Effects of Macroprudential Policy on Systemic Risk and Bank Risk Taking*

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Abstract

Using an international sample of 95 banks from 21 European and North American countries spanning from 2008 to 2014, this paper assesses the effectiveness of a large set of general and housing macro-prudential policies in controlling banks' systemic importance and risk-taking incentives. Empirical findings indicate that tightening the general capital requirements, sector specific capital buffers, along with housing countercyclical capital requirements and Debt-Service-to-Income lending criteria significantly reduce banks' contribution to systemic risk and their individual risk-taking. A similar effect has been obtained for loosening real estate loans loss provisioning. Furthermore, the nexus between macroprudential policies and banks' risk is shaped through several channels like bank size, the share of foreign bank assets, banking sector competition and the independence of supervisory authority.

1. Introduction

The 2008 global financial crisis forced central authorities and policymakers to reconsider the regulatory framework and their primarily objectives. In the pre-crisis years the capacity of the authorities to mitigate financial vulnerabilities was limited as their main objectives were price stability and economic activity (from a macroeconomic perspective) and idiosyncratic risk (from a microeconomic perspective) (IMF, 2013). The post-crisis events determined central authorities to rely more on macroprudential policies in order to reduce systemic risk, increase financial stability and build a safer financial system that could reduce the probability of future crises. According to the literature (see e.g. Lim et al., 2011; Claessens et al., 2013; Aydinbas et al., 2015; Cerutti et al., 2017b), the main objective of macroprudential policy is to limit the financial risk that affects the whole system (systemic risk). As noted by Cerutti et al. (2017b) macroprudential policy seeks to increase the resilience of financial system to shocks, limit the build-up of vulnerabilities over time, control the structural vulnerabilities that could rise from inter-linkages and control the „too-big-to-fail" institutions.

Macroprudential policy complements microprudential measures and interacts

with other types of tools, especially monetary policy (Aydinbas et al., 2015). Microprudential policy aims to limit the distress at individual institutions, while macroprudential policy focuses on financial system-wide distress. Both types of policies have to be implemented in a coordinated way, as individual institutions play an important role in the build-up and spread of systemic risk and the implementation of macroprudential policies should take into consideration their impact on individual institutions. Therefore, these policies are highly complementary, controlling the contribution to systemic risk of financial institutions. To limit systemic vulnerabilities and to achieve financial stability, macroprudential policy has to be supported by strong supervision and enforcement and filled by suited policies, such as monetary policy, fiscal and structural policies, competition policy, as well as crisis management and resolution policies (IMF, 2013).

The low monetary policy interest rates in the period prior to the crisis allowed banks to take on more risk, softening the lending conditions for all categories of borrowers (Maddaloni and Peydro, 2013). To transfer the additional assumed credit risk banks resorted to Credit Default Swaps and Collateralized Loan Obligations, actually posing greater systemic risk effects (Nijskens and Wagner, 2011).

The main instruments that can be used to mitigate excessive credit growth and leverage are: countercyclical capital buffer, sector specific requirements, loan-to-value caps, loan-to-income caps, and, debt service-to-income caps (ESRB, 2014). If the economy is threatened by liquidity crisis, macroprudential policy can limit the banking vulnerabilities through taxes on noncore bank liabilities or on FX-denominated bank liabilities (these instruments can limit the banking loan growth indirectly). The loan growth can also be limited by altering the incentives of using bank-capital oriented tools, such as counter-cyclical capital requirements, forward-looking provisioning and leverage cap. Another source of systemic risk is given by the status of 'too-big-to-fail' institutions that leads to misaligned incentives and moral hazard. The measures used to control this risk can be capital-based (systemic risk buffer, additional own funds and conservation buffer requirements) and liquidity-based.

Thus, macroprudential policy has two main objectives: to limit the build-up of systemic risk (time dimension) and to increase the resilience of financial system to future shocks (cross-sectional dimension). The instruments used can be credit-related, liquidity-related and capital-related (Aydinbas et al., 2015). There is not a general accepted mix of instruments, these being adopted based on individual macroeconomic conditions: source of risk, financial development, type of exchange regime and the degree of international financial integration (Lim et al., 2011; Claessens et al., 2013).

In this paper, we assess whether macroprudential policies implemented at the country level have a significant impact on banks' contribution to systemic risk, as well as on their level of risk-taking. In a first step, we estimate banks' systemic importance employing the *Conditional Value at Risk (CoVaR)* methodology developed in Adrian and Brunnermeier (2016) and the *Marginal Expected Shortfall*

(MES) methodology proposed by Acharya et al. (2017).[1] In addition, we determine the level of bank risk-taking by using the *Value at Risk (VaR)* methodology and the *Distance to Default (DTD)*.

In a second step, we analyze in a panel that includes 95 banks the impact of macroprudential policies on banks' systemic importance and risk-taking. We consider a large set of general and housing (real estate) policies implemented by 21 countries from Europe and North America during 2008 to 2014. The general macroprudential policies include capital requirements, sector specific capital buffers and reserve requirements on foreign and local currency denominated accounts. The housing macroprudential tools cover countercyclical capital requirements, loan loss provisioning, Debt-Service-to-Income (DSTI) lending criteria and risk weights on housing loans.

Overall, empirical findings indicate that tightening general capital requirements, sector specific capital buffers, along with housing countercyclical capital requirements and DSTI lending criteria can significantly reduce banks' systemic importance and also their individual risk-taking. For real estate loans loss provisioning we find a negative impact, tighter rules enhancing the level of risk. Furthermore, the nexus between macroprudential policies and banks' risk is shaped through several channels like bank size, the level of foreign bank assets, banking sector competition and the independence of supervisory authority.

This paper aims to contribute to the existing literature on systemic risk and macroprudential policies. First, we contribute to the literature on systemic risk determinants by considering a large set of general and housing macroprudential tools implemented by supervisory authorities in order to increase the resilience of the banking sector during crisis. A number of studies argue that excessive risk-taking can be restrained through more stringent prudential measures on either supply side (e.g. bank capital) or demand side (e.g. loan-to-value ratios) (Maddaloni and Peydro, 2013). However, regarding the impact of prudential policies on systemic risk there is little empirical evidence. Therefore, we investigate the macroprudential policies' impact on both individual risk-taking and on banks' contribution to systemic risk. A macroprudential policy tool can be effective in controlling banks' individual risk but mislead the financial contagion effects among the system.

Second, we extend the channels through which macroprudential policies could influence banks' systemic importance and their risk-taking behavior. We provide empirical evidence that the contribution to systemic risk of large banks can be decreased through higher reserve requirements on accounts denominated in foreign and local currencies and higher risk-weights applied to housing loans. The resilience of financial institutions from banking systems that hold important shares of foreign assets can be enhanced by loosening the reserve requirements and the countercyclical capital requirements. In case of less competitive banking markets, lower reserve requirements on domestic currency denominated accounts, lower countercyclical capital requirements and relaxed DSTI lending criteria are efficient in controlling systemic risk. In countries with higher degree of independence of supervisory

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[1] CoVaR accounts for time-varying contagion spillovers from a particular bank to the system (contribution to systemic risk), while MES considers the time-varying contagion effects from the system to a particular bank (exposure to systemic risk).

authority, regulators should tighten the general capital requirements, but reduce the sector specific and countercyclical buffers to enhance the stability of the banking sector.

The current study differs from previous literature regarding the effectiveness of macroprudential policy in terms of instruments considered and channels through which these tools could influence banks' risk. It is related with the study of Bluhm and Krahnen, (2014), but however their paper studied only the impact of two macroprudential instruments (systemic capital requirements and systemic risk charges) on individual banks' contribution to systemic risk. In addition to the previous literature we use different market-based measures in order to quantify systemic risk (banks' systemic contribution defined through CoVaR and banks' exposure to systemic risk estimated through MES) and individual risk-taking (VaR and DTD). Bluhm and Krahnen (2014), for example, measured systemic risk through SVaR and banks' systemic contribution through Shapley value. Our most important contribution is related to investigating the effects of the relationship among various determinants of systemic risk (banks' size, international activity, banking sector competitiveness and the degree of supervisory authority independence) and macroprudential instruments on financial stability.

The remainder of the paper is organized as follows: Section 2 summarizes the review of related literature. Section 3 presents the methodology. Section 4 describes the sample and data. Section 5 reports the empirical results. Section 6 concludes.

2. Related Literature

Microprudential policy, through ensuring the resilience of individual institutions, has an important contribution to the resilience of the entire banking system. However, it is not sufficient, due to the complexity of financial system, and needs to be complemented by macroprudential policy. Macroprudential policy takes into consideration the procyclicality of the financial system (e.g. countercyclical capital buffers), the contribution of financial institutions to systemic risk (e.g. SIFIs surcharges), the build-up of systemic risk in specific segments of the market (e.g. LTV ratio), the leverage in nonfinancial sectors (e.g. DSTI ratio) and systemic liquidity concerns (Osinski, et al., 2013).

In a 2013 report, IMF analyzed the number of countries that used macroprudential policies during 2000-2012 period, concluding that emerging economies used them more frequently than advanced economies, and well before the 2008 financial crisis (IMF, 2013). Claessens et al. (2013) argued in their study that emerging economies were four times more likely to use macroprudential policies than advanced economies before crisis, and 3.3 times after crisis, as advanced economies started to introduce more prudential measures. This can be explained by the fact that emerging economies are more exposed to external shocks (due to capital flows) and their financial systems are less developed and less liberalized, and hence there is a more frequent necessity to contain market failures.

An extensive literature assesses the effectiveness of macroprudential policy tools on different measures of financial vulnerability and stability, e.g. Lim et al. (2011), Claessens, et al. (2013), Akinci and Olmstead-Rumsey (2018), Vandenbussche et al. (2015), Cerutti et al. (2017b), Corrado and Schuler (2017) and Altunbas et al. (2018). The use of macroprudential policies before the financial crisis

could have prevented the negative contagion spillovers (Van Oordt and Zhou, 2015). Dell'Ariccia et al. (2012) found that macroprudential policies can reduce the occurrence of credit booms and decrease the probability of booms bust.

Macroprudential capital-tools can reduce the probability of crises by enhancing resilience to shocks and reduce credit growth in the short-term, by increasing the costs of credit (Bridges et al., 2015; Noss and Toffano, 2016). This statement is confirmed, also, by the empirical studies, that sustain that macroprudential capital requirements reduce the default probabilities of individual banks and the probability of a systemic crisis by about 25% (Gauthies et al., 2012). These results are in line with Bluhm and Krahnen (2014) findings, sustaining that an increase in capital requirements ratio decreases banks' contribution to systemic risk. Dagher et al. (2016) indicate that an optimal level of bank capital that would have prevented the majority of past crises is between 15 to 23 percent of risk-weighted assets, as better-capitalized banks can continue lending more easily during downturns.

Macroprudential liquidity-tools, mainly reserve requirements, have contradictory results regarding their impact on credit growth. A number of studies affirm that raising reserve requirements can moderate credit growth (Lim et al., 2011; Fungacova et al., 2016), while other studies mitigate for no or only a weakly significant impact (Bruno et al., 2016; Kuttner and Shim, 2016). Borrower linked tools, such as limits on LTV and DSTI ratios have been found to improve banking resilience by reducing the credit risk on new loans (Hallissey et al., 2014) and moderate lending growth (Lim et al., 2011; Akinci and Olmstead-Rumsey, 2018; Kuttner and Shim, 2016).

Claessens et al. (2013) highlight that macroprudential policies help in controlling banking system vulnerabilities (asset growth, leverage growth, noncore vs. core liabilities). As the recent financial crisis was triggered by high assets prices and excessive credit growth, a strand of literature assesses the macroprudential policies' efficiency in restraining their growth and adverse effects. Akinci and Olmstead-Rumsey (2018) analyses the effect of macroprudential policy on domestic bank credit growth, housing credit growth and real estate price inflation, concluding that after the 2008 global financial crisis, macroprudential tightening was associated with lower bank credit growth, housing credit growth and real estate price inflation. These results are confirmed by Cerutti et al. (2017a) and Cizel et al. (2016) which find that in two years after the implementation of macroprudential policies, bank credit growth declines by 7.7 percentage points relative to the counterfactual of no measure.

