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Review of Economic Perspectives – Národohospodářský obzor
Vol. 21, Issue 3, 2021, pp. 259–290, DOI: 10.2478/revecp-2021-0012

The Impact of Seven Macroprudential Policy Instruments on Financial Stability in Six Euro Area Economies

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Abstract: The aim of this paper is to investigate whether macroprudential policy instruments can influence the credit growth rate and hence financial stability. We use a fixed effects panel regression model to test the following hypothesis for six euro area economies (Austria, Finland, Germany, Italy, Netherlands and Spain) during time span 2010 Q3 to 2018 Q4: "Macroprudential policy instruments (degree of maturity mismatch; interbank loans as a percentage of total loans; leverage ratio; non-deposit funding as a percentage of total funding; loan-to-value ratio; loan-to-deposit ratio; solvency ratio) enhance financial stability, as measured by credit growth". Our empirical results suggest that the degree of maturity mismatch, non-deposit funding as a percentage of total funding, loan-to-value ratio and loan-to-deposit ratio exhibit the predicted impact on the credit growth rate and therefore on financial stability. On the other hand, interbank loans as a percentage of total loans, leverage ratio, and solvency ratio do not exhibit the expected impact on the response variable. Since only four regressors (out of seven) have the signs predicted by our hypothesis, we can only partly confirm it.

Key words: Macroprudential policy, macroprudential instruments, systemic risk, financial stability.

JEL Classification: E58, G28, E60, E44

Received: 27 December 2020 / Accepted: 3 June 2021 / Sent for Publication: 9 September 2021

Introduction

The purpose of this paper is to investigate whether macroprudential policy instruments can influence the credit growth rate and hence financial stability. Macroprudential policy has gained in importance in the aftermath of the Global Financial Crisis and the Great Recession of 2007–2009. Against the backdrop of the crisis, the European capital, liquidity and risk regulation was overhauled and led to the enactment of the Capital Requirements Regulation (CRR, applicable as of 1 January 2014 and later CRR 2, applicable as of 28 June 2021) and the Capital Requirements Directive (CRD IV, applicable as of 1

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January 2014 and later CRD V, applicable as of 28 June 2021). A crucial realization of the policymakers in the fallout of the Great Recession was that monetary policy, microprudential policy, and fiscal policy do not possess a suitable toolkit required for the achievement of financial stability of the financial system as a whole. On that account, macroprudential policy landed in the limelight. Given that the research on appropriate macroprudential policy instruments, their interaction among themselves and with the instruments of other economic policies, suitable calibration of macroprudential instruments, etc. is relatively recent, there is still a substantial room for investigating and documenting evidence on how the usage of macroprudential policy instruments can improve financial stability of the financial system at large. Our paper is a contribution to this body of research.

Macroprudential policy is concerned with systemic risk, which is defined as »the risk that an event will trigger a loss of economic value or confidence in, and attendant increases in uncertainty about, a substantial portion of the financial system that is serious enough to quite probably have significant adverse effects on the real economy (Group of Ten, 2001).« There are three sources of systemic risk: Macroeconomic shocks which cause distress in the financial system; excessive leverage which leads to imbalances in the financial system; and increasing interconnectedness and herd behavior which exacerbates contagion risk (Constâncio, 2016). The formation of possible systemic risks in the financial system is monitored and countered with the usage of macroprudential policies. From the macroprudential perspective, for the soundness of the financial system as a whole it is not necessary nor sufficient that each individual institution is sound (Borio, 2011). What is important from the macroprudential perspective is the existence of correlated (common) exposures, diversification and pro-cyclicality (in other words, how system-wide risk can be magnified by interactions between the financial system and the real economy as well as by interactions within the financial system). The aim of macroprudential policy, tools, instruments and measures is therefore to build up capital and liquidity buffers in expansionary periods such that they can be drawn down in periods of financial distress. This dampens the pro-cyclicality of the financial system, which in turn improves financial stability (Borio, 2011). Financial stability is defined as a condition in which the financial system, consisting of markets, financial intermediaries and market infrastructures, does not yield to adverse impacts of shocks and financial imbalances (Borio, 2011; ECB, 2020a; Galati and Moessner, 2011). The first and foremost goal of macroprudential policy is achieving and maintaining financial stability (ECB, 2020a) by reducing systemic risk stemming from excessive procyclicality in the financial sector, from interconnections and other cross-sectional factors (Claessens, 2014). Macroprudential policy strives to ensure that the financial system does not magnify a downturn in the real economy (Aikman et al., 2019). Financial stability can be measured by, for instance, credit growth rate (credit to GDP gap); house price growth rate (house price index); cyclical fluctuations of the economy (deviation of real economic growth rate from its long-run trend rate of growth); systemic risk indicators; and with other variables.

Macroprudential policy instruments can be split into capital-based measures; liquidity-based measures; borrower-based measures, instrument-based measures and activity-based measures which restrict lending; restrictions on the financial sector balance sheet; taxation and levies; and additional disclosure requirements (ECB, 2020bc; Claessens, Ghosh and Mihet, 2013; Galati and Moessner, 2011; Ebrahimi Kahou and Lehar, 2017). Capital-based measures are, for instance, capital buffers for global systemically important

institutions and other systemically important institutions; countercyclical capital buffers to prevent the cyclical build-up of systemic risks; systemic risk buffers; and leverage restrictions. Liquidity-based measures are, for instance, liquidity coverage ratio and net stable funding ratio; and time-varying systemic liquidity surcharges (ECB, 2020bc; Claessens, Ghosh and Mihet, 2013). Borrower-based measures, instrument-based measures and activity-based measures which restrict lending are, for instance, mortgage limits at the level of an individual borrower; limits on large exposures; countercyclical change in risk weights for real estate exposures and intra-financial sector exposures; time-varying caps on debt-to-income ratio (DTI), loan-to-income ratio (LTI), loan-to-deposit ratio (LTD) and loan-to-value ratio (LTV); through-the-cycle valuation of margins or haircuts for repos; limits on lending to sectors; time-varying limits on credit growth; adjustments to specific loan-loss provisioning such as dynamic provisioning; and restrictions on asset composition and activities (Galati and Moessner, 2011; Ebrahimi Kahou and Lehar, 2017). Restrictions on the financial sector balance sheet are, for instance, time-varying limits on foreign exchange and interest rate mismatches; reserve requirements; and institution-specific limits on (bilateral) financial exposures. Taxation and levies are, for instance, taxes on specific assets and/or liabilities and levies on non-core liabilities (Claessens, Ghosh and Mihet, 2013; Galati and Moessner, 2011; Ebrahimi Kahou and Lehar, 2017).

For six euro area countries (Austria, Finland, Germany, Italy, Netherlands, and Spain) and time period 2010 third quarter to 2018 fourth quarter we investigate whether changes in certain macroprudential policy instruments (degree of maturity mismatch; interbank loans as a percentage of total loans; leverage ratio; non-deposit funding as a percentage of total funding; loan-to-value ratio; loan-to-deposit ratio; solvency ratio) enhance financial stability, measured by changes in credit growth rate (credit to GDP gap). We test the following hypothesis (H_1): "Macroprudential policy instruments (degree of maturity mismatch; interbank loans as a percentage of total loans; leverage ratio; non-deposit funding as a percentage of total funding; loan-to-value ratio; loan-to-deposit ratio; solvency ratio) enhance financial stability, as measured by credit growth". The choice of countries used in our empirical analysis was motivated by their size in terms of GDP (Germany, Italy, Spain and Netherlands are the biggest countries in the EU in terms of overall GDP); the usage of the euro (e.g. Poland, Sweden and Denmark are bigger than Finland in terms of GDP, but do not use the euro); availability of the data (we had to exclude France despite it being the second-biggest country in the EU in terms of overall GDP because certain data needed for the empirical analysis were missing); the north-south divide (Finland, Austria, Netherlands and Germany are known to be more austere, whereas Spain and Italy are more prone to spending); and being neighbours to our home country (Italy and Austria border on Slovenia).

Literature review

The impact of macroprudential capital buffers on financial stability

Meeks (2017) uses data for the UK and links capital requirements to house prices and mortgage spreads. The results of the study indicate that tighter macroprudential policy would have suppressed house price and mortgage lending growth in the early 2000s. A macroprudential rule that mechanically tracks the credit-to-GDP gap, as proposed by

the Basel Committee, produces greater fluctuations in credit than a rule which reacts to house price acceleration and mortgage spreads.

