Macroprudential policy and liquidity risk: Empirical evidence from EEA banks

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Abstract

Macroprudential policy aims to enhance financial stability and to address liquidity risk by implementing measures to enhance resilience to liquidity shocks. This paper aims to empirically test what is the effect of macroprudential policy on liquidity risk of European Economic Area banks. Using an unbalanced panel covering a sample of over 8000 observations in 2005-2022 we find a reduction in liquidity risk measured both as assets to deposits ratio (LiquidADST), as well as in the liquidity risk exposure ratio (LRE) in response to a tightening of macroprudential policy. This effect is delayed and appears in the second year after the policy change. We also find that immediate effect of the policy is an elevated long-term liquidity risk proxied with LiquidADST and LRE. The effects of this policy depend on the instrument types, i.e., whether they are borrower-targeted, capital based, liquidity oriented or fiscal instruments. We find that borrower – oriented instruments increase liquidity risk immediately. Capital-based instruments reduce liquidity risk. Liquidity-oriented instruments are associated with an increased long-term liquidity risk. We find an ambiguous effect of taxes and levies targeted at financial institutions on liquidity risk. Our findings contribute to the literature on the determinants of bank liquidity risk as well as provide new insights to research on macroprudential policy.

Key words: bank liquidity risk, macroprudential policy, liquid assets, LRE

JEL classification: E44, E58, G21, G28

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1. Introduction

Liquidity risk in banks is the risk that a bank may struggle to meet its short-term financial obligations. This risk can arise if a bank cannot quickly convert its assets into cash or secure funding without incurring significant losses. It involves the challenge of selling assets quickly without a significant loss in value, known as asset liquidity risk. Additionally, it includes the difficulty of obtaining sufficient funding, termed funding liquidity risk. This can occur if a bank's usual funding sources, such as deposits or short-term borrowing, become unavailable, possibly due to a loss of confidence in the bank or a broader market liquidity crisis. Another aspect of liquidity risk is the mismatch between the maturities of assets and liabilities, where long-term loans are funded with short-term deposits, potentially leading to issues if depositors withdraw their money unexpectedly. Lastly, market liquidity risk refers to the difficulty of conducting large transactions without significantly impacting market prices. Banks manage liquidity risk through various strategies, including maintaining high-quality liquid assets, diversifying funding sources, and monitoring cash flows. Regulatory standards like Basel III also require banks to maintain adequate liquidity levels to withstand stress scenarios.

The 2007-2009 Global Financial Crisis (GFC) had a profound impact on macroprudential policy worldwide. It fundamentally reshaped regulatory approaches and practices in several ways. The crisis highlighted the interconnectedness of financial institutions and markets, emphasizing the rapid transmission of risks across borders. This underscored the importance of addressing systemic risks that could threaten the stability of the entire financial system. Prior to the crisis, regulatory focus was primarily on the solvency of individual institutions. However, the crisis shifted attention towards maintaining overall financial stability. This led to the development and refinement of new macroprudential tools designed to mitigate systemic risks. These tools include countercyclical capital buffers, liquidity requirements, leverage ratios, and stricter supervision of systemically important financial institutions (SIFIs). Overall, the GFC prompted a significant overhaul of regulatory frameworks and practices worldwide, leading to the rise of macroprudential policy as a critical component of ensuring financial stability and preventing future crises. Liquidity risk is one of the key areas addressed in the post-GFC regulations.

Before the 2007–2009 financial crisis, banking regulations focused mainly on capital requirements. However, during the crisis, many banks faced significant liquidity issues despite being well-capitalized. In response, the Basel Committee introduced global liquidity standards to address risks associated with liquidity transformation. The crisis revealed the banking sector's excessive leverage, inadequate liquidity reserves, and weaknesses in governance and risk management. To address these issues, the Basel Committee issued principles for sound liquidity risk management and supervision in September 2008 and later enhanced the Basel II capital framework. In 2010, the Group of Governors and Heads of Supervision announced new global minimum capital standards, known as "Basel III," which included stricter capital requirements and liquidity measures. These reforms were gradually implemented from 2013 to 2019 and aimed to strengthen the overall regulation and oversight of banks, especially those with systemic importance.

The 2007-2009 financial crisis and subsequent regulations highlighted the importance of bank liquidity. Research has identified various factors influencing liquidity, including capital ratios, asset size, debt ratios, and economic indicators like GDP growth and inflation. One study by Fu et al. (2016) examined banks in 14 Asia-Pacific economies, noting a significant increase in liquidity from 2005 to 2012, especially among large banks and those in developing countries. They observed a trade-off between the financial stability provided by strict capital requirements and the benefits of liquidity creation.

Tang et al. (2024) focused on the impact of Fintech in China, finding that Fintech development reduced liquidity creation while increasing diversification, with state-owned and smaller banks showing less reaction. Another study by Berger and Bouwman (2009) measured liquidity creation in U.S. banks and found a positive correlation between liquidity creation and bank value, with large banks generating the most liquidity.

Wu et al. (2024) analyzed the effects of Fintech adoption in U.S. banks from 2015 to 2021, revealing a consistent reduction in liquidity creation, including during the COVID-19 pandemic. Berger et al. (2024) explored the impact of government guarantees, such as deposit insurance, on bank liquidity, demonstrating that these guarantees could reduce liquidity creation by up to 10%.

Karakas and Acar (2022) studied Turkish banks and found that internal and macroeconomic factors, such as the deposit-to-liabilities ratio, financial assets ratio, and GDP growth rate, had varying effects on liquidity. They highlighted the importance of sensitive and

effective liquidity management, especially during crises. Finally, Kladakis et al. (2022) discussed how increased regulation and oversight following the financial crisis affected banks' ability to create liquidity, noting that stronger supervisory policies led to more liquidity creation, whereas stricter regulatory regimes had the opposite effect. They also found a strong relationship between liquidity, bank size, equity-to-assets ratio, and unemployment. Overall, these studies illustrate the complex interplay of factors affecting bank liquidity, including regulatory changes.

The analysis of liquidity risk in banking has been approached through various metrics, reflecting its complexity. Some commonly used indicators include the ratio of liquid assets to total assets, also known as liquidity exposure, which measures a bank's ability to meet short-term obligations. This ratio, while indicating a bank's capacity to handle immediate cash needs, may also suggest inefficiency if too high, as liquid assets typically yield lower returns.

Other measures of liquidity risk include the 'deposit run-off ratio' and the comparison of illiquid assets against short-term liabilities. Scholars have also explored dynamic funding risk through approaches like the stock, cash flow, and hybrid methods. One significant concern with the liquidity ratio is that it does not account for factors like incoming cash flows or changes in liabilities, potentially overlooking key aspects of a bank's financial situation.

Liquidity risk exposure specifically refers to the potential for a bank to struggle with meeting its short-term obligations due to a lack of liquid assets or funding. This risk can arise from asset-liability mismatches, sudden withdrawals, market disruptions, or decreased investor confidence. It poses serious threats, including financial distress, increased funding costs, and loss of reputation. Hence, effective management of liquidity risk is crucial, involving the maintenance of sufficient liquid assets, prudent funding strategies, and contingency plans to handle liquidity shocks.

[Insert figures 1 to 4 here]

In Figures 1-4, we present boxplots of two proxies of liquidity risk, that is liquid assets to deposits and short-term funding (LiquidADST) and liquidity risk exposure (LRE) . Figures 1 and 3 display the variables by country. They show that the LiquidADST reaches its highest values in countries such as Luxembourg, Denmark, Portugal, France, Italy, Latvia, and the Netherlands. The lowest values are observed in France, Germany, Italy, Poland, Norway,

Slovakia, Spain, and Sweden. Additionally, the smallest range of values is seen in Estonia, Germany, Bulgaria, and Romania. Moving on to LRE, Figure 3 shows that this index has the highest values in Norway, Italy, France, and Greece, and the lowest in Latvia, Poland, and Portugal. The smallest range of values is observed in Estonia, Hungary, Norway, Bulgaria, and Sweden.

Figures 2 and 4 illustrate how the index values have changed over the years. It is evident that during the 2007-2009 crisis and shortly after, LiquidADST had lower values than in the years 2012-2014. In 2015, there was another decline in values, followed by a rise, with the index reaching its highest values in 2020-2021. LRE, on the other hand, remained at a similar level throughout most of the study period, but a decline in its value has been observed since 2019.

This paper adds to existing research on the efficacy of macroprudential policies and to the research on the determinants of liquidity risk. While previous studies have primarily examined how these policies impact credit growth and systemic risk (as demonstrated by Cerutti et al., 2017, Altunbas et al., 2018, and Meuleman and Vander, 2020), our unique contribution lies in our comprehensive analysis of their effectiveness in mitigating bank liquidity risk across different countries. This approach leverages cross-sectional variation among nations to provide a deeper understanding of macroprudential policy outcomes. The article also provides a valuable addition to the existing research on bank liquidity. To our knowledge, there have been no studies to date that examine the impact of macroprudential policy on liquidity risk. So far, authors studying liquidity risk have focused on issues such as the impact of Fintech, bank regulation and supervision, interest rates, or other types of risk.

Using information from 1186 banks across the EEA countries (comprising 7928 observations), we find that macroprudential policy has a significant impact on bank risk. We also find that the impact of macroprudential tools on liquidity risk differs among tools (ie lending standards restrictions, limits on currency and maturity mismatch, provisioning systems, and taxes on financial activities). Additionally, our research identifies varying responses to changes in macroprudential tools across banks, influenced by their specific balance sheet characteristics. Particularly noteworthy is the finding that smaller banks with weaker capitalization and lower loan loss provisions tend to exhibit more pronounced reactions to adjustments in macroprudential policies.

The remainder of this paper is organized as follows. The next section discusses measurements of bank liquidity risk and how macroprudential policies can impact bank risk. Section 3 outlines our identification strategy and the data utilized in our analysis, whereas Sections 4 and 5 detail the primary findings and validate their robustness. The final section succinctly summarizes our key conclusions.

2. Literature review and hypotheses

Our study aims to investigate the relationship between macroprudential policy and liquidity risk. The literature on liquidity creation is already rich in publications examining how particular phenomena affect liquidity risk. The most important results of these studies are briefly presented in this section.

In line with contemporary financial intermediation theory, banks are essential entities in the economy as they serve dual functions: generating liquidity and managing risk transformation. Financial intermediaries play a crucial role in offering protection against sudden liquidity disruptions. Consequently, the oversight of these intermediaries holds significant importance for central banks and remains a common subject of discussion within the policymaking sphere. The challenge of liquidity risk stems from the mismatch between incoming revenues and outgoing expenses, as highlighted by Holmström and Tirole in 1998. In an ideal scenario, this misalignment wouldn't pose a problem if individuals could readily offer future income as collateral through financial agreements with external parties. However, due to various constraints, this isn't always feasible in practice, leading individuals to potentially face liquidity shortages.

Extensive research delves into banks' function as risk managers. A wealth of literature explores topics such as bank risk-taking behaviors, the implementation of prudential regulations and supervision, and market discipline to mitigate risks. According to theories on risk transformation, banks mitigate risk by offering low-risk deposits to fund higher-risk loans (Diamond, 1984). This risk transformation process sometimes coincides with liquidity generation, such as when banks issue easily accessible deposits to support less liquid loans. However, it's crucial to note that liquidity creation and risk transformation don't always align perfectly—the volume of liquidity generated can vary significantly relative to the risk being managed. Hence, it's imperative to analyze both facets of banks' roles and discern the differences between them.

This perspective concerning banks' function as risk managers suggests that increased capital enhances their capacity to absorb risk, consequently bolstering their ability to generate liquidity. The process of liquidity creation exposes banks to risk—higher levels of liquidity creation entail heightened probabilities and severity of losses incurred when liquidating illiquid assets to fulfill customers' liquidity needs (Allen and Gale, 2004). Capital serves as a buffer against risk and amplifies banks' capability to bear risks (Coval and Thakor, 2005), thus higher capital ratios might enable banks to expand their liquidity provision.

Another perspective suggests that bank capital could hinder the process of liquidity creation by rendering the bank's capital framework less vulnerable (Diamond and Rajan, 2000, 2001). A more resilient capital structure prompts the bank to engage less in monitoring its borrowers, thus limiting its lending capacity. Increased equity capital makes it challenging for the bank, which is now less vulnerable, to commit to borrower oversight, thereby impeding its ability to foster liquidity. Furthermore, capital might also diminish liquidity creation by displacing deposits (Gorton and Winton, 2000). Berger and Bouwman (2008) term this concept "financial fragility-crowding out."

2.1. Research on liquidity creation

Liquidity creation represents a vital function executed by banks within the economy. The aftermath of the recent financial crisis serves as a stark reminder that even with adequate capital levels, financial institutions can encounter significant challenges in liquidity management, as evidenced by the observations of Diaz and Huang in 2017.

In 2009, Berger and Bouwman introduced a comprehensive framework to measure liquidity creation. They analyze how liquidity creation impacts bank performance within the United States. Their argument revolves around the notion that boosting liquidity leads to an expansion in net surpluses distributed among stakeholders and the broader non-banking public. Their research indicates that the act of creating liquidity enhances the overall value of banks. Essentially, when banks engage in liquidity creation, they convert more liquid liabilities (such as demand deposits) associated with lower interest rates into less liquid assets (like commercial loans) that yield higher revenues. As a result, the surplus distributed to shareholders increases.

Consequently, bank shareholders are incentivized to encourage bank managers to ramp up liquidity creation efforts.

Since the publication of Berger and Bouwman's influential paper in 2009, research interest in liquidity creation has surged significantly. The literature examining the impact of regulations on liquidity creation has predominantly focused on capital adequacy requirements at the bank level. It has generally concluded that there exists a negative correlation between capital ratios and liquidity creation, primarily attributed to the financial fragility effect (Fungacova et al., 2017; Casu et al., 2019). However, a minority of researchers (Berger and Bouwman, 2009; Tran et al., 2016) have identified a positive relationship in their studies.

2.2. Liquidity ratios in the literature

Authors have approached the analysis of liquidity risk through various lenses, recognizing the complexity of capturing it with a single metric. On one hand, they've proposed indicators such as the liquidity exposure calculated as liquid assets over total assets (Molyneux and Thornton, 1992) or noninterest income as a proportion of total assets (Barth et al., 2003). Demirgüç-Kunt et al. (2003) view liquidity risk as the ratio of liquid assets to total assets, using it to assess regulatory measures and banking concentration (Igan and Mirzaei, 2020). Additionally, liquidity risk exposure has been explored through metrics like the 'deposit run-off ratio' (Brown et al., 2020) or, alternatively, by assessing illiquid assets against short-term liabilities (Pasiouras and Kosmidou, 2007). On the other hand, scholars have introduced new perspectives on dynamic funding risk, including the stock approach, cash flow approach, and hybrid approach (Matz and Neu, 2007; BCBS, 2008).