Considering the individual measures, Akinci and Olmstead-Rumsey (2018) found that capital requirements (both general and sector specific), loan-to-value caps and/or debt-to-income ratio are effective in reducing general credit, respectively, housing credit growth. These results are in line with the findings of Lim et al. (2011) regarding the LTV and DSTI measures, while IMF (2013) and Dimova et al. (2016) confirmed the results regarding the capital requirements and the LTV and DTI ratios for emerging countries. On the other hand, reserve requirements do not have a significant impact on credit growth in Akinci and Olmstead-Rumsey (2018), while Lim et al. (2011), IMF (2013) and Claessens et al. (2013) found that reserve requirements reduce credit growth and asset price inflation. If we refer to

international banking and the effects of spillovers, macroprudential policies implemented by one country in order to limit domestic credit might play a role on the international bank lending and financial stability. Avdjilev et al. (2017) studied the effects of LTV limits and local currency reserve requirements for 16 banking systems and 53 counterparty countries from 2000 to 2014. They concluded that the tightening of both LTV limits and local currency reserve requirements are associated with an increase in international bank lending of banks headquartered abroad to borrowers in the country that implemented the respective measure. When enacted by a home country (banks' headquarter is in that country), such a tightening is transmitted abroad by international banks in the form of higher growth in lending to borrowers in other destinations.

Besides credit growth, there are also other measures of systemic risk, such as: systemic liquidity, leverage and capital flows. In order to control liquidity risk, Lim et al. (2011) show that limits on maturity mismatch are effective in reducing the wholesale funding (credit/deposit ratio). Corrado and Schuler (2017) argue that targeting the interbank financing through stricter liquidity measures (liquidity coverage ratio and net stable funding ratio) reduces the severity of a breakdown in interbank lending. Banks that have higher leverage ratios and larger fractions of interbank assets are considered more vulnerable and should hold more capital (Gauthies et al., 2012). Highly levered banks contributed more to systemic risk, also, in a study by Brunnermeier et al. (2012) on US bank holding companies. The effects of excessive leverage can be mitigated through caps on the DSTI and foreign currency lending, ceilings on credit growth, reserve requirements, countercyclical capital requirements and dynamic provisioning (Lim et al., 2011). These results are also confirmed by Claessens et al. (2013), who add, as a measure that reduces the leverage and asset growth during boom times the loan-to-value ratio.

Given these results, both academics and policymakers plead for banking regulation to include a macroprudential perspective (Hanson et al., 2011; Gauthies et al., 2012). Gauthies et al. (2012) and Vallascas and Keasey (2012) sustain the initiative to regulate bank's leverage.

3. Methodology

We assess the impact of macroprudential policies implemented by supervisory authorities on banks' systemic importance and risk-taking using a panel framework. First, we analyze the nexus between general and housing macroprudential measures and banks' risk. Second, in a difference-in-difference setting we estimate the effectiveness of the instruments across different types of financial institutions and banking markets. The sample includes 95 banks from 21 countries (Canada, Europe and USA) and the period accounts for 28 quarters during 2008-2014.

3.1 The Impact of Macroprudential Measures on Systemic Risk

To assess the impact of macroprudential policies on systemic risk the following regression is estimated via OLS Fixed Effects with country level clustered standard errors:

$$Systemic\ Risk_{ij,t} = \beta_0 + \beta_1 \times Macroprudential\ Policies_{ij,t-1} + \Phi \times Bank\ controls_{ij,t-1} + \Psi \times Market\ \&\ Macro\ controls_{j,t-1} + \varphi_i + \mu_j + \upsilon_t + \varepsilon_{ij,t} \tag{1}$$

The dependent variable is represented by bank i's from country j contribution to systemic risk in quarter t expressed by *Conditional Value at Risk (CoVaR)* and reflects the loss of the system's market capitalization. As robustness assessment we also employ the *Marginal Expected Shortfall (MES)* that reflects bank i's from country j exposure to systemic risk in quarter t (expressed in % loss of the banks' market capitalization).

The main regressors of interest are represented by general macroprudential policies (Capital requirements, Sector capital buffers, Reserve requirements on foreign currency (FX) denominated accounts and Reserve requirements on local currency denominated accounts) and housing macroprudential policies (Countercyclical capital requirements, Loan loss provisioning, Debt-Service-to-Income (DSTI) lending criteria and Risk weights on housing loans) adopted by country j in period t-1. The specification includes bank characteristics (Size, Capitalization, Credit risk, Liquidity risk and Funding), market and macro controls (Lerner index, Foreign bank assets and Inflation), and, bank fixed effects. Variables are winsorized within the 1% and 99% percentiles and lagged one period. Their definition is given in Table 1 and a detailed description is provided in Section 4.

Table 1 Description of Variables

Variables	Definition	Level	Source
Dependent variables			
CoVaR	Conditional Value at Risk of Adrian and Brunnnermeier (2016). The systemic risk measure is expressed in units of percentage loss of the system's market value of equity within a quarter. It is determined using Quantile Regression method, as the average return on the system's market equity on the days the bank i's market equity experienced its 1% worst outcomes. System is defined by the Market capitalization of the sample. Higher values are associated with increased contribution of banks to systemic risk.	bank-quarter	Own estimations based on market data from Worldscope, Datastream and FITCH and balance sheet data from Worldscope.
MES	Marginal expected shortfall of Acharya et al. (2017). The systemic risk measure is expressed in units of percentage loss of the banks' market value of equity within a quarter. The measure is determined using DCC - GJR GARCH method as the average return on bank's market equity on the days the total market capitalization of the sample experienced its 1% worst outcomes. System is defined by the Market capitalization of the sample. Higher values are associated with increased exposure of banks to systemic risk.	bank-quarter	Own estimations based on market data from Worldscope, Datastream and FITCH and balance sheet data from Worldscope.
VaR	Value at Risk measure of Dowd (1998), Jorion (1997) and Saunders (1999). The individual risk measure is expressed in units of percentage loss of the banks' market equity within a quarter. Higher values are associated with increased banks' individual risk.	bank-quarter	Own estimations based on market data from Worldscope, Datastream and FITCH and balance sheet data from Worldscope.
DTD	Individual risk measure of Duan and Wang (2016). The individual risk measure is expressed in standard deviations of banks' distance to default within a quarter. Higher values are associated with reduced banks' individual risk.	bank-quarter	Credit Rating Initiative of Risk Management Institute
Macroprudential policy measures			
Capital requirements	Change in capital requirements. Implementation of Basel capital agreements. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Cerutti et al. (2016)

Sector capital buffers	Sum of changes in sector-specific capital buffers across the residential, consumer, and other sectors. Requires banks to finance a larger fraction of these exposures with capital. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Cerutti et al. (2016)
Reserve requirements FX	Change in reserve requirements on foreign currency-denominated accounts. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Cerutti et al. (2016)
Reserve requirements local	Change in reserve requirements on local currency-denominated accounts. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Cerutti et al. (2016)
Countercyclical capital requirements	Housing - countercyclical capital requirements. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Akinci and Olmstead-Rumsey (2018)
Loan loss provisioning	Housing - loan loss provisioning. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Akinci and Olmstead-Rumsey (2018)
DSTI lending criteria	Debt to service income limits lending criteria. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Kuttner and Shim (2016)
Risk weights on housing loans	Risk weights applied to housing loans. Positive values are associated with the number of tightening events, negative values with the number of loosening events, 0 reflects no action.	country-quarter	Kuttner and Shim (2016)

Bank controls

Size	log(Total assets)	bank-quarter	Worldscope
Capitalization	Common equity/Total assets (%)	bank-quarter	Worldscope
Credit risk	Provisions for loan losses/Gross loans (%)	bank-quarter	Worldscope
Liquidity risk	Net loans/Short term debt & Current portion of long term debt (%)	bank-quarter	Worldscope
Funding	Deposits/Total assets (%)	bank-quarter	Worldscope

Macro controls

Lerner index	Lerner index, a measure of market power in the banking market, which compares the output pricing and the marginal costs.	country-year	World Bank
Foreign bank assets	Foreign bank assets/Total bank assets (%)	country-year	World Bank
Supervisory authority independence	The degree to which the supervisory authority is independent from the government and legally protected from the banking industry. The index ranges between 0 and 3, higher values indicating greater independence.	country-year	Barth et al. (2013)
Inflation	Inflation measured by the consumer price index	country-year	World Bank

Notes: This table summarizes the definition of variables used in the empirical analysis, along with their frequency and data sources.

3.2 The Impact of Macroprudential Measures on Banks' Risk Taking

The impact of macroprudential policies on banks' individual risk is examined using the following regression specification estimated using the OLS Fixed Effects with country level clustered standard errors:

$$Individual\ Risk_{ij,t} = \beta_0 + \boldsymbol{\beta_1 \times Macroprudential\ Policies_{ij,t-1}} + \Phi \times Bank\ controls_{ij,t-1}$$
$$+ \Psi \times Market\ \&\ Macro\ controls_{j,t-1} + \varphi_i + \mu_j + v_t + \varepsilon_{ij,t} \quad (2)$$

The dependent variable is represented by bank i's from country j individual risk in quarter t expressed by the *Value at Risk (VaR)* measure proposed by Jorion (1997). In a robustness exercise, we employ the *Distance to Default (DTD)* measure of Duan and Wang (2012). Both measures require data on market equity. VaR reflects the maximum percentage loss of the banks' market equity within a quarter for a given confidence level, higher values corresponding to increased banks' individual risk. DTD measures the deviation of assets value from the default point, higher values being associated with reduced banks' individual risk.

The main regressors of interest that consists of general and real estate macroprudential policies as well as the bank characteristics and market and macro controls are the same as in Eq. (1). Variables are winsorized within the 1% and 99% percentiles and lagged one period. Their definition is given in Table 1 and a detailed description is provided in Section 4.

3.3 Further Analysis

In the second part of the analysis, we investigate the impact of macroprudential measures adopted by central authorities across different banks and banking systems. We use the difference-in-difference methodology in order to assess if the impact of the adopted macroprudential measures was amplified or diminished by different characteristics of banks or banking market conditions.

First, we considered the size of banks, as it is often associated in the literature as a key determinant for the bank's systemic importance (Tarashev et al., 2010; Vallascas and Keasey, 2012; Laeven et al., 2016). In addition, size might create incentives for financial institutions to take on more risk as a result of the "too-big-to-fail" belief (Brown and Dinc, 2009).

Next, we account for the impact of the share of foreign assets in total banks assets at the country level. We choose the banking system foreign assets to highlight the international activity of banks and the risks they assume in an interconnected banking network. Interconnection poses greater threats to the stability of banking systems starting to serve as a mechanism for the propagation of shocks (Acemoglu et al., 2015).

Other banking market characteristics considered are the level of competition proxied by the Lerner index, and, the degree to which the supervisory authority is independent from the government and legally protected from the banking industry. Banking competition offers details regarding the banks disposal to reflect the regulatory changes imposed by central authorities. The degree of supervisory authority's independence it is important because governments cannot influence the adopted policies to their advantage.

In order to assess the impact of macroprudential measures across different types of banks and banking markets the following empirical regression form is estimated using the OLS Fixed Effects with country level clustered standard errors:

$$Risk_{ij,t} = \beta_0 + \boldsymbol{\beta_1} \times \boldsymbol{Macroprudential\ Policies_{ij,t-1}} + \boldsymbol{\beta_2} \times \boldsymbol{Macroprudential}$$
$$\boldsymbol{Policies_{ij,t-1}} \times Z_{(i)j,t-1} + \boldsymbol{\beta_3} \times Z_{(i)j,t-1} + \Phi \times Bank\ controls_{ij,t-1} + \Psi \times Market\ \&\ Macro \quad (3)$$
$$controls_{j,t-1} + \varphi_i + \mu_j + \upsilon_t + \varepsilon_{ij,t}$$

$Risk_{ij,t}$ takes alternatively the form of systemic risk (*CoVaR* and *MES*) and individual risk (*VaR* and *DTD*). $Z_{(i)j,t-1}$ reflects banks' characteristics (size) or banking systems conditions (share of foreign assets among total banking assets, Lerner index, and the independence of supervisory authority). The main regressors of interest that consists of general and real estate macroprudential policies as well as the bank characteristics and market and macro controls are the same as in Eq. (1). Variables are winsorized within the 1% and 99% percentiles and lagged one period. Their definition is given in Table 1 and a detailed description is provided in Section 4.