Similarly, Clancy and Merola (2017) empirically shed light on the effectiveness of countercyclical capital regulation in small open economies that do not have access to traditional stabilization mechanisms such as nominal interest rates and exchange rates (because of a pegged exchange rate regime or because of being members of the monetary union). The authors use data for the Irish economy and the recent housing crash episode. The results of the study indicate that a proactive use of the countercyclical capital regulation (as manifested in Basel III regulation) which responds to credit growth can smooth economic fluctuations and mitigate adverse effects of boom-boost cycles. If banks are required to build up capital buffers in times of economic boom, the damage from a subsequent contraction is attenuated.

In a comparable manner, Akram (2014) examines the effects of a certain macroprudential policy instrument (higher bank capital requirements, as set out in Basel III) on the Norwegian economy. The findings of the study indicate that changes in capital requirements first impact the lending rates, and through them other variables in the model, in particular house prices and credit growth. Moreover, the author empirically determines the optimal countercyclical capital buffer (CCyB) rate and duration (found to be at 2.5% and lasting for 1–12 quarters) in response to several shocks. The changes in the CCyB rate have a modest effect on output and inflation.

In the same vein, Gauthier, Lehar and Souissi (2012) define macroprudential capital requirements for individual Canadian banks such that each bank's capital requirement reflects its contribution to the risk of the entire system. The optimal levels of capital from a macroprudential perspective are found to deviate from the actual capital levels by as much as 25%. They are not strongly related to bank size, as measured by total assets. Macroprudential capital requirements decrease the default probabilities of individual banks as well as the probability of a systemic crisis by around 25%. Macroprudential capital requirements are found to be positively correlated with future losses in equity, as well as with future capital raises. The conclusion of the study is that macroprudential policy measures can significantly contribute to financial stability.

The impact of borrower-based macroprudential policy instruments on financial stability

Gadatsch, Mann and Schnabel (2018) recognize that the role of the central bank in macroprudential policy is of important consideration. They employ a new instrumental variable to assess the efficiency of macroprudential policy. Their results suggest that borrower-based macroprudential measures have had a statistically significant and strong dampening impact on credit growth in the European Union. These findings matter in particular against the backdrop of the growing precariousness of the European residential real estate market.

In a similar fashion, Gross and Población (2017) develop a micro-macro model framework to assess the efficacy of borrower-based macroprudential instruments, in particular loan-to-value (LTV) and debt-service-to-income (DSTI) ratio caps by using household survey data of four European countries. The simulation results suggest that the DSTI caps are more effective in reducing household risk. In particular, under DSTI policy, a lower

reduction in loan volumes is needed to achieve the same reduction in household sector loss rates (as compared to the reduction in loan volumes needed by using the LTV caps).

Similarly, Poghosyan (2020) investigates the effectiveness of macroprudential policy measures, such as loan-to-value (LTV) and debt-service-to-income (DSTI) ratios, in twenty-eight EU countries over the time span 1990–2018. The author evaluates the impact of select macroprudential instruments on house prices and credit for up to four years. The findings of the study demonstrate that there indeed is a significant impact of lending restrictions on house prices and credit: The maximum impact of -1.5% is reached after three years. When endogeneity is controlled for, the impact is even more pronounced and reaches -3.0% after three years. That said, the mentioned impact varies across types of measures taken and country groups.

Along the same lines, Richter, Schularick and Shim (2019) attempt to answer the question of whether, and to what extent, the usage of macroprudential policy instruments interferes with the primary goal of monetary policy to stabilize output and inflation. The authors shed light on the effect of changes in maximum loan-to-value (LTV) ratios on output and inflation. The results of the empirical analysis demonstrate that a ten-percentage point decline in the maximum LTV ratio engenders a 1.1-percentage point decrease in output over a four-year horizon; however, the effects are larger in emerging market economies. This impact is likened to the impact of a twenty-five basis points increase in the monetary policy interest rate. The impact of LTV changes on inflation is insignificant. Another finding of the paper is that the tightening of LTV limits has a more pronounced impact on the real economic variables than the loosening of LTV ratio rules. Changes in the maximum LTV ratio have substantial causal effects on house price appreciation and credit growth. The authors conclude that macroprudential policy does not substantially interfere with monetary policy.

Another similar study is that of Morgan et al. (2019) who examine the effectiveness of the loan-to-value (LTV) ratio on housing loans by using a sample of 46 countries and 4000 banks from these countries. The findings of the study are that the LTV policy successfully reduces mortgage loans (by 5.9% after one year). The usage of other macroprudential tools may have a complementary effect to LTV, in particular for large banks. The LTV policy is less effective for large banks and banks with a large portfolio of nonperforming loans. This finding is discouraging since housing loans should be reduced in precisely these two types of banks. Another macroprudential tool that is found to be statistically significant, are the limits on domestic currency loans – this tool reduces mortgage loans by 11.6% (after one year of the implementation of the measure).

Similarly, Kim and Oh (2020) analyze the effect of certain macroprudential policy instruments – in particular, the loan-to-value (LTV) and debt-to-income (DTI) ratios on macroeconomic and financial variables, such as commodity price index (CPI) and industrial production (IP), house prices, and household loans in Korea. The findings indicate that LTV and DTI changes have a substantial impact on all four aforementioned response variables, albeit the impact on house prices and household loans shows up faster. This effect is particularly strong when both LTV and DTI policies act in tandem.

A similar study is that of Nakatani (2020) who empirically examines the impact of a certain macroprudential policy instrument (loan-to-value (LTV) ratio) on the probability of a banking crisis and its interaction with other macroeconomic policies (monetary policy,

exchange rate regime, and capital controls). The impact of adjustments in the LTV ratio on the probability of a banking crisis is investigated with a probit model and by drawing on data encompassing 65 economies and the time span 2000–2006. The finding of the study is that the selected macroprudential policy (LTV cap) is able to influence the crisis probability via credit channel (credit growth). Moreover, the effectiveness of the LTV ratio is contingent on its interactions with other macroeconomic policies. Changes in the LTV cap seem to be able to influence the crisis probability in economies that are characterized by a floating exchange rate regime, inflation targeting, and/or no capital controls in place. Hence, coordination between monetary policy, macroprudential policy, exchange rate policy, and capital controls proves to be quite crucial in reducing the crisis probability.

Macroprudential policy in core versus peripheral EU countries or in different countries of a currency union

Rubio and Carrasco-Gallego (2016) analyze the optimal implementation of macroprudential policies in the euro area. In 2016, Spain was the only country in the eurozone without a macroprudential regulator. Hence, the authors use Spain to study incomplete coordination in the use of macroprudential policies in the euro area. The macroprudential policy the authors focus on is the countercyclical loan-to-value ratio which is set such that it responds to credit deviations from the steady state. The results of the study indicate that the implementation of the countercyclical loan-to-value ratio enhances welfare and promotes financial stability. Macroprudential policies alleviate credit booms resulting from expansionary shocks. In expansionary periods, the LTV ratio is reduced, hence lowering the amount of the loan which can be taken out for a given appraised property value, or, equivalently, increasing the required down payment for a given appraised property value.

Similary, Badarau, Carias and Figuet (2020) use a small two-country model with financial frictions to illustrate that macroprudential policies in core economies can have, through interbank lending, destabilizing spillover effects on a financially dependent periphery. Another policy is tested where the core regulator internalizes these negative spillover effects if the counterpart in the financially dependent periphery can no longer absorb it. The findings suggest that internalization of the spillover effects is preferable to national rules under certain conditions. The countercyclical capital buffer is the most discussed macroprudential policy tool, however, there are also other instruments such as dynamic limits on the loan to value ratio which may enable a wider stabilization margin. That said, there is no harmonizing legislative framework for these instruments in the Capital Requirements Directive (CRD IV) and the authority over such additional tools remains national.

In a similar fashion, Brzoza-Brzezina, Kolasa and Makarski (2015) empirically examine if macroprudential policy (in particular, changes in the loan-to-value (LTV) ratio) in the peripheral euro area countries could enhance macroeconomic stability in the same countries. The findings of the study indicate that macroprudential policy can significantly reduce credit and output volatility in peripheral euro area countries. When the maximization of household welfare is taken as the criterion for optimal macroprudential policy, similar conclusions are reached. For macroprudential policy to be efficient as a stabilizing tool and to prevent desynchronization of financial cycles between the core and the peripheral euro area economies, it should be applied in a decentralized manner (instead of uniformly in both the core and the periphery).

