procyclicality, macroprudential policy, microprudential regulations.

Streszczenie: Celem artykułu jest określenie, w jaki sposób instrumenty polityki makroostrożnościowej i wybrane regulacje mikroostrożnościowe oraz ich interakcje wpływają na wrażliwość dźwigni i ryzyka płynności na makroekonomiczny cykl koniunkturalny. Przeprowadzona analiza na populacji 782 banków wskazuje, że zarówno instrumenty makroostrożnościowe, jak i regulacje mikroostrożnościowe mają nieistotny ekonomicznie wpływ na procykliczność dźwigni podczas okresu bez kryzysu. Instrumenty makroostrożnościowe ograniczają procykliczność ryzyka płynności w okresie bez kryzysu i powodują wzrost procykliczności dźwigni podczas kryzysu. Regulacje ograniczające zakres czynności wykonywanych przez banki ograniczają procykliczność ryzyka płynności w okresie bez kryzysu. Związki interakcyjne między instrumentami makroostrożnościowymi ograniczającymi ry-

zyko kredytobiorcy i regulacjami ograniczającymi zakres czynności wykonywanych przez banki są skuteczne w redukcji procykliczności dźwigni w okresie kryzysu.

Słowa kluczowe: dźwignia, płynność, procykliczność, polityka makroostrożnościowa, regulacje mikroostrożnosciowe.

1. Introduction

Leverage and liquidity risk of the banking sector have become an area of a deepened research in the finance literature due to their dynamic changes across the business cycle, and thus potential to amplify procyclicality of the financial sector [Bank of England 2009, CGFS 2012, ESRB 2014a, b].

Previous research on bank risk, and in particular on leverage and liquidity risk, shows that bank size is an important driver of sensitivity of bank risk to its determinants. In this study, we contribute to previous research in this area [see: Adrian, Shin 2010; Haq, Heaney 2012; Acharya, Viswanathan 2010; Acharya, Ryan 2016; Laux, Rauter 2016] by looking at the role of macroprudential policy and microprudential regulations in the link between the business cycle and bank leverage, as well as bank liquidity risk across countries. We aim to answer several questions. First, do macroprudential policies reduce the procyclicality of leverage and liquidity risk during non-crisis period? What is the role of microprudential regulations in this procyclicality? Second, do macroprudential policy instruments affect sensitivity of leverage and liquidity risk to the business cycle during the crisis period? Third, is concurrent application of the macroprudential policies and microprudential regulations effective in reducing the procyclicality of leverage and liquidity risk? To find the answers to these questions we apply the two-step GMM Blundell and Bond's [1998] approach to individual bank data from over 60 countries.

The rest of the paper is organized as follows. Section 2 presents literature review. Section 3 covers research design and data. Section 4 presents analysis of research results. Finally, Section 5 presents the implications of our research.

2. Related literature

Our study is related to three broad streams in the banking and financial literature. The first one focuses on the factors which may be significant in explaining bank risk [Kane, Unal 1988; Flannery, James 1984; Haq, Heaney 2012]. This literature, however, considers only the drivers of equity risk measures, i.e. systematic risk proxied by beta coefficient; idiosyncratic risk; total risk (bank equity return standard deviation); interest rate risk (interest rate beta) – see: Kane and Unal [1988], Flannery and James [1984] and Haq and Heaney [2012]) – and credit risk (measured as loan loss provisions divided by total assets), and is not interested in analysing the

differences in the levels of leverage. In the same vein, Haq and Heaney [2012] find mixed evidence on the relation between bank specific factors and bank risk measures in 15 European countries. Their study, however, does not cover the macroeconomic factors affecting bank leverage.

Another stream in the literature focuses on procyclicality of banking risk [Czerwińska, Jajuga 2016; Olszak 2015], and in particular of leverage [Adrian, Shin 2010; Acharya, Viswanathan 2010; Acharya, Ryan 2016; Laux, Rauter 2016; Olszak, Kowalska 2016] and on procyclicality of liquidity risk, proxied by loans to deposits ratio (LTD, see e.g. Olszak and Kowalska [2016]. This procyclicality is, however, approximated in a much diversified way. Adrian and Shin [2010] measure it as a positive association between leverage (i.e. total assets divided by total equity) and liquidity risk (i.e. proxied by total asset growth). This approach is used in several papers (see for example, Damar et al. [2013] and Beccalli et al. [2015]), but seems to be quite controversial. It seems better to proxy this procyclicality by looking at the association between leverage and the business cycle (as suggested in a stylized paper by Bank of England [2009]). Therefore, Acharya and Ryan [2016] and Laux and Rauter [2016] recommend capturing this procyclicality by looking at the association between leverage growth and the business cycle. Some papers on procyclicality of leverage show that leverage plays a significant role in the amplification of financial shocks through balance sheets [Adrian, Shin 2010; Acharya, Viswanathan 2010]. These studies also find that there is some link between leverage and liquidity in investment banks [Adrian, Shin 2010] and that market liquidity and funding liquidity are affected by the build-up of leverage in the financial sector [Acharya, Viswanathan 2010]. In a recent paper Laux and Rauter [2016] document strong procyclicality of leverage, and show that fair value accounting contributes to the positive relation between the GDP growth and book leverage growth during expansionary periods. This procyclicality is stronger in the case of commercial than in the case of savings banks. In a recent paper Olszak and Kowalska [2016] show that during the non-crisis periods, leverage is not necessarily procyclical. The procyclicality is however, visible during the crisis period, in particular in the sample of large banks. As for liquidity risk, it has been found to be procyclical during non-crisis period and countercyclical during the crisis (see: Olszak and Kowalska [2016]).

