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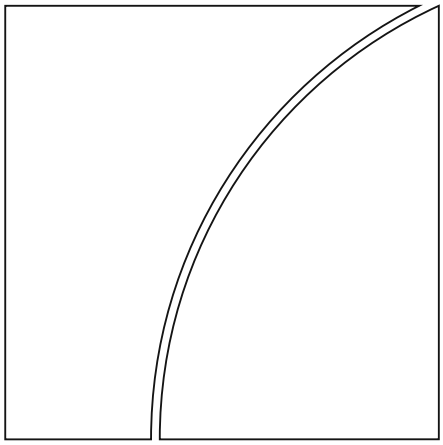

BIS Working Papers

No 636

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May 2017

Paper produced as part of the BIS Consultative Council for the Americas (CCA) research project on "The impact of macroprudential policies: an empirical analysis using credit registry data" implemented by a Working Group of the CCA Consultative Group of Directors of Financial Stability (CGDFS)

JEL classification: E43, E58, G18, G28.

Keywords: macroprudential policies, bank lending, credit registry data, meta-analysis.

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This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

The impact of macroprudential policies and their interaction with monetary policy: an empirical analysis using credit registry data

Leonardo Gambacorta and Andrés Murcia[1]

Abstract

This paper summarises the results of a joint research project by eight central banks in the Americas region to evaluate the effectiveness of macroprudential tools and their interaction with monetary policy. In particular, using meta-analysis techniques, we summarise the results for five Latin American countries (Argentina, Brazil, Colombia, Mexico and Peru) that use confidential bank-loan data. The use of granular credit registry data helps us to disentangle loan demand from loan supply effects without making strong assumptions. Results from another three countries (Canada, Chile and the United States) corroborate the analysis using data for credit origination and borrower characteristics. The main conclusions are that (i) macroprudential policies have been quite effective in stabilising credit cycles. The propagation of the effects to credit growth is more rapid (they materialise after one quarter) for policies aimed at curbing the cycle than for policies aimed at fostering resilience (which take effect within a year); and (ii) macroprudential tools have a greater effect on credit growth when reinforced by the use of monetary policy to push in the same direction.

Keywords: macroprudential policies, bank lending, credit registry data, meta-analysis.

JEL classification: E43, E58, G18, G28.

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1. Introduction

The recent Global Financial Crisis (GFC) has made it clear that the systemic dimension of financial stability cannot be ignored. Treating the financial system as merely the sum of its parts leads one to overlook the historical tendency for credit to swing from boom to bust. We have gained valuable experience in the use of macroprudential policies but their implementation still raises a number of issues. One is how to evaluate the impact of macroprudential policies, especially when more than one tool is activated. Another is the interaction of these tools with other instruments such as monetary policy. Bearing those caveats in mind, the effectiveness of macroprudential policies should be analysed with respect to the specific goals they are designed to achieve, that is, to increase the resilience of the financial system or, more ambitiously, to tame financial booms and busts.

Evidence for the effectiveness of macroprudential policies is mixed and more work is needed. Part of the explanation could be that most of the evidence gathered so far is based on aggregate data at either the country level or the bank level. Very limited use has been made of credit registry data with the notable exceptions of a study on the activation of dynamic provisioning in Spain (Jimenez et al (2016)) and a study on the effects of reserve requirements in Uruguay (Camors et al (2016)).

To study the impact of macroprudential policies and their interaction with monetary policy, we initiated (under the auspices of the Consultative Council for the Americas (CCA)) a joint project covering the eight countries that are BIS shareholders (Argentina, Brazil, Canada, Chile, Colombia, Mexico, Peru and the United States). Five of these countries (Argentina, Brazil, Colombia, Mexico and Peru) made use of credit registry data and followed a common approach in which the impact of macroprudential tools on lending growth was estimated using the same methodology and data. The use of granular credit registry data helps us to disentangle loan demand from loan supply effects without making strong assumptions. The analysis from this exercise was then complemented by work conducted in the three other CCA countries (Canada, Chile and the United States) on the effects of specific policies using information on credit origination and borrower characteristics.

Latin America is a good laboratory for the evaluation of the effectiveness of macroprudential tools, given that their use has had a relatively long history there (Jara et al (2009), Tovar et al (2012), Agénor and Pereira da Silva (2016)).[2] Graph 1 shows that the vast majority (around 80%) of existing macroprudential tools have been applied in EMEs (see also Altunbas et al (2017)). Moreover, five of the eight countries involved in the project have well developed credit registry frameworks and data that allow for an estimation of the transmission from macroprudential impulses to the given policy objective without making too many assumptions.

The confidentiality of credit registry data meant that we were unable to combine our data into a unique data set. This means that we had to run separate country-by-country regressions and compare them. In order to ensure that results were comparable, we implemented a common empirical strategy. Great attention was paid to limiting differences in the definition of variables and the treatment of data. In spite of our standardised approach, we faced a major issue in comparing macroprudential

[2] Annex A gives details of the macroprudential tools for the eight CCA countries involved in the project.

policies that can be very different in nature. To tackle this, we used meta-analysis techniques that helped summarise the results of different country estimates. This type of analysis also let us estimate the relevance of different policy characteristics (or tools) in explaining the heterogeneity of policy effects. Given the nature of the data set at the bank-borrower level, it is important to bear in mind that each coefficient used as an input in the meta-analysis is obtained using a huge number of observations (up to 20 million in some cases) and typically associated with a low standard error. This improves the precision of the calculation of the semi-elasticity of lending to the various macroprudential policies. As usual, when we use meta-analysis techniques to summarise results, there is a challenge with inference, as the number of coefficients tends to be small, reducing the degrees of freedom.

Table 1 describes the different types of macroprudential tool used in the region of the Americas using the categorisation presented in Claessens et al (2013). In particular, only 22% of the policy actions had the direct objective of increasing the resilience of the financial sector, using capital liquidity or provisioning requirements, while 78% had the main purpose of dampening the cycle – ie were used by authorities to dampen an expected credit boom or credit crunch. In particular, the use of reserve requirements has been particularly active in the region. It is also noticeable that more episodes of tightening have taken place than of easing. As it has been extensively documented (Igan and Tan (2015)), credit behaviour in Latin America tends to be highly correlated with the dynamics of external capital flows. In that sense, the use of macroprudential policies has been accompanied in many cases by capital flow management tools.

The main novelty of this paper is that we compare the effectiveness of macroprudential policies by using highly granular data. The richness of our data helps us disentangle shifts in loan demand and those in loan supply, and isolate the impact of macroprudential tools on credit dynamics and that on banking sector risks. We also shed some light on the link between monetary and macroprudential policies, by studying whether responses to changes in macroprudential tools vary with monetary policy conditions. Our initiative complements that undertaken by the International Banking Research Network (IBRN), where researchers from 15 central banks and two international organisations use confidential bank-level data to analyse the existence of cross-border prudential policy spillovers (Buch and Goldberg (2017)). By focusing on domestic credit, our paper complements to some extent the IBRN analysis.

Using information from the five countries that reported information for the meta-analysis, our main results can be summarised in the following way. First, the macroprudential policies implemented by our sample of countries have been effective in dampening credit cycles. In particular, macroprudential policies used with the main purpose of curbing the cycle have been particularly successful in reducing credit growth, even in the short term (within three months). The manifestation of the effects of capital-based requirements is less rapid, taking place within a year. Second, the effectiveness of macroprudential tools is affected by the contemporaneous use of monetary policy. Macroprudential tools that acted as a complement to monetary policies (ie pushing in the same direction) were more effective than those that acted as a substitute for monetary policies (ie pushing in the opposite direction).