4. Data

4.1 Sample

Our sample consists of 95 publicly listed banks from 21 countries. The majority of these banks are located in Europe, but we also added banks from Canada and USA (Appendix B summarizes the distribution of banks among countries). We extended our sample with banks from USA and Canada, as they implemented important measures to sustain the resilience of the banking system (i.e., TARP program)[2] and to limit the boom of real estate credit (i.e., tax credit for homebuyers). In addition, the USA banking system consists of the majority of the global systemically important banks. The sample includes 26 USA financial institutions, 63 banks from Europe (among which 56 are from European Union, and 37 banks from Eurozone), and 6 Canadian banks.

The analyzed financial institutions have a total assets value of approximately 38 trillion dollars at the end of 2014 (Appendix 2), ranging from 12$ billion to $2.6 trillion. From these banks, 12 are included in the G-SIBs list published in November 2016 by the Financial Stability Board. The European Banking Authority considers banks with an exposure over 200 billion EUR as systemically important institutions and recommends they be subjected to the same disclosures as the G-SIBs (16 countries from our sample are included in the EBA list as of 2016). In addition, we also include other financial institutions that can generate negative contagion spillover across the system and are systemically important from a national perspective.

4.2 Dependent Variables

To assess the effectiveness of macroprudential policies implemented by central banks from our sample countries, we analyzed their impact on banks' contribution to systemic risk and risk-taking.

The global financial crisis showed that the failure of large complex cross-border financial institutions can have severe effects on the financial system and the economy, both domestically and globally. Considering the major implications of large and highly interconnected financial institutions, authorities and regulators were forced to implement new measures to increase their resilience to shocks and limit

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[2] TARP (Troubled Asset Relief Program) provided capital to 707 banks that totaled $245.1 billion.

their exposures. Once contagion risk is spreading, authorities have limited alternatives to stop it, undermining financial stability. One of the solutions to restore the confidence is to bailout the banks in need, but the central resources are limited. Therefore, the primary question is which financial institutions authorities should favor. At this point, it is important to identify the systemic importance of banks.

Several researchers (see e.g. Adrian and Shin, 2010) have conducted theoretical research on the identification of systemically important financial institutions. Considering this literature as a starting point, our systemic risk indicators are measured in a time-varying manner through *CoVaR (Conditional Value at Risk)* of Adrian and Brunnermeier (2017) and *MES (Marginal Expected Shortfall)* of Acharya et al. (2017). Both measures are based on weekly market capitalization data extracted from Datastream. While *CoVaR* captures the negative spillover effects of a reduction in a bank's market capitalization to the system (i.e., contribution to systemic risk), *MES* estimates the contagion developments when the system as a whole is undercapitalized to a particular bank (i.e., exposure to systemic risk). System is defined by the total market capitalization of the banks from our sample. *CoVaR* and *MES* are calculated separately for each bank using weekly returns of market capitalization for the period 2005-2014 to account for the build up phase in the pre-crisis period and the propagation phase during the crisis. Returns on bank i's market capitalization in week t are computed as follows:

$$R^i_{\text{Market capitalization}(t)} = \frac{\text{Market capitalization}^i_t}{\text{Market capitalization}^i_{t-1}} - 1 \qquad (4)$$

Returns on the system's market capitalization in week t are determined using the aggregated values of our all banks' market capitalization:

$$R^{\text{sys}}_{\text{Market Assets }(t)} = \sum_i \frac{\text{Market capitalization}^i_t}{\sum_i \text{Market capitalization}^i_t} \times R^i_{\text{Market capitalization}(t)} \qquad (5)$$

To determine CoVaR we use the quantile regression method following the procedure of Adrian and Brunnermeier (2017), while for MES we use a DCC-GJR GARCH model as in Acharya et al. (2017). The weekly values are then summed within a quarter for each bank. The descriptive statistics presented in Table 2 show that during 2008-2014, the quarterly average contribution to systemic risk of all banks from our sample translates to about 5% loss of the system's market equity. On the other hand, the exposure to systemic risk of the banks involves a quarterly loss of the banks' market equity of about 8%. A detailed situation of each bank's average contribution and exposure to systemic risk is provided in Appendix B.

Table 2 Descriptive Statistics

Variable	Unit	Mean	Standard deviation	p25	p50	p75	Min	Max	Number of observations
Dependent variables									
CoVaR	unit	0.046	0.029	0.030	0.040	0.054	0.002	0.263	2660
MES	unit	0.078	0.053	0.046	0.068	0.094	0.008	0.525	2660
VaR	unit	0.118	0.063	0.075	0.109	0.144	0.020	0.518	2642
DTD	unit	1.964	2.120	0.483	1.637	2.954	-1.572	17.760	2466
Macroprudential policy measures									
Capital requirements	0 – 1	0.069	0.254	0.000	0.000	0.000	0.000	1.000	2660
Sector capital buffers	0 – 3	0.030	0.216	0.000	0.000	0.000	0.000	3.000	2660
Reserve requirements FX	-3 – 1	0.017	0.214	0.000	0.000	0.000	-3.000	1.000	2660
Reserve requirements local	-3 – 1	-0.015	0.240	0.000	0.000	0.000	-3.000	1.000	2660
Countercyclical capital requirements	0 – 2	0.017	0.161	0.000	0.000	0.000	0.000	2.000	1794
Loan loss provisioning	0 – 1	0.004	0.067	0.000	0.000	0.000	0.000	1.000	1794
DSTI lending criteria	-1 – 1	0.013	0.142	0.000	0.000	0.000	-1.000	1.000	1278
Risk weights on housing loans	-1 – 1	0.004	0.115	0.000	0.000	0.000	-1.000	1.000	1278
Bank controls									
Size	Log(bil. €)	25.817	1.496	24.663	25.712	27.008	23.092	28.927	2157
Capitalization	%	7.700	3.500	4.900	7.000	10.000	0.700	26.100	2156
Credit risk	%	0.300	0.400	0.100	0.200	0.400	-0.700	4.100	2102
Liquidity risk	%	13.102	39.227	3.370	5.393	9.627	0.544	691.222	2095
Funding	%	52.300	16.400	39.900	52.700	66.900	2.700	86.300	2153
Macro controls									
Lerner index	unit	0.257	0.110	0.198	0.273	0.320	-0.049	0.601	2232
Foreign bank assets	%	17.554	20.067	6.000	12.000	18.000	2.000	89.000	2108
Inflation	%	2.218	2.275	0.750	1.777	3.157	-4.480	14.108	2660
Supervisory authority independence	0-3	2.148	0.599	2.000	2.000	3.000	1.000	3.000	2576

The bank risk-taking is computed using the *Value at Risk (VaR)* and *Distance-to-Default (DTD)* measures. *VaR* is estimated separately for each bank using weekly returns of market equity for the period 2005-2014. The risk we assess is the reduction of each bank's market capitalization. For quantifying this idiosyncratic risk we determine the *VaR* indicator that expresses the maximum possible loss (as a percent of the total market capitalization) that a bank could register for a given confidence level α (usually 99%), over a specific period of time.[3] The qth quantile (corresponding to the significance level q=1-α) of the following loss function is estimated using the quantile regression method:

$$q = Prob(R^i_{Market\ capitalization,t} \leq VaR^i_{q,t}) \qquad (6)$$

The weekly estimates obtained are then summed within a quarter for each bank. The descriptive statistics reported in Table 2 show that during 2008-2014 period our sample is characterized by a quarterly average of individual risk of about 12% loss of banks' market capitalization, with important differences among banks. The safest bank presents a quarterly average of 4% loss of its market capitalization, while the riskiest one has a quarterly average individual risk of 26% loss of its market equity (as depicted in Appendix B).

Distance-to-Default (DTD) was retrieved from Duan and Wang (2012). The measure is constructed as a function of different input variables that are firm-specific or common to all firms within an economy. The selected common variables that have the greatest predictive power for banks' default are stock index returns and interest rates. The firm-specific variables consist of volatility-adjusted leverage, liquidity, profitability, relative size, market misevaluation/future growth opportunities and idiosyncratic volatility. For banks, it is necessary to include also liabilities with a haircut at the default point, as they have high leverage levels. The method that captures these is the transformed-data *MLE* proposed by Duan et al. (2012). Descriptive statistics (Table 2) shows an average *DTD* indicator of 1.96 standard deviations of banks' distance to default within a quarter. Higher values are associated with reduced banks' individual risk.

The risk measures we use as dependent variables combine accounting data (size, leverage) with market data (stock prices). In comparison with other risk measures, like for example the widely used Z-score that rely on accounting data, DTD can provide forward-looking information reflected in banks' market capitalization movements. However, the 2008 financial crisis showed the need to adjust both accounting and market-based risk measures with the interlinkages among financial institutions, thus approaches like CoVaR or MES can better reflect contagion spillovers across the banking system as well as the importance of banks within a system.

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[3] This theoretical developments of the Value at Risk indicator can be found in Jorion (1997).

4.3 Independent Variables

4.3.1 Macroprudential Policies

In order to assess the effectiveness of macroprudential policies we use several databases, compiled by Akinci and Olmstead-Rumsey (2018), Kuttner and Shim (2016), Cerutti et al. (2017b) and Vandenbussche et al. (2015). These databases describe the macroprudential policies adopted during the period 2000-2014 by various countries (see Appendix 1 for a detailed description of each database).

Kuttner and Shim (2016)[4], Akinci and Olmstead-Rumsey (2018) and Cerutti et al. (2017b) used an index that captures the policy changes within a quarter, with entries of 1 if the prudential tool was tightened, -1 if the instrument was loosen and 0 when no change occurs. If multiple actions in the same direction (tightening or loosening) occur within a given quarter, the entries could take on the values of 2 and -2 or 3 and -3. In addition, a tightening and a loosening measure adopted within the same quarter would cancel each other.

In the following analysis, we will focus on the previously mentioned databases as they used the same mechanism in defining the policy changes[5]. In addition, the first three databases have various measures from several categories: solvency, liquidity, housing, non-housing that will allow us to run a series of comparative analyses. Other arguments for choosing these three databases are that they include the same countries and the period considered is larger than that assessed by Bakker and Klingen (2012) and Vandenbussche et al. (2015).

From the databases mentioned above, we use data regarding non-housing measures *(general macroprudential policies)*: capital requirements, sector capital buffers, reserve requirements on foreign-currency denominated accounts and on local currency-denominated accounts, and real estate specific measures *(housing macroprudential policies)*: countercyclical capital requirements, loan loss provisioning, DSTI lending criteria and risk weights on housing loans. Our analysis focuses on non-housing macroprudential measures aimed to increase the financial system's resilience and on housing related policy tools designed to restore the stability of real estate sector, as advanced economies used primarily this type of policies (Akinci and Olmstead-Rumsey, 2018). From borrower-based macroprudential policies we focused on DSTI lending criteria, as this measure is not related to the real estate market, property prices reaching unsustainable levels during the real estate bubble. As confirmed by Gross and Garcia (2016), DTI ratios are more effective than LTV caps reducing the household risk (probability of default and loss-given-default) while implying less pronounced macro feedback effects. Descriptive statistics are highlighted in Table 2, while the definitions of macroprudential measures and sources are provided in Table 1.

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[4] The database of Kuttner and Shim (2016) contains monthly values for each policy change. In order to facilitate the comparison between databases we transformed the monthly values to quarterly values, by summing the values of each quarter months.