The third stream in the financial economics literature analyses the factors explaining financial stability of banks [Barth et al. 2006; Lim et al. 2011; Cerutti et al. 2015; Claessens et al. 2014; Olszak et al. 2016, 2017], and the procyclicality of the banking sector as a macroprudential policy objective [Lim et al. 2011; Cerutti et al. 2015; Claessens et al. 2014]. Barth et al. [2006] show that microprudential regulations and supervision (both official and private) may have some impact on the occurrence of banking crises. However, they do not necessarily reduce their frequency.

The contemporary literature on macroprudential policy shows that macroprudential policy instruments are important in affecting the procyclicality of leverage. Lim et al. [2011] explore the links between macroprudential policy instruments and developments in leverage and credit, using aggregated annual data from 49 countries in years 2000-2010. They document evidence suggesting that the presence of policies such as the loan to value ratio (LTV) and debt to income ratio (DTI) limits, ceilings on credit growth, reserve requirements and dynamic provisioning rules can mitigate the procyclicality of credit and leverage (i.e. they reduce the positive sensitivity of credit and leverage to the business cycle, proxied by the real GDP growth). Claessens et al. [2014], find that borrower-targeted instruments are effective in reducing the growth in bank's leverage, asset and non-core liabilities. Countercyclical instruments also help mitigate the increases in bank leverage, but they are of little effect thorough the cycle. Some policies are counterproductive during the downswing, serving to aggravate declines, which is consistent with the *ex-ante* nature of the macroprudential tools. Cerutti et al. [2015] show that the usage of macroprudential policies is generally associated with lower growth in aggregated credit, notably in household credit. Olszak et al. [2016b] show that macroprudential policy instruments may have been effective in reducing the procyclical impact of capital ratio on lending during the last financial crisis. This effect is particularly strong in the sample of large banks.

In this study, we contribute to previous research by testing the role of macroprudential policy and microprudential regulations in the link between the business cycle and bank leverage, as well as bank liquidity risk across countries. We aim to verify several hypotheses, focusing on the impact of regulations on sensitivity of leverage and liquidity risk to the business cycle during non-crisis period and in the last financial crisis period. The first set of hypotheses refers to the potential role of macroprudential policies and microprudential regulations in the sensitivity of solvency and liquidity risk during the non-crisis period. The other set of hypotheses concentrates on the role of macro- and microprudential regulations in the procyclicality of leverage and liquidity risk during the last financial crisis. And finally, the third group of hypotheses focuses on the interactions between macro- and microprudential regulations and on the effects of these interactions on the procyclicality of leverage and liquidity risk during the non-crisis and crisis period.

Macroprudential policies aim at reduction of risk taking by banks and by bank borrowers, in particular during the non-crisis period, and therefore we predict that they should reduce the procyclicality of leverage and liquidity risk during the non--crisis period (hypothesis H1a). As for the impact of the microprudential regulation, previous evidence does not suggest its potential to affect the levels of bank risk and its procyclicality. We therefore, expect that microprudential regulations do not affect significantly the sensitivity of leverage and liquidity risk to the business cycle (hypothesis H1b). Macroprudential policies protect banks from the crisis due to higher risk buffers (capital and reserves). We thus predict that banks' leverage and

liquidity risk should be immune to GDP in the crisis period in countries in which more macroprudential policies were applied in the pre-crisis period (hypothesis H2a). Previous evidence on microprudential regulations only shows that they may be effective in affecting procyclicality of loan loss provisions [Olszak et al. 2017]. However, there is no guidance as to the potential effects of these regulations on procyclicality of leverage and liquidity risk during the crisis period. In lack of such evidence, we are going to test the potential role of such regulations in the sensitivity of leverage and of liquidity risk on to the business cycle during the crisis period. We expect that concurrent application of macroprudential policies and microprudential regulations may be effective in reducing the procyclicality of leverage and liquidity risk (hypothesis H3).