In a comparable manner, Palek and Schwanebeck (2019) investigate the optimal macroprudential and monetary policy mix in a currency union in the presence of idiosyncratic and aggregate shocks. The findings suggest that when the same macroprudential policy instrument is implemented across the entire currency union, the economy as a whole is stabilized, but there are costs to be incurred in the form of welfare losses. When different countries in a currency union implement different macroprudential tools, the shocks can be fully dealt with, but not in an optimal manner.

The implications of different macroprudential regulation in home and foreign economies (between domestic banks in the home economy and branches of foreign banks in the home economy)

Rubio (2020) considers a two-country DSGE model with housing and credit constraints to study an increase in bank flows to those banks with lower regulatory levels, known as "leakage". This happens due to a lack of reciprocity of macroprudential instruments between domestic banks in the domestic economy and foreign banks in the domestic economy and leads to less effective macroprudential policies, thereby compromising financial stability. In the study, macroprudential policies are represented by the countercyclical loan-to-value ratios. The findings suggest that financial stability and welfare gains are larger when there exists a reciprocity agreement on macroprudential policy across countries. Reciprocity mechanisms are needed for optimal effectiveness of macroprudential policy, although the severity of macroprudential rules implemented by the foreign lenders in the domestic economy does not need to be as high as the one implemented by domestic lenders, since borrowers prefer domestic lenders.

In the same vein, Reinhardt and Sowerbutts (2015) examine whether macroprudential regulations have an impact on international banking flows. The findings of the study suggest that when the home macroprudential authority takes a capital action, the domestic non-bank institutions start borrowing more from foreign banks. This implies that different stringencies of capital regulation (stricter for domestic banks) give foreign banks regulated by their home authorities a competitive advantage. On the other hand, when the home macroprudential authority tightens lending standards (by placing more stringent limits on the loan-to-value ratios for house purchases), the domestic non-bank institutions do not borrow more from foreign banks. Foreign banks increase their lending to those host countries which have tighter macroprudential regulation in place, but only if these stricter rules do not apply to them. The findings of the study give some food for thought for international reciprocation of macroprudential rules, as well as for the choice and calibration of macroprudential policy instruments.

Similarly, Dumičić (2018) investigates the effectiveness of macroprudential policies in the Central and Eastern European (CEE) countries in attenuating financial stability risks stemming from excessive credit growth. The findings demonstrate that macroprudential policies were more effective in weakening the flow of credit to households than the flow of credit to the non-financial corporate sector prior to the global financial crisis with the onset in 2007. This is predominantly because the non-financial corporate sector had access to not only domestic bank credit, but also to non-bank and cross-border credit. The conclusion of the paper is that some international cooperation among policymakers is warranted so as to align macroprudential policies and prevent "regulatory arbitrage" – the

circumvention of stricter regulation in one jurisdiction and the exploitation of laxer laws in another jurisdiction.

Could macroprudential policy framework have prevented the Global Financial Crisis of 2007?

Aikman et al. (2019) argue that a robust macroprudential policy regime might have prevented the last financial crisis. A macroprudential framework with a stringent mandate and powers to adjust financial system leverage and maturity/liquidity transformation as well as to limit household sector indebtedness could have substantially weakened the negative macroeconomic effect ensuing from the bursting of the real estate bubble in the last financial crisis. Especially three factors made the last financial crisis so calamitous: Excessive indebtedness in the household sector, an increase in short-term funding sources (relative to the amount of stable, long-term funding sources) at financial institutions, and an increase in leverage at financial intermediaries. These vulnerabilities can explain between two thirds and three quarters of the fall in the United States' GDP which occurred as a result of the financial crisis.

Similarly, Houben and Kakes (2013) investigate the interactions of financial imbalances and macroeconomic policies in the countries that joined the European Monetary Union (EMU) in 1999 or shortly thereafter. They establish that country-specific imbalances came to the fore once the EMU was set up. Since economic conditions in the EMU countries differed, the uniform monetary policy exacerbated these differences and potential vulnerabilities. The researchers argue that national macroprudential policies are required to mitigate financial imbalances and divergences in national financial cycles in individual countries constituting a currency union. Suitable macroprudential policies might have been able to alleviate or prevent the recent financial crisis by bolstering the financial system's solvency, stability and resilience to systemic shocks.

Interactions between macroprudential and monetary policy: Should financial stability strictly be the prerogative of macroprudential policy and price stability strictly the prerogative of monetary policy or should these two goals and policies overlap?

Agénor and Pereira da Silva (2014) construct a model to analyze the interactions between macroprudential policy (involving reserve requirements) and monetary policy. A change in reserve requirements has an impact on many factors (e.g. strength of the cost channel, strength of the wealth and interest rate effect on aggregate demand, response of monetary policy to the level of inflation) which affect excess demand (hence inflationary pressure). In the long run, the impact of a change in the reserve requirement ratio may be contradictory – lower reserve requirements may actually reduce excess demand, thereby reducing the inflation rate. Understanding the operation of macroprudential policy tools is of utmost importance, since they may affect the monetary transmission, thereby interfering with monetary policy.

Similarly, Tayler and Zilberman (2016) shed light on the roles of macroprudential policy and monetary policy in a model with financial frictions, such as credit risk, bank losses and bank capital costs. In the presence of credit shocks, macroprudential countercyclical regulation is found to be more effective than monetary policy in achieving price, financial and macroeconomic stability. In this setting, the unfavorable procyclical spillover

consequences of a financial shock are completely eliminated by a countercyclical response to credit risk which restores the equilibrium price of credit. In the face of supply shocks, a combination of macroprudential regulation with monetary (anti-inflationary) policy proves to be the most efficient. In this setting, a countercyclical response to credit risk makes it possible for the policymaker to resist supply shocks, but not to eliminate them altogether. The source of economic shocks thus first needs to be identified for the policymakers to be able to make the right decisions about macroprudential and monetary policy response. The results of the study lead us to believe that the macroprudential provisions of Basel III standards are needed and effective in moderating the output-inflation trade-off.

In a comparable fashion, Greenwood-Nimmo and Tarassow (2016) investigate the impacts of monetary and macroprudential shocks on financial fragility, measured as credit extension (credit to GDP ratio) and as the financial ratio (ratio of corporate credit to internal funds). The findings of the study show that a contractionary monetary shock exacerbates financial fragility by increasing the credit to GDP ratio as well as by increasing the ratio of corporate credit to internal funds. On the other hand, a credit-constraining macroprudential shock in isolation (if interest rates are free to adjust to the macroprudential shock) reduces the credit to GDP ratio in the short run but does not reduce the financial ratio. However, if macroprudential policy is not used in isolation (if interest rates are not free to adjust to the macroprudential shock), both the credit to GDP ratio and the financial ratio significantly decline. In light of these findings, it can be concluded that a combination of monetary and macroprudential policies may be most suitable for attaining financial stability.

Another similar study is that of Kiley and Sim (2017) who employ a quantitative model to shed light on the interaction of monetary and macroprudential policies. The findings of the empirical analysis are that monetary policy should react strongly to differences in credit spreads, as it can only partially insulate the economy from the negative effects of financial shocks. On the other hand, optimal macroprudential policy (leverage tax according to Ramsey) can increase welfare and stabilize macroeconomic activity in the face of financial shocks to intermediation. Certain financial shocks are better suited to monetary stabilization (notably risk premium and natural rate of interest shocks), whereas others are more amenable to the macroprudential approach (in particular shocks to intermediation, as captured by volatility shocks). Both types of shocks are relevant for credit spread fluctuations; however, the shocks to intermediation are less relevant for economic fluctuations, implying that the effectiveness of simple macroprudential rules is constrained.

In a similar vein, Klingelhöfer and Sun (2019) use the case of China to demonstrate that reserve requirements, supervisory pressure and housing-market policies can be employed for macroprudential purposes. Their empirical results show that selected macroprudential policy measures have a clear-cut effect on credit, but no significant impact on output. Macroprudential policy may be employed to maintain financial stability without a reduction in economic activity, or as a supplement to monetary policy to alleviate the build-up of financial vulnerabilities which are a side effect of expansionary monetary policy. A multi-instrument framework is optimal since a mix of macroprudential and monetary policy seems to be best placed to attain both financial stability and price stability/macroeconomic stability objectives.

Similarly, Bruno, Shim and Shin (2017) investigate the effectiveness of macroprudential policies in twelve Asia-Pacific economies over the time span 2004–2013 by drawing on macroprudential and capital management flow (CFM) data. The findings of the study demonstrate that the banking sector and bond market CFM tools have a positive effect on reducing the growth in bank inflows and bond inflows. Another finding of the study is that macroprudential policies (banking inflow measures) are more effective in slowing down cross-border lending when they act in tune with monetary policy, contributing to monetary tightening, than when both policies pull in opposite directions. This is consistent with the fact that when macroprudential and monetary policy work in opposite directions, economic agents are receiving contradictory signals – they are simultaneously told to borrow more and to borrow less.