One of the most popular liquidity measures is Liquid assets over total assets ratio (Khan et al., 2017; Meriläinen and Junttila, 2020; Altunbaş et al., 2023; Ahmed and Calice, 2023). The ratio of liquid assets over total assets, also known as the liquid asset ratio or liquidity exposure, is a financial metric used to assess a company's ability to meet its short-term obligations with its readily available assets. Liquid assets typically include cash, cash equivalents, and assets that can be quickly converted into cash without significant loss in value, such as marketable securities or accounts receivable. Total assets encompass all assets owned by the company, including both current assets (such as cash, inventory, and accounts

receivable) and non-current assets (such as property, plant, and equipment). In our study, we utilize a modified version of this indicator to account for the presence of large extreme values. This modification enhances the precision of the indicator.

The liquid asset ratio is calculated as:

$$\text{LiquidADST} = \frac{\text{Liquid Assets}}{\text{Deposits and short}-\text{term funding}}$$

A higher liquidity ratio indicates that a larger proportion of a company's assets are in liquid form, which suggests a stronger ability to meet short-term obligations and withstand financial challenges. Conversely, a lower liquidity ratio may indicate potential liquidity issues or difficulties in meeting short-term obligations.

However, a high value of this ratio could also be viewed as inefficiency. Liquid assets typically generate lower returns compared to other investment opportunities, implying that maintaining high liquidity levels could result in missed income-generating opportunities for the bank. Therefore, it becomes essential to strike a balance between liquidity and profitability. As highlighted by Moore (2010), the liquidity ratio has its limitations, as it fails to consider factors such as incoming cash flows from repayments, increases in liabilities, and the overall demand for bank funds.

Another measure is Liquidity risk exposure (Saunders and Cornett, 2006; Mohammad et al., 2020). It refers to the vulnerability of a bank's financial position to disruptions in its ability to meet its short-term obligations due to a shortage of liquid assets or difficulty in obtaining funding.

Banks face liquidity risk when they cannot readily convert their assets into cash to meet withdrawal demands from depositors or to fund their operational needs. This risk arises from a variety of factors, including mismatches between the maturity and liquidity of assets and liabilities, sudden withdrawals of deposits, market disruptions, or adverse changes in investor confidence.

Liquidity risk exposure can have serious consequences for banks, including the inability to meet obligations, loss of reputation, increased funding costs, and ultimately, financial

distress or failure. Therefore, managing liquidity risk is a critical aspect of bank management, involving the maintenance of adequate levels of liquid assets, prudent funding strategies, and contingency planning to ensure the bank's ability to withstand liquidity shocks.

The liquidity risk exposure ratio is calculated as:

$$\text{LRE} = \frac{\text{Loans} - \text{Deposits}}{\text{Total Assets}}$$

2.3. Regulation and its impact on liquidity risk

Prior to the 2007–2009 financial crisis, regulatory efforts in the banking sector predominantly centered on capital requirements. However, even with sufficient capitalization, numerous banks encountered notable liquidity challenges amid the crisis. Considering this, the Basel Committee took action by implementing global liquidity standards aimed at mitigating the risks linked to extensive liquidity transformation.

Even prior to the collapse of Lehman Brothers in September 2008, the necessity for a fundamental overhaul of the Basel II framework had become evident. The banking sector entered the financial crisis burdened by excessive leverage and insufficient liquidity reserves. These vulnerabilities were compounded by deficient governance structures, ineffective risk management practices, and flawed incentive systems. This precarious amalgamation was epitomized by the misjudgment of credit and liquidity risks, alongside unsustainable credit expansion.

In response to these pressing risk factors, the Basel Committee issued Principles for sound liquidity risk management and supervision in the same month that Lehman Brothers filed for bankruptcy. Subsequently, in July 2009, the Committee released a comprehensive set of documents aimed at fortifying the Basel II capital framework, particularly in relation to the treatment of complex securitization positions, off-balance sheet entities, and exposures in the trading book. These enhancements formed part of a broader initiative to bolster the regulation

and oversight of globally active banks, prompted by vulnerabilities exposed during the financial market turmoil.

In September 2010, the Group of Governors and Heads of Supervision (GHOS) unveiled elevated global minimum capital standards for commercial banks, following an agreement reached in July concerning the overarching framework of capital and liquidity reforms, now known as "Basel III". These new capital and liquidity standards received endorsement at the G20 Leaders' Summit in Seoul in November 2010 and were subsequently ratified at the December 2010 Basel Committee meeting.

The proposed standards were formally issued by the Committee in mid-December 2010 (and have since undergone revisions). The enhanced Basel framework revises and reinforces the three pillars established by Basel II, while extending its scope in various areas. Most of the reforms are being phased in between 2013 and 2019, encompassing stricter requirements for the quality and quantity of regulatory capital, introduction of the capital conservation buffer, implementation of the countercyclical capital buffer, adoption of the leverage ratio, imposition of liquidity requirements including the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR), and additional measures for systemically important banks, including enhanced loss absorbency and robust arrangements for cross-border supervision and resolution.

2.4. Macroprudential policy effects on risk

Macroprudential policy affects financial stability through various channels, that is growth channel (inter alia credit growth, assets growth, housing credit and real estate prices), risk-taking channel (mostly in banks) and profitability channel. Our special interest in the risk-taking channel. The literature in this field shows that macroprudential policies help in mitigating risk levels in the banking industry (Altunbas et al., 2018; Ely et al., 2021, Gaganis et al., 2021, Meuleman and Vennet, 2020). Altunbas et al. (2018) who present findings derived from an extensive panel encompassing stock listed banks across 61 advanced and emerging nations. Their research underscores the efficacy of macroprudential policy in reducing bank risk, proxied with Z-Score change and Expected default frequency change. Furthermore, they note that the magnitude of this impact varies depending on bank-specific attributes: smaller, less capitalized, and more reliant on wholesale funding institutions exhibit more pronounced responses to shifts in macroprudential policy. Ely et al. (2021) consider the impact of 12 macroprudential tools on Z-score of individual banks in 45 countries in 2000-2010. They find

heterogenous effects of this policy on risk. Asset-based tools, foreign currency limits, reserve requirements, credit growth limit increased the risk of banks. In contrast, tools targeted at systemically important financial institutions, dynamic provisions, loan-to-value caps, concentration limits and limits on interbank transactions decreased risk-taking of banks. Taxes on financial institutions, leverage limits and countercyclical tools did not exert any statistical impact on risk. This study also shows that the effects of macroprudential policy on risk-taking may depend on bank size, liquidity, leverage and banking sector structure. Another study, by Gaganis et al. (2021) examines whether and how macroprudential policies and corporate governance interact in shaping bank risk. They show that the impact of bank corporate governance on risk-taking depends critically on the macroprudential policies in force. The results depend on country level development, time-period, microprudential regulations, national culture and shareholder rights. This study also shows, that increased number of macroprudential policy tools is associated with decreased stability, indicating at increased risk-taking by banks. Mueleman and Vennet (2020) show that announcements of macroprudential policy actions have a downward effect on systemic risk of stock listed European banks. Their findings underscore a huge diversity of effects of this policy, with some tools increasing the risk, and others yielding opposite impact. As in previous research, they also consider the role of bank business model factors.

Following the research presented above we can see that many empirical studies suggest that macroprudential policy generally reduces risk-taking of banks (Altunbas et al., 2018; Meuleman and Vennet, 2020). However, this research also shows increased risk-taking by banks upon implementation of macroprudential policy (Meuleman and Vennet, 2020; Ely et al., 2021; Gaganis et al., 2021). thus improving bank financial stability. Therefore, put forward two alternate hypotheses:

H1a. Macroprudential policy lowers liquidity risk.

H1b. Macroprudential policy increases liquidity risk.

This body of literature also highlights that the impact of policy on different aspects of bank operations, and in particular risk-taking varies depending on the types of instruments employed (Altunbas et al., 2018; Ely et al., 2021, Gaganis et al., 2021, Meuleman and Vennet, 2020).). Consequently, we propose a hypothesis that:

H2. The effect of macroprudential policy on bank liquidity risk depends on the types of instruments.

3. Methodology and data description

To explore the impact of macroprudential policy measures on bank liquidity risk, three essential components are required: (1) establishing a suitable empirical framework (Section 3.1), (2) defining our metrics for bank liquidity risk and its components (Section 3.2), and (3) developing an index that effectively gauges the macroprudential policy stance in each country (Section 3.3). In Section 3.4, a comprehensive description of the data is provided.

3.1. Identification strategy

We evaluate the bank liquidity risk in connection with the implementation of macroprudential policy measures by employing a dynamic panel framework, akin to methodologies utilized by Cerutti et al. (2017) and Akinci and Olmstead-Rumsey (2018). This approach enables us to discern both the immediate effects and the longer-term dynamics. To be precise, we estimate the following dynamic panel regression model at the bank level, employing yearly frequency data:

$$Y_{i,j,t} = \alpha_0 + \alpha_1 MPI_{j,t} + \beta BCOV_{i,j,t} + \varepsilon_{i,j,t}$$

Equation (1)

To consider the role of macroprudential policy instrument types we consider a modified Equation (1) that includes also a sum of MPI instrument types. To answer the question

regarding the relative importance of the specific instrument types, we include all the instrument types in one equation. This model reads as follows:

$$Y_{i,j,t} = \alpha_0 + \alpha_m \sum_{m=-2;\, t=1}^{m=4;\, t=T} MPI_{m,j,t} Instrument\ type + \beta BCOV_{i,j,t} + \gamma C_{j,t} + \varepsilon_{i,j,t}$$

Equation (2)

Where for macroprudential policy type *m*, bank *i* and year *t* in country *j*, the variables are the following.

Yi,j,t is the is the liquidity risk ratio. We look at two proxies of liquidity risk: the ratio of liquid assets to deposits and short-term funding; and liquidity risk exposure (Saunders and Cornett, 2006; Khan et al., 2017; Meriläinen and Junttila, 2020; Mohammad et al., 2020; Nguyen and Nguyen, 2022; Altunbaş et al., 2023; Ahmed and Calice, 2023).

MPI is the macroprudential policy index. In equation (2) the m denotes the instrument type. To test hypotheses we consider immediate effect of the policy, in the year of effective implementation of either tightening or loosening, because such policy changes, according to the information provided in the MaPPED are preceded with policy announcements that take place at least two years ahead of implementation, in particular for the tightening actions. We also consider also one-year lagged and 2 – year lagged MPI.

BCOV is a vector of bank control and other variables (see Table 1). Bank-specific variables include bank capitalization *(CAP)*, ratio of loans to total assets *(LOANS)*, loan loss provisions to total loans (*LLP)*, return on equity (*ROE)*, overhead costs to total assets ratio (OVERHC), logarithm of total assets (*SIZE)* and the Herfindahl index of concentration for the market *(HHI)*. *C* is a vector of country-level variables which include *Deposit Insurance Coverage*, the growth rate of real GDP (*GDP GROWTH)*, The interest rate *(INT)* and unemployment *(UNEMPL)*. $\varepsilon_{i,j,t}$ means estimation error; α_0, α_m, β, and γ, are vectors of estimated coefficients.

[Insert Table 1 around here]

Our primary variable of interest is the macroprudential policy stance, denoted as MPI. This variable is constructed using qualitative information from the Macroprudential Policies Evaluation Database (MaPPED) (Budnik and Kleibl, 2018), compiled by the European Central Bank in collaboration with experts from national central banks and supervisory authorities of all EU member states. MaPPED provides a comprehensive overview of the "life cycle" of policy instruments, encompassing both genuinely macroprudential measures and microprudential measures with significant implications for the entire banking system. The database facilitates an analysis of macroprudential policy in terms of tightening and loosening actions, types of measures (tools), the nature of policy actions, and the objectives of the policy.

MaPPED is based on a meticulously designed questionnaire and includes precise dates for policy measure announcements and their effective implementation. Consequently, we have access to all policy actions undertaken within each EEA member state from 2005 to 2021. Given that the coverage of the MPI variable begins in 2005, we can assess not only the impact of MPI on liquidity risk in the year of changes to macroprudential policy instruments but also the effects of instruments implemented one and two years prior.

3.2. Liquidity risk and its determinants

Following the literature, we employ two measures of Liquidity in this study. *LiquidADST* is the ratio of the value of liquid assets (easily converted to cash) to short-term funding plus total deposits. Liquid assets include cash and due from banks, trading securities and at fair value through income, loans and advances to banks, reverse repos and cash collaterals. Deposits and short-term funding includes total customer deposits (current, savings and term) and short term borrowing (money market instruments, CDs and other deposits). Banks invest in liquidity as it helps insulate their loans from the effects of monetary shocks (Khan et al., 2017; Meriläinen and Junttila, 2020; Nguyen and Nguyen, 2022; Altunbaş et al., 2023; Ahmed and Calice, 2023).

Alternatively, in the study we use the *LRE* ratio. Liquidity risk exposure is measured by the financing gap that measures the possibility of banks being unable to meet their financial obligations in a timely manner (Saunders and Cornett, 2006; Mohammad et al., 2020).

The model also includes bank-specific factors that are considered to be important determinants of bank liquidity. Bank capitalization (*CAP*) is measured by the ratio of equity to total assets and is expected to have a positive association with bank liquidity (Berger and Bouwman, 2009; Karakas and Acar, 2022). Capital infusion bolsters banks' ability to absorb losses, reducing their likelihood of default, particularly during crises. Banks with ample capital are inherently less risky and can secure deposits at more favorable interest rates.

LOANS denotes the ratio of loans to total assets (Ahmed, 2021; Barongo and Mbelwa, 2024). The loan-to-assets ratio reflects the primary income source of a bank. A higher ratio signifies that the bank derives a greater portion of its income from loans and investments, whereas a lower ratio suggests revenue is sourced from non-interest-earning activities like trading or asset management. The ratio of loans to total assets significantly impacts a bank's liquidity risk by influencing the availability of liquid assets, cash flow predictability, and funding stability. A higher ratio typically means more assets are tied up in less liquid loans, which can exacerbate liquidity risk, especially in times of financial stress. Banks need to carefully balance their asset portfolios to ensure sufficient liquidity while maintaining profitability. Effective liquidity management practices and adherence to regulatory requirements are crucial to mitigate the risks associated with a high loans-to-assets ratio. Based on the reviewed literature, a positive impact of this variable on liquidity risk can be expected.