3. Research design and data

To compute the sensitivity of individual banks' leverage and funding risk to bank specific and macroeconomic factors and to the crisis, we estimate two separate equations (one for leverage and the other for liquidity), denoted as:

$$y_{i,t} = \alpha\, y_{i,t-1} + \sum_{k=1}^{6} \gamma_k \,\mathrm{BSV}_{i,t-1} \; + \; \sum_{s=1}^{2} \varphi_s \;\mathrm{BC}_{j,t} \; + \delta_1 \,\mathrm{Crisis} + \; \delta_2 \,\mathrm{Crisis} * \mathrm{GDP}_{j,t} + \beta_1 \mathrm{MPI}_j + \beta_2 MPI_j * \mathrm{GDP}_{j,t} \; + \beta_3 \mathrm{MPI}_j * \mathrm{Crisis} + \beta_4 \mathrm{MPI}_j * \mathrm{GDP}_{j,t} \; * \mathrm{Crisis} + \beta_5 \mathrm{Regrestr}_j + \beta_6 \mathrm{Regrestr}_j * \mathrm{GDP}_{j,t} \; + \beta_7 R\mathrm{egrestr}_j * \mathrm{Crisis} + \beta_8 \mathrm{Regrestr}_j * \mathrm{GDP}_{j,t} \; * \mathrm{Crisis} + \beta_9 \mathrm{MPI}_j * \mathrm{Regrestr}_j + \beta_{10} \mathrm{MPI}_j * \mathrm{Regrestr}_j * \mathrm{GDP}_{j,t} \; + \beta_{11} \mathrm{MPI}_j * \mathrm{Regrestr}_j * \mathrm{Crisis} + \beta_{12} \mathrm{MPI}_j * \mathrm{Regrestr}_j * \mathrm{GDP}_{j,t} \; * \mathrm{Crisis} \; + \vartheta_i + \varepsilon_{i,t},$$

where:

- i – the number of the bank; j – the number of the country; t – the number of observation for the i^{th} bank or j^{th} country;
- $y_{i,t}$ – dependent variable, i.e. leverage (in the case of the leverage model; defined as total assets divided by equity capital) and liquidity (in the case of the liquidity risk model; this variable equals loans of the nonfinancial sector to deposits of the nonfinancial sector; this ratio is a proxy for maturity mismatch of the bank's balance sheet; it measures funding liquidity risk), $y_{i,t-1}$ – lagged dependent variable;
- BSV – bank specific variable which includes: leverage, liquidity; Loans – loans to total assets (our measure of credit risk); L growth – real annual loans growth rate. It measures sensitivity of solvency and liquidity risk to changes in bank lending activity; Deposits – deposits of the nonfinancial customers divided by total assets (included only in the model of leverage); Dep banks – deposits from banks divided by total assets (included only in the model of liquidity risk); QLP – quality of the lending portfolio (it equals loan loss provisions divided by average loans); size – logarithm of assets;

- BC – business cycle measures proxied by the GDP and ΔUnempl, i.e.: GDP – real GDP per capita growth. A positive coefficient suggests procyclicality of leverage or liquidity risk, respectively, during non-crisis period. A negative coefficient would imply economic insignificance of business cycle to levels of leverage and liquidity risk during non-crisis period;
- Δ Unempl – annual change in the unemployment rate;
- Crisis – dummy variable equal to one in 2008, 2009, 2010 and 0 otherwise; Crisis*GDP – interaction term between Crisis and GDP (it informs about the sensitivity of leverage or liquidity risk to GDP during crises; a positive coefficient in the leverage model, suggests the procyclicality of leverage'; a negative coefficient on Crisis*GDP in the model of liquidity risk, implies counter-cyclicality of the liquidity risk);
- MPI denotes aggregated index of macroprudential policy instruments, i.e. borrower targeted instruments (denoted as "Borrower") and financial institutions' restrictions (denoted as "Financial").

The values of these indices were calculated following the approach of Olszak et al. [2017]. Regrestr is defined as the restrictions on activities conducted by banks (see: Barth et al. [2006]).

3.1. Estimation methods and the dataset

Our econometric model involves explanatory variables, in particular bank-specific variables, which may be endogenous and this may result in an estimation bias. In order to limit this possible estimation bias, we consider the system of generalized method of moments (GMM) developed by Blundell and Bond [1998] with Windmeijer's [2005] finite sample correction. We control for the potential endogeneity of bank specific variables in the two-step system GMM estimation procedure, by the inclusion of up to two lags of explanatory variables as instruments. The UNEMPL, as well as the country and the time dummy variables are the only variables considered exogenous.