[5] Vandenbussche et al. (2015) studied the macroprudential measures adopted by countries from Central and Eastern Europe in period 2000Q1–2010Q4, focusing on the effective value of individual measures that could be subject of interpretation when we transform the values to reflect policy changes.

We consider the impact of the above macroprudential measures as they were the most frequently implemented during 2008-2014 period in countries from our sample. Although, the usage of macroprudential policies increased after 2000s, the regulatory authorities started to share a greater recognition for the relevance of macroprudential policies after the financial crisis. Therefore, we examine the impact of macroprudential policy during the crisis phase ($2008Q_3$-$2011Q_4$) and post-crisis ($2012Q_1$-$2014Q_4$) to capture the deteriorating financial conditions and their consequences.

We expect that tighter capital regulation, including capital requirements, sector capital buffers and countercyclical capital requirements, reduce systemic risk as they increase the cost of funding or constrain the credit growth. This situation may be managed through more stringent credit conditions supported by borrowers that may decrease the credit demand. In the same time it can improve the financial situation of banks as a result of borrowing loans to clients that meet the tighten requirements, thus lowering the risks assumed. The same mechanism can be applied also for risk-weights on housing loans when the target is the real estate sector.

Higher reserve requirements may increase the cost of funding less liquid assets such as residential mortgages and may force banks to reduce their supply and, therefore the level of risk-taking. If we refer to provisioning requirements, these may force banks to save a larger portion of their earnings to cover potential losses, reducing their profits. Consequently, a bank with lower profitability increases the cost of funding and tightens credit conditions with the same effect as capital measures. Increasing the DSTI ratio makes more difficult for households with limited own funds and low income to qualify for a credit, thereby reducing the risk assumed by banks, and implicitly their contribution to systemic risk. Table 3 summarizes the number of tightening and loosening events of the macroprudential measures by year (Panel A) and by country (Panel B). Overall, data highlight the necessity to provide urgent liquidities to financial market and to increase banks' resilience to further shocks. For example, sector capital buffers were increased on average three times in one quarter, while reserve requirements on foreign-currency denominated accounts and on local currency-denominated accounts were loosen three time in one quarter.

Table 3 Tightening and Loosening Events of Macroprudential Policy Actions During 2008 – 2014

Panel A Tightening and Loosening Events by Year

	Number of tightening events								*Number loosening events*							
	2008	2009	2010	2011	2012	2013	2014	Total	2008	2009	2010	2011	2012	2013	2014	Total
General macroprudential policy actions																
Capital requirements	0	0	0	32	43	43	66	184	0	0	0	0	0	0	0	0
Sector capital buffers	18	0	0	5	14	14	12	63	0	0	0	0	0	0	0	0
Reserve requirements FX	2	4	26	9	15	15	5	76	9	9	0	6	0	0	0	24
Reserve requirements local	2	4	11	14	5	15	0	51	7	12	0	11	52	0	5	87
Housing macroprudential policy actions																
Countercyclical capital requirements	115	104	104	104	104	116	242	889	0	0	0	0	0	0	0	0
Loan loss provisioning	104	112	104	104	104	104	242	874	0	0	0	0	0	0	0	0
DSTI lending criteria	97	96	105	107	238	380	380	1403	0	5	0	0	0	0	0	5
Risk weights on housing loans	101	96	96	102	238	380	380	1393	6	0	0	0	0	0	0	6

Panel B Tightening Events by Country

Country	Number of banks	General macroprudential policy actions *Number of tightening events*				Housing macroprudential policy actions *Number of tightening events*			
		Capital requirements	Sector capital buffers	Reserve requirements FX	Reserve requirements local	Countercyclical capital requirements	Loan loss provisioning	DSTI lending criteria	Risk weights on housing loans
Austria	4	8	0	0	0	8	8	40	40
Belgium	2	4	0	0	0	4	4	20	20
Canada	6	12	0	0	0	168	168	168	168
Czech Republic	1	2	0	0	0	2	2	10	10
Denmark	4	8	0	0	0	8	8	40	40
France	7	14	0	0	0	14	14	70	70
Germany	2	4	0	0	0	4	4	20	20
Hungary	1	2	0	0	0	2	2	11	10
Ireland	2	4	2	0	0	4	4	20	20
Italy	11	22	0	0	0	22	22	110	110
Netherlands	1	2	0	0	0	2	2	10	10
Norway	2	4	0	0	0	4	4	22	20
Poland	6	6	12	6	6	18	12	72	66
Portugal	3	6	0	0	0	6	6	30	30
Romania	1	2	0	0	0	2	2	11	10
Russian Federation	2	4	2	10	10	56	56	20	20
Spain	5	10	5	0	0	15	10	55	55
Sweden	4	8	8	0	0	12	8	40	40
Switzerland	8	16	24	0	0	24	24	80	80
Turkey	5	10	10	60	35	10	10	50	50
USA	18	36	0	0	0	504	504	504	504
Total	*95*	*184*	*63*	*76*	*51*	*889*	*874*	*1403*	*1393*

If we refer to the number of tightening and loosening actions by year, for both categories of measures (housing and non-housing) the number of tightening events increased during 2011 – 2014, compared with previous period (Table 3, Appendix A). This can be explained by the fact that, countries from Europe adopted the majority of macroprudential measures during the sovereign debt crisis, as the systemic risk of European banks reached its height in late 2011. During this crisis, the largest increase in contribution to systemic risk came from the Italian and Spanish banks (Black et al., 2016)

Central authorities from all countries reacted to financial difficulties by limiting (tightening) or encouraging the activity (loosening) in order to improve banking stability. In Europe, during the analyzed period, Italy implemented 286 tightening actions, followed by Switzerland (248) and Turkey (235), while Czech Republic implemented only 26 tightening actions. The implemented measures restricted the conditions for borrowers in several countries, including France, Italy, Spain, Switzerland, and Poland (Table 3, Appendix B).

4.3.2 Bank-Control Variables

Empirical specifications control for banks' characteristics, in order to capture the strategies they follow for risk management. Therefore, we account in our regression analysis for banks' size (logarithm of Total Assets), capitalization (Common Equity to Total Assets), credit risk (Provisions for Loan Losses to Gross Loans), liquidity risk (Net Loans to Short Term Debt and Current portion of Long Term debt) and the funding structure (Deposits to Total Assets). Variables are extracted from Worldscope and their definition is given in Table 1.

Literature suggests that size and leverage are the key determinants of banks' contribution to systemic risk. The banks' dimension is recognized in various papers as an important determinant of systemic importance of an institution (Tarashev, et al., 2010; Vallascas and Keasey, 2012; Mayordomo et al., 2014; Laeven et al., 2016). Vallascas and Keasey (2012) provide evidence from an extensive sample of European listed banks regarding the importance of banks' size in their exposure to systemic risk. This might be explained by the fact that relatively large banks are more likely to benefit from regulatory forbearance and this might create incentives to invest in risky activities (Brown and Dinc, 2009). On the other side, Dermine and Schoenmaker (2010) sustain that limiting the banks' size will generate a lack of credit risk diversification, that is needed to reduce the cost of financial distress.

Previous studies show that systemic risk is associated with high level of leverage. Adrian and Shin (2010) and Danielsson et al. (2013) highlight the importance of financial leverage in influencing systemic risk. Vallascas and Keasey (2012) consider that in order to increase banks' resilience to systemic events, central authorities should apply restrictions on banks' leverage and constrain the liquidity requirements. On the other hand, Weiβ et al. (2014) sustain that neither bank size nor leverage are persistent determinants of systemic risk across financial crises, however, global systemic risk is generated by characteristics of regulatory regime. Other important determinants of systemic risk during the recent financial crisis have been credit and liquidity risk (Lopez-Espinosa et al., 2012). Finally, the ratio of deposits to

total assets has been used also by Anginer et al. (2014b) in order to explain financial stability, measured by Z-score.

Descriptive statistics for these variables are presented in Table 2. We can observe that on average during 2008-2014 banks from our sample had a capitalization of 7% (ranging from 4.9% to 26.1%) and a share of deposits in total assets of about 52%. There are important differences among banks regarding credit risk and liquidity risk.

4.3.3 Macro and Sector-Specific Variables

To estimate the impact of macroprudential measures on systemic and individual risk we control for sector-specific and macroeconomic characteristics. Therefore, we add an indicator that accounts for banking competition (Lerner index), banking foreign activity (foreign bank assets among total bank assets) and, finally, as macro variable we employ the inflation rate. Variables are extracted from World Bank and their definitions are detailed in Table 1.

The level of banking competition influences the level of bank risk-taking. Anginer et al. (2014a) provided empirical evidence that greater competition encourages banks to take on more diversified risks, making the banking system less fragile to shocks. On the other hand, Beck et al. (2013) and Jimenez et al. (2013) found that an increase in competition, measured by the Lerner index, is associated with larger increase in banks' fragility. Foreign currency loans contribute to systemic risk by creating a significant exchange-rate-induced credit risk. This situation occurs mainly in European countries, were loans denominated in EUR or CHF predominate. Yesin (2013) found that systemic risk is substantial in the non-euro area and relatively low in the euro area. Finally, in order to account for the macroeconomic environment we used the inflation rate. Although the financial situation started to deteriorate beginning with 2007 (significant losses from subprime mortgages in US), the difficulties have been transmitted to the economy lately. Inflation rate for the sample countries registered the highest values during 2008 year, followed by a substantial reduction during 2009. This variable was also used by Weiβ et al. (2014) as macro control variable in order to explain systemic risk.

The descriptive statistics presented in Table 2 show that the banking systems from our sample are characterized by an average Lerner index of 0.25. Foreign loans represent on average 17.55% of total assets, with important differences among banks (standard deviation 20.07%). There are banking systems with the majority of banks' activity focused on foreign denominated loans (the ratio of foreign assets to total assets is 89%), while there are banking systems which banks manifest risk aversion and prefer to focus on domestic denominated loans.

5. Results

This section presents estimates of the general and housing macroprudential policies effects on banks' systemic importance and risk-taking level. The impact was assessed in a panel framework using the OLS methodology. Also, we explore the asymmetric responses of banks' risk to macroprudential measures considering their size and a number of banking sector characteristics like foreign assets holdings, competition and independence of the supervisory authority.

5.1 The Impact of Macroprudential Policies on Systemic Risk

Table 4 presents the results of the macroprudential measures impact on banks' contribution to systemic risk expressed by *CoVaR*. The main regressors of interest include country specific macroprudential measures implemented by governments and take values from -3 to 3. Positive values are associated with the number of tightening events within a quarter, while negative values are linked to the number of loosening events (0 reflects no action). Column (1) depicts the benchmark model that includes all types of macroprudential policies, column (2) covers the general prudential measures, and, column (3) focuses on housing specific measures. In columns (4)-(11) we include alternatively the macroprudential tools. All models include bank controls, sector specific and macro characteristics, and, bank fixed effects. Positive coefficients correspond to an enhanced contribution to systemic risk (harmful effect), while negative coefficients are associated with a reduction in banks' systemic importance (beneficial effect).

The baseline model (column 1) provides evidence for highly significant effectiveness of sector capital buffers, countercyclical capital requirements and DSTI lending criteria in reducing banks' systemic importance. These results are in line with the literature regarding the impact of various macroprudential policies on systemic risk. The target of capital buffers is to increase banks' capacity to absorb losses generated by the interconnection among banks, while countercyclical capital requirements' aim is to mitigate procyclicality (Bui et al., 2017). Lim et al. (2011) concluded that countercyclical capital requirements are effective in reducing systemic risk, but the magnitude depends on the source of shock. Claessens et al. (2013) and Hallissey et al. (2014) argue that borrower-based measures (DSTI) are effective in reducing asset growth, curbing the associated risk.