Following Distinguin, Roulet, and Tarazi (2013) and Fu et al. (2016) asset quality is included in the model and is measured by the ratio of loan loss provisions to total loans *LLP*. The level of loan loss provisions reflects a bank’s expected losses in its loan portfolios. Based on the literature, a positive effect on bank liquidity is expected. Loan loss provisions play a critical role in managing liquidity risk by ensuring that banks have a buffer against potential loan defaults. This proactive measure helps maintain the stability and liquidity of the bank, supports regulatory compliance, enhances market confidence, and ensures operational flexibility. However, it requires careful management to balance provisioning with the need to maintain adequate liquidity for daily operations. By managing loan loss provisions effectively, banks can better navigate financial uncertainties, maintain robust liquidity positions, and contribute to overall financial stability.

As proposed in previous studies (Flannery and Rangan, 2008; Kladakis et al., 2022), return on equity *ROA* is used to measure bank profitability. The 'pecking order theory of finance' suggests that since acquiring additional capital can be expensive, banks may find it

more feasible to build capital reserves through increased retained earnings. ROA is a critical determinant of a bank's ability to manage liquidity risk effectively. Higher ROA reflects greater profitability and efficient asset management, enabling banks to build liquidity reserves, maintain cash flow, and meet regulatory requirements. It also enhances market confidence and reduces borrowing costs, further supporting liquidity. Conversely, lower ROA limits these capabilities, increasing a bank's exposure to liquidity risk. Banks must strive to maintain a healthy ROA by optimizing their asset utilization and managing costs efficiently. By doing so, they can ensure adequate liquidity, safeguard against financial shocks, and maintain financial stability in various economic conditions. Based on the literature, a negative impact of ROA on liquidity risk is expected.

OVERHC is a modified version of the cost to total income ratio. Due to insufficient data, we decided to only include overheads costs. This ratio measures the efficiency of a bank by comparing its operating costs to its operating income. The cost-to-income ratio is a vital measure of a bank's operational efficiency and has significant implications for liquidity risk. A high OVERHC ratio indicates inefficient cost management, leading to reduced profitability, limited free cash flow, and increased vulnerability to liquidity shocks. This inefficiency can erode market confidence, increase funding costs, and strain liquidity management efforts. Banks must focus on maintaining a balanced cost-to-income ratio by enhancing operational efficiency, diversifying income sources, and adhering to effective liquidity management practices. Doing so helps mitigate liquidity risk, ensuring financial stability and resilience in both stable and turbulent economic conditions. As in the case of the cost-to-income ratio used in other studies (Kladakis et al., 2022; Tang et al., 2024), a higher value of this ratio means lower efficiency, hence a positive impact of this variable on liquidity risk is expected.

In our analysis, we include the logarithm of total assets *SIZE* to adjust for bank size. Larger banks often enjoy implicit assurances, like being deemed 'too big to fail', along with enhanced diversification prospects and facilitated access to interbank markets (Fecht et al., 2011; Fu et al., 2016; Wu et al., 2024). Larger banks benefit from greater access to funding, diversified asset portfolios, economies of scale, and regulatory scrutiny, all of which contribute to reducing liquidity risk. They are also perceived as more stable, have better access to liquidity support, and are able to manage systemic risks more effectively. However, large banks must navigate the complexities of their operations and the stringent regulatory requirements that come with their size. By leveraging their extensive resources, large banks can maintain robust liquidity positions, ensuring stability and resilience in both normal and adverse economic

conditions. The literature indicates a different impact of bank size on liquidity risk, therefore it is difficult to predict the direction of the impact of this variable.

We also use country-level variables. To control for local market competition, we include *HHI*, the Herfindahl index of concentration for the market or markets in which the bank is present (Berger and Bouwman, 2009). A low degree of concentration means that the industry is closer to a perfect competition scenario, where many firms of more or less equal size share the market. Increases in the Herfindahl index generally indicate a decrease in competition and an increase of market power, whereas decreases indicate the opposite. High HHI levels indicate concentrated markets with dominant banks that generally have better access to liquidity and funding sources, though they pose systemic risks if they face liquidity issues. Low HHI levels suggest competitive markets with many smaller banks that may face higher individual liquidity risks due to limited market power and funding access. Banks need to manage liquidity risk by diversifying funding sources, maintaining adequate liquidity buffers, and complying with regulatory requirements. Market concentration and competition dynamics must be carefully considered in liquidity management strategies to ensure financial stability and resilience against economic shocks. Based on the literature, a negative impact of HHI on liquidity risk is expected.

The second country-level variable is *Deposit Insurance Coverage*. It is a variable used by Demirguc-Kunt in a comprehensive database created in 2005, and then again in 2015. It is counted as a ratio between deposit coverage limit and GDP per Capita. Data on deposit coverage limit comes from the International Association of Deposit Insurers database and from database created by Demirguc-Kunt in 2015. Data on GDP per Capita comes from the Eurostat database. Overall, while deposit insurance provides important benefits in terms of financial stability and depositor confidence, it also introduces moral hazard and reduces market discipline, which can potentially increase risk in the banking system. Therefore, effective regulation and supervision are necessary to mitigate these risks and ensure the stability of the financial system. The literature indicates a positive impact of this variable on liquidity risk.

Finally, the study employs three macroeconomic country-level variables to control for the effects of these factors on bank liquidity. The growth rate of real GDP *GDP GROWTH* captures the effect of the business cycle (Nguyen and Nguyen, 2022; Kladakis et al., 2022) and is measured as the logarithm difference of successive GDP values. GDP growth is a macroeconomic indicator that reflects the overall health of an economy. Its impact on liquidity

risk in banks is profound, as economic growth influences the demand for loans, the quality of bank assets, and the stability of funding sources. Positive GDP growth enhances liquidity through increased loan demand, improved asset performance, stable funding, and higher profitability. Conversely, economic downturns can increase liquidity risk by reducing loan demand, deteriorating asset quality, challenging funding access, and compressing profitability. Banks need to continuously monitor economic conditions and GDP trends to adjust their liquidity management strategies accordingly. By maintaining adequate liquidity buffers, diversifying funding sources, and complying with regulatory requirements, banks can mitigate liquidity risk and ensure financial stability across economic cycles. Based on previous research, this variable is expected to have a positive impact on liquidity risk.

The interest rate, denoted as *INT* (Vodova, 2013; Karakas and Acar, 2022), represents a Harmonized Euro Area Rate applicable to Euro Zone countries, while for other nations, it reflects the long-term government bond yield. Data pertaining to this variable is sourced from Eurostat. Interest rates significantly impact liquidity risk in banks by influencing the cost of funds, deposit flows, asset values, and overall profitability. Higher interest rates can increase funding costs and compress margins, while lower rates can reduce the incentive for depositors to keep funds in the bank, impacting liquidity. Effective management of interest rate risk, through dynamic asset-liability management and regulatory compliance, is crucial for maintaining adequate liquidity and ensuring the stability of the banking sector. Banks must continuously monitor interest rate trends and adjust their liquidity management strategies accordingly to mitigate risks and capitalize on opportunities presented by changes in the interest rate environment. The literature indicates a positive impact of this variable on liquidity risk.

UNEMPL stands for unemployment, and it is calculated as the number of unemployed people as a ratio of the total labor force of the bank's host country (Kladakis et al., 2022; Raz et al., 2024). The unemployment rate impacts liquidity risk in banks through multiple channels, including increased loan defaults, reduced deposit inflows, lower loan demand, and deteriorating asset quality. High unemployment can lead to economic slowdowns, increased regulatory scrutiny, and market volatility, all of which exacerbate liquidity risks for banks. To manage these risks, banks need to adopt comprehensive liquidity management strategies that include effective ALM (Asset and Liability Management), diversified funding sources, and robust stress testing. By preparing for potential increases in unemployment and their associated impacts, banks can maintain liquidity and ensure financial stability even in challenging

economic environments. As the literature suggests, this variable is expected to have a positive impact on liquidity risk.

3.3. Macroprudential policy indicators

Our key variable is a proxy for the macroprudential policy stance, denoted as MPI. This variable is constructed using qualitative information from the Macroprudential Policies Evaluation Database (MaPPED) (Budnik and Kleibl, 2018), collected by the European Central Bank in collaboration with experts from national central banks and supervisory authorities of all EU member states. Given that our bank-level dataset is annual, we must follow several steps in designing the MPI.

First, each effectively tightened policy tool is assigned a value of 1, while loosened policy measures are assigned a value of -1 (see De Schryder and Opitz, 2021). Within each year, multiple instruments may be tightened or loosened, with a diverse range of modifications (e.g., activation of new tools, recalibration of existing tools such as changes in level or scope, or maintaining the current level and scope). As the literature does not provide clear guidance on the relative importance of these modifications, we assign the MPI a value based on the difference between tightening and loosening macroprudential policy actions.

The analysis of MaPPED reveals several country-year observations where the values for both tightening and loosening are identical. For these observations, the precise direction of the policy's impact on banking activities is ambiguous, suggesting that the effects on bank liquidity might be unclear. Therefore, we assume that in such cases, the effects of tightening and loosening cancel each other out, resulting in an MPI value of 0.

The summary of the construction of MPI is presented below:

$$MPI_{j,t} = \begin{cases} +\sum tightened\ tool_{m,j,t} \\ 0, \quad no\ policy\ action\ or\ actions\ cancel\ out \\ -\sum loosened\ tool_{m,j,t} \end{cases}$$

Where *m* denotes macroprudential policy type in a year *t* in a country *j*.

The construction of our MPI indicates that its value is contingent upon the selection of individual tools. The MaPPED database encompasses a broad spectrum of policy instruments, including the following categories: lending standards restrictions, liquidity requirements, provisioning systems, and taxes on financial activities.

In our analysis, we focus on instruments that have been employed heterogeneously, at the discretion of national regulators, and are not subject to EU-level legal acts (i.e., directives or regulations). We also exclude instruments that are primarily focused on a single country. Consequently, we consider four groups of instruments: lending standards restrictions, limits on currency and maturity mismatch, provisioning systems, and taxes on financial activities. Each of these groups comprises several specific tools.

The values of MPI are diversified across years, types and countries (see Figures 1, 2 and 3). However, they denote the fact that in most of the years and countries the policy was mostly tightened, with a positive value of MPI. As illustrated in Figure 1, the period following the Global Financial Crisis (GFC) of 2007/2009 experienced significant policy modifications, characterized by numerous tightening measures within our sample. An examination of the EEA countries reveals that the majority of the countries in our sample implemented tightened macroprudential policies. When it comes to types of instruments, we can clearly see that instruments from the Levy_tax and Liquid_MM groups dominate. LLP has the smallest share.

[Insert Figures 5-7 around here]

Figures 8 and 9 present type of actions over the years and per countries. The charts show a noticeable increase in macroprudential policy tightening in 2010 compared to previous years. The highest number of tightenings was recorded in 2011, after which their number decreased and remained between approximately 100 and 200. From 2012, individual loosenings began to appear, and from 2015, a significant trend of numerous macroprudential policy loosenings became evident. Regarding individual countries, Austria, France, and Germany experienced the most tightenings, while Romania, Slovakia, and Spain had the least. France also recorded the most loosenings of macroprudential policy, although this trend was also evident in Cyprus and Denmark.

[Insert Figures 8-9 around here]

3.4. Data description

We construct an annual panel dataset encompassing both commercial and cooperative banks within the European Economic Area (EEA) from 2007 to 2021. The initiation of the sample in 2007 ensures the inclusion of a year with sufficient data coverage. The primary data source is BankFocus, supplemented with data on specific variables from Eurostat and the International Monetary Fund (IMF). Banks lacking the requisite data for our model were excluded from the analysis. The study utilizes unconsolidated data, resulting in a sample comprising 7928 observations from 1186 banks across the following EEA countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden. Due to inadequate data availability, Iceland, Ireland, and Liechtenstein were excluded from the sample.

[Insert Table 2 around here]

In Table 2 we report the summary statistics for the variables used. The three dependent variables used in the study exhibit a range of values. LiquidADST has a wide range from 0.868 to 1318. Unlike the other dependent variable, LRE takes on negative values, ranging from -82.5 to 91.2. Moving on to the independent variables, CAP ranges from 0.826 to 94.8, while Loans have a very similar range, from 0.73 to 97.1. LLP and ROA, on the other hand, take on negative values, with LLP ranging from -3.14 to 9.72, and ROA from -5.08 to 8.35. OVERHERC spans a wide range from 0.0297 to 27.1. Size values range from 9.39 to 19.8. HHI ranges from 0.0000106 to 0.444. Deposit_Insurance_Coverage values range from 0.585 to 20.9, GDP_Growth from -0.0989 to 0.0799, IntRATE from 0.616 to 7.12, and finally, Unempl from 2.98 to 24.4. Regarding macroeconomic variables, MPI ranges from -2 to 4, while the specific instruments are as follows: LendStandRestrict from -1 to 4, Levy/tax from -1 to 2, Liquid&MM from 0 to 3, and finally, LLP from -1 to 2.

The correlation matrix (Appendices A1 and A2) illustrates the degree to which variables influence each other. The strongest relationship is between the Loans variable and the dependent variables (-0.52 for LiquidADST and 0.65 for LRE, respectively). The rest of the banking and macroeconomic variables do not strongly influence each other. Regarding macroeconomic variables, there is a relationship observed between the variables LendStandRestrict, Levy_tax, and Liqud_MM with the MPI variable (with values of 0.43, 0.69,

and 0.49, respectively). Variables related to individual instruments do not interact with each other.

In our analysis we also use Random Forest. Random Forest (RF) is an ensemble machine learning method commonly used in many research applications due to its high predictive and explanatory power (Athey & Imbens, 2019). As a machine learning technique, it does not rely so heavily on mathematical and theoretical assumptions and provides accurate predictions even for non-linear and complex relations within the data (Athey et al., 2019). Predictions from the model are provided by constructing multiple decision trees using random subsets of data and features. Individual trees are dividing the values along the variables in the dataset to create small subsets of similar outcome results to enrich the prediction. Each tree in the forest votes and the majority decision becomes the final prediction (Athey & Imbens, 2019). This method effectively captures complex, non-linear interactions among variables, making it robust and flexible compared to traditional models. In the context of this research, it will serve as an additional robustness check to validate the results further.

[Insert Table 3 around here]

RF not only provides good predictive power but also shines in the explanatory part. Variable importance scores in RF indicate the relevance of each predictor by measuring the average improvement in the splitting criterion (e.g., Gini impurity) that each variable contributes across all trees (Loecher, 2022). These scores allow for identifying key variables influencing the model's predictions. Unlike statistical significance in traditional models, which test if a variable's effect is distinguishable from zero, variable importance scores rank predictors based on their overall contribution to the model's accuracy. This provides a more nuanced understanding of variable impact, especially in capturing non-linear relationships and interactions, enhancing prediction and explanation. This paper will use variable importance scores to measure the impact of macroprudential policy instruments on the dependent variables compared to the control factors.