We use pooled cross-section and time series data of individual banks' balance sheet items and profit and loss accounts from 67 countries and country-specific macroeconomic indicators for these countries, over a period from 2000 to 2011. The balance sheet and profit and loss account data are taken from the consolidated financials available in the Bankscope database, whereas the macroeconomic data were accessed from the World Bank and the IMF web pages. Due to the fact that a large number of banks included in the sample are located in Japan, USA and in Russia, we exclude these banks to make sure that our results are not affected by the estimation bias, resulting from concentration of our research sample. The data on macroprudential indices, measuring the relative application of macroprudential instruments across countries were taken from the dataset of Cerutti et al. [2015]. To measure microprudential regulations restrictiveness we use overall activities restrictions index (denoted as RESTRICTIONS) developed by Barth et al. [2006, 2013].

We follow a three-stage procedure in the estimation of the model of leverage and model of liquidity risk. In the first stage, we estimate the regression in which we include only bank specific and macroeconomic variables, applying besides the 2-step GMM approach, more traditional approaches, i.e. ordinary least squares and fixed effects regression. Next, we estimate the models in which we also include interaction terms between the macroprudential policy and the business cycle during the crisis, as well as models including interaction terms between the activities restriction index and the business cycle during the crisis. Such an approach gives us opportunity to assess the effect of policies on the procyclicality of leverage or liquidity risk. And finally, in the third stage we estimate regressions covering the interactions between macroprudential policies and microprudential regulations, to find out whether such interactions add to the procyclicality of leverage and liquidity risk.

4. Research results

We present our results for the impact of macro- and microprudential policies in Table 1 (for leverage) and in Table 2 (for liquidity risk). These tables refer to the first two stages in our research strategy, presented in the previous section. In Table 3 we present the result for the interaction between macroprudential policy and microprudential regulation restrictiveness, which is the third stage of our research procedure. This section is divided into three subsections. Subsection 4.1 covers results on the effects of regulatory instruments on the procyclicality of leverage. Subsection 4.2 presents the effects of regulations on the procyclicality of liquidity risk. And finally, Subsection 4.3 includes the analysis of the effects of interacted macroprudential and microprudential regulations on the sensitivity of leverage to the business cycle during the last financial crisis.

4.1. Macroprudential policy and microprudential regulations and their effect on the procyclicality of leverage

In the first four columns in Table 1 we present the effect of the bank specific variables and business cycle on the levels of leverage of individual banks. Consistent with previous evidence [Olszak, Kowalska 2016] we find that the business cycle does not affect bank leverage in an economically significant way during the non-crisis period, because the regression coefficients are negative. However, during the crisis period, the association between the leverage and business cycle is positive (and statistically significant in the OLS regression), which implies the procyclicality of leverage. As can be seen from Table 1, macroprudential policy does not exert an empirically significant impact on the sensitivity of leverage to the business cycle during the non-crisis period, because all the coefficients on double interaction *Regulation*GDP* are statistically insignificant. However, in countries in which more macroprudential instruments (in particular those reducing the risks-taking by banks) were applied in

the pre-crisis period, leverage during the crisis turned out to be more procyclical, because the coefficient of the triple interaction term (*Regulation*GDP*Crisis*) is positive and statistically significant.

Table 1. Sensitivity of leverage to the business cycle and micro- and macroprudential instruments