Along the same lines, Rubio and Carrasco-Gallego (2014) examine the effects of macroprudential and monetary policy implementation on business cycles, welfare, and financial stability. The empirical results suggest that the stability of a system is enhanced when both macroprudential and monetary policy act in a coordinated way (as opposed to when they act in a non-coordinated manner). In the face of a technology or housing demand shock, the macroprudential authority would reduce the LTV cap so as to rein in the credit boom, thereby attaining its ultimate goal of financial stability. The interaction between both policies improves the welfare of the society (in particular when both policies act in a non-coordinated manner). There is, however, a trade-off in welfare between borrowers and savers in the non-coordinated game. This notwithstanding, the savers' welfare loss can be offset by the borrowers to attain a Pareto-superior result.

Similarly, Rubio and Comunale (2018) examine the impact of macroprudential policies in a monetary union on macroeconomic and financial stability in Lithuania and in the rest of the euro area. Two different macroprudential policy frameworks are considered in the model: One where the ECB includes financial stability into its policy goals; and another one where a national macroprudential authority uses a certain macroprudential policy instrument (the loan-to-value (LTV) ratio). Both policy frameworks prove to be effective in increasing the resilience of the financial system. When financial stability is included in ECB's policy goals, inflation volatility increases. On the other hand, the LTV rule does not lead to higher inflation volatility. As such, having two different instruments for two different policy goals is a better choice from the cost-benefit perspective.

An opposing view is held by van den End (2016) who criticizes the position of the European Central Bank (ECB) and the Federal Reserve (Fed) that price stability is the primary goal of monetary policy and quantitative easing (QE), whereas financial stability is secondary and addressed by macroprudential policy. van den End (2016) in his paper argues that financial stability should not be separated from monetary policy as manifested through Quantitative Easing. Regression analysis for a set of eleven countries demonstrates that a decline in equity prices and an increase in corporate bond rates lead to a decrease in the inflation rate. Hence, liquidity-driven booms can have an adverse impact on inflation, which is an argument for taking into consideration asset bubbles when designing monetary policy. Since asset bubbles harm both financial stability and inflation, asset price developments and financial stability concerns should be accounted for in the conduct of QE and hence in the conduct of monetary policy.

Data, Hypothesis and Methodology

Data and variables

All the data used in our empirical analysis were retrieved from the Statistical Data Warehouse of the European Central Bank (SDW, 2020a), henceforth ECB SDW, apart from the data on the loan-to-value ratio, which were retrieved from the Integrated Macroprudential Policy Database of the International Monetary Fund (IMF, 2020), henceforth IMF iMaPP, and apart from the data on the unemployment rate and GDP, which were retrieved from Eurostat (Eurostat, 2021).

The following explanatory variables, representing macroprudential policy instruments, are employed in our model:

- *DMM = degree of maturity mismatch*, measured as the degree to which bank's short-term liabilities exceed its short-term assets.
- *INL = interbank loans as a percentage of total loans,* measured as interbank loans divided by total loans.
- *LR = leverage ratio*, measured as total assets divided by total equity.
- *NDF = non-deposit funding as a percentage of total funding*, measured as the non-deposit funding, divided by the total funding.
- *LTV = loan-to-value ratio;* measured as the amount borrowed, divided by the appraised value of the property.
- *LDR = loan-to-deposit ratio;* measured as total amount of loans, divided by total amount of deposits.
- *SR = solvency ratio;* measured as total own funds, divided by risk-weighted assets.

Additionally, we introduce four supplementary control variables to our model in order to account for the differences among countries with regard to their economic development (proxied by the unemployment rate and GDP growth rate), financial stress, and borrowing costs for households:

- *CLIFS = country-level index of financial stress.* The CLIFS includes six, mainly market-based, financial stress measures that capture three financial market segments: Equity markets, bond markets and foreign exchange markets. In addition, when aggregating the sub-indices, the CLIFS takes the co-movement across market segments into account (SDW, 2020b; Duprey, Klaus and Peltonen, 2015).
- *BCH = total cost of borrowing to households for house purchase* (interest rate; percent per annum; the total is calculated by weighing the volumes with a moving average defined for the cost of borrowing purposes).
- *UNR = unemployment rate.*
- *GDP = quarterly growth rate of the gross domestic product.*

The following response variable, representing financial stability, is used in our model:

- CGR = *credit growth rate,* measured by a domestic credit-to-GDP gap.

Our model is applied to six euro area countries (Austria, Finland, Germany, Italy, Netherlands and Spain) and thirty-four quarters (2010 Q3 to 2018 Q4).

Hypothesis and the expected relationship between explanatory variables and the response variable

We test the following hypothesis (H_1): "Macroprudential policy instruments (degree of maturity mismatch; interbank loans as a percentage of total loans; leverage ratio; non-deposit funding as a percentage of total funding; loan-to-value ratio; loan-to-deposit ratio; solvency ratio) enhance financial stability, as measured by credit growth."

A high degree of maturity mismatch in banking can lead to financial stability concerns. A maturity mismatch occurs when the maturities of banks' assets and liabilities differ. An increase in mortgage lending has led to exacerbated maturity mismatches since banks prefer to acquire short-term liabilities (funding sources) at a lower cost and subsequently extend loans with longer maturities (e.g. mortgages) which are entered on the assets side of the balance sheet (Jorda et al., 2014). Long-term loans bring in a higher return than what banks pay for short-term funding sources (supposing that the yield curve is normal), implying that a maturity mismatch may increase banks' net interest margins (Goodhart and Perotti, 2015a). However, such an increase in profitability owing to reliance on cheaper short-term funding simultaneously engenders a higher exposure to liquidity risk and potentially substantial losses in a liquidity crisis (Perotti and Suarez, 2011). The last Great Financial Crisis of 2007 was partly due to excessive amounts of unstable funding for illiquid assets (Goodhart and Perotti, 2015b). Therefore, it is not just adequate capitalization of banks that contributes to financial stability; another aspect is adequate measuring and managing of the level of banks' liquidity and their resilience to liquidity shocks. In the aftermath of the Great Financial Crisis of 2007, the Basel Committee on Banking Supervision (henceforth BCBS) acknowledged the need to contain the excesses of maturity transformation, the result of which was the creation of two new liquidity standards – LCR (liquidity coverage ratio to control short-term liquidity risk) and NSFR (net stable funding ratio to monitor structural resilience). While we do not introduce LCR and NSFR to our empirical model due to insufficiently long time series for these two ratios, we do use DMM – degree of maturity mismatch and NDF – non-deposit funding expressed as a percentage of total funding as two of our explanatory variables. A high degree of maturity mismatch indicates that a bank has more short-term liabilities (cheap funding sources) than short-term assets and more long-term assets (mortgages and other loans extended to customers) than long-term liabilities, implying that the bank is trying to increase its net interest margin at the expense of higher liquidity risk and potential losses in a liquidity crisis. Likewise, a high percentage of non-deposit funding in the total funding sources of a bank indicates that a bank is striving to expand its balance sheet at the expense of maturity mismatches, higher liquidity risk and greater dependence on market conditions. *We assume that an increase in DMM will have a positive effect on credit growth, thereby compromising financial stability. Moreover, we presume that an increase in non-deposit funding expressed as a percentage of total funding (NDF) will have a positive effect on credit growth, thereby endangering financial stability.*

Another macroprudential policy instrument that we have decided to include in our analysis are interbank loans expressed as a percentage of total loans (INL). The higher the INL ratio, the more likely a common shock to banks' external assets or liabilities will have systemic repercussions (i.e., will not stay with just one bank, but will be transferred also to other banks in the system). The lower the INL ratio, i.e. the less lending among banks and the more diversified banks' portfolios, the lower the likelihood and the strength of

the propagation of contagion (Roncoroni et al., 2019). *We suppose that an increase in the INL ratio will have a positive effect on credit growth, thereby undermining financial stability.*