Estimated random forest models on both target variables are well fitted to the data and can be used as an additional tool to gain insights into the analyzed phenomenon (model on LiquidADST explains more than half of the variance, and models on LRE explain almost 80% of the dependent variable variability). Importance scores, which give information about the importance of a given variable to the prediction, are aligned in both models (although the ranges of the statistics differ due to the different goodness of fit of both scenarios, the ordering of most

important variables stays relatively the same). They show that the control variables used in both models perform well, and are useful in explaining the variability of the phenomenon, which further validates the choice of the predictor in the later linear models.

Even when controlling for non-linear effects (which is a typical advantage of machine learning estimations), the importance of the variables remains high (scores above 5-10, which can be loosely translated in a similar way as statistical significance in the econometric models). In models explaining LiquidADST controls for LLP and GDP growth, they perform relatively poorer; however, their importance rises when including the first MPI control. What is most important from the perspective of this study is that all MPI control variables remain vital for providing explanatory power in explaining the variability of both LiquidADST and LRE – their importance across all models is mostly stable, with importance scores around 10-15. It shows that even when using a less traditional and parameter-agnostic approach with machine learning estimations, MPI controls are important predictors for the modelled dependent variables, which further validates this study. Insights into the actual power and the direction of relations between the variables, which can be directly used for interpretation, must be taken from white-box econometrics models, which are presented further in this study.

4. Empirical results

The main results are reported in Tables 4 to 7. The results are divided into several sections. First, the results for the entire sample are presented in Section 4.1. In Section 4.2 we show the impact of individual instruments, while in Sections 4.3 and 4.4 respectively we present the results considering the impact of bank-specific and macroeconomic variables. In Section 4.5 we conduct robustness checks and sensitivity analysis.

4.1. Baseline results

In Table 4 we present the baseline regression results of specifications (1) and (2) using the MPI. The table is split into two parts: first four columns use the LiquidADST as dependent variable, while the last four columns use the LRE.

[Insert Table 4 around here]

In the case of the variable LiquidADST, it can be observed that the impact of MPI is not statistically significant in the year of implementation. However, one and two years after implementation, a strong effect increasing liquidity risk expressed by LiquidADST can be noticed. For the variable LRE, the effect appears immediately, showing an increase in liquidity risk, confirming Hypothesis H1b. Only two years after implementation, a risk-reducing effect can be observed. Therefore, it can be said that the effect of the MPI variable is varied, with a strong tendency to increase liquidity risk.

When it comes to banking variables, a varied impact of CAP and LLP variables can be observed. Both significantly reduce liquidity risk expressed by LiquidADST, while they increase risk expressed by the variable LRE. Loans increase liquidity risk using both dependent variables. ROA significantly reduces liquidity risk expressed by LiquidADST but does not have a statistically significant impact on LRE. Size and HHI do not significantly affect LiquidADST, but both increase LRE, thereby increasing liquidity risk. Moving to macroeconomic variables, Deposit_Insurance_Coverage significantly increases liquidity risk for both LiquidADST and LRE. GDP_Growth and Unempl have no impact on LiquidADST, but significantly increase LRE. IntRate increases liquidity risk for both dependent variables.

4.2. The role of macroprudential policy instruments

In Table 5 we present the impact of individual macroprudential policy instruments. Once again, the table is divided into two parts - the first three columns display results for LiquidADST, while the last three columns are for LRE. The table first shows the immediate effect and then the effect one and two years after the implementation of each instrument separately for both dependent variables.

[Insert Table 5 around here]

The results clearly indicate a varied effect of individual instruments, confirming Hypothesis 2. Moving on to discuss the impact of specific instruments, it can be observed that Lending Standard Restriction has the strongest effect. It increases liquidity risk expressed in both LiquidADST and LRE. This effect appears immediately after implementation and persists one and two years later. On the other hand, Levy tax shows no immediate impact nor one year later. Its effect only appears after two years and is diverse - it increases liquidity risk expressed by LiquidADST while also reducing risk indicated by LRE. The instrument related to Liquidity and Maturity Mismatch affects differently depending on the dependent variable. For LiquidADST, the effect appears only after two years, increasing liquidity risk, while for LRE, the effect is immediate but opposite. As for LLP, its effect appears immediately for both dependent variables, causing an increase in liquidity risk.

4.3. Sensitivity analysis - the role of bank-specific determinants

Previous research shows that the impact of macroprudential policy in risk is heterogenous and depends on bank-specific factors ((Altunbas et al., 2018; Ely et al., 2021, Gaganis et al., 2021, Meuleman and Vennet, 2020), including size, liquidity ratio, leverage ratio, deposits ratio, . In Table 6 we present the results of the analysis of the impact of individual bank-specific factors. The table is divided based on the dependent variable - the first four columns display results for LiquidADST, while the remaining four columns are for LRE.

[Insert Table 6 around here]

The analysis results for individual banking variables indicate that most of them do not have statistically significant effects on MPI strength. The interaction with the CAP variable shows a negative value immediately and with a lag of 1 or 2 years after policy instrument

implementation. This suggests that in better-capitalized banks, the impact of macroprudential policy on liquidity risk is weaker. For the LLP variable, the effect appears with a one-year lag, indicating that banks with higher loan loss provisions experience a weaker influence from macroprudential policy. Similarly, for the Size variable, the effect emerges after two years, showing that larger banks also experience a weaker impact of macroprudential policy intervention. Conversely, regarding the Loans variable, a one-year lag reveals that banks with higher loan-to-assets ratios react more strongly to macroprudential policy.

4.4. Sensitivity analysis - the role of country-level factors

The effects of the macroprudential policy are also driven by country-specific and macroeconomic factors, including competition and market structure (Olszak and Kowalska, 2022, Ely et al., 2021), microprudential regulations (Gaganis et al., 2021), business cycle (Olszak and Kowalska, 2022; Lim et al., 2011). Therefore, in our analysis we also consider a variety of such factors, covering: deposit insurance coverage (microprudential regulations of importance for liquidity in banks), GDP growth, interest rate and unemployment rate (business cycle factors), and Herfindahl-Hirshman index (market concentration/structure). In Table 7 we present the results of the analysis of the impact of country-level factors. The table is divided based on the dependent variable - the first four columns display results for LiquidADST, while the remaining four columns are for LRE.

[Insert Table 7 around here]

The results show that the level of deposit insurance coverage, HHI (Herfindahl-Hirschman Index), and GDP growth rate do not influence the strength of macroprudential policy effectiveness. However, it is evident that with a one-year and two-year delay in a higher inflation environment, macroprudential policy has a stronger impact. Conversely, a higher unemployment rate weakens the influence of macroprudential policy with a one-year and two-year delay.

4.5. Robustness checks

In this section, we conduct several tests to assess the robustness of our results when introducing additional variables: Rule of Law, Multiple supervisors dummies and Financial Development index.

[Insert Tables 8-10 around here]

As seen in the results, introducing the new variable has no impact on the estimation outcomes. In all three cases, the direction of change remained the same. For the variable LiquidADST, the influence of MPI is not statistically significant in the year of implementation. However, noticeable effects emerge one and two years later, significantly increasing liquidity risk. In contrast, for the variable LRE, the impact is immediate, leading to an increase in liquidity risk. It's only after two years that a risk-reducing effect becomes apparent.

5. Conclusions

This study contributes to the existing literature on the effectiveness of macroprudential policies by offering a distinct perspective. While prior research has primarily focused on the impact of these policies on credit growth and systemic risk, our analysis uniquely explores their efficacy in managing bank liquidity risk across diverse countries. By leveraging cross-sectional data from 1,186 banks across EEA countries (totaling 7,928 observations), we uncover significant insights into the influence of macroprudential measures on bank risk.

Contrary to conventional findings on risk-taking, our study reveals that macroprudential policies raise liquidity risk within our sample. Moreover, we observe varied impacts among different macroprudential tools: lending standards restrictions increase liquidity risk, measures addressing liquidity and maturity mismatch exhibit ambiguous effects, provisioning systems elevate liquidity risk, and taxes on financial activities show mixed impacts on liquidity risk.

Furthermore, our research identifies heterogeneous responses among banks to changes in macroprudential tools, influenced by their specific balance sheet characteristics. Notably, smaller banks with weaker capitalization and lower loan loss provisions tend to demonstrate more pronounced reactions to adjustments in macroprudential policies.

Acknowledgements: We gratefully acknowledge the financial support provided by the National Science Centre (NCN) in Poland, decision no. 2019/35/B/HS4/02471.

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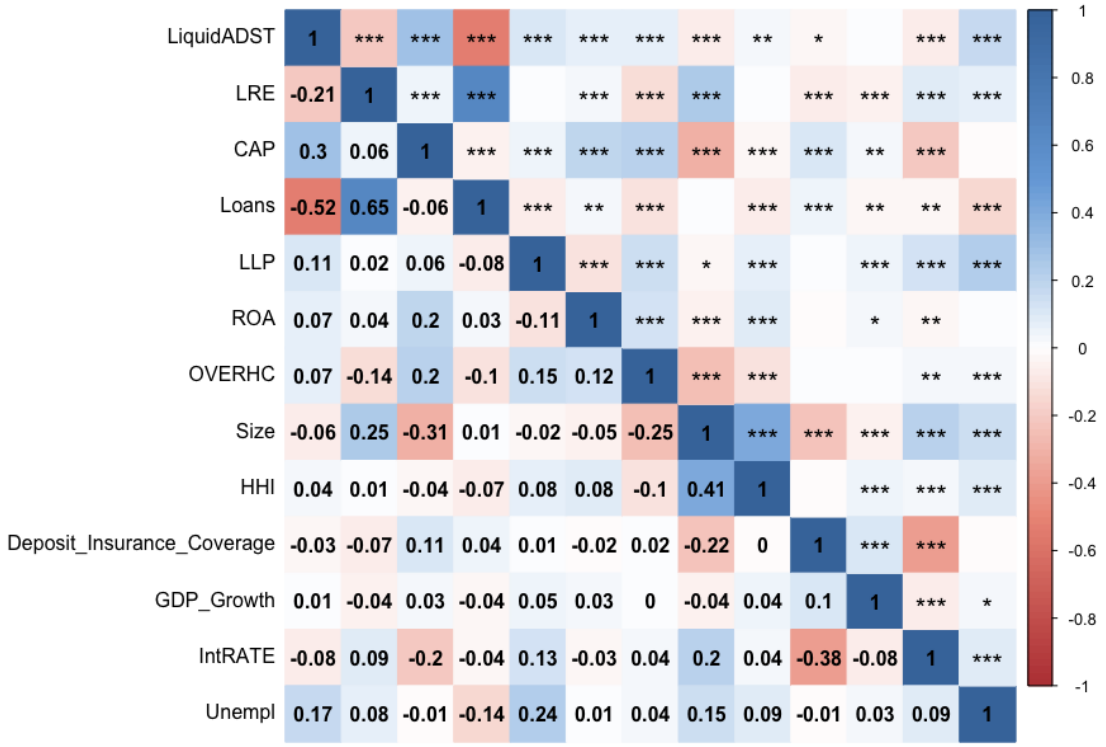
Appendix

Table A1. Correlation matrix

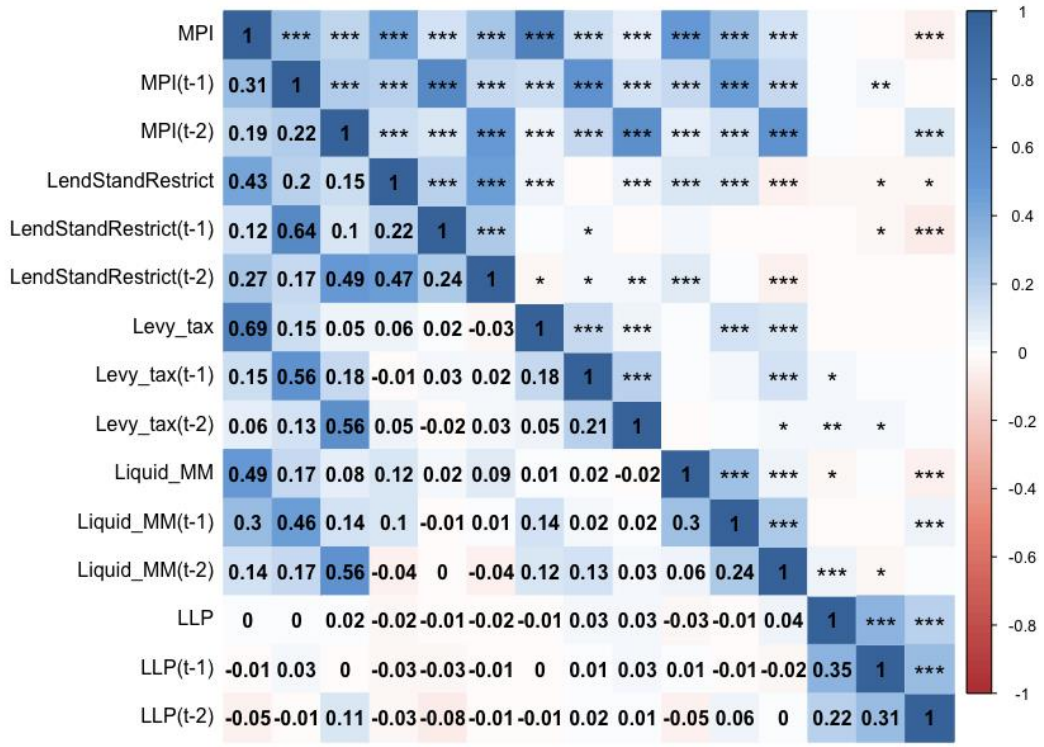
PANEL A: Correlation matrix of the main variables



Notations: Variables definitions in Table 1. LiquidADST - Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; $CAP_{(t-1)}$ - The ratio of equity to total assets; $Loans_{(t-1)}$ – The ratio of loans to total assets; $LLP_{(t-1)}$ – The ratio of loan loss provisions to total loans; $ROA_{(t-1)}$ – The return on assets; $OVERHC_{(t-1)}$ – The overheads costs to income ratio; $Size_{(t-1)}$ – The logarithm of total assets; $HHI_{(t-1)}$ – The Herfindahl index of concentration for the market or markets in which the bank is present.; Deposit Insurance Coverage - The ratio between deposit coverage limit and GDP per Capita; GDP GROWTH - The logarithm difference of successive GDP values; INT - The interest rate; UNEMPL - The number of unemployed people as a ratio of the total labor force of the bank's host country; *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table A2. Correlation matrix