Leverage	ols	fe	GMM	GMM	GMM Borrower	GMM Financia	GMM Regrestr
	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)
1	2	3	4	5	6	7	8
Leverage(-1)	0.831 (108.2)	0.484*** (37.04)	0.916*** (48.00)	0.827*** (31.28)	0.922*** (42.37)	0.920*** (44.12)	0.889*** (36.60)
Liquidity(-1)	–0.025 (–2.91)	–0.037** (–2.58)	0.061*** (2.68)	0.028* (1.68)	0.062*** (2.60)	0.067*** (2.79)	0.053** (2.43)
Loans(-1)	0.033 (3.19)	0.037** (2.00)	–0.047* (–1.88)	–0.019 (–1.06)	–0.048* (–1.81)	–0.055** (–2.09)	–0.038 (–1.59)
ΔLoans(-1)	0.004 (2.63)	0.003 (1.42)	–0.002 (–0.71)	0.000 (0.07)	–0.002 (–0.72)	–0.001 (–0.48)	–0.002 (–0.59)
Deposits(-1)	–0.012 (–2.71)	0.000 (0.02)	–0.002 (–0.18)	–0.018** (–2.03)	–0.009 (–0.92)	–0.009 (–0.92)	–0.004 (–0.47)
QLP(-1)	–0.057 (–1.95)	0.022 (0.62)	–0.136** (–2.48)	–0.098** (–2.13)	–0.117** (–2.25)	–0.108** (–2.03)	–0.166*** (–2.94)
Size(-1)	0.594 (8.10)	0.737** (2.49)	0.061 (0.45)	0.582*** (3.27)	–0.010 (–0.06)	0.069 (0.47)	0.135 (0.81)
GDP	–0.070 (–3.16)	–0.039 (–1.46)	–0.041 (–1.19)	–0.056** (–2.38)	–0.025 (–0.54)	–0.065 (–1.19)	–0.039 (–1.04)
ΔUnempl	–0.111 (–2.05)	–0.080 (–1.42)	–0.339** (–2.47)	–0.125 (–1.64)	–0.299** (–2.08)	–0.412** (–2.57)	–0.345*** (–2.65)
Crisis	–0.557 (–3.83)	–0.391** (–2.19)	–0.054 (–0.26)	–0.465*** (–2.94)	0.170 (0.50)	0.066 (0.12)	–0.485* (–1.70)
Crisis*GDP	0.051 (1.66)	0.003 (0.10)	0.048 (0.79)	0.044 (1.13)	–0.006 (–0.07)	–0.089 (–0.84)	0.105 (1.65)
Regulation					0.277 (0.67)	–0.117 (–0.68)	0.241 (1.22)
Regulation*GDP					–0.017 (–0.21)	0.011 (0.32)	0.009 (0.25)
Regulation*Crisis					–0.935 (–1.17)	–0.208 (–0.48)	–1.273*** (–2.92)
Regulation*GDP*Crisis					0.185 (1.21)	0.149** (1.99)	0.024 (0.31)
cons	–0.563 (–0.85)	3.055 (1.40)	–0.392 (–0.30)	–0.558 (–0.45)	0.470 (0.33)	0.282 (0.19)	–0.165 (–0.12)
Year dummies	no	no	yes	yes	yes	yes	yes
Country dummies	no	no	yes	yes	yes	yes	yes
Year & Country dummies	no	no	no	yes	no	no	no

1	2	3	4	5	6	7	8
AR1			–5.52***	–5.54***	–5.77***	–5.77***	–5.3***
AR2			2.56**	2.63***	2.24**	2.25**	2.36**
Sargan test			827.08***	1725.7***	788.86***	764.46***	740.16***
Hansen test			398.96***	755.67	360.83***	358.93***	360.13***
No of observ.	6017	6017	6017	6017	5341	5341	5378
No of banks		771	771	771	689	689	687

Notes: ols – denotes ordinary least squares regression, fe – denotes fixed effects model; GMM – denotes the 2-step system GMM Blundell and Bond's [1998] approach with Windmeijer's [2005] finite sample correction; coef – is the regression coefficient; Regulation, covers macroprudential policy and microprudential regulation, i.e., Borrower, Financial and Regrestr, respectively; T-statistics are given in parentheses. ***, ** or * next to coefficients indicate that coefficients are significantly different from zero at the 1%, 5%, or 10% levels, respectively.

Source: own study.

As for the impact of microprudential regulations, we find that during the non-crisis period activities restrictions (Regrestr) do not have a statistically significant effect on the sensitivity of leverage to the business cycle, because the regression coefficients on double interaction of *Regulation*GDP* are statistically insignificant. Restrictions on the range of activities which banks can conduct also do not reduce the procyclicality of leverage during the crisis period, because the coefficient on *Regulation*GDP*Crisis* is statistically insignificant (see the last column in Table 1).

4.2. Macroprudential policy and microprudential regulations and their effect on the procyclicality of liquidity risk

In Table 2 we present the results for the sensitivity of liquidity risk, proxied with LTD ratio, to bank specific variables and to the business cycle and the role of macro- and microprudential instruments in the procyclicality of this liquidity. Consistently with previous evidence (see: Olszak and Kowalska [2016]), we find that liquidity risk is strongly procyclical during the non-crisis period (see the positive and statistically significant coefficients on GDP in all estimations in Table 2) and statistically countercyclical during the last financial crisis (see the negative association between liquidity and double interaction term of Crisis*GDP). Macroprudential policy does seem to affect procyclicality of liquidity during the non-crisis period, because the regression coefficients on Regulation*GDP (see the columns denoted as "GMM Borrower" and "GMM Financial") are negative and statistically significant and definitely stronger than the positive coefficients on GDP. In particular, if we look at the role of the borrower targeted instruments, we find that in countries in which more such instruments were applied, bank procyclicality of liquidity risk was reduced from 0.897 to –1.126 (this is the result of –2.122 + 0.897). What's more, borrower targeted instruments seem to increase the procyclicality of LTD during the crisis