We report separately the results associated with non-housing measures (column 2) as the number of banks jumps from 49 to 75 and the number of observations increases accordingly. For this specification the capital requirements imposed by Basel agreements become statistically significant, as the aim of Basel III requirements is to improve bank' capacity to absorb shocks, develop prudent risk management practices and raise the resilience of individual banks in times of distress. The importance of higher regulatory capital levels in reducing systemic risk is highlighted in various papers (Bluhm and Krahnen, 2014; Laeven et al., 2016). These results are confirmed by models (4)-(7), which accounts for the separate influence of the general macroprudential policies.

Although insignificant, reserve requirements for deposits denominated in local and foreign currency have a negative impact on the dependent variable being associated a reduction in the banks' contribution to systemic risk (columns 6 and 7). A similar conclusion has been obtained by Bruno et al. (2016) and Kuttner and Shim (2016).

Turning to housing sector related macroprudential measures (model 3) the only tools that maintain their significance are countercyclical capital requirements and DSTI lending criteria. The significant impact of these measures is confirmed also in models (8) and (10).

When the impact of loan loss provisioning mechanism is analyzed separately from the other prudential variables, results show an increase in banks' systemic

importance (slightly significant). For the Hong Kong banking system, Wong et al. (2011) found that the loan-loss provisioning is a main determinant of systemic risk and the countercyclical tools for loan-loss reserves might be effective in reducing the risk in the banking system. On the other side, higher loan loss provisions can be a signal of higher default risk (Floreani et al., 2015) and, therefore, of greater contagion spillovers across the system.

Regarding the control variables, our paper is in line with the general acceptance that better-capitalized banks contribute less to systemic risk (Tarashev, et al., 2010; Bluhm and Krahnen, 2014).[6] For the coefficient corresponding to size our findings are similar to Weiβ et al. (2014) who empirically show that banks' size is not a persistent determinant of systemic risk across financial crises. Banking market competition and the share of foreign assets among total banking assets limit the banks' systemic importance due to risk diversification, while the level of inflation from one country increases the contribution of banks to systemic risk.

We also examined the impact of macroprudential measures on systemic risk using *MES* as dependent variable. Results depicted in Appendix C show that a significant reduction in banks' exposure to systemic risk is associated with the tightening of capital requirements, sector capital buffers, countercyclical capital requirements, loan loss provisioning and DSTI lending criteria, confirming thus the previous empirical output.

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[6] Large banks actively build-up capital that exceeds the regulatory minimum requirements (Berger et al., 2008). While better-capitalized banks are associated with a lower contribution to systemic risk, they might engage in risky operations (Perotti et al., 2011). To control for this behavior, we replace the capitalization ratio with a capital in excess ratio in alternative specifications. Capital in excess for a given bank is computed as the difference between actual and minimal capital requirement (including bank specific pillar 2 requirements). Unreported results highlight that measures like sector capital buffers, countercyclical capital requirements and DSTI lending criteria could significantly reduce systemic risk when controlling for excess capital available to banks, confirming thus our main findings.

Table 4 The Impact of Macroprudential Policies on Systemic Risk: Dependent Variable Expressed by Conditional Value at Risk

Dependent variable: Conditional Value at Risk (CoVaR)	(1) All policies	(2) General policies	(3) Housing policies	(4) General policies	(5) General policies	(6) General policies	(7) General policies	(8) Housing policies	(9) Housing policies	(10) Housing policies	(11) Housing policies
Capital requirements	-0.002 (0.003)	-0.003** (0.001)		-0.003** (0.001)							
Sector capital buffers	-0.005*** (0.000)	-0.005** (0.002)			-0.005** (0.002)						
Reserve requirements FX	-0.000 (0.003)	-0.000 (0.003)				-0.002 (0.003)					
Reserve requirements local	-0.000 (0.002)	-0.003 (0.002)					-0.003 (0.002)				
Countercyclical capital requirements	-0.009*** (0.002)		-0.014*** (0.001)					-0.011** (0.004)			
Loan loss provisioning	-0.002 (0.002)		-0.001 (0.002)						0.003* (0.002)		
DSTI lending criteria	-0.009*** (0.002)		-0.009*** (0.002)							-0.010*** (0.002)	
Risk weights on housing loans	-0.003* (0.001)		-0.002 (0.001)								-0.006 (0.004)
Size	-0.028** (0.010)	-0.023* (0.011)	-0.027** (0.010)	-0.022* (0.011)	-0.023** (0.011)	-0.023* (0.011)	-0.023* (0.011)	-0.017*** (0.005)	-0.016*** (0.005)	-0.027** (0.010)	-0.027** (0.010)
Capitalization	-0.538*** (0.139)	-0.609*** (0.125)	-0.562*** (0.147)	-0.616*** (0.121)	-0.621*** (0.124)	-0.611*** (0.126)	-0.610*** (0.126)	-0.520*** (0.158)	-0.513*** (0.154)	-0.513*** (0.127)	-0.524*** (0.130)
Credit risk	0.472 (0.428)	0.805 (0.586)	0.555 (0.386)	0.813 (0.585)	0.807 (0.594)	0.832 (0.581)	0.840 (0.581)	-0.058 (0.359)	-0.015 (0.371)	0.146 (0.445)	0.119 (0.443)
Liquidity risk	0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Funding	0.009 (0.005)	-0.020 (0.021)	0.009 (0.005)	-0.020 (0.021)	-0.021 (0.021)	-0.021 (0.021)	-0.021 (0.021)	-0.000 (0.012)	-0.001 (0.012)	-0.000 (0.010)	-0.002 (0.011)
Lerner index	0.009 (0.011)	-0.038** (0.018)	0.008 (0.011)	-0.037* (0.018)	-0.038* (0.018)	-0.038* (0.018)	-0.038* (0.018)	-0.010 (0.010)	-0.007 (0.011)	0.015 (0.011)	0.011 (0.010)
Foreign bank	-0.001**	0.000	-0.001**	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001*	-0.001*

Foreign bank assets	-0.001**	0.000	-0.001**	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001*	-0.001*
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
Inflation	0.002*	0.004**	0.002*	0.004**	0.004**	0.004**	0.004**	0.001*	0.001*	0.002**	0.002**
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Observations	843	1,877	843	1,877	1,877	1,877	1,877	1,158	1,158	880	880
R-squared	0.106	0.241	0.101	0.239	0.239	0.238	0.239	0.094	0.091	0.096	0.092
Number of banks	49	75	49	75	75	75	75	50	50	51	51
No of countries	21	21	21	21	21	21	21	21	21	21	21
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

5.2 The Impact of Macroprudential Policies on Individual Risk

Results regarding the impact of macroprudential policies on individual risk captured by Value at Risk indicator are presented in Table 5. Model (1) includes the complete set of macroprudential policies and accounts for bank controls, sector specific and macro characteristics, and, bank fixed effects. Column (2) summarizes the estimated coefficients for the general macroprudential policies, while column (3) provides the empirical estimates for the prudential measures related to the real estate sector. For the remaining models (4) to (11) each measure is included one at a time. A positive coefficient corresponds to an enhanced individual risk-taking (harmful effect), while a negative coefficient is associated with a reduction in banks' level of risk-taking (beneficial effect).

Estimation results regarding the baseline model (column 1) highlight that the most effective measures in reducing significantly the individual banking risk are sector specific capital buffers, as well as housing sector related tools like countercyclical capital requirements, DSTI lending criteria and risk-weights on housing loans. These results strengthen the necessity to hold higher levels of capital as safety net (Gauthies et al., 2012; Bluhm and Krahnen, 2014) and to counteract the risks generated by the housing sector because of excessive lending. Overall, results highlight that macroprudential measures targeting the housing sector are more effective than those targeting the entire banking activity where only one measure is statistically significant. Akinci and Olmstead-Rumsey (2018) also pointed out that measures targeting the housing sector were more effective than those targeting the entire banking activity considering that housing credit growth was much larger, on average, than total credit growth during the 2008 financial crisis.

The effectiveness of higher levels of capital in reducing individual banking risk is confirmed by model (2) that focuses on macroprudential measures aimed to sustain the entire banking activity and, also, in models (4), (5) and (8) that analyze the capital measures individually. The positive effects of capital requirements (corresponding to Basel capital agreements) are in line with the literature that sustain the need of higher capital requirements in reducing bank risk-taking, such as Behr et al. (2010) and Thakor (2014), but in this case only in markets with a low degree of concentration. Beltratti and Stulz (2012) found that large banks with more Tier 1 capital, more deposits, less exposure to US real estate and less funding fragility performed better during crisis.

Reserve requirements for liabilities denominated in domestic currency reduce banks' risk (models 1, 2 and 7), while reserve requirements for foreign currency denominated liabilities increase the risk incentives of banks (models 1, 2 and 6), but the associated coefficients are not statistically significant. As an explanation for these findings might be the fact that reserve requirements were mainly used by emerging countries (Bustamante and Hamann, 2015) that have limited observations in our sample. In line with our results, Bruno et al. (2016), Kuttner and Shim (2016) and Akinci and Olmstead-Rumsey (2018) found no or only a weakly significant impact of higher reserve requirements on credit growth, and therefore, on the risk assumed.

The effectiveness of countercyclical capital requirements, DSTI lending criteria and of the risk-weights applied to housing loans is confirmed when we analyze the impact of the whole set of housing measures (model 3) and of the

individual housing measures on bank risk-taking (models 8 to 11). Kuttner and Shim (2016) and Akinci and Olmstead-Rumsey (2018) recognize the positive effects of DSTI ratios in reducing the credit housing growth and the risks associated with it, by cutting the riskier borrowers.

Loan loss provisioning measure has a negative, but statistically insignificant impact on individual risk in models (1) and (3) when the impact of this measure is assessed together with the other housing and general measures. Model (9) presents the output for loan loss provisioning measure taken individually. In this situation, the impact becomes positive and statistically significant, the provisioning on non-performing loans generating an increase of bank risk-taking and, implicitly, the manifestation of moral hazard. Bouvatier and Lepetit (2012) sustain the initiative of Basel Committee for the implementation of a forward-looking provisioning system to address procyclicality, taking into account the expected losses.

We also examined the impact of macroprudential measures on banks' individual risk using *DTD* as dependent variable. Higher levels of *DTD* indicator are associated with enhanced stability of banks thus a positive coefficient corresponds to lower individual risk-taking (beneficial effect), while a negative coefficient is associated with increased risk-taking (harmful effect). Results depicted in Appendix D show that a significant reduction in banks' exposure to systemic risk is associated with stronger capital requirements, sector capital buffers, countercyclical capital requirements, loan loss provisioning and DSTI lending criteria, confirming the previous empirical output.[7]

5.3 Robustness Checks

We checked the robustness of our results by employing several alternative specifications (Table 6). First, we run the regression without macro and market specific controls. Models 1 and 2 present the empirical coefficients corresponding to the macroprudential policies' impact on systemic risk, while models 3 and 4 focus on banks' individual risk-taking. The findings confirm the effectiveness of additional capital holdings by banks to reduce the associated risks, as both sector capital buffers and countercyclical capital requirements for real estate loans remain negative and statistically significant. Also the DSTI criterion for real estate loans maintains its significance and beneficial effects in reducing banks' systemic importance and risk-taking. Further, we include country fixed effects (models 5-8). In the third robustness check (models 9-12), we add to the baseline regression year fixed effects. Finally, we changed the clustering from country level to bank level (models 13-16). The results obtained remain very similar with the baseline specification, strengthening the importance to implement sector specific capital buffers, countercyclical capital requirements and borrower-based macroprudential measures.

As reverse causality among macroprudential policy measures and risk might affect our results we also consider the GMM estimation method. To control for

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[7] We also investigated the impact of macroprudential policies on banks' Z-score, a widely used insolvency measure based only on accounting data. Z-score reports banks' return on assets and capitalization to the standard deviation of return on assets, comparing the capital buffer with the potential risk of default. Its interpretation is similar with DTD, higher values indicating higher distance from the default point, thus lower risk taking. Results presented in Appendix E are in line with the main findings.

potential endogeneity we employ the First Difference GMM estimator of Arellano and Bond (1991). The general prudential measures and housing specific policies are considered endogenous and instrumented with lagged values in the first difference equation. The bank level and country level controls are considered exogenous, being instrumented with their level.