Related literature. The evidence for the impact of macroprudential policies is still mixed and additional work is required before solid conclusions can be reached. For instance, recent evidence suggests that debt-service-to-income ratio (DSTI) caps and, probably to a lesser extent, loan-to-value ratio (LTV) caps are more effective than

capital requirements in containing asset growth (Claessens et al (2013)). Indeed, the recent activation of the Basel III countercyclical capital buffers on risk-weighted domestic residential mortgages in Switzerland seems to have had little impact on credit extension (Basten and Koch (2015)), although it had some effect on mortgage pricing. But the main goal of the Basel III countercyclical capital buffers is to increase the banking sector's resilience, not to smooth the credit cycle. Restraining a boom is perhaps no more than a welcome side effect of capital-related macroprudential tools (Drehmann and Gambacorta (2012)).

A second issue pertains to the different nature of macroprudential objectives and instruments. In this area, there is no one-size-fits-all approach. Which tools to use, how to calibrate them and when to deploy them will depend on how the authorities view the vulnerabilities involved, and how confident they are in their analysis. The legal and institutional setup will also be relevant. Moreover, a given instrument's effects will depend on a variety of other factors that need to be assessed against the chosen objective. Some instruments may work better in achieving the narrow objective of strengthening financial system resilience rather than the broader one of constraining the cycle. For instance, countercyclical capital buffers aim at building cushions against banks' total credit exposures, whereas LTV caps only affect a targeted set of new borrowers (and usually only those who are highly leveraged). This argues in favour of capital buffers when the objective is to improve overall resilience. But LTV caps may work better if the aim is to curb specific types of credit extension.

The literature suggests that some instruments may work better to achieve the narrow aim of increasing financial system resilience than the broader aim of constraining the cycle. Some cross-country studies using country-level data point to their effectiveness in limiting excessive credit growth (Cerutti et al (2017), Bruno et al (2017)), especially in the housing sector (Akinci and Olmstead-Rumsey (2015)). There is also evidence that the effects appear to be smaller in financially more developed and open economies (Cerutti et al (2017)).

There is also a need to shed more light on the interaction between monetary and macroprudential policies. For example, there is considerable, although not undisputed, evidence supporting the view that search for yield in a low interest rate environment contributed to the build-up of the GFC through the so-called risk-taking channel of monetary policy (Borio and Zhu (2014), Adrian and Shin (2014), Altunbas et al (2014)). This channel could be particularly relevant when economic agents anticipate that low rates will persist or that monetary policy will always be eased in case of market turmoil – a type of put option offered by the central bank to financial markets. But macroprudential policies could also influence the transmission of monetary policy. For example, changes in LTV or DSTI caps could alter lending conditions and, therefore, consumption decisions. Moreover, by influencing credit conditions, macroprudential policies could also affect real interest rates, indirectly modifying the monetary policy stance, even in the absence of any direct changes to policy rates.

The interaction between these types of policy could have additional implications, in which credit behaviour is often strongly correlated with international capital inflows. An increase in monetary policy rates in reaction to financial stability concerns could have the adverse effect of a sudden increase in capital inflows, which could exacerbate domestic credit and asset price bubbles. In this case, the use of macroprudential policies or capital flow management policies would be critical (Freixas et al (2015)).

On the interaction of monetary and macroprudential polices, evidence obtained from DSGE models[3] and empirical analyses suggests that both policies are complements rather than substitutes, although the results vary by type of shock. Some of these models predict that in the wake of a financial shock, even if the reaction in terms of macroprudential policy should be larger, both types of policy should work in the same direction (Agénor et al (2012, 2016)). In the presence of productivity and demand shocks, the policy responses could differ depending on the size and nature of the shocks (IMF (2013a)). In particular, according to some models with endogenous financial distortions, macroprudential policies must react to credit cycles and the optimal monetary policy response will depend on the size of the respective shocks and the riskiness of balance sheets, including capital buffers and bank leverage (Brunnermeier and Sannikov (2014)).

Recent empirical evidence for Asian economies suggests that macroprudential policies tend to be more successful when they complement monetary policy by reinforcing monetary tightening rather than when they act in the opposite direction (Bruno et al (2017)). IMF (2013b) discusses a number of episodes in which macroprudential tools have been used in conjunction with monetary policy to produce successful outcomes in terms of financial and monetary stability objectives. In addition, some authors have argued that it would be imprudent to rely exclusively on monetary policy frameworks when seeking to tame financial booms and busts. Since some financial cycles, such as credit cycles, are very powerful, monetary and fiscal policies should also play a role (Borio (2014)).

Finally, some studies analyse the effectiveness in a cross-country setup. Cerutti et al (2017) find that the effectiveness of macroprudential policies on credit growth, other things being equal, is lower in advanced economies, which tend to have deep and sophisticated markets that offer alternative sources of non-bank finance, and in open economies that tend to allow borrowers to obtain funds from across the border. Cizel et al (2016) document shifting of credit provision to the shadow banking sector following the adoption of macroprudential measures, with stronger substitution effects found for advanced economies. Reinhardt and Sowerbutts (2015) show further evidence of cross-border leakages for capital requirements, but do not find such effects for loan restriction tools, such as LTV and DSTI caps. Aiyar et al (2014) analyse the experience for the United Kingdom and find that capital requirements can be circumvented by foreign bank branches that are not affected by regulation, or by the shadow banking sector. The recent multi-study initiative of the IBRN (Buch and Goldberg (2017)) confirms this finding and shows that the effects of prudential instruments sometimes spill over borders through bank lending, but also shows that such effects have not been large on average. Interestingly, international spillovers vary across prudential instruments and across banks. Bank-specific factors such as balance sheet conditions and business models drive the amplitude and direction of spillovers to lending growth rates.

Outline. The remainder of the paper is organised as follows. The next section describes the empirical strategy and how we used the credit registry data. Section III discusses the main findings of country papers. Section IV presents the country-by-country results using meta-analysis techniques. The last section contains our main conclusions.

[3] See, for instance, Angelini et al (2012), Alpanda et al (2014) and Lambertini et al (2013).

2. Empirical strategy

Credit register data are typically highly confidential. This means that it is not possible to pool country-level data. Instead, it is necessary to run regressions at a country level and compare results. This does not allow the cross-sectional variability at the country level to be exploited; however, it does let us tackle the potential existence of national differences in the transmission mechanism, allowing each regression to be tailored to take into account different institutional characteristics and/or financial structures. To make comparisons possible, the country level analysis has to use the same modelling strategy and data definition (as far as data sources allow in terms of coverage, collection methods and definitions). In other words, the policy experiment has to be coordinated by using a baseline model specification and by running similar tests.

In order to implement a common approach for the countries participating in the project, we prepared a research protocol in which the equations and the definition of variables was initially discussed and agreed. Country teams complemented the analysis in their respective papers checking the robustness of the results by modifying the baseline models to take into account of country specific characteristics.