Table 2. Sensitivity of liquidity risk to the business cycle and micro- and macroprudential instruments

Liquidity	ols	fe	GMM	GMM	GMM Borrower	GMM Financial	GMM Regrestr
	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)	coef (*t*-stat)
1	2	3	4	5	6	7	8
Liquidity(-1)	0.760*** (41.43)	0.627*** (22.32)	0.477*** (3.85)	0.531*** (6.76)	0.624*** (4.26)	0.652*** (5.16)	0.693*** (5.14)
Leverage(-1)	–0.045*** (–2.93)	–0.024 (–0.93)	–0.033 (–0.74)	–0.076** (–2.48)	–0.019 (–0.36)	–0.002 (–0.03)	–0.012 (–0.26)
Loans(-1)	0.201*** (9.32)	0.007 (0.20)	0.425*** (3.09)	0.354*** (4.02)	0.210 (1.24)	0.185 (1.28)	0.169 (1.10)
ΔLoans(-1)	0.009*** (2.60)	0.011*** (3.13)	0.011 (1.59)	0.020*** (3.50)	0.007 (1.03)	0.016** (2.25)	0.010* (1.68)
Dep banks(-1)	–0.005 (–0.60)	0.043*** (2.65)	0.042 (1.36)	0.040* (1.85)	0.055 (1.48)	0.051* (1.71)	0.075** (2.43)
QLP(-1)	–0.160*** (–2.71)	–0.361*** (–5.15)	–0.216* (–1.78)	–0.293*** (–2.78)	–0.258* (–1.83)	–0.201 (–1.52)	–0.186 (–1.37)
Size(-1)	0.165 (1.12)	3.746*** (6.38)	0.640 (1.34)	0.942** (2.46)	1.670*** (2.72)	0.780 (1.47)	1.411*** (2.81)
GDP	0.237*** (5.31)	0.137** (2.56)	0.310*** (2.72)	0.162** (2.44)	0.897*** (5.26)	0.569*** (3.26)	0.372*** (3.08)
ΔUnempl	–0.326*** (–2.99)	–0.226** (–2.02)	–1.660*** (–4.49)	–0.349*** (–2.95)	–1.497*** (–3.74)	–1.686*** (–4.41)	–1.460*** (–3.98)
Crisis	0.305 (1.04)	0.281 (0.79)	2.039*** (3.21)	0.156 (0.46)	1.126 (1.06)	5.844*** (3.65)	2.424*** (2.63)
Crisis*GDP	–0.124** (–1.97)	0.016 (0.24)	–0.499*** (–3.01)	–0.092 (–1.29)	–1.423*** (–6.03)	–0.759*** (–2.72)	–0.650*** (–3.13)
Regulation					5.110*** (3.15)	1.251* (1.75)	0.061 (0.12)
Regulation* GDP					–2.122*** (–6.62)	–0.285** (–2.22)	–0.154 (–1.33)
Regulation* Crisis					–1.937 (–0.61)	–3.085** (–2.21)	0.943 (0.94)
Regulation* GDP*Crisis					3.503*** (6.13)	0.293 (1.20)	0.096 (0.46)
cons	4.531*** (3.42)	–4.017 (–0.92)	3.363 (0.73)	3.110 (0.87)	–3.500 (–0.62)	1.509 (0.33)	–4.967 (–1.06)
Year dummies	no	no	yes	yes	yes	yes	yes
Country dummies	no	no	yes	yes	yes	yes	yes
Year & Country dummies	no	no	no	yes	no	no	no
AR1			–11.32***	–11.93***	–10.71***	–10.93***	–10.7***
AR2			–0.35	–0.15	1.15	0.25	–0.81
Sargan test			5216.61***	5747.68***	4059.93***	4627.07***	4658.28***

1	2	3	4	5	6	7	8
Hansen test			483.69***	727.35	419.24***	434.7***	431.16***
No of observ.	5861	5861	5861	5861	5191	5191	5231
No of banks		733	733	733	652	652	649

Notes: ols – denotes ordinary least squares regression, fe – denotes fixed effects model; GMM – denotes the 2-step system GMM Blundell and Bond's [1998] approach with Windmeijer's [2005] finite sample correction; coef – is the regression coefficient; Regulation, covers macroprudential policy and microprudential regulation, i.e., Borrower, Financial and Regrestr, respectively; T-statistics are given in parentheses. ***, ** or * next to coefficients indicate that coefficients are significantly different from zero at the 1%, 5%, or 10% levels, respectively.