Specifications presented in Table 7 show that policy measures based on sector capital buffers, countercyclical capital requirements and DSTI lending criteria could significantly reduce banks' systemic importance as well as their risk taking, confirming thus the robustness of the findings obtained using the OLS method. Appendix F, which presents the effect of each macroprudential measure separately, shows similar results.

The validity of the instrumental variables set is confirmed by the Hansen J statistic for most models in Table 7 (with the exception of columns 2 and 5). The null hypothesis of the Hansen test is that the instruments are not correlated with the residuals. For the models shown in Table (7) we use as instruments the lags of the macroprudential variables from 1 to 5[8], while for the models presented in Appendix E we use as instruments all possible further lags.[9]

Finally, we re-run the empirical specifications using a restrictive sample of banks from Europe. Results presented in Appendix G show that the main findings are very similar for European banks in terms of sign, magnitude and significance.

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[8] We comply with the rule that he number of instruments should be below the number of cross-sections.
[9] We used a *collapse* option to reduce the number of instruments to the minimum.

Table 5 The Impact of Macroprudential Policies on Individual Bank Risk: Dependent Variable Expressed by Value at Risk

Dependent variable: Value at Risk (VaR)	(1) All policies	(2) General policies	(3) Housing policies	(4) General policies	(5) General policies	(6) General policies	(7) General policies	(8) Housing policies	(9) Housing policies	(10) Housing policies	(11) Housing policies
Capital requirements	-0.005 (0.006)	-0.009** (0.004)									
Sector capital buffers	-0.012*** (0.004)	-0.010** (0.004)		-0.008** (0.004)	-0.010** (0.004)						
Reserve requirements FX	0.004 (0.006)	0.006 (0.006)				0.002 (0.008)					
Reserve requirements local	-0.000 (0.003)	-0.007 (0.004)					-0.003 (0.004)				
Countercyclical capital requirements	-0.015*** (0.005)		-0.026*** (0.005)					-0.022* (0.011)			
Loan loss provisioning	-0.001 (0.002)		-0.000 (0.002)						0.008*** (0.002)		
DSTI lending criteria	-0.016** (0.006)		-0.013*** (0.004)							-0.024*** (0.008)	
Risk weights on housing loans	-0.019*** (0.006)		-0.018*** (0.004)								-0.026*** (0.006)
Size	-0.008 (0.017)	-0.031 (0.018)	-0.007 (0.018)	-0.030 (0.018)	-0.032 (0.019)	-0.032 (0.018)	-0.031 (0.019)	-0.005 (0.017)	-0.004 (0.017)	-0.024 (0.022)	-0.024 (0.023)
Capitalization	-0.820*** (0.203)	-0.932*** (0.233)	-0.853*** (0.202)	-0.929*** (0.225)	-0.941*** (0.228)	-0.938*** (0.239)	-0.925*** (0.237)	-0.885*** (0.228)	-0.871*** (0.223)	-0.574* (0.295)	-0.587* (0.294)
Credit risk	-0.110 (0.991)	1.981 (1.164)	0.015 (0.962)	2.007 (1.146)	2.004 (1.189)	2.043* (1.160)	2.061* (1.159)	-0.359 (0.444)	-0.275 (0.411)	-0.522 (0.892)	-0.602 (0.944)
Liquidity risk	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.001 (0.001)	0.001 (0.001)
Funding	0.035 (0.031)	-0.070 (0.075)	0.033 (0.032)	-0.071 (0.075)	-0.072 (0.076)	-0.073 (0.076)	-0.073 (0.076)	0.004 (0.042)	0.003 (0.043)	-0.002 (0.048)	-0.006 (0.050)
Lerner index	0.016 (0.022)	-0.044 (0.033)	0.014 (0.024)	-0.044 (0.034)	-0.046 (0.034)	-0.045 (0.034)	-0.046 (0.034)	-0.018 (0.015)	-0.014 (0.016)	0.053* (0.029)	0.043 (0.030)
Foreign bank assets	-0.001** (0.000)	0.002 (0.003)	-0.001** (0.000)	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)	0.002 (0.003)	-0.001* (0.001)	-0.001* (0.001)	-0.001* (0.001)	-0.001* (0.001)

Inflation	0.001	0.004*	0.001	0.004*	0.004*	0.004*	0.004*	-0.000	-0.000	0.004*	0.001	0.001
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Observations	843	1,877	843	1,877	1,877	1,877	1,877	1,158	1,158	1,877	880	880
R-squared	0.071	0.201	0.063	0.197	0.197	0.196	0.196	0.072	0.068	0.196	0.046	0.045
Number of banks	49	75	49	75	75	75	75	50	50	75	51	51
No of countries	21	21	21	21	21	21	21	21	21	21	21	21
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

Table 6 The Impact of Macroprudential Policies on Systemic Risk and Individual Risk: Robustness Assessment

Part 1

Variables	A. Without macro controls				B. With country FE			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	CoVaR	MES	VaR	DTD	CoVaR	MES	VaR	DTD
Capital requirements	-0.001	0.000	-0.007	-0.156	0.001	0.002	0.004	-0.081
	(0.002)	(0.005)	(0.006)	(0.138)	(0.003)	(0.005)	(0.005)	(0.141)
Sector capital buffers	-0.004***	-0.006***	-0.011***	0.028	-0.003***	-0.006**	-0.006**	0.067
	(0.001)	(0.002)	(0.003)	(0.118)	(0.001)	(0.002)	(0.002)	(0.129)
Reserve requirements FX	-0.001	-0.003	0.005	0.401**	0.002	0.002	0.015*	0.297**
	(0.004)	(0.007)	(0.007)	(0.138)	(0.004)	(0.007)	(0.007)	(0.112)
Reserve requirements local	0.000	-0.001	-0.001	-0.035	-0.002	-0.005	-0.013**	-0.012
	(0.003)	(0.005)	(0.004)	(0.173)	(0.003)	(0.006)	(0.005)	(0.144)
Countercyclical capital requirements	-0.012***	-0.018***	-0.020***	-0.001	-0.015***	-0.023***	-0.030***	0.055
	(0.001)	(0.002)	(0.003)	(0.095)	(0.002)	(0.003)	(0.007)	(0.169)
Loan loss provisioning	0.001	-0.001	-0.000	-0.446***	-0.003	-0.008	-0.006**	-0.261*
	(0.001)	(0.002)	(0.002)	(0.040)	(0.003)	(0.005)	(0.003)	(0.132)
DSTI lending criteria	-0.008***	-0.013***	-0.014**	0.077	-0.007**	-0.010*	-0.010	0.055
	(0.002)	(0.003)	(0.006)	(0.084)	(0.003)	(0.005)	(0.006)	(0.166)
Risk weights on housing loans	-0.000	0.000	-0.018***	0.083	0.000	0.001	-0.011*	0.127*
	(0.001)	(0.001)	(0.005)	(0.063)	(0.001)	(0.001)	(0.006)	(0.064)
Size	-0.030***	-0.057***	-0.014	0.468	-0.023***	-0.047***	-0.005	0.306
	(0.009)	(0.015)	(0.018)	(0.416)	(0.008)	(0.013)	(0.013)	(0.189)
Capitalization	-0.616***	-1.044***	-0.890***	35.434***	-0.484***	-0.829***	-0.746*	30.171***
	(0.145)	(0.200)	(0.229)	(6.586)	(0.105)	(0.146)	(0.358)	(3.385)
Credit risk	0.540	1.404	-0.229	-19.433	0.775*	1.907**	0.774	-28.176*
	(0.434)	(0.833)	(1.065)	(16.047)	(0.402)	(0.805)	(0.624)	(13.735)
Liquidity risk	-0.000	-0.000	-0.000*	0.002	-0.000	-0.000	-0.000	0.002
	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)	(0.000)	(0.003)
Funding	0.010*	0.024**	0.039	-0.429	0.009*	0.021**	0.034	-0.411
	(0.005)	(0.008)	(0.029)	(0.578)	(0.004)	(0.007)	(0.024)	(0.514)
Lerner index								
Foreign bank assets								
Inflation								
Observations	906	906	906	863	906	906	906	863
R-squared	0.090	0.091	0.063	0.198	0.114	0.116	0.106	0.245
Number of banks	53	53	53	51	53	53	53	51
No of countries	21	21	21	21	21	21	21	21
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO	NO	NO	NO
Country FE	NO	NO	NO	NO	YES	YES	YES	YES
Cluster	Country	Country	Country	Country	Country	Country	Country	Country

Part 2

Variables	C. With year FE				D. Bank level clustering			
	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	CoVaR	MES	VaR	DTD	CoVaR	MES	VaR	DTD
Capital requirements	0.000	0.001	0.005	-0.032	-0.002	-0.002	-0.005	-0.096
	(0.003)	(0.006)	(0.005)	(0.160)	(0.002)	(0.004)	(0.003)	(0.098)
Sector capital buffers	-0.004***	-0.007***	-0.007**	0.088	-0.005***	-0.008***	-0.012***	0.059
	(0.001)	(0.002)	(0.003)	(0.140)	(0.001)	(0.002)	(0.002)	(0.089)
Reserve requirements FX	0.001	0.002	0.012	0.352***	-0.000	-0.000	0.004	0.294**
	(0.003)	(0.007)	(0.007)	(0.096)	(0.003)	(0.005)	(0.004)	(0.124)
Reserve requirements local	-0.002	-0.005	-0.012**	-0.105	-0.000	-0.002	-0.000	-0.010
	(0.003)	(0.005)	(0.005)	(0.148)	(0.002)	(0.003)	(0.003)	(0.079)
Countercyclical capital requirements	-0.013***	-0.020***	-0.025***	-0.046	-0.009*	-0.012*	-0.015**	-0.146
	(0.002)	(0.003)	(0.008)	(0.217)	(0.005)	(0.007)	(0.006)	(0.230)
Loan loss provisioning	-0.002	-0.007	-0.006*	-0.360***	-0.002	-0.007***	-0.001	-0.328***
	(0.003)	(0.005)	(0.003)	(0.104)	(0.001)	(0.002)	(0.002)	(0.057)
DSTI lending criteria	-0.008**	-0.012**	-0.013*	0.133	-0.009***	-0.013***	-0.016**	0.084
	(0.003)	(0.005)	(0.006)	(0.160)	(0.002)	(0.004)	(0.007)	(0.084)
Risk weights on housing loans	-0.001	-0.000	-0.013*	0.069	-0.003	-0.004	-0.019***	0.110
	(0.001)	(0.002)	(0.007)	(0.127)	(0.002)	(0.004)	(0.005)	(0.143)
Size	-0.024**	-0.044**	-0.007	-0.121	-0.028***	-0.047***	-0.008	-0.109
	(0.010)	(0.017)	(0.014)	(0.171)	(0.008)	(0.014)	(0.016)	(0.343)
Capitalization	-0.480***	-0.808***	-0.742***	28.687***	-0.538***	-0.889***	-0.820***	30.741***
	(0.106)	(0.153)	(0.332)	(3.080)	(0.114)	(0.177)	(0.195)	(5.634)
Credit risk	0.857*	1.983**	0.710	-23.066	0.472	1.187	-0.110	-11.140
	(0.401)	(0.793)	(0.571)	(13.267)	(0.435)	(0.818)	(0.781)	(15.107)
Liquidity risk	0.000	0.000	-0.000	0.002	0.000	-0.000	-0.000	0.002
	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)	(0.000)	(0.000)	(0.003)
Funding	0.009*	0.021**	0.030	-0.330	0.009	0.021	0.035	-0.327
	(0.004)	(0.009)	(0.026)	(0.437)	(0.008)	(0.016)	(0.028)	(0.387)
Lerner index	0.008	0.011	0.014	-0.797	0.009	0.014	0.016	-0.782
	(0.011)	(0.015)	(0.014)	(0.494)	(0.008)	(0.014)	(0.020)	(0.518)
Foreign bank assets	-0.001***	-0.000	-0.001***	-0.029	-0.001***	-0.000	-0.001***	-0.029
	(0.000)	(0.000)	(0.000)	(0.027)	(0.000)	(0.000)	(0.000)	(0.022)
Inflation	0.001	0.002	-0.000	0.008	0.002***	0.004***	0.001	-0.118***
	(0.001)	(0.002)	(0.002)	(0.064)	(0.001)	(0.001)	(0.001)	(0.030)
Observations	843	843	843	800	843	843	843	800
R-squared	0.117	0.112	0.104	0.266	0.106	0.101	0.071	0.241
Number of banks	49	49	49	47	49	49	49	47
No of countries	21	21	21	21	21	21	21	21
Bank FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	NO	NO	NO	NO
Country FE	NO	NO	NO	NO	NO	NO	NO	NO
Cluster	Country	Country	Country	Country	Bank	Bank	Bank	Bank