From mid-2021, the amended EU regulation sets forth a binding leverage ratio, which is a non-risk-based measure of banks' assets in relation to capital. The amount of an institution's Tier 1 capital base needs to amount to at least 3% of its non-risk-weighted assets ("exposure measure", which is a sum of on-balance sheet exposures, derivative exposures, securities financing transactions, and off-balance sheet items)[3]. On top of that, the global systemically important institutions (G-SIIs) will need to maintain an additional leverage ratio buffer. The purpose of the leverage ratio is to provide a backstop to the risk-based measures and to prevent excessive leverage from building up. It does not distinguish one asset class from another (Linklaters LLP, 2019ab). We have decided to employ the leverage ratio as one of the macroprudential policy instruments for which we are interested in its impact on financial stability. This is because the banks have already been reporting it for some years now despite the fact that it is not yet binding. Moreover, it is one of the few measures which do not depend on the risk-weighted assets, but simply on assets without having risk weights applied to them. *Our conjecture is that an increase in the leverage ratio (measured as total assets divided by total equity) will have a positive impact on credit growth, thereby compromising financial stability.*

The most widespread macroprudential policy tools, which have existed already prior to the development of Basel III, CRR and CRD IV standards and legal requirements, are the loan-to-value (LTV) caps and debt-to-income (DTI) or debt-service-to-income (DSTI) caps. LTV ratio limits the amount of the loan relative to the value of the property. The DSTI ratio limits the debt servicing cost relative to the borrower's disposable income (Szpunar, 2017). The LTD ratio (henceforth LDR) limits the amount of the loans which can be extended for each unit of currency of deposits. If the LDR is excessively high, a bank may not have sufficient liquidity in the event of loan defaults in a period of financial distress. These tools predominantly impact the supply and demand for mortgages. We have decided to introduce the LTV ratio and the loan-to-deposit ratio (LDR) as our borrower-based explanatory variables since sufficiently long time series exist for these variables, and because many papers which we have reviewed use precisely these macroprudential policy instruments to study the effect of changes in them on financial stability. *We expect that an increase in the LTV ratio will have a positive effect on credit growth, thereby undermining financial stability. Furthermore, we presume that an increase in the LDR will have a positive effect on credit growth, thereby compromising financial stability.*

The Basel III rules, which are, by and large, transposed into the EU legislative requirements, introduced new macroprudential instruments in 2013, such as a countercyclical capital buffer (CCyB), which limits the build-up of systemic risk in an expansionary period (Szpunar, 2017). Other buffers, which need to be met with CET1 capital, are systemic risk buffer (SRB), global systemically important institutions buffer (G-SII buffer), other

[3] In our analysis we actually use a more traditional definition of the leverage ratio (i.e., total assets divided by total equity), but the general idea is the same. We use the traditional definition of the leverage ratio because the time series for the leverage ratio which uses the new definition (Tier 1 capital divided by exposure measure) is not yet long enough.

systemically important institutions buffer (O-SII buffer), and capital conservation buffer (CCoB). Moreover, higher CET1 ratios, and by extension higher solvency ratios (SR), can also be seen as a macroprudential policy instrument, since supervisory authorities in the EU (the national supervisory authorities and the European Central Bank) in the Pillar 2 supervisory review process set capital requirements for individual banks in the EU by considering their individual risk profiles and stress test results after having conducted a peer-comparison and considered micro- and macro-prudential indicators. *We assume that an increase in solvency ratio (SR) will have a negative effect on credit growth, thereby enhancing financial stability.*

While the remaining four explanatory variables (CLIFS – country-level index of financial stress; BCH – total cost of borrowing to households for house purchase; UNR – unemployment rate; and GDP – quarterly growth rate of the gross domestic product) are not macroprudential policy instruments, the corollary of which is that they are not particularly relevant for the topic of this paper (but are solely used to explain the differences among countries and to improve the explanatory power of our model), we will nonetheless explain our reasoning behind their expected impact on the response variable. The CLIFS includes market-based, financial stress measures that capture three financial market segments: Equity markets, bond markets and foreign exchange markets (SDW, 2020b; Duprey, Klaus and Peltonen, 2015). *We suppose that an increase in the country-level index of financial stress (CLIFS) will have a negative effect on credit growth.* Regarding BCH – total cost of borrowing to households for house purchase, we assume that when the borrowing costs increase, the demand for mortgages declines (however, banks may be more eager to extend loans and earn a higher net interest margin). *Thus, we assume that an increase in the total cost of borrowing to households for house purchase (BCH) will have a negative effect on credit growth.* Regarding UNR – unemployment rate, we suppose that when more people in the active population are jobless, their ability to take out a loan declines (since they have no steady source of income and would thus not be able to pay the mortgage instalments). *As such, we assume that an increase in the unemployment rate will have a negative impact on credit growth.* Regarding GDP – quarterly growth rate of the gross domestic product, our conjecture is that a higher GDP growth rate signifies that the economy is expanding, therefore the demand for credit by households and corporations should be higher. *Hence, we presume that an increase in the quarterly GDP growth rate will have a positive impact on credit growth.*

The expected impact of an increase in individual explanatory variables on the credit growth rate and on financial stability is depicted in Table 1.

Table 1. The expected impact (positive or negative) of a unit increase in individual explanatory variables on credit growth rate and on financial stability and the expected signs of regression coefficients

Explanatory variable experiencing a one-unit increase	Impact on CGR (expected sign of the regression coefficient)	Impact on financial stability
DMM	+	-
NDF	+	-
INL	+	-
LR	+	-
LTV	+	-
LDR	+	-
SR	-	+
CLIFS	-	/
BCH	-	/
UNR	-	/
GDP	+	/

Notes: A plus (+) implies a positive impact; whereas a minus (-) stands for a negative effect. Slash (/) indicates that the variable does not belong to macroprudential policy instruments and that the impact of a change in this variable on financial stability is not known, may not be relevant, and/or we cannot opine on it.

Methodology

In order to test our hypothesis (H_1: *"Macroprudential policy instruments (degree of maturity mismatch; interbank loans as a percentage of total loans; leverage ratio; non-deposit funding as a percentage of total funding; loan-to-value ratio; loan-to-deposit ratio; solvency ratio) enhance financial stability, as measured by credit growth."*), we employ a quantitative research method of panel econometrics. Panel regression renders it possible to study variables having both the space dimension (in our case several economies) as well as the time dimension (in our case several quarters). This research method controls for the omitted variables, alleviates the problem of collinearity among the explanatory variables, dismisses heterogeneous effects, and may reduce the measurement errors and endogeneity bias by including the lags of the regressors. The problem of spurious regression can be circumvented by using the differences of the variables expressed as percentage changes (Festić, 2015; Festić, Kavkler and Repina, 2011; Hahn and Hausman, 2002; Murray, 2006). We use the fixed effects panel regression model for the following reasons (Gujarati, 2003; Allison, 2009; Hsiao, 1985; Wooldridge, 2010): We assume that the differences between various economies and/or quarters can be accommodated by introducing a different intercept, whereas the slope coefficients remain constant. The combination of time series and cross-section observations gives us less collinearity among variables, more variability, more degrees of freedom, more efficiency, and more informative data. Panel data can better detect effects that cannot be identified in data with only one dimension. Panel regression was used to study economic developments in a group of countries over a certain time period by, for instance, Zimčík (2016), Kubík (2010), Mészáros and Kiss (2020), Yilmaz and Koyuncu (2019), and Macek (2014). We assume that the

individual, or cross-section specific, error component (unobserved effect) ε_i, and one or more regressors DMM, INL, LR, NDF, LTV, LDR, SR, CLIFS, BCH, UNR and GDP may be correlated. In this case, the estimates obtained from the fixed effects model are unbiased (whereas those obtained from the random effects model would be biased).

The estimation of our models (1)(2)(3) is in line with the assumptions we make about the intercept, the slope coefficients, and the error term, u_{it} (Gujarati, 2003). Since we expect to see some differences in the data across countries and through time, we will assume that the slope coefficients are constant but the intercept varies over individuals (1) or time (2) or both (3). As such, we will introduce thirty-three time dummies (one dummy less than the number of quarters) where, for instance, Dum17_3 takes a value of 1 for observation in the third quarter of the year 2017 and 0 otherwise, and similarly for the rest of the dummies and quarters. We take the fourth quarter of the year 2018 as the base quarter with the intercept of λ_0. We also introduce differential intercept dummies to allow for the fixed effect intercept to vary across countries. For instance, D_{SPA_i} = 1 if the observation belongs to Spain, and otherwise 0. In order to avoid the situation of perfect collinearity, we only use thirty-three dummy variables, that is one less than the number of quarters (which is thirty-four). There is no dummy for observations belonging to country Austria (α_1 represents the intercept of Austria). $\alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$ are differential intercept coefficients which indicate by how much the intercepts of FIN = Finland, GER = Germany, ITA = Italy, NET = Netherlands, and SPA = Spain differ from the intercept of AUS = Austria. Austria is thus our comparison country. For our model to be correctly specified, the country dummies, the time dummies and the coefficients of DMM, INL, LR, NDF, LTV, LDR, SR, CLIFS, BCH, UNR and GDP would need to be statistically significant (Gujarati, 2003).