Source: own study.

period, because the coefficient on Regulation*GDP*Crisis (see the column "GMM Borrower") is positive and significant (at 1%). As for the impact of microprudential regulations, we find that during the non-crisis period activities restrictions (Regrestr) do not have a statistically significant effect on the sensitivity of liquidity risk to the business cycle, because the regression coefficients on double interaction of Regulation*GDP are statistically insignificant. The same effect is found for the crisis period.

4.3. Interactions between macroprudential policy and microprudential regulations and their effect on the procyclicality of leverage and liquidity risk

Concurrent application of restrictive microprudential regulations and macroprudential policy instruments targeted at risk-taking by borrowers seems to significantly influence the sensitivity of leverage to the business cycle during the non-crisis period, because the coefficient on *MPI*Regrestr*GDP* is positive and statistically significant in the first regression in Table 3 (see the column denoted "Borrower"). Such an effect implies that the interaction between these regulations results in an increased procyclicality of leverage during the non-crisis period. However, interfacing these instruments during the crisis period does seem to have an economically significant impact on the procyclicality of leverage and reduces this procyclicality. In particular, the coefficient on *MPI*Regrestr*GDP*Crisis* is negative (equal to –0.490) and statistically significant at 10% (in estimation included in the column denoted as "Borrower"), implying that the application of both these tools seems to reduce the procyclical impact found individually for macroprudential instruments. Thus, the interaction of macro- and microprudential instruments may be effective in reducing the procyclicality of leverage.

Concurrent application of restrictive microprudential regulations (restrictions on bank activities) and macroprudential instruments (i.e. instruments targeted at risk-taking by banks) does affect significantly the sensitivity of liquidity risk to

the business cycle during the non-crisis period, because the coefficient on Macropr index*Microprud*GDPG per capita is negative and statistically significant in regression presented in the last column in Table 3.

Table 3. The effect of interactions between macroprudential policy and microprudential regulations on the sensitivity of leverage and liquidity risk to the business cycle during the crisis and non-crisis period

Leverage	Borrower	Financial	Liquidity	Borrower	Financial
	coef (*t*-stat)	coef (*t*-stat)		coef (*t*-stat)	coef (*t*-stat)
1	2	3	4	5	6
Leverage(-1)	0.904 ***	0.884 ***	Liquidity(-1)	0.642 ***	0.714 ***
	(35.41)	(33.26)		(4.20)	(4.97)
Liquidity(-1)	0.041 *	0.049 **	Leverage(-1)	0.000	0.004
	(1.85)	(2.30)		(0.00)	(0.07)
Loans(-1)	–0.021	–0.035	Loans(-1)	0.170	0.104
	(–0.84)	(–1.45)		(0.94)	(0.61)
ΔLoans(-1)	–0.003	–0.002	**ΔLoans**(-1)	0.011	0.019 **
	(–1.03)	(–0.62)		(1.43)	(2.52)
Deposits(-1)	–0.016 *	–0.017 *	Dep banks(-1)	0.088 **	0.080 **
	(–1.65)	(–1.77)		(2.26)	(2.31)
QLP(-1)	–0.159 ***	–0.167 ***	QLP(-1)	–0.248	–0.166
	(–2.72)	(–2.92)		(–1.56)	(–1.08)
Size(-1)	–0.121	0.079	Size(-1)	2.203 ***	1.687 **
	(–0.65)	(0.45)		(2.96)	(2.53)
GDP	–0.007	–0.019	GDP	0.746 ***	0.292
	(–0.15)	(–0.36)		(4.17)	(1.37)
ΔUnempl	–0.296 **	–0.342 **	**ΔUnempl**	–1.332 ***	–1.285 ***
	(–2.32)	(–2.32)		(–3.18)	(–2.97)
MPI	0.393	–0.039	MPI	6.612 **	0.902
	(0.44)	(–0.22)		(2.26)	(1.05)
MPI*GDP	–0.317 *	–0.017	MPI*GDP	–2.442 ***	0.049
	(–1.89)	(–0.46)		(–3.57)	(0.32)
Regrestr	0.227	0.436	Regrestr	–0.507	–0.077
	(1.14)	(1.55)		(–0.7)	(–0.09)
Regrestr*GDP	0.024	0.007	Regrestr*GDP	0.169	–0.067
	(0.51)	(0.11)		(0.91)	(–0.29)
MPI*Regrestr	–0.792	–0.266	MPI*Regrestr	1.540	0.887
	(–1.39)	(–1.16)		(0.98)	(1.43)
MPI*Regrestr*GDP	0.222 *	0.026	MPI*Regrestr*GDP	–0.122	–0.293 *
	(1.72)	(0.55)		(–0.32)	(–1.73)
Crisis	–0.865 *	–0.654	Crisis	2.544	7.298 ***
	(–1.73)	(–0.82)		(1.44)	(2.70)
Crisis*GDP	0.016	0.038	Crisis*GDP	–1.557 ***	–0.721 *
	(0.20)	(0.33)		(–4.26)	(–1.70)
MPI*Crisis	1.158	–0.228	MPI*Crisis	–5.187	–4.384 **
	(0.44)	(–0.46)		(–0.81)	(–2.38)
MPI*GDP*Crisis	0.784 **	0.048	MPI*GDP*Crisis	4.979 ***	0.040
	(2.14)	(0.63)		(3.84)	(0.14)