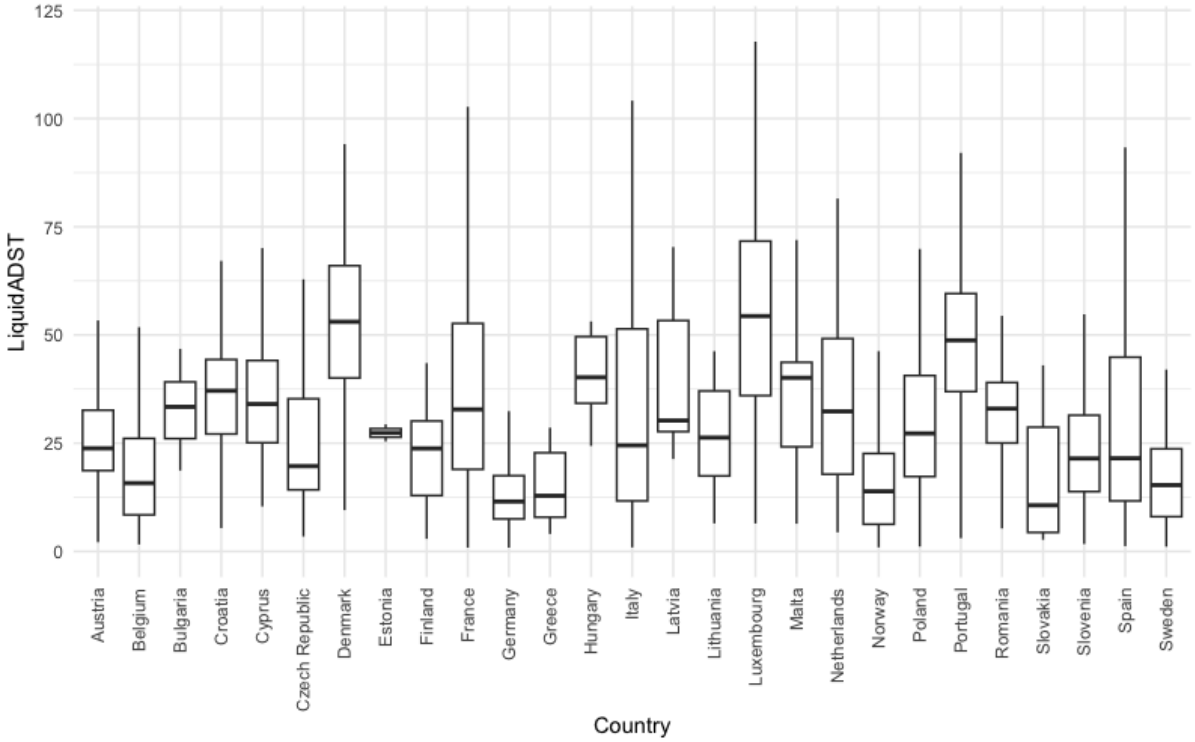
PANEL B: Correlation matrix of instrument types



Notations: Variables definitions in Table 1. MPI - Index measuring overall stance of macroprudential policy; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning; *, ** and *** denote significance at 10%, 5% and 1% levels, respectively.

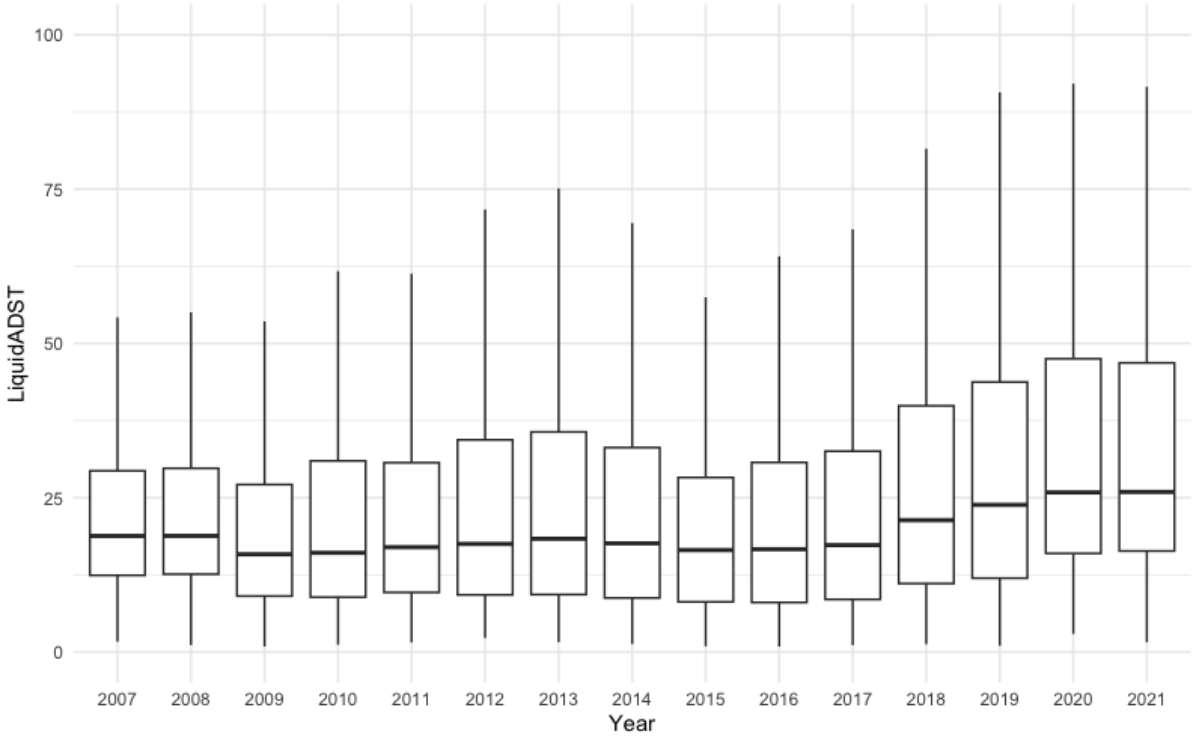
Figures to be included in the main text

Figure 1. LiquidADST boxplot in different countries



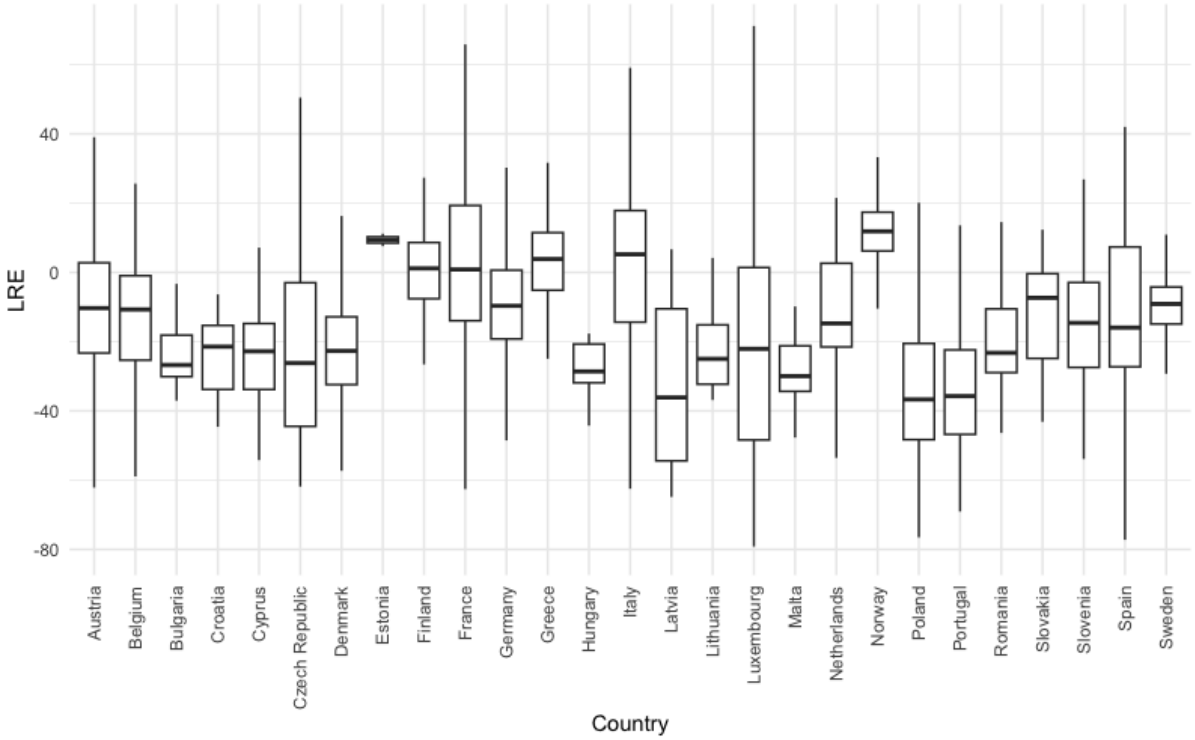
Source: Authors' elaboration using Orbis Focus database.

Figure 2. LiquidADST boxplot in each year



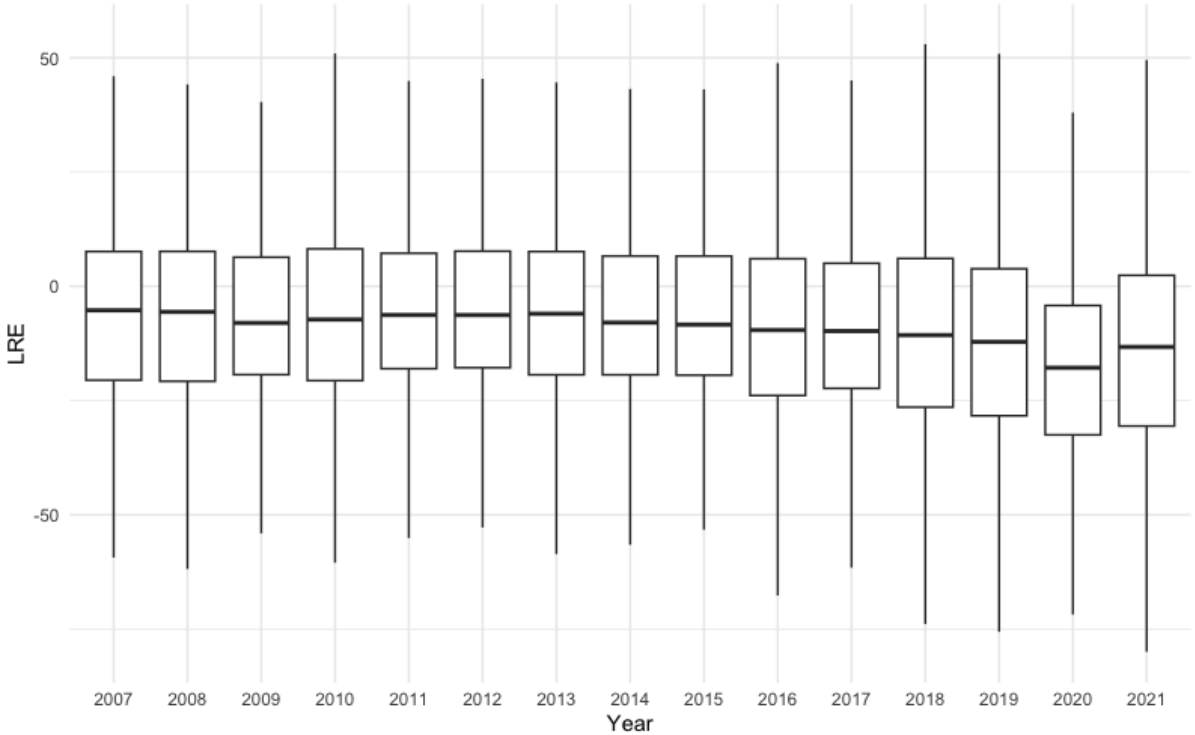
Source: Authors' elaboration using Orbis Focus database.

Figure 3. LRE boxplot in different countries



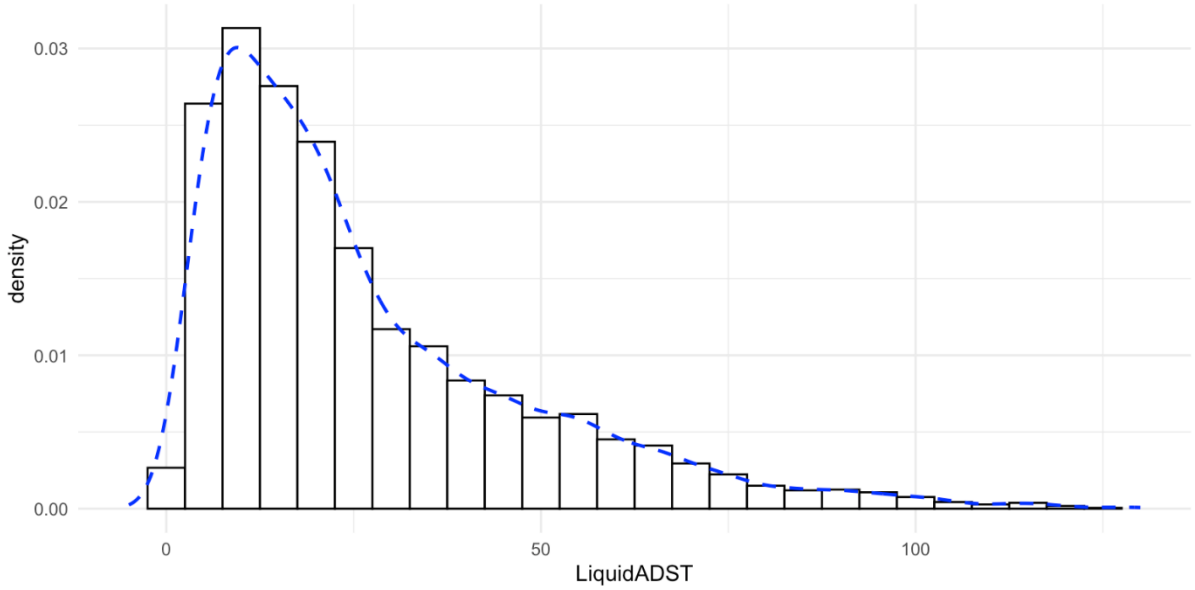
Source: Authors' elaboration using Orbis Focus database.