Table 7 The Impact of Macroprudential Policies on Systemic Risk and Individual Risk: Robustness Assessment Using First Difference GMM

	Conditional Value at Risk (CoVaR)			Value at Risk (VaR)		
	(1) All policies	(2) General policies	(3) Housing policies	(4) All policies	(5) General policies	(6) Housing policies
Capital requirements	-0.004 (0.003)	-0.000 (0.001)		0.003 (0.004)	0.003* (0.002)	
Sector capital buffers	-0.008*** (0.003)	-0.006*** (0.002)		-0.013** (0.005)	-0.006* (0.003)	
Reserve requirements FX	0.001 (0.003)	-0.005*** (0.002)		0.006 (0.006)	-0.010* (0.006)	
Reserve requirements local	-0.002 (0.003)	-0.002 (0.002)		-0.008* (0.004)	-0.002 (0.003)	
Countercyclical capital requirements	-0.036*** (0.009)		-0.046*** (0.010)	-0.063*** (0.009)		-0.079*** (0.012)
Loan loss provisioning	0.022*** (0.001)		0.023*** (0.001)	0.020*** (0.002)		0.022*** (0.002)
DSTI lending criteria	-0.012*** (0.003)		-0.011*** (0.003)	-0.019*** (0.007)		-0.017*** (0.006)
Risk weights on housing loans	-0.003 (0.006)		0.002 (0.006)	-0.017*** (0.005)		-0.010* (0.006)
Size	-0.032*** (0.012)	-0.013 (0.010)	-0.032*** (0.011)	-0.029 (0.022)	-0.005 (0.015)	-0.021 (0.021)
Capitalization	-0.082 (0.142)	-0.275** (0.112)	0.015 (0.131)	0.217 (0.237)	0.129 (0.207)	0.407* (0.244)
Credit risk	-0.704* (0.403)	-0.356** (0.178)	-0.262 (0.362)	-2.130*** (0.734)	-0.633* (0.325)	-1.440** (0.695)
Liquidity risk	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	-0.000 (0.000)	0.000* (0.000)	-0.000 (0.000)
Funding	0.002 (0.006)	-0.000 (0.005)	0.002 (0.006)	0.013 (0.018)	0.003 (0.015)	0.015 (0.018)
Lerner index	-0.021* (0.012)	-0.008 (0.005)	-0.002 (0.009)	0.030 (0.041)	0.030* (0.017)	0.064* (0.037)
Foreign bank assets	-0.000 (0.000)	-0.000 (0.000)	-0.001* (0.000)	-0.000 (0.001)	0.001 (0.001)	-0.001 (0.001)
Inflation	-0.002* (0.001)	-0.001** (0.000)	-0.002*** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)
Observations	798	1817	798	798	1817	798
Number of banks	46	73	46	46	73	46

Number of countries	21	21	21	21	21	21
Number of instruments	48	28	28	48	28	28
AR(2) test p value	0.00	0.00	0.00	0.00	0.00	0.00
Hansen test	28.04	24.77	18.18	30.79	41.87	23.62
Hansen test p-value	0.67	0.07	0.31	0.53	0.00	0.10

5.4 The Impact of Macroprudential Policies on Risk Across Bank and Market Level Characteristics

This section presents the empirical results on the impact of macroprudential measures adopted by central authorities on systemic risk and risk-taking behavior taken across different banks and banking systems. Using the difference-in-difference methodology we assess if the impact of the adopted macroprudential measures is amplified or diminished by the size of banks or banking sector characteristics like foreign assets holdings, competition and independence of supervisory authority. We analyze the impact of general and housing policy instruments on all measures of risk (i.e., systemic risk estimated through *CoVaR* and *MES*, and, individual risk estimated through *VaR* and *DTD*). The empirical output reported corresponds to the baseline model.

First, we examine the interactive effects of general and housing macroprudential measures and banks' size on their systemic importance and individual risk. A number of papers show that smaller banks pose a greater contribution to systemic risk than larger ones. Larger banks are less systemic important due to the fact that they developed various risk management tools, allowing them to manage efficiently the risks assumed. This could be the result of better diversification possibilities as larger banks have access to more credit markets and can better hedge credit risk through credit derivative transactions (Behr et al., 2010). Results presented in Table 8 show that reserve requirements (for foreign and local denominated liabilities) are beneficial in reducing the systemic importance of large banks (models 1-2, and models 5-6). This conclusion applies also to the impact of reserve requirements for FX liabilities on individual risk as shown in model 3. The coefficient associated with the link between reserve requirements for local currency-denominated accounts and *VaR* has a negative sign associated, but it is insignificant (model 7). To highlight the economic relevance of our estimates we calculate the difference in semi-elasticities for small and large banks (25th versus 75th percentile, corresponding to a logarithmic value of the total assets of 24.7 versus 27.1). Tightening FX reserve requirements reduces banks contribution to systemic risk (CoVaR) of large banks by 30.5 percent more than of small banks. The effect on individual risk (VaR) translates to 31.7 percent. In case of local reserve requirements the impact on systemic risk (CoVaR) is associated with a 15.3 percent higher decrease.[10] As for the risk-weights applied to housing loans, our results suggest that tightening actions associated with this policy conducts to a decrease in banks' systemic importance for large banks (models 9 and 10). In contrast, the distance to default of large banks decreases in countries that register tightening events of risk weights on real estate loans, indicating an enhancement of the risk-taking (model 12).

Next, we assess the interacting effects between the international activity of banks and risk. The empirical output from Table 9 highlight that banks from countries with a large share of foreign assets in total banking system assets, that conducted tightening events of reserve requirements for both in local and foreign currencies denominated liabilities, increased their systemic importance and individual risk (Table 9, models 1 to 8). The associated semi-elasticities are 3.7

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[10] The semi-elasticities are calculated based on the average value of CoVaR (4.6 percent) and the average value of VaR (11.8 percent).

percent in case of CoVaR (model 1) and 4.5 percent in case of VaR (model 3).[11] Tightening reserve requirements reduces banks' contribution to systemic risk (CoVaR) in systems with low international activity by 3.7 percent more than in systems with high shares of FX assets, while the VaR wil be reduced by 4.5 percent more. Turning to housing macroprudential measures, we found a significant impact on banks' individual risk in countries with a large share of foreign assets. Banks from these countries that experienced tightening of countercyclical capital requirements increased their risk-taking (model 11) and reduced their distance to default (as the coefficient on *Countercyclical capital requirements × Foreign assets* in model 12 is negative and significant). An opposing effect is found for DSTI lending criteria on real estate loans (models 15 and 16). Greater restrictions for this ratio present a beneficial effect in reducing the incentives to take on more risk of banks from countries with high international presence in the banking sector.

Competition between financial institutions can lead to excessive risk-taking creating financial instability that should be controlled by macroprudential policy (IMF, 2013). On the other side, high levels of competition may determine the possibility of mergers and takeovers between banks that creates „too big to fail" institutions hard to be controlled by macroprudential authorities. Results presented in Table 10 show that for less competitive banking systems (with associated higher values of the Lerner index), strong macroprudential measures are not effective in limiting the incentives of banks to take on more risk and to decrease their systemic importance (Table 10). In fact, banks from less competitive banking markets that tightened the reserve requirements on accounts denominated in local currencies (models 5-8) and the countercyclical capital requirements (models 9-12) increased their contribution to systemic risk and individual risk-taking. Tightening domestic reserve requirements reduces banks contribution to systemic risk (CoVaR) of banks from highly competitive systems by 28.6 percent more than of banks from lowly competitive banking systems (model 5). Regarding countercyclical capital requirements the impact is associated with a reduction of banks' CoVaR by 51.7 percent more in case of highly competitive banking systems in comparison with lowly competitive ones (model 9).[12] Tightening the sector specific capital buffers significantly increase banks behavior to take on more risk (as suggested by the positive coefficient on *Sector capital buffers × Competition* in model 3) and reduce the distance to default (model 4) in less competitive markets, while their impact on systemic importance is not significant. DSTI lending criteria also has harmful effects for less competitive markets, increasing banks' systemic importance (model 13).

In a further analysis, we consider the overall independence of supervisory authority index proposed by the Brath et al. (2013) that reflects the degree to which the supervisory authority is independent from the government and legally protected from the banking industry. Higher values indicate greater independence. Table 11 depicts that the general macroprudential measures that prove to be effective for

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[11] The differences in semi-elasticities are calculated for countries with low versus high international activity (we compare the 25th versus 75th percentile, corresponding to a share of foreign assets in total assets of 6 percent versus 18 percent).

[12] We compare the 25th versus 75th percentile of the Lerner index corresponding to a value of 0.198 versus 0.320.

banking systems with high degree of supervisory authority's independence from the government are stronger capital requirements. The coefficient on the interaction term *Capital requirements × SAI* is negative and significant for *CoVaR* (model 1), *MES* (model 2) and *VaR* (model 3) and positive for *DTD* (model 4), suggesting a reduction in banks' systemic importance and DTD. In contrast, tightening the sector capital buffers and reserve requirements for accounts denominated in local currency will increase the systemic and individual risk for banks from countries with greater independence for supervisory authorities (models 13-16).

Regarding the housing related macroprudential policies, results show an adverse and significant impact (Table 12). Countercyclical capital requirements, loan loss provisions and risk-weights applied to housing loans increase the systemic importance and risk-taking incentives of banks from countries with greater independence for supervisory authorities.

To sum up, the macroprudential measures that proved their efficiency in limiting banks' risk-taking and systemic importance are heterogeneous across banks' size and banking markets' characteristics like the share of foreign assets, the competition or the supervisory authority's degree of independence. Capital related policies proved more effective in controlling the contribution of banks to systemic risk than instruments that target the borrowers (like DSTI for example). Robustness checks similar to those run in section 5.1.3 confirm the validity of the findings.