Impact of macroprudential tools on bank lending

The first step is to evaluate the impact of a change in macroprudential tools on credit availability using a panel methodology. To this end, we use four different specifications. In the first, we use controls for bank-specific characteristics and their interaction with macroprudential tools (Equation 1). In the second specification, we control for the interaction between macroprudential tools with changes in monetary policy (Equation 2). The third equation controls for the interaction of macroprudential policies with business cycle conditions (Equation 3). These three equations aim at answering the following questions:

(i) Are macroprudential tools effective in altering credit growth?

(ii) How is the effectiveness of macroprudential policies affected by monetary policy conditions?

(iii) How is the effectiveness of macroprudential policies altered by business cycle conditions?

Macroprudential tools and loan supply shifts

As a first step, we evaluate the impact of macroprudential tools at the loan level using the following regression:[4]

$$\Delta Log\ Credit_{bft} = \delta_f + \sum_{j=1}^{4} \beta_j \Delta \text{Macropru}_{t-j} + \sum_{j=1}^{4} \beta'_j \Delta \text{Macropru}_{t-j} * \tilde{X}_{bt-j} + \\ + controls_{bft} + quarter_t + \varepsilon_{bft} \quad (1)$$

[4] The regression is similar to that used in Jimenez et al (2014) to study the impact of monetary policy changes on bank lending by means of credit registry data. For the sake of simplicity, here we consider the case of only one macroprudential tool. However, in many cases, more than one macroprudential tool could be in place at any one time.

where $\Delta Log\ Credit_{bft}$ is the first difference of the logarithm of actual value of loans by bank b to firm f at time t. We include as explanatory variables the change in the macroprudential tool lagged four periods ($\Delta\text{Macropru}_{t-j}$) and its interaction with a vector of bank-specific characteristics (X_{bt-j}). We also include a complete set of firm fixed effects (δ_f), quarterly dummies to control for seasonal effects (θ_t) and control variables ($controls_{bft}$) that include bank-specific and loan characteristics.[5] Our main coefficients of interest are the vectors β and β' that indicate the change of credit induced by the specific macroprudential tool and its interactions with bank-specific characteristics.[6] The test is on the overall significance of $\sum_{j=1}^{4}\beta_j$ and $\sum_{j=1}^{4}\beta'_j$.

The inclusion of interaction terms between macroprudential tools and bank-specific characteristics ($\Delta\text{Macropru}_{t-j} * X_{bt-j}$) is essential for evaluating whether responses to macroprudential shock differ by type of bank (ie strongly capitalised vs weakly capitalised banks; large vs small banks; highly liquid vs less liquid banks etc). In the vector X of bank-specific characteristics, we include indicators of capital, liquidity, size and funding structure. Bank balance-sheet data are demeaned so that we can interpret $\sum_{j=1}^{4}\beta_j$ as the effect on the average bank. We employ lagged values of macroprudential and monetary policy changes as the latter may be influenced by lending conditions. A model with interaction terms was also used in Buch and Goldberg (2017) for evaluating whether spillovers effects of prudential tools depend on bank specific characteristics.

The approach underlying equation (1) builds on the bank lending channel literature. In order to discriminate between loan supply and loan demand movements, the literature has focused on cross-sectional differences between banks.[7] This strategy relies on the hypothesis that certain bank-specific characteristics (for example size, liquidity and capitalisation) influence only loan supply movements, while demand for bank loans is independent of these characteristics. Broadly speaking, this approach assumes that, after a monetary tightening (macroprudential tightening in our case), banks differ in their ability to shield their loan portfolios. In particular, smaller and less well capitalised banks, which suffer a high degree of informational frictions in financial markets, face a higher cost in raising non-secured deposits and are constrained to reduce their lending by more. For their part, illiquid banks are less able to shield themselves from the effect of a policy tightening on lending simply by drawing down cash and securities. This literature does not analyse the macroeconomic impact of the "bank lending channel" on loans but predicates the existence of such channel upon the evident fact that banks respond differently to changes in monetary policy conditions.

[5] Loan characteristics differ among country regressions depending on the availability of information. In particular some country team included controls to identify whether the loans are collateralized (Argentina, Brazil and Colombia) and have a different remaining maturity (Colombia). Some country teams also included credit risk variables at the firm level to identify those debtors that presented payment delays in specific loan contracts (Brazil and Colombia) and others some dummies for identifying different types of credit lines (Argentina).

[6] In the baseline, we assume fixed effects by debtors and standard error clustered at the bank level. However, country teams have checked the robustness of the results by using alternative clustering approaches. For a general discussion on different approaches used to estimating standard errors in finance panel data sets, see Petersen (2009).

[7] For a review of the literature on the distributional effects of the "bank lending channel" see, among others, Gambacorta (2005).

It is worth stressing that the use of granular data allows us to take crucial steps in addressing the identification challenge to disentangle loan demand from loan supply shifts. In particular, we analyse the effects of macroprudential and monetary conditions and economic activity on the granting of loans with individual firm records depending on the strength of bank balance sheets measured by bank capital and liquidity ratios, controlling for time-varying observed and unobserved firm heterogeneity with firm- fixed effects.

One limit of the above described panel approach is that the results obtained indicate the effects for the average bank-firm loan. If the average loan is relatively small, it could be difficult to derive any implication for the macro relevance of the result. To tackle this issue country teams performed as a robustness check a weighted OLS regression by firm relevance (by size of loan).

Interaction between monetary and macroprudential policies

In the second step of the analysis, we aim at evaluating whether responses to macroprudential policies vary with monetary policy conditions. We test this by introducing in equation (1) interaction terms between our macroprudential tool variable and a monetary policy indicator (ie changes in the real money rate, Δr_t,):

$$\Delta Log\ Credit_{bft} = \delta_f + \sum_{j=1}^{4}\beta_j \Delta \mathrm{Macropru}_{t-j} + \sum_{j=1}^{4}\delta_j \Delta \mathrm{r}_{t-j} + \sum_{j=1}^{4}\gamma_j \Delta \mathrm{Macropru}_{t-j} * \Delta \mathrm{r}_{t-j} + controls_{bft} + quarter_t + \varepsilon_{bft} \quad (2)$$

The reason for this test is to verify the effectiveness of macroprudential tools when monetary policy pushes in the same or opposite direction. The main test is on the significance of $\sum_{j=1}^{4}\gamma_j$. In particular, we can construct a test taking the first derivative of equation (2) with respect to changes in macro policy and monetary policy, respectively:

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta \mathrm{Macropru}_{t-1}} = \sum_{j=1}^{4}\beta_j + \sum_{j=1}^{4}\gamma_j \Delta r_t$$

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta r_t} = \sum_{j=1}^{4}\delta_j + \sum_{j=1}^{4}\gamma_j \Delta \mathrm{Macropru}_{t-1}$$

Since $\sum_{j=1}^{4}\beta_j$ and $\sum_{j=1}^{4}\delta_j$ are expected to be negative (both monetary and macroprudential policies tightening reduce bank lending), the effect of a change of one policy on the other will depend on the sign of the cross derivative $\frac{\partial^2 \Delta Log\ Credit_{bft}}{\partial \Delta \mathrm{Macropru}_{t-1} \partial \Delta r_t} = \sum_{j=1}^{4}\gamma_j$. Each policy will reinforce the other if $\sum_{j=1}^{4}\gamma_j < 0$. By contrast, if a macroprudential policy tightening reduces the effectiveness of a monetary policy tightening and vice versa then we should observe $\sum_{j=1}^{4}\gamma_j > 0$. [8]

[8] This analysis could be seen as analogous to the study of the interaction between fiscal and monetary policy. For example, with monetary policy, both conventional and unconventional, having reached the limits of its effectiveness, fiscal policy may be more effective, so the cross-derivative between the two policies should be positive (Buiter (2010)). For Woodford (2011), a fiscal multiplier well in excess of one is possible when monetary policy is constrained by the zero lower bound and, in this case, welfare increases if government purchases expand to partially fill the output gap that arises from the inability to lower interest rates. In our paper, we abstract from welfare criteria and we simply judge whether the effectiveness of the macroprudential tools in modifying bank lending is influenced by monetary policy conditions.