Figure 4. LRE boxplot in each year



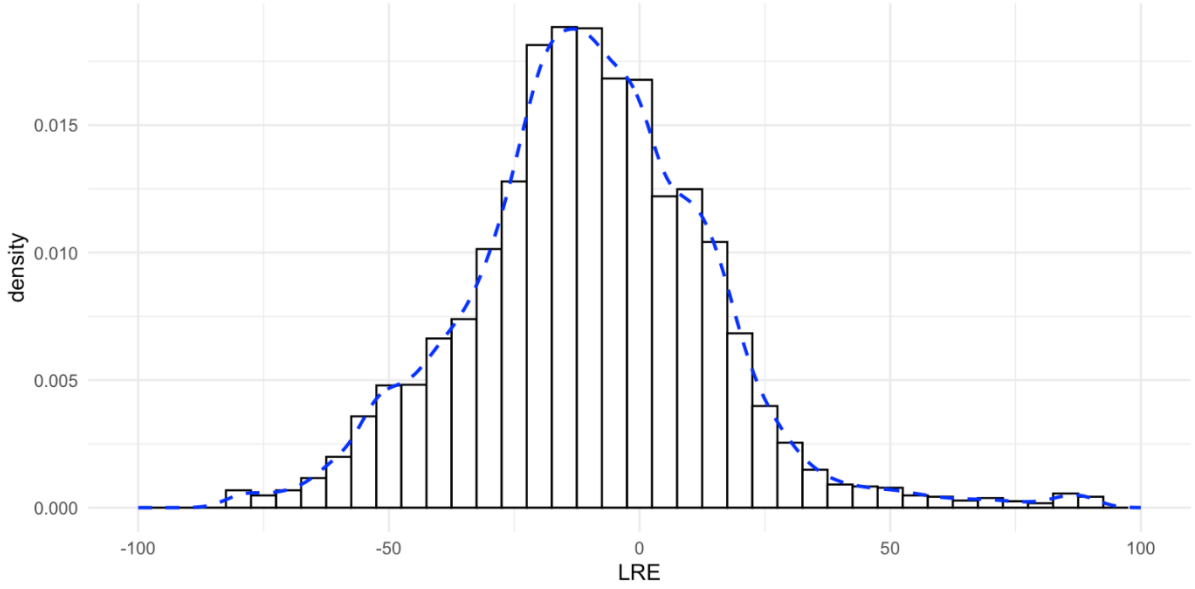
Source: Authors' elaboration using Orbis Focus database.

Figure 5. LiquidADST density



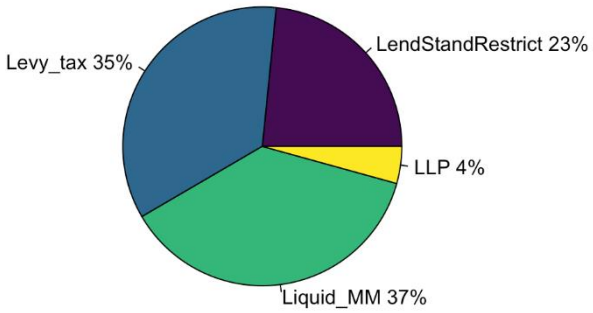
Source: Authors' elaboration using Orbis Focus database. Note: chart adjusted to remove extreme values.

Figure 6. LRE density



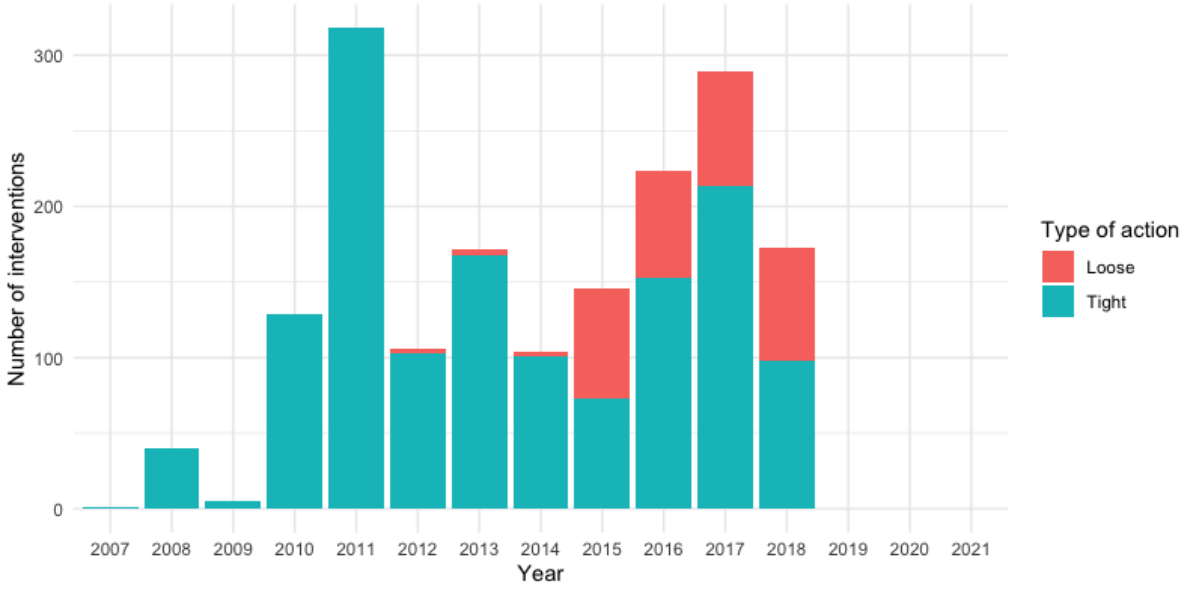
Source: Authors' elaboration using Orbis Focus database. Note: chart adjusted to remove extreme values.

Figure 7. Types of macroprudential policy tool



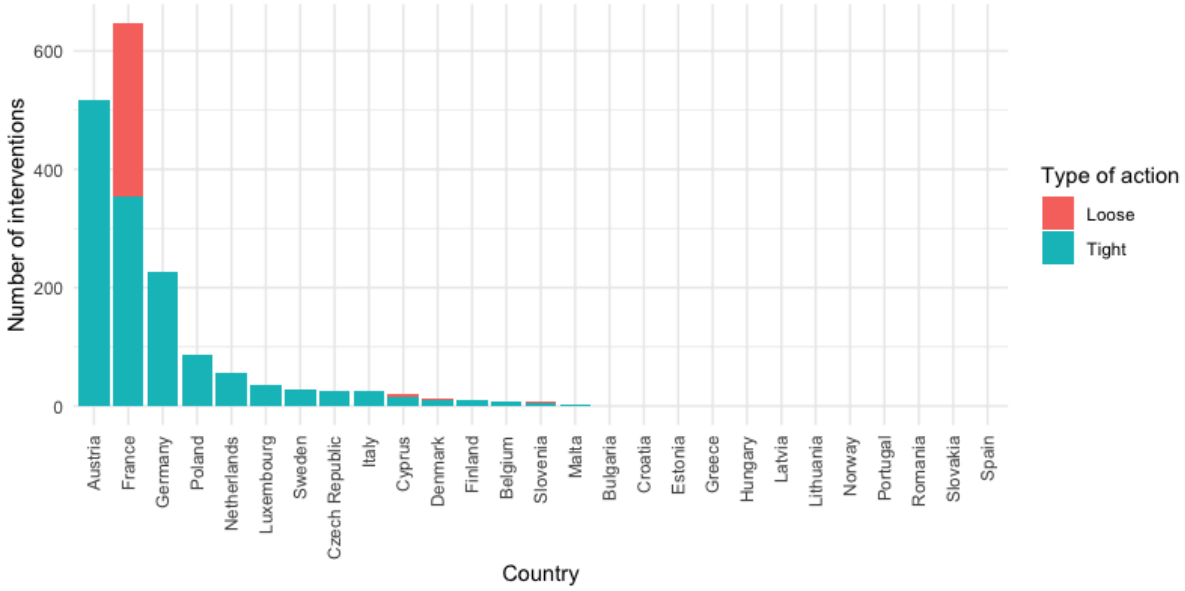
Source: Authors' elaboration using MaPPED database. Notations: Variables definitions in Table 1. LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning.

Figure 8. Type of actions over the years



Source: Authors' elaboration using MaPPED database.

Figure 9. Type of actions per countries



Source: Authors' elaboration using MaPPED database.

Tables to be included in the main text

Table 1. Variable names, definitions and source

Dependent variables	Description	Used by	Source
LiquidADST	Liquid assets over deposits and short-term funding.	Khan et al. (2017) Meriläinen and Junttila (2020) Nguyen and Nguyen (2022) Altunbaş et al. (2023) Ahmed and Calice (2023)	BankFocus
LRE	Liquidity risk exposure.	Saunders and Cornett (2006) Mohammad et al. (2020)	BankFocus
Macroprudential policy variables	**Description**	**Used by**	**Source**
MPI	Index measuring overall stance of macroprudential policy	Meuleman and Vennet (2020) Cehajic and Kosak (2022)	MaPPED
LendStandRestrict	Lending standards restrictions		MaPPED
Levy_tax	Levies/taxes on financial institutions		MaPPED
Liquid_MM	Liquidity requirements and limits on currency and maturity mismatch		MaPPED
LLP	Loan loss provisioning		MaPPED
Independent variables	**Description**	**Expected impact on liquidity risk**	**Used by**	**Source**
Banking specific variables				
CAP	The ratio of equity to total assets.	+	Berger and Bouwman (2009) Karakas and Acar (2022)	BankFocus
LOANS	The ratio of loans to total assets.	+	Ahmed (2021) Barongo and Mbelwa (2024) Raz et al. (2022)	BankFocus
LLP	The ratio of loan loss provisions to total loans.	+	Distinguin, Roulet, and Tarazi (2013) Fu et al. (2016)	BankFocus

ROA	The return on assets.	-	Flannery and Rangan (2008) Kladakis et al. (2022) Wu et al. (2024) Tang et al. (2024)	BankFocus
OVERHC	The overheads costs to income ratio.	+	Kladakis et al. (2022) Tang et al. (2024)	BankFocus
SIZE	The logarithm of total assets.	+/-	Fecht et al. (2011) Fu et al. (2016) Wu et al. (2024)	BankFocus
HHI	The Herfindahl index of concentration for the market or markets in which the bank is present.	-	Berger and Bouwman (2009)	BankFocus
Macroeconomic variables				
Deposit Insurance Coverage	The ratio between deposit coverage limit and GDP per Capita.	+	Demirguc-Kunt et al. (2005, 2015)	Authors' calculation based on data from Eurostat, Demirguc-Kunt's (2005, 2015) database and International Association of Deposit Insurers database
GDP GROWTH	The logarithm difference of successive GDP values.	+	Nguyen and Nguyen (2022) Kladakis et al. (2022)	IMF
INT	The interest rate.	+	Vodova (2013) Karakas and Acar (2022)	IMF, Eurostat
UNEMPL	The number of unemployed people as a ratio of the total labor force of the bank's host country.	+	Kladakis et al. (2022) Raz et al. (2024)	IMF

Table 2. Descriptive statistics – overall

	mean	stde	medi	mini	maxi
LiquidADST	28,3	34,1	20,1	0,868	1318
LRE	-10,1	24,4	-10,3	-82,5	91,2
$CAP_{(t-1)}$	9,63	5,41	8,87	0,826	94,8
$Loans_{(t-1)}$	59,6	18,2	62,3	0,73	97,1
$LLP_{(t-1)}$	0,431	1,02	0,213	-3,14	9,72
$ROA\_bank_{(t-1)}$	0,438	0,768	0,294	-5,08	8,35
$OVERHC_{(t-1)}$	2,37	1,88	2,09	0,0297	27,1
$Size_{(t-1)}$	14,2	1,78	14,3	9,39	19,8
$HHI_{(t-1)}$	0,0134	0,0437	0,000967	0,0000106	0,444
Deposit_Insurance_Coverage	6,38	3,6	6,78	0,585	20,9
GDP_Growth	0,0146	0,0299	0,0184	-0,0898	0,0799
IntRATE	2,5	1,11	2,2	0,616	7,17
Unempl	6,4	3,07	5,62	2,98	24,4
MPI	0,139	0,483	0	-1	3
$MPI_{(t-1)}$	0,198	0,589	0	-1	4
$MPI_{(t-2)}$	0,223	0,635	0	-2	4
LendStandRestrict	0,0499	0,222	0	-1	3
$LendStandRestrict_{(t-1)}$	0,0936	0,394	0	-1	4
$LendStandRestrict_{(t-2)}$	0,0855	0,344	0	-1	3
Levy/tax	0,0346	0,343	0	-1	2
$Levy/tax_{(t-1)}$	0,0371	0,338	0	-1	2
$Levy/tax_{(t-2)}$	0,0488	0,367	0	-1	2
Liquid&MM	0,0966	0,363	0	0	3
$Liquid\&MM_{(t-1)}$	0,102	0,357	0	0	3
$Liquid\&MM_{(t-2)}$	0,137	0,45	0	0	3
LLP	0,00946	0,0994	0	0	2
$LLP_{(t-1)}$	0,0151	0,13	0	-1	2
$LLP_{(t-2)}$	0,0184	0,161	0	-1	2

Notations: Variables definitions in Table 1. LiquidADST - Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; $CAP_{(t-1)}$ - The ratio of equity to total assets; $Loans_{(t-1)}$ – The ratio of loans to total assets; $LLP_{(t-1)}$ – The ratio of loan loss provisions to total loans; $ROA\_bank_{(t-1)}$ – The return on assets; $OVERHC_{(t-1)}$ – The overheads costs to income ratio; $Size_{(t-1)}$ – The logarithm of total assets; $HHI_{(t-1)}$ – The Herfindahl index of concentration for the market or markets in which the bank is present.; Deposit Insurance Coverage - The ratio between deposit coverage limit and GDP per Capita; GDP GROWTH - The logarithm difference of successive GDP values; INT - The interest rate; UNEMPL - The number of unemployed people as a ratio of the total labor force of the bank's host country; MPI - Index measuring overall stance of macroprudential policy; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning.