Table 8 Risk, Macroprudential Measures and Size

Dependent variables	(1) CoVaR	(2) MES	(3) VaR	(4) DTD	(5) CoVaR	(6) MES	(7) VaR	(8) DTD	(9) CoVaR	(10) MES	(11) VaR	(12) DTD
Reserve requirements FX × Size	-0.006*** (0.002)	-0.010*** (0.003)	-0.016*** (0.004)	0.274*** (0.081)								
Reserve requirements local × Size					-0.003* (0.001)	-0.005* (0.003)	-0.006 (0.003)	0.202*** (0.065)				
Risk weights on housing loans × Size									-0.007*** (0.002)	-0.010*** (0.003)	-0.004 (0.004)	-0.167** (0.073)
Reserve requirements FX	0.155*** (0.050)	0.254** (0.088)	0.408*** (0.106)	-6.672*** (2.111)								
Reserve requirements local					0.071* (0.036)	0.121* (0.067)	0.139 (0.087)	-5.006*** (1.636)				
Risk weights on housing loans									0.155*** (0.051)	0.238*** (0.078)	0.065 (0.101)	4.278** (1.852)
Size	-0.023* (0.011)	-0.017 (0.017)	-0.032 (0.018)	0.891 (0.609)	-0.023* (0.011)	-0.018 (0.018)	-0.032 (0.019)	0.930 (0.596)	-0.028** (0.010)	-0.042** (0.016)	-0.024 (0.023)	0.209 (0.476)
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Market controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,877	1,877	1,877	1,774	1,877	1,877	1,877	1,774	880	880	880	837
R-squared	0.240	0.233	0.199	0.393	0.240	0.233	0.197	0.393	0.094	0.093	0.045	0.215
Number of banks	75	75	75	72	75	75	75	72	51	51	51	49
No of countries	21	21	21	21	21	21	21	21	21	21	21	21
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

Table 9 Risk, Macroprudential Measures and Foreign Assets

Dependent variables	(1) CoVaR	(2) MES	(3) VaR	(4) DTD	(5) CoVaR	(6) MES	(7) VaR	(8) DTD	(9) CoVaR	(10) MES	(11) VaR	(12) DTD	(13) CoVaR	(14) MES	(15) VaR	(16) DTD
Reserve requirements FX × Foreign assets	0.014** (0.006)	0.027** (0.010)	0.044*** (0.015)	-1.034*** (0.229)												
Reserve requirements local × Foreign assets					0.014* (0.008)	0.020 (0.014)	0.050** (0.017)	-1.181** (0.467)								
Countercyclical capital requirements × Foreign assets									0.004 (0.007)	0.006 (0.011)	0.033* (0.017)	-0.583** (0.228)				
DSTI lending criteria × Foreign assets													-0.007 (0.006)	-0.009 (0.010)	-0.029* (0.015)	0.769*** (0.237)
Reserve requirements FX	-0.005 (0.003)	-0.013** (0.005)	-0.007 (0.008)	0.394*** (0.114)												
Reserve requirements local					-0.005* (0.003)	-0.011* (0.005)	-0.012** (0.005)	0.310 (0.178)								
Countercyclical capital requirements									-0.013** (0.005)	-0.019* (0.009)	-0.031** (0.013)	0.206 (0.121)				
DSTI lending criteria													-0.008* (0.004)	-0.011* (0.006)	-0.013* (0.007)	-0.058 (0.085)
Foreign assets	0.026 (0.098)	0.096 (0.153)	0.215 (0.301)	-10.123 (7.844)	0.027 (0.099)	0.098 (0.154)	0.218 (0.301)	-10.241 (7.852)	-0.076 (0.047)	-0.072 (0.069)	-0.133* (0.065)	-2.253 (2.503)	-0.073* (0.036)	-0.037 (0.043)	-0.139* (0.067)	-2.923 (2.931)
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Market controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,877	1,877	1,877	1,774	1,877	1,877	1,877	1,774	1,158	1,158	1,158	1,092	880	880	880	837
R-squared	0.239	0.232	0.197	0.393	0.240	0.232	0.199	0.393	0.094	0.083	0.073	0.257	0.096	0.094	0.048	0.218
Number of banks	75	75	75	72	75	75	75	72	50	50	50	48	51	51	51	49
No of countries	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

Table 10 Risk, General Macroprudential Measures and Competition

Dependent variables	(1) CoVaR	(2) MES	(3) VaR	(4) DTD	(5) CoVaR	(6) MES	(7) VaR	(8) DTD	(9) CoVaR	(10) MES	(11) VaR	(12) DTD	(13) CoVaR	(14) MES	(15) VaR	(16) DTD
Sector capital buffers × Competition	0.020 (0.022)	0.028 (0.034)	0.074* (0.038)	-1.264** (0.506)												
Reserve requirements local × Competition					0.018* (0.008)	0.038*** (0.014)	0.035* (0.015)	-1.016*** (0.241)								
Countercyclical capital requirements × Competition									0.195*** (0.055)	0.307*** (0.081)	0.594*** (0.043)	-3.951 (2.849)				
DSTI lending criteria × Competition													0.042* (0.021)	0.075* (0.037)	0.100 (0.072)	-1.792 (1.700)
Sector capital buffers	-0.011 (0.008)	-0.016 (0.012)	-0.035** (0.015)	0.375* (0.186)												
Reserve requirements FX					-0.008* (0.003)	-0.018*** (0.004)	-0.013* (0.005)	0.447*** (0.124)								
Countercyclical capital requirements									-0.050*** (0.009)	-0.078*** (0.013)	-0.139*** (0.010)	0.780 (0.556)				
DSTI lending criteria																
Competition (Lerner index)	-0.067*** (0.012)	-0.078*** (0.013)	-0.104*** (0.031)	3.443*** (1.051)	-0.066*** (0.012)	-0.078*** (0.012)	-0.102*** (0.030)	3.391*** (1.047)	-0.040*** (0.011)	-0.062*** (0.018)	-0.079*** (0.014)	0.830* (0.430)	-0.015 (0.011)	-0.019 (0.018)	-0.050*** (0.015)	-0.436 (0.372)
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Market controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,658	1,658	1,658	1,567	1,658	1,658	1,658	1,567	1,062	1,062	1,062	1,003	872	872	872	829
R-squared	0.265	0.229	0.181	0.373	0.255	0.232	0.179	0.374	0.110	0.094	0.093	0.243	0.097	0.084	0.053	0.217
Number of banks	74	74	74	71	74	74	74	71	49	49	49	47	51	51	51	49
No of countries	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

Table 11 Risk, General Macroprudential Measures and Supervisory Authority's Independence (SAI)

Dependent variables	(1) CoVaR	(2) MES	(3) VaR	(4) DTD	(5) CoVaR	(6) MES	(7) VaR	(8) DTD	(9) CoVaR	(10) MES	(11) VaR	(12) DTD	(13) CoVaR	(14) MES	(15) VaR	(16) DTD
Capital requirements × SAI	-0.039** (0.015)	-0.062** (0.026)	-0.100** (0.034)	3.809** (1.657)												
Sector capital buffers × SAI					0.023*** (0.005)	0.034*** (0.008)	0.051*** (0.009)	-0.514*** (0.164)								
Reserve requirements FX × SAI									0.003 (0.003)			-0.052 (0.133)				
Reserve requirements local × SAI													0.004** (0.002)	0.006** (0.003)	0.006 (0.003)	-0.281*** (0.099)
Capital requirements	0.037** (0.014)	0.059** (0.025)	0.087*** (0.029)	-3.301** (1.332)												
Sector capital buffers					-0.050*** (0.010)	-0.072** (0.016)	-0.110*** (0.017)	0.996*** (0.306)								
Reserve requirements FX									-0.008 (0.005)	-0.015 (0.010)	-0.023** (0.010)	0.293 (0.230)				
Reserve requirements local													-0.011*** (0.004)	-0.021*** (0.006)	-0.015* (0.008)	0.655** (0.244)
Supervisory authority's independence (SAI)	0.044*** (0.015)	0.094*** (0.025)	0.048 (0.039)	-1.496*** (0.472)	0.001 (0.004)	-0.000 (0.007)	-0.004 (0.006)	-0.288** (0.108)	0.001 (0.004)	0.000 (0.007)	-0.004 (0.006)	-0.295** (0.105)	0.002 (0.004)	0.001 (0.007)	-0.003 (0.006)	-0.309** (0.112)
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Market controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,877	1,877	1,877	1,774	1,877	1,877	1,877	1,774	1,877	1,877	1,877	1,774	1,877	1,877	1,877	1,774
R-squared	0.252	0.248	0.205	0.407	0.242	0.232	0.201	0.397	0.239	0.231	0.198	0.398	0.240	0.233	0.197	0.399
Number of banks	75	75	75	72	75	75	75	72	75	75	75	72	75	75	75	72
No of countries	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

Table 12 Risk, General Housing Measures and Supervisory Authority's Independence (SAI)

Dependent variables	(1) CoVaR	(2) MES	(3) VaR	(4) DTD	(5) CoVaR	(6) MES	(7) VaR	(8) DTD	(9) CoVaR	(10) MES	(11) VaR	(12) DTD	(13) CoVaR	(14) MES	(15) VaR	(16) DTD
Countercyclical capital requirements × SAI	0.013*** (0.003)	0.021*** (0.006)	0.042*** (0.005)	-0.399* (0.213)												
Loan loss provisioning × SAI					0.002* (0.001)	0.000 (0.001)	0.004*** (0.001)	-0.110** (0.042)								
DSTI lending criteria × SAI									0.003 (0.003)	0.006 (0.005)	0.005 (0.011)	0.157 (0.182)				
Risk weights on housing loans × SAI													0.016*** (0.003)	0.026*** (0.004)	0.018* (0.009)	0.346 (0.197)
Countercyclical capital requirements	-0.033*** (0.005)	-0.051*** (0.009)	-0.091*** (0.010)	0.684* (0.366)												
Loan loss provisioning																
DSTI lending criteria									-0.015*** (0.004)	-0.024*** (0.007)	-0.032* (0.017)	-0.037 (0.289)				
Risk weights on housing loans													-0.033*** (0.005)	-0.054*** (0.008)	-0.056*** (0.015)	-0.437 (0.324)
Supervisory authority's independence (SAI)	-0.001 (0.003)	-0.002 (0.005)	-0.007 (0.005)	-0.128 (0.094)	-0.001 (0.003)	-0.001 (0.005)	-0.006 (0.005)	-0.133 (0.083)	-0.001 (0.001)	-0.001 (0.002)	-0.009** (0.004)	0.008 (0.142)	-0.001 (0.001)	-0.001 (0.002)	-0.009** (0.004)	0.006 (0.139)
Bank controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Market controls	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,158	1,158	1,158	1,092	1,158	1,158	1,158	1,092	880	880	880	837	880	880	880	837
R-squared	0.095	0.084	0.080	0.260	0.091	0.081	0.073	0.260	0.096	0.094	0.051	0.215	0.094	0.093	0.050	0.214
Number of banks	50	50	50	48	50	50	50	48	51	51	51	49	51	51	51	49
No of countries	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Cluster	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country	Country

6. Conclusion

In this paper, we assess whether macroprudential policies implemented by supervisory authorities have a significant impact on banks' contribution to systemic risk and their risk-taking incentives. We consider a large set of general and housing related policies that affected 95 banks from 21 countries from Europe and North America during 2008 to 2014. The general macroprudential tools include capital requirements, sector specific capital buffers and reserve requirements on foreign and local currency denominated accounts. The real estate specific macroprudential policies consist of countercyclical capital requirements, loan loss provisioning, DSTI lending criteria and risk weights on housing loans.

Overall, empirical findings indicate that general and sector specific capital buffers, along with housing countercyclical capital requirements and DSTI lending criteria significantly reduce banks' systemic importance and their individual risk-taking. For real estate loans loss provisioning we find a harmful effect as tighter rules enhance the level of risk.

In addition, we provide empirical evidence that the nexus between macroprudential policies and banks' risk is shaped through several bank and market level channels. The contribution to systemic risk of large banks can be decreased through higher reserve requirements on accounts denominated in foreign and local currencies and higher risk-weights applied to housing loans. The resilience of financial institutions from banking systems that hold important shares of foreign assets can be enhanced by loosening the reserve requirements and the countercyclical capital requirements. In case of competitive banking markets, lower reserve requirements on domestic currency denominated accounts, lower countercyclical capital requirements and relaxed DSTI lending criteria are efficient in controlling systemic risk. In countries with higher degree of independence of supervisory authority, regulators should tighten the general capital requirements, but reduce the sector specific and countercyclical buffers to enhance the stability of the banking sector.

Our results provide useful implications for policymakers. During crisis periods, when most of economies threatened by negative contagion spillover effects among financial institutions, the level of systemic risk could be controlled through macroprudential tools like reserve requirements, countercyclical capital requirements, DSTI lending criteria and risk-weights applied to housing loans. The macroprudential policies can also support banks to adjust their risk taking during turbulent periods, especially the real estate specific ones. However, when designing regulatory frameworks based on macroprudential tools, it is important for financial supervisors to consider the channels that could influence the relationship between policy measures and risk. Being on a direction of tightening/loosening general and housing policy measures has more potential when accounting for characteristics like size, international activity, competition and supervisory authority's independence.

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