Macroprudential policies over the cycle

The third step of the analysis is to evaluate whether the effectiveness of macroprudential policies varies over the business cycle. For this, we have included in the baseline equation interaction terms between macroprudential tool indicators and real GDP growth:

$$\Delta Log\ Credit_{bft} = \delta_f + \sum_{j=1}^{4} \beta_j \Delta \text{Macropru}_{t-j} + \sum_{j=1}^{4} \eta_j \Delta \text{Macropru}_{t-j} * \Delta LogGDP_{t-j} + controls_{bft} + quarter_t + \varepsilon_{bft} \quad (3)$$

To identify whether the effectiveness of the macroprudential policies varies over the business cycle, the test is on the overall significance of $\sum_{j=1}^{4} \eta_j$. Even in this case, we can explain the test taking the first derivative of equation (3) with respect to changes in macroprudential policy:

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta \text{Macropru}_{t-1}} = \sum_{j=1}^{4} \beta_j + \sum_{j=1}^{4} \eta_j * \Delta LogGDP_{t-j}$$

Since $\sum_{j=1}^{4} \beta_j$ is expected to be negative (macroprudential policies tightening reduce bank lending), the effect of a macroprudential tightening/easing on lending growth will depend upon the sign of the cross derivative $\sum_{j=1}^{4} \eta_j$. For example, a macroprudential policy tightening will be stronger in an economic expansion ($\Delta LogGDP_{t-j} > 0$) if $\sum_{j=1}^{4} \eta_j < 0$ and vice versa. Buch and Goldberg (2017) propose a similar specification with a measure of the output gap and Credit to GDP ratio as a proxy of the financial cycle.

Intensive vs extensive margins

The econometric strategy presented above was mainly focused on the evaluation of the effects of macroprudential policies at the intensive margin (changes of lending relationships already in place between a firm and a given bank). However, firms could also start new credit lines or use some existing credit lines more than others. Indeed, the effects of macroprudential policies could be mitigated if firms can obtain credit from the less affected banks. In order to analyse the effects at the extensive margin (the overall effect for the firm), we estimated an equation at the firm level. Hence, to assess the macro relevance of changes in the macroprudential tool, we need to turn from bank-firm to firm-level estimation. More specifically we estimated the following model:

$$\Delta Log\ Credit_{ft} = \delta_p + \delta_i + \beta^* \Delta \text{Macropru}_{t-1} + controls_{ft} + quarter_t + \varepsilon_{ft} \quad (4)$$

where $\Delta Log\ Credit_{bft}$ is the change in the logarithm of actual credit by all banks to firm f over a given period after the introduction or change in a macroprudential tool, $\delta_p\ and\ \delta_i$ are the province and industry fixed effects.

Meta-analysis techniques

In order to summarise the results obtained at the country level, we use meta-analysis techniques. This approach is very helpful when studies are not perfectly comparable but evaluate the same or a closely related question. This technique allows the results of different studies to be combined and summarised and an overall significance to be estimated. In financial economics, the applications of meta-analysis are still limited. One example is provided by Buch and Goldberg (2014), who summarise the

magnitude and transmission of liquidity shocks on global banks across countries; Arnold et al (2014) explored the reasons for corporate hedging, combining different estimations in the literature. More recently, Buch and Goldberg (2017) summarise by means of meta-analysis the results of a multi-study initiative of the IBRN to study cross-border prudential policy spillovers.

In our analysis, each observation is represented by the evaluation of the effects of a macroprudential policy on credit growth by means of one of the equations (1)–(3) discussed above. In Table 2, we report the characteristics of the macroprudential tools evaluated by country teams using the common approach. In particular, we have analysed eight different macroprudential tools. Following the classification in Claessens et al (2013), we have four types of policies with the main objective of enhancing the financial sector's resilience and four types of policies aimed at dampening the credit cycle. We analysed a total of 15 episodes of introduction/changes of such tools (twelve tightening and three easing).

We conduct the analysis in two separate steps. In a first step using *meta-analysis*, we are able to estimate a range of the effect of macroprudential policies on credit growth. In a second step, using *meta-regressions*, we look to identify some variables that help to explain the differences among the coefficients reported by country studies. This second step is particularly relevant in our case since the reported coefficients present a large level of heterogeneity. This is, in some sense, expected, since the macroprudential policies and populations were diverse. For a more detailed explanation of meta-analysis techniques, see Annex B.

Difference-in-difference analysis

The effects of macroprudential policies on credit supply were also tested using a difference-in-difference analysis, which identifies a causal relationship pre and post the introduction of a macroprudential policy by using a counterfactual. In particular, following Khwaja and Mian (2008) we evaluate whether the same firm borrowing from two different banks (affected and not affected by the regulation) experienced a different change in lending.[9] Since the comparison is across banks for the same firm, firm-specific demand shocks are absorbed by firm fixed effects, and in this way it is possible to insulate the effects of an unanticipated shock on credit supply.

For evaluating the responses of the supply of credit to changes in specific macroprudential policies, we estimated a similar equation to the one presented in Jimenez et al (2016), in which they estimate the effects of changes in provision requirements in Spain on credit commitments. In particular, we use the following specification:

$$\Delta Log\ Credit_{bf}(Impact\ period) = \delta_f + \beta Macropru\ (Counterfactual)_b + \\ + controls_{bf} + \varepsilon_{bf} \qquad (5)$$

where $\Delta Log\ Credit_{bf}(Impact\ period)$ refers to the change in log of the credit from bank b to the firm f in the window after the implementation of the macroprudential policy. We can consider a one-year window after the macroprudential tool started to

[9] The counterfactual was defined in different ways by country teams. Some of them (Brazil, Colombia) used the information from a period in which the policy was not employed. Other country teams (Argentina, Mexico) defined the counterfactual also using information from banks or institutions to which the new rule does not apply.

be in place. δ_f are firm fixed effects and $controls_b$ are the same variables at the bank level that are employed in the previous equations. All these controls were taken one quarter before the introduction of the macroprudential tool. $Macropru\ (Counterfactual)_b$ represents the evaluation of a specific macroprudential policy to a set of credits that are not subject to the specific regulation.

The advantage of this setting is that β can be interpreted as the additional annual change of credit growth with respect to the referenced group (counterfactual). In other words, it can be interpreted as a semi-elasticity in the sense that it represents the change of the credit growth to the average firm in response to the increase of one unit in the macroprudential requirement.

Data issues

In the shared approach, we used a common definition of variables and the same frequency. In particular, we used bank-level data at the quarterly frequency and matched them with macro controls (GDP, current account deficit, etc). We have controlled for the presence of possible outliers by winsorising all the variables used in the regression at 1%.