CROSS-SECTION FIXED EFFECTS MODEL

$$\begin{aligned} CGR_{it} = {} & \alpha_1 + \alpha_2 D_{FIN_i} + \alpha_3 D_{GER_i} + \alpha_4 D_{ITA_i} + \alpha_5 D_{NET_i} + \alpha_6 D_{SPA_i} \\ & + \beta_2 DMM_{it} + \beta_3 INL_{it} + \beta_4 LR_{it} + \beta_5 NDF_{it} \\ & + \beta_6 LTV_{it} + \beta_7 LDR_{it} + \beta_8 SR_{it} + \beta_9 CLIFS_{it} \\ & + \beta_{10} BCH_{it} + \beta_{11} UNR_{it} + \beta_{12} GDP_{it} + u_{it} \end{aligned} \qquad (1)$$

where AUS = Austria; FIN = Finland, GER = Germany, ITA = Italy, NET = Netherlands, SPA = Spain;
i = ith cross-sectional unit;
t = tth time period;
α_1 = intercept of Austria;
D = differential intercept dummy;
$\alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$ = differential intercept coefficients;
u_{it} = error term;
$DMM, INL, LR, NDF, LTV, LDR, SR, CLIFS, BCH, UNR\ and\ GDP$ = explanatory variables;
CGR = response variable.

PERIOD FIXED EFFECTS MODEL

$$CGR_{it} = \lambda_0 + \lambda_1 Dum_{10_3} + \lambda_2 Dum_{10_4} + \cdots + \lambda_{33} Dum_{18_3} + \beta_2 DMM_{it} + \beta_3 INL_{it} + \beta_4 LR_{it} + \beta_5 NDF_{it} + \beta_6 LTV_{it} + \beta_7 LDR_{it} + \beta_8 SR_{it} + \beta_9 CLIFS_{it} + \beta_{10} BCH_{it} + \beta_{11} UNR_{it} + \beta_{12} GDP_{it} + u_{it} \quad (2)$$

where Dum = time dummy.

CROSS-SECTION FIXED EFFECTS AND PERIOD FIXED EFFECTS MODEL

$$CGR_{it} = \alpha_1 + \alpha_2 D_{FIN_i} + \alpha_3 D_{GER_i} + \alpha_4 D_{ITA_i} + \alpha_5 D_{NET_i} + \alpha_6 D_{SPA_i} + \lambda_0 + \lambda_1 Dum_{10_3} + \lambda_2 Dum_{10_4} + \cdots + \lambda_{33} Dum_{18_3} + \beta_2 DMM_i + \beta_3 INL_i + \beta_4 LR_i + \beta_5 NDF_i + \beta_6 LTV_i + \beta_7 LDR_i + \beta_8 SR_i + \beta_9 CLIFS_i + \beta_{10} BCH_i + \beta_{11} UNR_{it} + \beta_{12} GDP_{it} + u_{it} \quad (3)$$

We test the stationarity of the time series with an Augmented Dickey-Fuller test (ADF test) where:

H_0: $\delta = 0$; there is a unit root; the time series is non-stationary.

H_1: $\delta \neq 0$; there is not a unit root; the time series is stationary.

The H_0 is rejected if $p < 0.05$ (significant at 5%).

In order to determine if fixed effects are present in our model, we use the "redundant fixed effects test" where:

H_0: The fixed effects are redundant.

H_1: Fixed effects are present in the model.

The H_0 is rejected if $p < 0.05$ (significant at 5%).

Results and Discussion

All our explanatory variables as well as the response variable are stationary at the first difference ($p < 0.05$, hence H_0 is rejected; the unit root is not present; the time series is stationary), but most of them are not stationary at level (Table 2). Since the linear combination of the series in a regression analysis should be at the highest order of integration, all our time series are integrated of order one, i.e. I(1). To denote that all variables are taken at the first difference for stationarity, all regressors and the regressand have a "D" in front of their name (e.g. CGR becomes DCGR; CLIFS becomes DCLIFS and so forth for the rest of the variables) in Table 3. We tried introducing lags and the logarithmic form to our models; however, those models proved to be less statistically significant and less robust than the models we present in this paper.

Table 2. Unit root test (Fisher ADF-test)

Response and explanatory variables	Level (x) ADF-Fisher Chi-square statistic (ADF-Fisher Chi-square probability)	First difference d(x) ADF-Fisher Chi-square statistic (ADF-Fisher Chi-square probability)
CGR	24.4016 (0.0179)	69.9105 (0.0000)
CLIFS	46.8881 (0.0000)	101.466 (0.0000)
DMM	2.22430 (0.9990)	51.4455 (0.0000)
INL	18.2151 (0.1093)	109.090 (0.0000)
LR	11.5974 (0.4785)	60.0722 (0.0000)
NDF	14.7617 (0.2547)	73.2002 (0.0000)
LTV	0.37028 (0.9848)	38.9251 (0.0000)
BCH	2.94476 (0.9959)	40.3715 (0.0001)
LDR	10.2787 (0.5915)	95.2010 (0.0000)
SR	6.46343 (0.8909)	72.6688 (0.0000)
GDP	49.5418 (0.0000)	139.711 (0.0000)
UNR	17.9229 (0.1181)	59.5057 (0.0000)

Notes: P-values for the Fisher-ADF panel unit root test are computed using the asymptotic Chi-square distribution and given in brackets. The maximum number of lags was automatically selected with Schwarz Information Criterion.

Empirical results, set out in Table 3, indicate that cross-section fixed effects, period fixed effects, as well as cross-section fixed effects and period fixed effects together are present in our model since the F probability of the redundant fixed effects test for each of the models is less than 0.05. Fixed effects are present in the model where the intercept varies

over individual countries (cross-section fixed effects model); where the intercept varies over time (period fixed effects model); and where the intercept varies both over individual countries and over time (cross-section fixed effects and period fixed effects model). The slope coefficients are constant in all models.

Regarding our hypothesis, H_1, which states that (Table 1):

- an increase in CLIFS has a negative effect on CGR,
- an increase in DMM has a positive effect on CGR,
- an increase in INL has a positive effect on CGR,
- an increase in LR has a positive effect on CGR,
- an increase in NDF has a positive effect on CGR,
- an increase in LTV has a positive effect on CGR,
- an increase in BCH has a negative effect on CGR,
- an increase in LDR has a positive effect on CGR,
- an increase in SR has a negative effect on CGR,
- an increase in GDP has a positive effect on CGR,
- an increase in UNR has a negative effect on CGR,

we can only partially confirm it, given that the results of our empirical model (Table 3) indicate that:

- an increase in CLIFS has a positive effect on CGR (this impact rebuts our prediction; however, it is not relevant for our hypothesis, since CLIFS is not a macroprudential policy instrument),
- an increase in DMM has a positive effect on CGR (thus confirming our hypothesis),
- an increase in INL has a negative effect on CGR (thus rejecting our hypothesis),
- an increase in LR has a negative effect on CGR (thus rejecting our hypothesis),
- an increase in NDF has a positive effect on CGR (thus confirming our hypothesis),
- an increase in LTV has a positive effect on CGR (thus confirming our hypothesis),
- an increase in BCH has a negative effect on CGR (this impact corroborates our prediction; however, it is not relevant for our hypothesis, since BCH is not a macroprudential policy instrument),
- an increase in LDR has a positive effect on CGR (thus confirming our hypothesis),
- an increase in SR has a positive effect on CGR (thus rejecting our hypothesis),
- an increase in GDP has in two models a positive effect on CGR (thus confirming our hypothesis) and in one model a negative effect on CGR (thus rejecting our hypothesis),
- an increase in UNR has a negative effect on CGR (thus confirming our hypothesis).

Furthermore, the constant, CLIFS, DMM, INL and NDF are statistically significant in all models at a 1% or 5% significance level. SR is statistically significant in the period fixed effects model as well as in the period fixed effects and cross-section fixed effects model. LR is statistically significant in the cross-section fixed effects model. LDR is statistically

significant in the period fixed effects model. On the other hand, LTV, BCH, UNR and GDP are not statistically significant in any of the models.