1	2	3	4	5	6
Regrestr*Crisis	–1.382 *** (–3.15)	–2.286 *** (–2.76)	Regrestr*Crisis	2.097 (1.62)	1.741 (1.01)
Regrestr*GDP*CRISIS	–0.020 (–0.21)	–0.054 (–0.43)	Regrestr*GDP*CRISIS	–0.318 (–1.00)	–0.234 (–0.67)
MPI*Regrestr*Crisis	1.066 (0.63)	1.024 (1.65)	MPI*Regrestr*Crisis	–5.035 (–1.40)	–0.863 (–0.71)
MPI*Regrestr*GDP* Crisis	–0.490 * (–1.74)	0.007 (0.07)	MPI*Regrestr*GDP* Crisis	–0.019 (–0.03)	0.625 ** (2.32)
cons	2.171 (1.41)	1.457 (1.01)	cons	–8.832 (–1.35)	–6.236 (–1.09)
Year dummies	yes	yes	Year dummies	yes	yes
Country dummies	yes	yes	Country dummies	yes	yes
Year & Country dummies	no	no	Year & Country dummies	no	no
AR1	–5.68 ***	–5.57 ***	AR1	–9.00 ***	–10.17 ***
AR2	2.11 **	1.88 *	AR2	0.53	–0.53
Sargan test	677.23 ***	675.91 ***	Sargan test	3599.51 ***	4031.16 ***
Hansen test	326.46 ***	316.48 ***	Hansen test	375.84 ***	375.37 ***
No o f observ.	4772	4772	No of observ.	4638	4638
No of banks	614	614	No of banks	579	579

Notes: GMM – denotes the 2-step system GMM Blundell and Bond's [1998] approach with Windmeijer's [2005] finite sample correction; coef – is the regression coefficient; T-statistics are given in parentheses. ***, ** or * next to coefficients indicate that coefficients are significantly different from zero at the 1%, 5%, or 10% levels, respectively.

Source: own study.

Additionally, interfacing these instruments during the crisis period does also seem to have an economically significant impact on the procyclicality of liquidity risk. In particular, the coefficient on MPI*Regrestr*GDP*Crisis is positive and statistically significant (see the last column in Table 3), implying that the application of both these tools seems to decrease the counter-cyclical impact found individually for microprudential regulations and macroprudential policies (see the negative coefficients on Regulation*GDP*Crisis in the last three columns in Table 2). Thus, interaction of macro- and microprudential instruments does not seem to be effective in reducing the procyclicality of liquidity risk during the crisis period.

4. Conclusions

This paper aimed to test the role of macroprudential policies and microprudential regulations and their interactions on the sensitivity of leverage and liquidity funding risk to the business cycle during both the non-crisis and crisis period. With this study, we have identified several economically significant phenomena. First, we have found that both macroprudential and microprudential instruments have

insignificant impact on the procyclicality of leverage in the non-crisis period. In contrast, for liquidity risk this impact in the non-crisis period has been shown to be countercyclical and statistically significant. Second, macroprudential instruments increase the procyclicality of leverage and liquidity risk during the crisis period. Microprudential regulations have not been able to reduce the procyclicality of both leverage and liquidity risk during the last crisis. Third, interaction between macroprudential instruments targeted at risk-taking by borrowers and restrictions on the range of activities taken by banks has been found to be effective in reducing the procyclicality of leverage during the crisis period. With reference to liquidity risk, we have shown that interaction between macroprudential instruments targeted at risk-taking behaviour of bank and activities restrictiveness index reduces countercyclicality of liquidity risk.

Our results have implications for the regulatory and supervisory policy. We show that microprudential regulations, in particular these which limit the range of activities conducted by banks, may be effective in reducing the procyclicality of liquidity risk during the non-crisis period. Therefore, limiting the range of bank operations could be considered as a step in the policy-decisions. Macroprudential instruments do not necessarily work to limit the procyclicality of leverage. However, they seem to be an important driver of increased countercyclicality of liquidity risk, in particular during the non-crisis period. Consequently, they should be implemented to decrease the procyclicality of liquidity risk.

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