As for the definition of the change in macroprudential variable, we used a dummy $\Delta Macropru_t$) that takes the value of +1 if the macroprudential tool has been tightened in a given quarter and –1 if it has been eased. It is zero if no changes have occurred during that quarter. This approach has been widely applied (Kuttner and Shim (2012); Altunbas et al (2017); Akinci and Olmstead-Rumsey (2015); Buch and Goldberg (2017). It does not weight for the size of the change of the macroprudential tool (or whether it represents a binding constraint for firms/individuals) but it simplifies the comparison of the effectiveness of different macroprudential policies.

Indeed, the macroprudential tools analysed in this paper are of different types and they are not straightforward to compare in terms of their potential effects. Certainly one natural source of heterogeneity in the effects of macroprudential tools along the different dimensions of credit emerges from the types of policy that are implemented. Some countries such as Argentina, Brazil, Colombia and Peru present a mix of policies (capital-based instruments, provisioning, changes in reserve requirements, establishment of liquidity ratios and, in some cases, modifications in dividend distribution rules, or the establishment or changes in LTV and DTI ratios). Meanwhile, Mexico focuses on a specific change in its rules for provisioning. More details of the different policies employed in the Americas are provided in Table 1.[10]

The macroprudential toolkit tends to be large, combining an array of different instruments. As one might expect, the purpose of various policies can differ. For instance, some instruments are intended to increase the financial sector's resilience, while others focus on dampening the cycle. In that respect, the effects of specific macroprudential tools on credit growth can differ. Claessens et al (2013) distinguish

[10] Inside the CCA-CGDFS working group, even countries which have not been too active in the use of macroprudential policies (Canada, Chile and the United States) identified some relevant measures to evaluate. Calem et al (2017) aim at evaluating recent changes introduced by the CCAR and Dodd-Frank stress tests and Leveraged Lending Guidance. Allen et al (2017), using information at the borrower level, focus on the evaluation of policies in the housing market related to changes in LTV ratios in Canada and, finally, Alegría et al (2017) estimate the effect of loan-to-value ratios in the housing loan market originating from an unexpected Chilean central bank statement concerning housing price dynamics.

between the goals and the types of policy that are commonly used. Macroprudential tools with the main objective of enhancing the financial sector's resilience include countercyclical capital requirements, leverage restrictions, general or dynamic provisioning, the establishment of liquidity requirements, among others. Within the category of macroprudential tools aimed at dampening the credit cycle, Claessens et al (2013) include changes in reserve requirements, variations in limits on foreign currency exchange mismatches, and cyclical adjustments to loan-loss provisioning, margins or haircuts. Other macroprudential policy aims include reducing the effects of contagion or shock propagation from systemically important financial institutions (SIFIs) or networks. In this group might also be included policies such as capital surcharges linked to systemic risk, restrictions on asset composition or activities, among others.

Using the categorisation presented in Claessens et al (2013), we classify policies according to their purpose. In particular, policies with the purpose of dampening the cycle – ie those used by authorities to dampen an expected credit boom or credit crunch[11]– are identified with the term *cyclical*. Macroprudential tools which are intended to increase the resilience of the financial sector, using capital or provisioning requirements, are identified with the term *capital*.[12]

For consistency, all variables have been expressed in real terms. In the case of Argentina (Aguirre and Repetto, 2017) and Mexico (Levin et al, 2017) results have been carefully checked by taking into account different model specifications for loans expressed in different currencies. In particular, Levin et al (2017) find that changes in provisioning had more effect on loans denominated in local currency than it did on credits denominated in foreign currency.

The vector of controls $(controls_{bft})$ includes macro variables, bank-specific characteristics and bank-firm relationship characteristics. In particular:

Macro controls: change in real GDP, change in monetary policy rate, effective exchange rate and current account deficit. All the variables are expressed in constant prices (base 2012).

Bank-specific characteristics: size (log of total assets); liquidity ratio (cash and securities over total assets), capital ratio (Tier 1 to total assets); funding composition (deposits over total liabilities). The Colombian team also included a securitisation activity dummy (equal to 1 if the bank is active in the securitisation market); and return on assets (ROA). Specific effects on credit could originate from regulation. Gomez et al (2017) also evaluate if a prudential instrument (such as capital) is binding or not by including specific indicators signalling whether a bank is close to the regulatory threshold (changes in macroprudential policies could more strongly affect banks that are more constrained by capital policies). In fact, they found that institutions with

[11] We included in this group the following instruments: (i) deposit requirement on external loans and (ii) the marginal reserve requirement on banking deposits, both in Colombia; (iii) tightening of the capital buffer and profit reinvestment requirement that took place in 2012; (iv) tightening in the foreign currency net global position, both in Argentina and (v) the changes in reserve requirements used in Brazil.

[12] We included the following policies in this group: (i) the introduction of dynamic provisions systems in Colombia; (ii) the introduction of a new provisioning system in Peru; (iii) the change of methodology for the calculation of banking provisions in Mexico; and (iv) the introduction and the tightening of a capital buffer and profit reinvestment mechanism in Argentina.

lower capital buffers tend to restrict their credit supply to a greater extent. The estimations provided for the meta-analysis by the Colombian group used a measure of the capital target for each financial institution as opposed to directly using the capital ratio.[13] All the studies consider individual banks including both domestic and foreign institutions (subsidiaries and branches).

One statistical issue is related to the potential endogeneity problem between changes in macroprudential policies and the evolution of credit and other business cycle indicators (that are included in the specification to control for loan demand effects). As for the relationship between macroprudential tools and credit, the use of micro data rules out the problem: using credit register data at the loan level excludes the possibility that macroprudential tools are influenced by the single borrower condition. Regarding the interaction between macroprudential tools and business conditions, we mitigate the problem by including time dummies and/or sector*time dummies. Some papers (eg Barroso et al (2017)) control for different types of fixed effects by firm and by bank. Levin et al (2017) and Aguirre and Repetto (2017) also use random effects to evaluate if their results are robust and do not find significant differences.

3. Summary of country papers

This section summarises the main results of the nine country papers prepared by the research project.

Argentina. Aguirre and Repetto (2017) evaluate the effects of two macroprudential policies in place in Argentina over the period 2009–14: (i) introduction and tightening of a capital buffer (CB) through a limit on dividend distribution; (ii) two changes in limits on foreign currency net global position (FGP) of financial institutions. The results indicate that both changes in CB and FGP are effective in smoothing credit cycles (measured as quarterly growth rates of the outstanding credit stock at the firm-bank level). In addition, the introduction and tightening of these policies appear to have had significant effect on the behaviour of non-performing loans.