The cross-section fixed effects and period fixed effects model has the highest explanatory power with R-squared of 0.47. The period fixed effects model follows with R-squared of 0.40. The cross-section fixed effects model has the lowest explanatory power with R-squared of 0.28. Prob. (F-statistic) in all models is less than 0.01, implying that each model as a whole is statistically significant.

Durbin-Watson (DW) statistics is the closest to 2.0 (a value which indicates there is no autocorrelation detected in the sample) in the cross-section fixed effects model (1.74) and in the cross-section fixed effects and period fixed effects model (1.73). DW statistics is favourable also in the period fixed effects model (1.53). Hence, it can be concluded that autocorrelation is not a problem in our models.

Multicollinearity is not a problem in our model either, as demonstrated in Table 4 with variance inflation factors (VIF). The variance inflation factor indicates the extent of correlation between one explanatory variable and the other explanatory variables in the model. A value of 1 indicates that a certain explanatory variable is not correlated with the other explanatory variables. Higher values of the VIF mean that it is difficult to correctly estimate the contribution of individual explanatory variables to the model. In particular, when a VIF is greater than 2.5 (which is equal to an R^2 of 0.6 with the other explanatory variables, since VIF is calculated as $\frac{1}{1-R^2}$), multicollinearity may be a problem in the model. In our case, all VIFs are less than 2.5, hence we may conclude that multicollinearity is not to be worried about in our model.

Since only four regressors (out of seven[4]) have the signs predicted by Hypothesis 1, we can only partly confirm Hypothesis 1.

Table 3. Empirical results

Response variable	Explanatory variable/statistics	Cross-section fixed effects	Period fixed effects	Cross-section fixed effects and period fixed effects
DCGR	C	-0.728075	-0.745621	-0.758829
		(-4.865145)	(-4.760587)	(-4.996315)
		(0.0000)***	(0.0000)***	(0.0000)***
	DCLIFS	10.05493	10.41394	9.265462
		(3.289016)	(2.374200)	(2.193578)
		(0.0012)***	(0.0188)**	(0.0298)**
	DDMM	0.717547	0.551275	0.706008
		(3.263169)	(2.486834)	(3.075393)
		(0.0013)***	(0.0140)**	(0.0025)***

[4] There are actually eleven regressors in our model; however, only seven of them can be considered "macroprudential policy instruments". Out of these seven regressors, four have the signs predicted by Hypothesis 1.

Response variable	Explanatory variable/statistics	Cross-section fixed effects	Period fixed effects	Cross-section fixed effects and period fixed effects
	DINL	-0.505964	-0.923895	-0.745492
		(-2.020483)	(-3.577365)	(-2.850754)
		(0.0448)**	(0.0005)***	(0.0050)***
	DLR	-0.643549	-0.459246	-0.471405
		(-1.957928)	(-1.341113)	-1.407078
		(0.0518)*	(0.1819)	(0.1615)
	DNDF	0.830868	0.738505	0.856188
		(3.389622)	(2.856750)	(3.381922)
		(0.0009)***	(0.0049)***	(0.0009)***
	DLTV	0.174180	0.223115	0.278861
		(0.816927)	(1.019497)	(1.263903)
		(0.4150)	(0.3096)	(0.2082)
	DBCH	-0.743123	-1.296563	-0.439293
		(-0.706574)	(-0.854002)	(-0.289621)
		(0.4807)	(0.3944)	(0.7725)
	DLDR	0.038454	0.112597	0.060153
		(0.757148)	(2.177770)	(1.126223)
		(0.4499)	(0.0309)**	(0.2619)
	DSR	0.284531	0.581717	0.593117
		(1.081068)	(2.020075)	(2.122628)
		(0.2811)	(0.0451)**	(0.0354)**
	DUNR	-0.533168	-0.117544	-0.299143
		(-1.454027)	(-0.255865)	(-0.657216)
		(0.1477)	(0.7984)	(0.5121)
	DGDP	-8.500579	3.917406	0.158779
		(-0.405552)	(0.158111)	(0.006687)
		(0.6856)	(0.8746)	(0.9947)
	R-squared	0.283482	0.398073	0.466447
	S.E. of regression	1.730722	1.719747	1.646072
	F-statistic	4.475648	2.368490	2.713746
	Prob. (F-statistic)	0.000000	0.000064	0.000002
	Sum squared resid	542.1674	455.4594	403.7234
	Durbin-Watson stat	1.736408	1.531956	1.729274
	Redundant fixed effects test (F prob.)	0.0017	0.0413	0.0022

Notes: In the table, all regressors and the regressand have a "D" in front of their name (e.g. CGR becomes DCGR; CLIFS becomes DCLIFS and so forth for the rest of the variables), since all variables are taken at the first difference for stationarity. The t-statistics are given in brackets below the coefficients and the p-values are given in brackets below the t-statistics. Significance levels are denoted as:

****Significant at 1%.*

***Significant at 5%.*

**Significant at 10%.*

Table 4. Variance inflation factors (VIF)

Explanatory variable	Cross-section fixed effects	Period fixed effects	Cross-section fixed effects and period fixed effects
C	1.480374	1.642297	1.685605
DCLIFS	1.156795	1.087183	1.095141
DDMM	2.328487	1.988499	2.033052
DINL	1.123095	1.090346	1.104904
DLR	1.424568	1.280056	1.332535
DNDF	2.186525	2.160369	2.071618
DLTV	1.113180	1.077083	1.122346
DBCH	1.258532	1.353976	1.437556
DLDR	1.208287	1.153642	1.219463
DSR	1.222297	1.247974	1.264878
DUNR	1.071187	1.147268	1.147776
DGDP	1.065883	1.059648	1.061643

Notes: All VIFs are less than 2.5, implying that multicollinearity is not a problem in our models.

Since we expect that the current level of credit growth may be determined by its past level, we have decided to introduce a lagged dependent variable to our model. We introduce one, two, and three lags (Table 5). If we did not include the lagged dependent variable, this could lead to omitted variable bias and unreliable results. In order to address the problem of potential endogeneity in our model, we tried introducing lags of the explanatory variables; however, such a model yielded statistically insignificant results. We also considered introducing instrumental variables; however, it is very difficult to find proper instruments which influence the response variable only through their impact on a certain explanatory variable and do no impact the response variable directly. Moreover, we would need as many instrumental variables as explanatory variables to identify parameters in a two-stage least-squares regression analysis. Since we have seven explanatory variables representing macroprudential policy instruments and four control variables (altogether eleven regressors), we would need seven or eleven instrumental variables, respectively, which is perhaps unrealistic, given that it is difficult to identify proper instrumental variables. Furthermore, we pondered on using instrumental variables in separate models (i.e. constructing a separate model for each of the explanatory variables); however, in economic reality our explanatory variables do not influence credit growth in isolation, but in tandem with other variables.

Table 5. Dependent variable with one, two, and three lags used in the cross-section fixed effects and period fixed effects model

Cross-section fixed effects and period fixed effects model				
Response variable	Explanatory variable/statistics	Dependent variable lagged one quarter: DCGR(-1)	Dependent variable lagged two quarters: DCGR(-2)	Dependent variable lagged three quarters: DCGR(-3)
DCGR	C	-0.635696	-0.595991	-0.763235
		(-3.732607)	(-3.480484)	(-4.155637)
		(0.0003)***	(0.0007)***	(0.0001)***
	DCLIFS	8.107184	9.742203	9.236518
		(1.880329)	(2.195632)	(2.041384)
		(0.0621)*	(0.0298)**	(0.0432)**
	DDMM	0.654986	0.645084	0.738462
		(2.790731)	(2.694400)	(3.045222)
		(0.0060)***	(0.0079)***	(0.0028)***
	DINL	-0.770868	-0.780027	-0.830149
		(-2.475794)	(-2.403139)	(-2.475246)
		(0.0145)**	(0.0176)**	(0.0146)**
	DLR	-0.504516	-0.416789	-0.352953
		(-1.489449)	(-1.224922)	(-1.000848)
		(0.1386)	(0.2227)	(0.3187)
	DNDF	0.784916	0.730641	0.850170
		(3.042529)	(2.731689)	(3.024011)
		(0.0028)***	(0.0071)***	(0.0030)***
	DLTV	0.270717	0.319609	0.363790
		(1.215961)	(1.419027)	(1.571527)
		(0.2260)	(0.1581)	(0.1184)
	DBCH	-0.337607	0.160104	0.488376
		(-0.220074)	(0.098811)	(0.288415)
		(0.8261)	(0.9214)	(0.7735)
	DLDR	0.050718	0.030710	0.026874
		(0.911750)	(0.526768)	(0.445633)
		(0.3634)	(0.5992)	(0.6566)
	DSR	0.518586	0.533482	0.679081