Table 3. Random forest for LiquidADST and LRE

	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LRE	LRE	LRE	LRE
	full	MPI	$MPI_{(t-1)}$	$MPI_{(t-2)}$	full	MPI	$MPI_{(t-1)}$	$MPI_{(t-2)}$
$CAP_{(t-1)}$	13.925.713	148.710.069	13.913.904	13.913.904	7.585.365	7.987.969	8.251.938	8.251.938
$Loans_{(t-1)}$	34.218.121	361.323.807	37.404.403	37.404.403	20.021.371	23.508.639	23.263.754	23.263.754
$LLP_{(t-1)}$	-1.146.274	0.5805093	-3.185.164	-3.185.164	4.197.796	4.114.689	3.884.705	3.884.705
$ROA\_bank_{(t-1)}$	8.744.590	94.226.449	4.767.188	4.767.188	3.972.506	4.222.855	4.416.675	4.416.675
$OVERHC_{(t-1)}$	9.421.323	92.336.394	9.308.427	9.308.427	8.161.078	8.865.036	8.972.053	8.972.053
$Size_{(t-1)}$	5.794.097	75.448.974	5.529.359	5.529.359	6.342.478	5.939.006	6.169.615	6.169.615
$HHI_{(t-1)}$	6.197.162	72.746.846	6.561.684	6.561.684	4.461.229	4.603.582	4.656.372	4.656.372
Deposit_Insurance_Coverage	15.222.356	136.282.412	14.674.462	14.674.462	4.169.272	4.078.824	4.247.715	4.247.715
GDP_Growth	2.935.907	50.417.625	2.758.342	2.758.342	2.365.116	2.437.566	2.343.629	2.343.629
IntRATE	9.635.788	125.815.051	9.038.939	9.038.939	4.781.504	4.433.891	4.440.507	4.440.507
Unempl	15.629.634	159.754.543	13.336.899	13.336.899	5.734.936	5.859.926	5.756.605	5.756.605
MPI	9.740.716	66.056.931	NA	NA	1.131.539	1.251.635	NA	NA
$MPI_{(t-1)}$	9.879.106	NA	13.113.970	NA	1.310.902	NA	1.340.057	NA
$MPI_{(t-2)}$	12.814.719	NA	NA	13.113.970	1.523.737	NA	NA	1.340.057

R^2	0.5394167	0.5459506	0.5552309	0.5566243	0.7884085	0.7934580	0.7934698	0.7935242

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; $CAP_{(t-1)}$ - The ratio of equity to total assets; $Loans_{(t-1)}$ – The ratio of loans to total assets; $LLP_{(t-1)}$ – The ratio of loan loss provisions to total loans; $ROA\_bank_{(t-1)}$ – The return on assets; $OVERHC_{(t-1)}$ – The overheads costs to income ratio; $Size_{(t-1)}$ – The logarithm of total assets; $HHI_{(t-1)}$ – The Herfindahl index of concentration for the market or markets in which the bank is present.; Deposit Insurance Coverage – The ratio between deposit coverage limit and GDP per Capita; GDP GROWTH - The logarithm difference of successive GDP values; INT - The interest rate; UNEMPL - The number of unemployed people as a ratio of the total labor force of the bank's host country; MPI - Index measuring overall stance of macroprudential policy.

Table 4. Main effects of MPI on LiquidADST and LRE

	LiquidADST (1)	LiquidADST (2)	LiquidADST (3)	LiquidADST (4)	LRE (5)	LRE (6)	LRE (7)	LRE (8)
	full sample	immediate effect	medium term - 1 year	medium term - 2 yars	full sample	immediate effect	medium term - 1 year	medium term - 2 yars
$CAP_{(t-1)}$	1.680***	1.668***	1.671***	1.675***	0.372***	0.370***	0.368***	0.371***
	(0.072)	(0.072)	(0.072)	(0.072)	(0.028)	(0.028)	(0.028)	(0.028)
$Loans_{(t-1)}$	-0.916***	-0.924***	-0.920***	-0.919***	0.716***	0.715***	0.715***	0.717***
	(0.027)	(0.027)	(0.027)	(0.027)	(0.012)	(0.012)	(0.012)	(0.012)
$LLP_{(t-1)}$	1.278***	1.364***	1.313***	1.335***	0.340***	0.338***	0.363***	0.339***
	(0.297)	(0.296)	(0.297)	(0.296)	(0.112)	(0.111)	(0.112)	(0.111)
$ROA\_bank_{(t-1)}$	1.137***	1.124***	1.116***	1.149***	0.054	0.040	0.055	0.057
	(0.429)	(0.430)	(0.429)	(0.429)	(0.164)	(0.164)	(0.164)	(0.164)
$OVERHC_{(t-1)}$	-0.572**	-0.592**	-0.577**	-0.591**	-0.211**	-0.207**	-0.221**	-0.216**
	(0.240)	(0.240)	(0.240)	(0.240)	(0.100)	(0.100)	(0.100)	(0.100)
$Size_{(t-1)}$	0.239	0.276	0.274	0.247	3.354***	3.362***	3.370***	3.373***
	(0.409)	(0.409)	(0.409)	(0.409)	(0.221)	(0.221)	(0.221)	(0.221)
$HHI_{(t-1)}$	-14.111	-14.090	-14.311	-14.088	17.014***	17.023***	16.716***	16.390***
	(11.650)	(11.663)	(11.653)	(11.652)	(5.054)	(5.055)	(5.055)	(5.053)
Deposit_Insurance_Coverage	-0.652***	-0.728***	-0.686***	-0.680***	0.210***	0.196***	0.222***	0.267***
	(0.147)	(0.146)	(0.144)	(0.144)	(0.064)	(0.063)	(0.062)	(0.062)
GDP_Growth	-6.648	-6.328	-6.240	-6.437	8.495***	8.576***	9.022***	8.746***
	(7.342)	(7.348)	(7.327)	(7.327)	(2.677)	(2.676)	(2.675)	(2.675)
IntRATE	-2.035***	-2.159***	-2.053***	-2.100***	3.139***	3.138***	3.198***	3.258***
	(0.340)	(0.339)	(0.332)	(0.331)	(0.139)	(0.137)	(0.135)	(0.134)
Unempl	-0.067	-0.167	-0.139	-0.100	0.416***	0.395***	0.382***	0.417***
	(0.152)	(0.150)	(0.150)	(0.151)	(0.064)	(0.063)	(0.063)	(0.064)

MPI	0.282	0.013			0.497***	0.527***		
	(0.504)	(0.498)			(0.184)	(0.183)		
$MPI_{(t-1)}$	-1.199***		-1.159***		0.227		0.294*	
	(0.411)		(0.407)		(0.152)		(0.150)	
$MPI_{(t-2)}$	-1.165***			-1.153***	-0.358**			-0.366***
	(0.379)			(0.379)	(0.140)			(0.140)
Constant	75.108***	76.086***	75.462***	75.532***	-115.598***	-115.428***	-115.704***	-116.424***
	(6.634)	(6.639)	(6.628)	(6.627)	(3.496)	(3.494)	(3.490)	(3.488)
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.211	0.209	0.210	0.210	0.378	0.378	0.377	0.378
Adjusted R^2	0.209	0.208	0.209	0.209	0.377	0.377	0.376	0.377
F Statistic	1,797***	1,775***	1,785***	1,786***	4,703***	4,687***	4,682***	4,688***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; $CAP_{(t-1)}$ - The ratio of equity to total assets; $Loans_{(t-1)}$ – The ratio of loans to total assets; $LLP_{(t-1)}$ – The ratio of loan loss provisions to total loans; $ROA\_bank_{(t-1)}$ – The return on assets; $OVERHC_{(t-1)}$ – The overheads costs to income ratio; $Size_{(t-1)}$ – The logarithm of total assets; $HHI_{(t-1)}$ – The Herfindahl index of concentration for the market or markets in which the bank is present.; Deposit Insurance Coverage – The ratio between deposit coverage limit and GDP per Capita; GDP GROWTH - The logarithm difference of successive GDP values; INT - The interest rate; UNEMPL - The number of unemployed people as a ratio of the total labor force of the bank's host country; MPI - Index measuring overall stance of macroprudential policy; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 5. The role of instrument types on LiquidADST and LRE – immediate and medium-term effects

	LiquidADST	LiquidADST	LiquidADST	LRE	LRE	LRE
	(1)	(2)	(3)	(4)	(5)	(6)
	immediate effect	medium term - 1 year	medium term - 2 yars	immediate effect	medium term - 1 year	medium term - 2 yars
LendStandRestrict	-2.861***	-2.453***	-1.404*	1.184***	0.569**	0.789***
	(1.078)	(0.647)	(0.755)	(0.392)	(0.242)	(0.278)
Levy.tax	0.485	-0.494	-1.798***	-0.131	-0.123	-0.586***
	(0.644)	(0.645)	(0.586)	(0.234)	(0.233)	(0.212)
Liquid.MM	0.978	-0.150	-1.285**	0.634***	0.222	-0.208
	(0.635)	(0.646)	(0.535)	(0.230)	(0.234)	(0.196)
LLP	-5.002**	-3.095	-1.438	1.715*	1.098	-0.358
	(2.453)	(1.929)	(1.528)	(0.899)	(0.707)	(0.562)
Bank control variables	yes	yes	yes	yes	yes	yes
Macroeconomic control variables	yes	yes	yes	yes	yes	yes
Observations	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.211	0.212	0.211	0.379	0.378	0.379
Adjusted R^2	0.210	0.210	0.209	0.377	0.377	0.377
F Statistic	1,799***	1,804***	1,798***	4,707***	4,689***	4,706***

Notations: Variables definitions in Table 1. LiquidADST - Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 6. The role of banking specific variables on LiquidADST and LRE

	LiquidADST (1)	LiquidADST (2)	LiquidADST (3)	LiquidADST (4)	LRE (5)	LRE (6)	LRE (7)	LRE (8)
	full sample	immediate effect	medium term - 1 year	medium term - 2 yars	full sample	immediate effect	medium term - 1 year	medium term - 2 yars
MPI	10.706*	15.773***			-2.618	-2.101		
	(6.047)	(5.749)			(2.212)	(2.098)		
$MPI_{(t-1)}$	2.730		6.506		-0.985		-1.001	
	(4.792)		(4.599)		(1.765)		(1.695)	
$MPI_{(t-2)}$	14.747***			14.754***	2.323			2.062
	(4.114)			(4.027)	(1.519)			(1.482)
$CAP_{(t-1)}\times MPI$	-0.413***	-0.507***			0.028	0.042		
	(0.093)	(0.092)			(0.034)	(0.033)		
$Loans_{(t-1)}\times MPI$	0.014	0.027			-0.008	-0.008		
	(0.028)	(0.027)			(0.010)	(0.010)		
$LLP_{(t-1)}\times MPI$	-0.241	-0.928*			-0.125	-0.128		
	(0.536)	(0.522)			(0.196)	(0.189)		
$ROA\_bank_{(t-1)}\times MPI$	-0.111	-0.188			-0.184	-0.391		
	(0.746)	(0.725)			(0.273)	(0.264)		
$OVERHC_{(t-1)}\times MPI$	-0.117	-0.113			0.087	0.086		
	(0.269)	(0.266)			(0.099)	(0.098)		
$Size_{(t-1)}\times MPI$	-0.511	-0.837***			0.225*	0.191		
	(0.338)	(0.322)			(0.124)	(0.118)		
$CAP_{(t-1)}\times MPI_{(t-1)}$	-0.376***		-0.387***		0.049*		0.053*	
	(0.077)		(0.075)		(0.029)		(0.028)	
$Loans_{(t-1)}\times MPI_{(t-1)}$	0.040*		0.056**		0.005		0.001	
	(0.024)		(0.023)		(0.009)		(0.008)	
$LLP_{(t-1)}\times MPI_{(t-1)}$	-0.780**		-0.976***		-0.148		-0.123	

	(0.335)		(0.327)		(0.124)		(0.120)	
$ROA\_bank_{(t-1)} \times MPI_{(t-1)}$	-0.533		-0.308		-0.164		-0.251	
	(0.473)		(0.462)		(0.175)		(0.171)	
$OVERHC_{(t-1)} \times MPI_{(t-1)}$	0.238		0.076		0.065		0.069	
	(0.209)		(0.203)		(0.077)		(0.075)	
$Size_{(t-1)} \times MPI_{(t-1)}$	-0.186		-0.474*		0.032		0.050	
	(0.268)		(0.257)		(0.099)		(0.095)	
$CAP_{(t-1)} \times MPI_{(t-2)}$	-0.471***			-0.421***	0.068***			0.059**
	(0.070)			(0.069)	(0.026)			(0.025)
$Loans_{(t-1)} \times MPI_{(t-2)}$	0.045**			0.060***	-0.002			-0.002
	(0.022)			(0.022)	(0.008)			(0.008)
$LLP_{(t-1)} \times MPI_{(t-2)}$	-0.104			-0.445	0.010			0.007
	(0.366)			(0.360)	(0.133)			(0.131)
$ROA\_bank_{(t-1)} \times MPI_{(t-2)}$	0.278			0.402	-0.706***			-0.774***
	(0.514)			(0.500)	(0.188)			(0.182)
$OVERHC_{(t-1)} \times MPI_{(t-2)}$	-0.208			-0.231	-0.144*			-0.114
	(0.209)			(0.206)	(0.077)			(0.075)
$Size_{(t-1)} \times MPI_{(t-2)}$	-0.955***			-1.027***	-0.176**			-0.155**
	(0.219)			(0.214)	(0.081)			(0.079)
Constant	70.583***	73.286***	74.374***	71.969***	-116.065***	-114.911***	-115.589***	-117.398***
	(6.740)	(6.668)	(6.661)	(6.658)	(3.529)	(3.516)	(3.496)	(3.502)
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.226	0.214	0.217	0.218	0.382	0.378	0.379	0.380
Adjusted R^2	0.223	0.212	0.215	0.216	0.380	0.377	0.377	0.379
F Statistic	1,978***	1,829***	1,864***	1,876***	4,773***	4,693***	4,706***	4,738***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; $CAP_{(t-1)}$ - The ratio of equity to total assets; $Loans_{(t-1)}$ – The ratio of loans to total assets; $LLP_{(t-1)}$ – The ratio of loan loss provisions to total loans; $ROA\_bank_{(t-1)}$ – The return on assets; $OVERHC_{(t-1)}$ – The overheads costs to income ratio; $Size_{(t-1)}$ – The logarithm of total assets; MPI - Index measuring overall stance of macroprudential policy; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 7. The role of macroeconomic variables on LiquidADST and LRE