Brazil. The Brazilian case was analysed by means of two different papers. One on the effects of reserve requirements as a countercyclical tool and the second on the role of changes in LTV on the mortgage market. Barroso et al (2017) found that reserve requirements tightening had a negative effect on credit. The effectiveness of reserve requirements falls as the liquidity of banks increases. On the other hand, and in contrast to the functioning of the risk-taking channel of monetary policy, the authors

[13] The capital ratio itself is not informative of how tight or easy bank capital may be for an individual bank. For example, a capital ratio of 2% above the minimum requirement could be perfectly adequate for most intermediaries but not for a bank that is particularly risk-averse. Moreover, there could be differences among bank businesses and capital management policies that could affect target bank capital levels. A way to overcome this problem is to use a measure of bank capital deviation from a desired or benchmark level. For this, it is necessary first to estimate a bank capital equation and then to calculate the deviation of the actual level of the bank capital ratio from the fitted value (residual). In this case a negative (positive) value of the residual indicates a capital level that is lower (higher) than the target/desired level. With this in mind, one can use the residual instead of the simple ratio in the previous equations. A possible reference for the bank capital equation is presented in Ayuso et al (2004). Brei and Gambacorta (2014; equation 1) extend this model to take into account the possible presence of a break during the crisis.

find that, during easing, less credit is provided in riskier loans. They also found evidence that the effects of reserve requirements on monetary policy were reinforced: the tightening in reserve requirements increases the effectiveness of monetary policy actions. Araujo et al (2017) estimate the impact of the specific case of the introduction of LTV limits for a set of subsidised loans between 2012 and 2014. They find that the LTV cap caused individuals more likely to borrow with a high LTV to make higher down payments, purchase cheaper houses, and default less. No similar effects are found on the, less affected, control group.

Canada. Allen et al (2017) combine loan-level administrative data with household-level survey data to analyse the impact of recent macroprudential policy changes in Canada using a micro-simulation model for the mortgage demand from first-time homebuyers. They find that policies targeting the LTV ratio are found to have a larger impact than policies targeting the DSTI ratio, such as amortisation. This is because there are more wealth-constrained borrowers than income-constrained borrowers entering the housing market.

Chile. Alegría et al (2017) document how specific warnings about real-estate markets, published in the Central Bank of Chile Financial Stability Report between June and December of 2012, affected bank lending policies. They found that warnings had a statistically significant effect reshaping the distribution of LTV ratios for granted loans. There is evidence of a shift out of mortgages with high LTV values, and into lower ratios during the period. They also reported different responses between private and state owned banks.

Colombia. Gómez et al (2017) analysed the impact of two macroprudential policies in the period 2006–09. In particular they evaluated the effects of the introduction of: (i) a *dynamic provisioning scheme for commercial loans* (DP); ii) *a countercyclical reserve requirement* (CRR) implemented in 2007 to control for excessive credit growth. The results indicate that DP and CRR had a negative effect on credit growth curbing excesses in the credit supply. A measure of the aggregate macroprudential policy stance suggests that the use of these policies has worked as an effective stabiliser of credit cycles and bank risk-taking. They also found that use of monetary policy and macroprudential policies have been used in the same direction, suggesting certain level of complementarities among policies.

Mexico. Using detailed credit register information, Levin et al (2017) evaluated the effects of a change in the calculation procedure for banking provisions (from a backward-looking to a forward-looking scheme). They found that a system of banking provisions based on expected losses reduced credit growth between 2009 and 2015. The effect is larger for loans denominated in local currency than for dollar-denominated credits. They also found that the use of internal methodologies for calculating banking provisions reduces the impact of that policy on credit growth.

Peru. Cabello et al (2017) analysed the effects on credit growth of two different macroprudential policies: (i) a new dynamic provisioning system (DP) and; (ii) the introduction of conditional reserve requirements on foreign currency liabilities that penalize banks that do not reduce their loans in foreign currency (CR). The authors found that DP had a significant effect on credit growth and CR had a significant effect on the share of loans denominated in foreign currency, which helped to stimulate the de-dollarisation process in Peru.

United States. Calem et al (2017) analyse how two types of recently used prudential policy affected credit supply in the United States. First, they test whether the US bank stress tests had any impact on the supply of mortgage credit. They find that the initiation of the Comprehensive Capital Analysis and Review (CCAR) stress tests in 2011 had a negative effect on the share of jumbo mortgage originations and approval rates at stress-tested banks – banks with worse capital positions were impacted more negatively. Second, they analyse the impact of the 2013 Supervisory Guidance on Leveraged Lending and the subsequent 2014 FAQ notice, which clarified expectations on the Guidance. They find that the share of speculative-grade term-loan originations decreased notably at regulated banks after the FAQ notice.

4. Summary of results using meta-analysis techniques

In order to detect evidence of the impact of macroprudential policies on credit growth, we employed meta-analysis techniques to summarise the results of the five country papers that used credit registry data. In particular, we used the coefficients obtained by the papers from Argentina, Brazil, Colombia, Mexico and Peru from the regressions (1)–(3) described in Section 2. These models could differ slightly from those used in the specific papers but are directly comparable between countries. For each equation, we have 13 observations (ie coefficients). Four of these observations correspond to the coefficients reported by Argentina (four policies,[14] one type of loan), one for Brazil (one policy, one type of loan), six coefficients reported by Colombia (three policies for two types of loan[15]), one for Mexico (one policy, one type of loan) and finally one for Peru (one policy, one type of loan). The estimated range of the effect of macroprudential tools combines the information of the reported coefficients and their respective standard error. As country teams evaluated different types of policies such as changes in reserve requirements (Colombia and Brazil), the introduction of additional capital buffers (Argentina), variations in provisioning systems (Colombia, Mexico and Peru) and restrictions on currency mismatching (Argentina) results can be compared using a meta-analysis technique. The full characteristics of the macroprudential policies summarised in the meta-analysis are reported in Table 2. In our commentary, for simplicity, we will refer to the papers by country name instead of author.

Due to the wide variety of macroprudential tools used and the different institutional characteristics of the countries analysed, we used a random effect estimation for the meta-analysis. This method allows us to estimate an expected range for the effectiveness of macroprudential policies on different dimensions of credit, taking into account not only the level of variation for each specific estimated coefficient, but also the level of variability of estimated coefficients among country estimations (see Annex B).

We anticipate that the way in which macroprudential policies are differentiated is quite relevant when explaining the differences among the estimated effects. In particular, as discussed above, we differentiate policies with the clear aim of dampening the cycle (*cyclical*) from those with the aim of increasing the financial

[14] The paper for Argentina separately evaluates the impact of the introduction of both policies and the tightening periods of them. This is the reason for reporting four different observations.

[15] A group of estimations for credit to firms and other for credit to individuals.

sector's resilience using capital or provisioning requirements (*capital)*. It is important to highlight that there are other possible ways of classifying the policies (see Claessens et al (2013)). For instance, one possibility is to draw a line between policies directed at financial institutions and those that are focused more on borrowers. However, this type of classification does not apply for the evaluated tools since all the policies considered in the common approach were supply-oriented. We don't analyse, for instance, cases of changes in LTV or DTI caps.

Another relevant distinction is related to the interaction of the specific macroprudential tools with monetary policy (see equation 2) and with business cycle conditions (see equation 3). With respect to the interaction of macroprudential policy with monetary policy (equation 2), we identified policies that reinforce the effects of monetary policy if the sign of the interaction terms between the policies (detected by the sum of the coefficient $\sum_{j=1}^{4} \gamma_j$ in equation 2) is negative and therefore the effect of the specific macroprudential policy on credit growth goes in the same direction as changes in monetary policy.

Effects of macroprudential policies on lending

We first analyse the impact of macroprudential policies on credit growth using random effects meta-analysis of the coefficients for equations 1, 2 and 3 and the combination of all the estimates. We compare the effects of macroprudential policies in the short term (ie after three months, by imposing j=1 in equation (1)-(3)) with effects after one year (j=1,…,4).

Tables 3 and 4 present the effects of macroprudential policies after three months and one year, respectively. When we combine all the observations together, we find that a tightening in macroprudential policy is associated with a reduction in annual credit growth of 4.2% after three months and 7.2% after one year.