Cross-section fixed effects and period fixed effects model				
Response variable	Explanatory variable/statistics	Dependent variable lagged one quarter: DCGR(-1)	Dependent variable lagged two quarters: DCGR(-2)	Dependent variable lagged three quarters: DCGR(-3)
		(1.807754)	(1.836769)	(2.270550)
		(0.0727)*	(0.0684)*	(0.0248)**
	DUNR	-0.157885	-0.319917	-0.374989
		(-0.342915)	(-0.674487)	(-0.760121)
		(0.7322)	(0.5011)	(0.4485)
	DGDP	14.19897	11.25664	9.545009
		(0.572637)	(0.429464)	(0.348774)
		(0.5678)	(0.6683)	(0.7278)
	DCGR lagged	0.129318	0.124881	-0.118725
		(1.626622)	(1.594496)	(-1.409353)
		(0.1060)	(0.1131)	(0.1611)
	R-squared	0.474228	0.449884	0.441054
	S.E. of regression	1.636036	1.656437	1.684489
	F-statistic	2.687106	2.401192	2.281476
	Prob. (F-statistic)	0.000003	0.000044	0.000139
	Sum squared resid	382.7558	378.6421	377.3881
	Durbin-Watson stat	1.982626	1.751593	1.790217
	Redundant fixed effects test (F prob.)	0.0033	0.0179	0.0046

Notes: In the table, all regressors and the regressand have a "D" in front of their name (e.g. CGR becomes DCGR; CLIFS becomes DCLIFS and so forth for the rest of the variables), since all variables are taken at the first difference for stationarity. In the first model, DCGR is lagged by one period; in the second model by two periods; and in the third model by three periods. The t-statistics are given in brackets below the coefficients and the p-values are given in brackets below the t-statistics. Significance levels are denoted as:
****Significant at 1%.*
***Significant at 5%.*
**Significant at 10%.*

The results in Tables 3 and 5 are similar with the following two exceptions:

- In the models without the lags of the dependent variable used as regressors, the first difference of the total cost of borrowing to households for house purchase (DBCH) always has a negative regression coefficient, whereas in the models with the lags of the dependent variable used as regressors the sign of the

regression coefficient of DBCH is negative when DCGR is lagged by one period and positive when DCGR is lagged by two and three periods. This inconsistency can perhaps be explained by the fact that DBCH is statistically insignificant in all models.

- In the models with the lags of the dependent variable used as regressors, the first difference of the quarterly GDP growth rate (DGDP) always has a positive regression coefficient, whereas in the models without the lags of the dependent variable used as regressors the sign of the regression coefficient of DGDP is negative in the cross-section fixed effects model and positive in the period fixed effects model and in the cross-section fixed effects and period fixed effects model. This inconsistency can perhaps be explained by the fact that DGDP is statistically insignificant in all models.

All three models where DCGR is used as a regressor and lagged by one, two or three periods produce good and mostly consistent results with the already mentioned exception of DBCH. Another exception worth underlining is that in the models where DCGR is used as a regressor and lagged by one or two quarters, the sign of its regression coefficient is positive, whereas in the model where DCGR is lagged by three quarters, the sign of its regression coefficient is negative.

It appears that the empirical results are to some extent contingent on the chosen empirical research method, as demonstrated in the section with literature review. Moreover, it could be argued that the empirical results to some extent vary with the choice of individual macroprudential policy instruments; time period; and set of economies. Our empirical results indicate that macroprudential policy instruments have a certain impact on financial stability; however, more research is needed into why specific macroprudential policy instruments seem to exhibit the theoretically predicted effects, whilst others do not. For instance, we would expect that an increase in solvency ratio stalls credit growth, thereby bolstering financial stability. However, our empirical results indicate that the opposite is the case. A plausible explanation for this can be found in the Modigliani-Miller theorem (Modigliani and Miller, 1958; Modigliani and Miller, 1963), often referred to as the "capital structure irrelevance principle". This theorem claims that, in an efficient market in the absence of asymmetric information, agency costs, bankruptcy costs, and taxes, the financing of a firm (i.e. with equity or with debt) does not impact its value. In other words, financing through own funds (capital) is not more expensive than acquiring funding sources in the form of debt. In an imperfect world with market failures, however, capital (own funds) is in general more expensive than debt, since the interest payments on debt are tax-deductible. The corollary of this is that in an efficient market an increase in solvency ratio should indeed not have any effect on credit growth; whereas in an inefficient market (which is what the real world is assumed to be), an increase in solvency ratio should increase bank's funding costs and make the bank more cautious when extending credit (partly because riskier loans are charged with higher risk weights, which makes it more difficult for the bank to meet the required capital ratios as set out in the Pillar 1 regulation and in Pillar 2 supervisory requirements).

Overall, the cross-section fixed effects and period fixed effects model without lagged DCGR used as a regressor and the cross-section fixed effects and period fixed effects model with DCGR lagged by one period used as a regressor produce the best results. The

signs of the regression coefficients in these two models are identical for all explanatory variables. As such, the results of these two models shall be used to draw conclusions.

Conclusion

While most papers that treat the relationship between macroprudential policy instruments and financial stability use the loan-to-value (LTV) ratio as the explanatory variable of choice, possibly due to the availability of data in the IMF's iMaPP database, our paper is original and unique in that it examines the impact of seven macroprudential policy instruments on financial stability in six euro area economies (Austria, Finland, Germany, Italy, Netherlands, and Spain) over time span 2010 Q3 – 2018 Q4 by drawing on the data available in the ECB's SDW database and the IMF's iMaPP database. Our research method – panel regression – is one of the common ones used in papers focusing on macroprudential matters. This notwithstanding, certain papers employ much more sophisticated and complex methods – which may or may not yield more nuanced results.

The research on macroprudential policy has been all the rage since the onset of the Great Financial Crisis and Great Recession in 2007. At that juncture it finally became apparent that certain causes of the crisis were of macroprudential nature – excessive interlinkages among financial institutions; insufficient attention being paid to liquidity as a possible source of systemic risk; excessive leverage; insufficient capital buffers; imprudent provisioning practices; excessive indebtedness etc. For more than ten years now, the policymakers and the academia have recognized the need for macroprudential policy as a separate policy in addition to the already well-established ones (monetary, fiscal, and microprudential policy) with its own toolkit, instruments, and goals. None of the other policies is focused on financial stability of the financial system as a whole and/or does not have at its disposal suitable tools and instruments to achieve financial stability. Macroprudential policy is the one which monitors the health of the financial system at large and prescribes changes in the calibration of macroprudential instruments – even at the expense of the soundness of individual financial institutions if required – with the aim of preventing excessive build-up of systemic risks, credit growth and house price growth, thereby reinforcing financial stability.

Our empirical results suggest that, of the investigated macroprudential policy instruments, degree of maturity mismatch (DMM), non-deposit funding as a percentage of total funding (NDF), loan-to-value ratio (LTV) and loan-to-deposit ratio (LDR) exhibit the predicted impact on credit growth rate and hence on financial stability. That said, interbank loans as a percentage of total loans (INL), leverage ratio (LR), and solvency ratio (SR) do not exhibit the expected impact on the response variable. The total cost of borrowing to households for house purchase (BCH), unemployment rate (UNR) and quarterly GDP growth rate (GDP) exhibit the predicted impact on the credit growth rate, whereas the country-level index of financial stress (CLIFS) does not. That being said, these four variables are not macroprudential policy instruments, therefore they do not have a bearing on our research apart from the fact that they help to control for the differences across countries. Taking all of the above into consideration, we can only partly confirm Hypothesis 1.

An extension of our research could encompass the consideration of a random effects model in a panel regression framework; the focus on only one macroprudential policy

instrument (e.g. loan-to-value ratio), longer time series and countries from all continents; the employment of more complex research methods; the inclusion of variables such as countercyclical capital buffer (CCyB), liquidity coverage ratio (LCR), and net stable funding ratio (NSFR) for which the time series span not more than five years; the consideration of several groups of euro area countries (e.g. Southern versus Northern European countries or Central versus Western versus Eastern European countries) and different time periods.

Disclaimer: The views and opinions expressed in this paper are solely those of the authors and do not in any way reflect the official policy, position or opinion of the Faculty of Economics and Business, University of Maribor or of Credit Suisse Group AG.

Acknowledgement: We would like to thank two anonymous reviewers for their valuable comments and suggestions.

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