	LiquidADST (1)	LiquidADST (2)	LiquidADST (3)	LiquidADST (4)	LRE (5)	LRE (6)	LRE (7)	LRE (8)
	full sample	immediate effect	medium term - 1 year	medium term - 2 yars	full sample	immediate effect	medium term - 1 year	medium term - 2 yars
MPI	-3.493	-3.243			9.216***	9.221***		
	(3.315)	(3.170)			(1.210)	(1.154)		
$MPI_{(t-1)}$	0.516		1.403		2.082***		2.528***	
	(1.920)		(1.864)		(0.708)		(0.686)	
$MPI_{(t-2)}$	0.905			3.067*	0.554			-0.082
	(1.740)			(1.689)	(0.644)			(0.617)
$HHI_{(t-1)}$×MPI	-8.444	-12.298			3.012	5.761		
	(17.156)	(16.765)			(6.382)	(6.278)		
Deposit_Insurance_Coverage×MPI	0.104	0.114			-0.123	-0.147*		
	(0.221)	(0.216)			(0.080)	(0.078)		
GDP_Growth×MPI	18.423	20.553			-62.015***	-44.550***		
	(43.988)	(42.539)			(15.875)	(15.299)		
IntRATE×MPI	0.445	0.419			-0.785***	-0.909***		
	(0.563)	(0.547)			(0.206)	(0.200)		
Unempl×MPI	0.166	0.124			-0.551***	-0.531***		
	(0.305)	(0.296)			(0.110)	(0.107)		
$HHI_{(t-1)}$×$MPI_{(t-1)}$	-1.154		-1.615		6.220*		7.664**	
	(9.754)		(9.566)		(3.626)		(3.601)	
Deposit_Insurance_Coverage×$MPI_{(t-1)}$	-0.287		-0.216		-0.092		-0.086	
	(0.177)		(0.172)		(0.064)		(0.063)	
GDP_Growth×$MPI_{(t-1)}$	6.527		11.059		-5.292		5.309	
	(26.054)		(24.805)		(9.462)		(9.038)	
IntRATE×$MPI_{(t-1)}$	1.292***		0.815**		-0.228		-0.137	
	(0.363)		(0.340)		(0.141)		(0.126)	
Unempl×$MPI_{(t-1)}$	-0.537***		-0.510***		-0.083		-0.218***	
	(0.171)		(0.162)		(0.063)		(0.060)	
$HHI_{(t-1)}$×$MPI_{(t-2)}$	3.034			2.094	3.348			2.506

	(6.988)			(6.952)	(2.554)			(2.545)
Deposit_Insurance_Coverage×MPI$_{(t-2)}$	-0.180			-0.096	0.070			-0.002
	(0.177)			(0.171)	(0.064)			(0.062)
GDP_Growth×MPI$_{(t-2)}$	2.385			3.294	9.643*			20.843***
	(14.934)			(14.271)	(5.421)			(5.169)
IntRATE×MPI$_{(t-2)}$	1.041**			0.067	-0.419**			-0.004
	(0.456)			(0.400)	(0.179)			(0.148)
Unempl×MPI$_{(t-2)}$	-0.548***			-0.532***	-0.061			-0.083
	(0.155)			(0.152)	(0.057)			(0.056)
Constant	76.479***	76.969***	75.287***	73.471***	-120.511***	-118.423***	-116.713***	-117.461***
	(6.761)	(6.670)	(6.654)	(6.660)	(3.535)	(3.505)	(3.484)	(3.510)
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.216	0.210	0.212	0.213	0.387	0.383	0.380	0.380
Adjusted R^2	0.213	0.208	0.210	0.211	0.385	0.381	0.379	0.378
F Statistic	1,855***	1,782***	1,810***	1,815***	4,865***	4,792***	4,734***	4,724***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; HHI$_{(t-1)}$ – The Herfindahl index of concentration for the market or markets in which the bank is present.; Deposit Insurance Coverage – The ratio between deposit coverage limit and GDP per Capita; GDP GROWTH - The logarithm difference of successive GDP values; INT - The interest rate; UNEMPL - The number of unemployed people as a ratio of the total labor force of the bank's host country; MPI - Index measuring overall stance of macroprudential policy; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Robustness checks

Table 8. The role of control variable Rule of Law on LiquidADST and LRE

	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LRE	LRE	LRE	LRE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	full sample	immediate effect	medium term - 1 year	medium term - 2 yars	full sample	immediate effect	medium term - 1 year	medium term - 2 yars
MPI	0.288	0.028			0.500***	0.533***		
	(0.503)	(0.498)			(0.184)	(0.183)		
$MPI_{(t-1)}$	-1.168***		-1.126***		0.240		0.307**	
	(0.411)		(0.407)		(0.152)		(0.150)	
$MPI_{(t-2)}$	-1.130***			-1.117***	-0.346**			-0.354**
	(0.379)			(0.379)	(0.140)			(0.140)
Rule.of.Law..Estimate	3.931***	4.198***	4.078***	4.048***	2.005***	2.032***	2.055***	1.940**
	(1.462)	(1.462)	(1.462)	(1.462)	(0.763)	(0.763)	(0.763)	(0.762)
Bank control variables	yes	yes	yes	yes	yes	yes	yes	yes
Macroeconomic control variables	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.212	0.210	0.211	0.211	0.379	0.378	0.378	0.378
Adjusted R^2	0.210	0.209	0.209	0.209	0.378	0.377	0.377	0.377
F Statistic	1,806***	1,785***	1,795***	1,796***	4,715***	4,699***	4,695***	4,700***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; MPI - Index measuring overall stance of macroprudential policy; Rule.of.Law_Estimate – Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 9. The role of control variable Multiple supervisors dummy on LiquidADST and LRE

	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LRE	LRE	LRE	LRE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	full sample	immediate effect	medium term - 1 year	medium term - 2 yars	full sample	immediate effect	medium term - 1 year	medium term - 2 yars
MPI	0.301	0.048			0.495***	0.524***		
	(0.503)	(0.498)			(0.184)	(0.183)		
$MPI_{(t-1)}$	-1.146***		-1.101***		0.223		0.290*	
	(0.412)		(0.407)		(0.152)		(0.150)	
$MPI_{(t-2)}$	-1.102***			-1.086***	-0.364***			-0.372***
	(0.379)			(0.379)	(0.140)			(0.140)
Multiple_Supervisors_dummy	4.525***	5.000***	4.791***	4.724***	-0.811	-0.748	-0.738	-0.890
	(1.605)	(1.603)	(1.603)	(1.604)	(0.893)	(0.893)	(0.893)	(0.893)
Bank control variables	yes	yes	yes	yes	yes	yes	yes	yes
Macroeconomic control variables	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.212	0.210	0.211	0.211	0.378	0.378	0.377	0.378
Adjusted R^2	0.210	0.209	0.209	0.209	0.377	0.377	0.376	0.377
F Statistic	1,806***	1,786***	1,795***	1,796***	4,703***	4,687***	4,682***	4,689***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; MPI - Index measuring overall stance of macroprudential policy; Multiple_Supervisors_dummy – Dummy equal to one when there are multiple deposit insurance supervisors; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 10. The role of control variable Financial Development index on LiquidADST and LRE

	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LRE	LRE	LRE	LRE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	full sample	immediate effect	medium term - 1 year	medium term - 2 yars	full sample	immediate effect	medium term - 1 year	medium term - 2 yars
MPI	0.288	0.030			0.496***	0.526***		
	(0.503)	(0.498)			(0.184)	(0.183)		
$MPI_{(t-1)}$	-1.158***		-1.115***		0.223		0.291*	
	(0.412)		(0.407)		(0.152)		(0.150)	
$MPI_{(t-2)}$	-1.130***			-1.116***	-0.361***			-0.369***
	(0.379)			(0.379)	(0.140)			(0.140)
Financial.Development.Index	10.738**	11.696***	11.206***	11.218***	-1.657	-1.603	-1.515	-1.831
	(4.277)	(4.276)	(4.278)	(4.277)	(2.304)	(2.305)	(2.305)	(2.303)
Bank control variables	yes	yes	yes	yes	yes	yes	yes	yes
Macroeconomic control variables	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.212	0.210	0.211	0.211	0.378	0.378	0.377	0.378
Adjusted R^2	0.210	0.209	0.209	0.209	0.377	0.377	0.376	0.377
F Statistic	1,806***	1,785***	1,794***	1,796***	4,704***	4,687***	4,683***	4,689***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LRE – Liquidity Risk Exposure; MPI - Index measuring overall stance of macroprudential policy; Financial.Development.Index – Aggregated overall index that summarizes how developed financial institutions and financial markets are in terms of their depth, access, and efficiency; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Tables to be included in the appendix

Table 11. The role of instrument types on LiquidADST – immediate and medium-term effects

	LiquidADST (1)	LiquidADST (2)	LiquidADST (3)	LiquidADST (4)	LiquidADST (5)
	Full sample	LendStandRestrict	Levy.tax	Liquid.MM	LLP
LendStandRestrict	-2.562**	-2.235*			
	(1.155)	(1.146)			
Levy.tax	0.786		0.400		
	(0.661)		(0.647)		
Liquid.MM	0.609			0.817	
	(0.646)			(0.643)	
LLP	-3.761				-4.560*
	(2.479)				(2.472)
$LendStandRestrict_{(t-1)}$	-2.999***	-2.315***			
	(0.670)	(0.645)			
$Levy.tax_{(t-1)}$	0.029		-0.320		
	(0.662)		(0.654)		
$Liquid.MM_{(t-1)}$	-0.036			0.156	
	(0.666)			(0.656)	
$LLP_{(t-1)}$	-2.813				-2.313
	(1.955)				(1.952)
$LendStandRestrict_{(t-2)}$	-0.699	-0.587			
	(0.805)	(0.800)			
$Levy.tax_{(t-2)}$	-1.728***		-1.805***		
	(0.594)		(0.592)		
$Liquid.MM_{(t-2)}$	-2.008***			-1.194**	
	(0.573)			(0.541)	
$LLP_{(t-2)}$	-1.654				-1.231
	(1.546)				(1.534)
Constant	77.209***	76.933***	74.574***	76.343***	76.420***
	(6.649)	(6.611)	(6.666)	(6.612)	(6.631)
Observations	7,928	7,928	7,928	7,928	7,928
R^2	0.215	0.212	0.210	0.210	0.210
Adjusted R^2	0.213	0.210	0.209	0.209	0.208

F Statistic	1,848***	1,804***	1,790***	1,790***	1,781***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 12. The role of instrument types on LRE – immediate and medium-term effects

	LRE (1)	LRE (2)	LRE (3)	LRE (4)	LRE (5)
	Full sample	LendStandRestrict	Levy.tax	Liquid.MM	LLP
LendStandRestrict	0.920**	0.868**			
	(0.419)	(0.416)			
Levy.tax	-0.153		-0.176		
	(0.240)		(0.235)		
Liquid.MM	0.563**			0.593**	
	(0.234)			(0.233)	
LLP	1.658*				1.467
	(0.906)				(0.904)
$LendStandRestrict_{(t-1)}$	0.508**	0.497**			
	(0.254)	(0.241)			
$Levy.tax_{(t-1)}$	-0.001		-0.020		
	(0.239)		(0.236)		
$Liquid.MM_{(t-1)}$	0.210			0.136	
	(0.240)			(0.237)	
$LLP_{(t-1)}$	0.987				0.979
	(0.713)				(0.712)
$LendStandRestrict_{(t-2)}$	0.564*	0.594**			
	(0.295)	(0.292)			
$Levy.tax_{(t-2)}$	-0.582***		-0.588***		
	(0.215)		(0.214)		
$Liquid.MM_{(t-2)}$	-0.023			-0.245	
	(0.213)			(0.198)	
$LLP_{(t-2)}$	-0.328				-0.395
	(0.568)				(0.564)
Constant	-117.241***	-115.958***	-116.858***	-116.185***	-116.326***

	(3.505)	(3.487)	(3.506)	(3.483)	(3.492)
Observations	7,928	7,928	7,928	7,928	7,928
R^2	0.380	0.378	0.378	0.378	0.377
Adjusted R^2	0.379	0.377	0.377	0.377	0.376
F Statistic	4,737***	4,701***	4,690***	4,694***	4,682***

Notations: Variables definitions in Table 1. LRE – Liquidity Risk Exposure; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning; *,** and *** denote significance at 10%, 5% and 1% levels, respectively

Table 13. The role of instrument types separately on LiquidADST – immediate and medium-term effects

	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST	LiquidADST
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	immediate effect	immediate effect	immediate effect	immediate effect	medium term – 1 year	medium term – 1 year	medium term - 1 year	medium term – 1 year	medium term - 2 yars	medium term - 2 yars	medium term - 2 yars	medium term - 2 yars
LendStandRestrict	-2.766**				-2.422***				-1.262*			
	(1.076)				(0.643)				(0.751)			
Levy.tax		0.440				-0.555				-1.857***		
		(0.643)				(0.644)				(0.586)		
Liquid.MM			0.959				0.074				-1.229**	
			(0.634)				(0.644)				(0.532)	
LLP				-4.957**				-2.923				-1.398
				(2.450)				(1.928)				(1.529)
Bank control variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Macroeconomic control variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.210	0.209	0.210	0.209	0.211	0.209	0.209	0.209	0.209	0.210	0.210	0.209
Adjusted R^2	0.208	0.208	0.208	0.208	0.209	0.208	0.208	0.208	0.208	0.209	0.208	0.208
F Statistic	1,783***	1,778***	1,782***	1,780***	1,794***	1,776***	1,779***	1,778***	1,779***	1,788***	1,781***	1,776***

Notations: Variables definitions in Table 1. LiquidADST- Liquid assets over deposits and short-term funding; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.

Table 14. The role of instrument types separately on LRE – immediate and medium-term effects

	LRE	LRE	LRE	LRE	LRE	LRE	LRE	LRE	LRE	LRE	LRE	LRE
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	immediate effect	immediate effect	immediate effect	immediate effect	medium term – 1 year	medium term – 1 year	medium term - 1 year	medium term – 1 year	medium term - 2 yars	medium term - 2 yars	medium term - 2 yars	medium term - 2 yars
LendStandRestrict	1.183***				0.537**				0.815***			
	(0.392)				(0.241)				(0.276)			
Levy.tax		-0.145				-0.115				-0.582***		
		(0.234)				(0.233)				(0.212)		
Liquid.MM			0.638***				0.171				-0.280	
			(0.230)				(0.233)				(0.195)	
LLP				1.614*				1.072				-0.367
				(0.899)				(0.706)				(0.563)
Bank control variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Macroeconomic control variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Observations	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928	7,928
R^2	0.378	0.377	0.377	0.377	0.377	0.377	0.377	0.377	0.377	0.378	0.377	0.377
Adjusted R^2	0.377	0.376	0.377	0.376	0.376	0.376	0.376	0.376	0.377	0.377	0.376	0.376
F Statistic	4,688***	4,680***	4,685***	4,679***	4,684***	4,676***	4,675***	4,678***	4,686***	4,688***	4,684***	4,675***

Notations: Variables definitions in Table 1. LRE – Liquidity Risk Exposure; LendStandRestrict - Lending standards restrictions; Levy_tax - Levies/taxes on financial institutions; Liquid_MM - Liquidity requirements and limits on currency and maturity mismatch; LLP - Loan loss provisioning; *,** and *** denote significance at 10%, 5% and 1% levels, respectively.