Graph 2 presents "forest plots" of the coefficients for the different country studies and equations. The aggregate estimated effect is represented by a red line accompanied by the respective confidence interval (blue rhombus). The effect after three months (upper panel) is more heterogeneous than the effect after one year (lower panel). In particular, after three months, we do not always detect a clear negative correlation between macroprudential policies and credit growth. In particular, the correlation with bank lending growth is weaker for those policies aimed at increasing resilience. However, the weaker effect vanishes considering the impact through longer horizons (after one year). In this case the effects of policies directed at increasing capital buffers are always significant (see lower panel). A tightening in this type of policy is associated with a decrease in annual credit growth of 3–6% depending on the model used (see Table 4). All in all, this indicates that prudential policies aimed at raising additional buffers through capital requirements or provisioning (*capital*) take more time to manifest their effects.

The analysis of the forest plots aggregates country team results without controlling for specific institutional characteristics that could differ across jurisdictions. To this end, as a second step in the meta-analysis, we corroborate the above results by means of meta-regressions that allow us to control for time-invariant country characteristics (see Annex B for details). The results are presented in Table 5. The overall findings confirm that tools employed to curb the cycle (*cyclical*) have a significant negative effect on lending supply after one year. By contrast, also in this case we find that policies that directly affect the capital levels (*capital*) of financial

institutions tend to have a non-significant effect in some specifications. When we combine all the observations together, both types of macroprudential tool have a significant impact on lending growth, but policies aimed at curbing the cycle (*cyclical*) have twice the effect of policies directed at increasing capital buffers.

All the above results are relatively robust and are confirmed in the individual country papers for Argentina, Brazil, Colombia, Mexico and Peru, even when alternative specifications or additional institutional characteristics are controlled for. Moreover, some of the country papers were able to shed some light on a possible differential impact of macroprudential tools among banks with different characteristics. In particular, there is some evidence that lending supply reacts differently for banks with a different level of risk and capitalisation (Brazil and Colombia).[16] However, there is limited significance of the standard indicators used in the bank lending channel literature (such as the capital and liquidity ratio) and this could be due to the fact that most Latin American banks maintain high levels of capital and liquidity buffer to protect themselves against external shocks. Indeed, significant effects of capitalisation are detected only when the capital buffer is calculated with respect to bank-specific targets, as banks can have different levels of risk-aversion.[17]

The interaction of macroprudential policies with monetary policy and the business cycle

The second step of the analysis described in Section 3 is to evaluate whether responses to macroprudential policies vary with monetary policy conditions. In particular, we analyse the sign of the sum of the coefficient $\sum_{j=1}^{4}\gamma_j$ in equation (2) reported by the five country teams that have access to credit registry data. Each policy reinforces the other if $\sum_{j=1}^{4}\gamma_j < 0$. By contrast, if a macroprudential policy tightening reduces the effectiveness of a monetary policy tightening and vice versa then we should observe $\sum_{j=1}^{4}\gamma_j > 0$.

The forest plot in Graph 3 indicates that, on average, the sum of the interaction term is negative and significant (see the blue rhombus that represents the estimated range of the interactions using a random effect analysis). Only for two out of the 13 episodes is the sum of the interaction terms non-statistically different from zero: the introduction in Argentina of a capital buffer regulation; and a tightening in requirement on external borrowing in Colombia. These results are confirmed in the meta-regression, where we also control for country-specific fixed effects (see the first

[16] In particular, the Colombian paper finds that a tightening in a macroprudential policy index (as a measure of the macroprudential policy stance) affects the supply of credit at less stable financial institutions (those that exhibit low levels in the Z-score indicator). Similarly, Calem et al (2017) find that the CCAR stress tests had a greater effect on the credit supply of less well capitalised banks.

[17] A way to overcome the uninformative content of the capital ratio is to use an alternative measure based on the deviation of bank capital from a desired or benchmark level. For example, the information reported by Colombia for the meta-analysis uses the specification proposed by Ayuso et al (2004) and Brei and Gambacorta (2014) for estimating a bank capital equation and calculating the deviation of the actual bank capital ratio from the fitted value (residual).

panel of Table 6). In particular, we don't find evidence that different types of policy (eg capital-based and cyclical) had differential levels of $\sum_{j=1}^{4}\gamma_j$.[18]

All in all, these results support the view that prudential policies and monetary policy reinforce each other. When these policies push in the same direction as monetary policy (ie both policies are tightened or both are eased) the effects have a larger impact on credit growth. In other words, macroprudential policies tend to be more effective in tackling credit cycles when they are accompanied by the use of countercyclical monetary policy.

The third step of the analysis is to evaluate whether the effectiveness of macroprudential policies varies over the business cycle. For this, we need to analyse the sign of the coefficients $\sum_{j=1}^{4}\eta_j$. For example, a macroprudential policy tightening will be stronger in an economic expansion ($\Delta LogGDP_{t-j} > 0$) if $\sum_{j=1}^{4}\eta_j$<0 and vice versa. From the forest plot in Graph 4, we can see that the signs of the sum of the interaction terms tend to be positive but the overall effect is not statistically different from zero. Interestingly, the meta-regression analysis reported in the second panel of Table 6 indicate that, once country-specific (and invariant) institutional factors are controlled for, policies directed at increasing the resilience of banking sector (*capital*) exhibit larger negative levels of $\sum_{j=1}^{4}\eta_j$, suggesting that a tightening in those policies tends to have larger effects on credit growth during an economic expansion.

Intensive vs extensive margins

The results obtained estimating a credit growth equation at the firm level (see equation 4) showed that the macroprudential rule has a negative and significant effect on the growth of total firm credit. According to the information provided by country teams for Colombia, Peru and Mexico, there are no statistical differences between the coefficients reported at the loan level and the ones reported at the firm level. This test is particularly important for the validity of the previous results (based on the intensive margin) because the effects of macroprudential policies could be mitigated if firms obtain additional credit from new banks instead than simply relying on existing credit lines.

The Brazilian team (Barroso et al (2017)) analysed the intensive vs extensive margin, running some additional tests. In particular, they investigated the possible existence of asymmetric effects between easing and tightening of reserve requirements. In contrast with the "pushing on a string" results for monetary policy, the authors find that reserve requirements are more effective in an easing than in a tightening episode. In particular, their results indicate that in case of an easing the elasticity for the intensive margin is substantially higher than for the extensive margin (1.27% vs 0.36%). This implies that, in the case of a reduction of reserve requirements,

[18] Our paper does not evaluate how macroprudential policies interact with fiscal policies. Martin and Philippon (2015) model a currency union and evaluate how the countries would have fared if they had conducted macroprudential policies to limit the increase in private debt. They find that this policy stabilises private demand and therefore employment, and it reduces the need for bank recapitalisation, leading to lower spreads and more room for countercyclical fiscal policy. Their experiment also uncovers a new interaction between macroprudential and fiscal policies. A biased government substitutes public debt for private debt in response to restrictive macroprudential policy, thereby undoing some of the macroprudential benefits. This suggests a complementarity between fiscal rules and macroprudential rules.

firms tend to obtain additional credit mainly through banks with which they had already a stable relationship.

The above results are also corroborated by Aguirre and Repetto (2017), who followed an alternative approach that considers the intensive vs the extensive margin at the bank level. In particular, they first run the baseline equation for a subsample of firms with loans over the whole period of analysis. The effect of macroprudential tools on credit growth for this subsample was then compared with the results obtained when considering all the firms in the sample (including the new and closed banking relationships). They find that macroprudential policy measures reduced credit growth in both samples, but more by cutting off lending to the larger sample (extensive margin) than by providing less credit to the same set of firms (intensive margin). This result is also in line with the evidence that in the case of shocks banks tend to modify their lending supply by less to firms with which they have a stable relationship (Bolton et al (2016)).

Macro relevance of the results

The results obtained using the panel approach indicate the effects for the average bank. If the average bank is small, it is difficult to derive any implication for the macro relevance of the result. To deal with this issue, country teams have also estimated OLS weighted by firm relevance (total amount of loans) for equation (1). The results reported in Table 7 indicate that the reported coefficients under both approaches (panel and weighted OLS) have in all case but one, the same sign and a similar magnitude. In other words, a tightening in a macroprudential policy predicts negative effects on credit supply at the micro level (effects on the average bank) but also at the macro level (aggregate dynamics of credit), which indicates the relevance of the results from a macroprudential perspective.

The only noticeable exception is the result from Brazil in which the panel estimation indicates a drop in lending supply by 2.1% for the average bank, while the weighted OLS reports an aggregate drop of 0.4%. As explained in Barroso et al (2017) the difference in the coefficient could be due to the fact that the biggest firms were better able to mitigate the effects of the tightening of reserve requirements by resorting to unaffected banks (three quarters of Brazilian banks were unaffected by reserve requirement policies even though the affected ones detain a large portion of the loan market share).

Difference-in-difference analysis

The results discussed above using panel data estimations were confirmed through the difference-in difference analysis discussed in Section 3. This test is particularly important as a significant effect of changes in macroprudential tools on credit growth could be related to other events occurring at the same time as the policies were implemented. To solve this problem, the effects of some macroprudential policies were evaluated using a counterfactual (difference-in difference) analysis in specific episodes (see Table 8 for a sum up of the tests).

Gomez et al (2017) confirmed that both macroprudential policies evaluated for Colombia had significant effects on credit supply. Using an identification strategy that stems in the time dimension (ie evaluating the effects before and after the policy shock) they found that a 1 percentage point increase in the provisioning to

commercial loans portfolio (as it was observed in the period evaluated) led to a decrease of 0.97 percentage points in credit growth after one year. In the case of the countercyclical reserve requirement, an increase of 10 basis points in the marginal reserve requirement to total liabilities ratio (as was observed in the period of analysis) leads to a decrease of 0.8 percentage points. These results are comparable with Jimenez et al (2016), who find that an increase of 14 basis points (equivalent to one standard deviation) in the ratio between provisions and total loans in Spain led to a decrease in committed lending by 2%.

Using a similar approach, Barroso et al (2017) estimate that the easing of reserve requirements in November 2008 generated an additional increase in monthly credit growth of 1.5%. The tightening in such requirements in March 2010 led to a decrease of 0.4% on average. Both results confirmed that reserve requirements had a significant impact on the credit cycle in Brazil. These results are in line with the findings in the literature. Analysing the case of Uruguay, Camors et al (2016) found that a 1 percentage point increase in total reserve requirements translated into an average fall in committed lending of 0.35%.

Aguirre and Repetto (2017) used a slightly different definition for the counterfactual experiment, based on the comparison between those institutions affected by the regulation vis a vis the unaffected. The results indicate that both the introduction of the countercyclical buffer and the reintroduction of the limit on the foreign currency position had a significant and negative effect on credit growth in Argentina. In particular, they found that the introduction of the limit on foreign currency generated an average decrease of 4.8% in credit growth. Moreover, the introduction of the countercyclical capital buffer is associated with a decrease in credit growth of 3.4%. In a similar way Aiyar et al (2014) analyse the experience of UK banks and find that an increase in the capital requirement ratio of 100 basis points induces, on average, a cumulative fall in lending growth of 6.5–7.5%.

5. Conclusions

The impact of macroprudential policies on credit growth remains an open issue. Most of the academic work on the subject has been based on aggregate- or bank-level information and has failed to reach conclusive results. This paper summarises the results of a joint project commissioned by the Consultative Council for the Americas that evaluates the effectiveness of macroprudential tools and their interaction with monetary policy. In particular, we used loan-level data and a common protocol for five Latin American countries (Argentina, Brazil, Colombia, Mexico and Peru) and corroborated the analysis using data on credit origination and borrower characteristics for other three countries (Canada, Chile and the United States). Given that, for confidentiality reasons, it was not possible to pool credit registry data sets, we used meta-analysis techniques to compare the results.

The main takeaways of the joint project are, first, that macroprudential policies have been successful in dampening credit cycles and reducing banking sector risk. In particular, macroprudential policies mainly aimed at curbing the cycle have been demonstrably effective in reducing credit growth even in the short term (within three months). The propagation of the effects for capital-based requirements is less rapid, taking place within a year. Country papers corroborated this result and suggested that bank-specific characteristics also influenced the impact of macroprudential

policies on credit. In particular, some of the contributions showed that the effects of macroprudential policies were more pronounced for less stable financial institutions (eg Colombia), less strongly capitalised banks (eg the United States and Brazil) and less liquid intermediaries (Brazil).

Second, the effectiveness of macroprudential tools is reinforced by the use of monetary policy and vice versa. Macroprudential tools that acted as a complement to monetary policies (ie pushed in the same direction) were relatively more effective.

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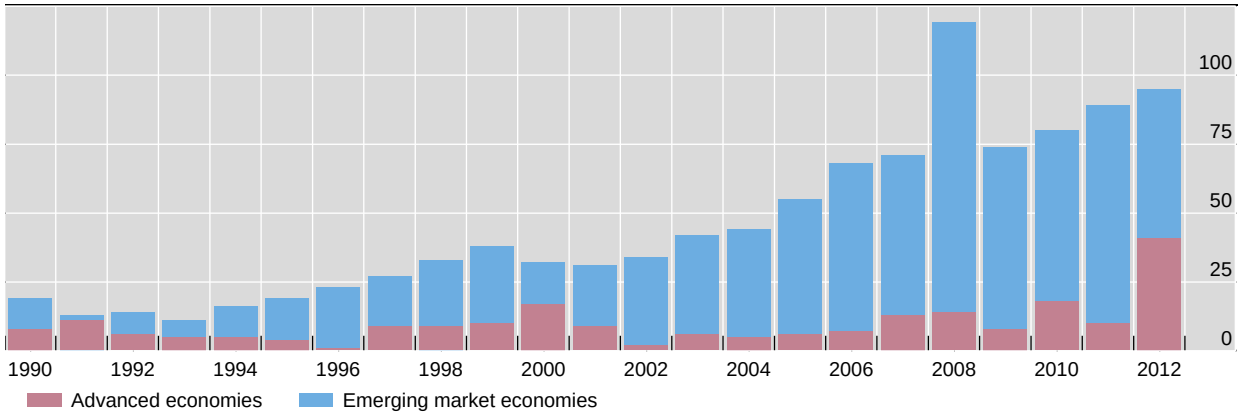
Graphs and tables

Use of macroprudential measures over time[1]

Number of macroprudential policy actions — Graph 1

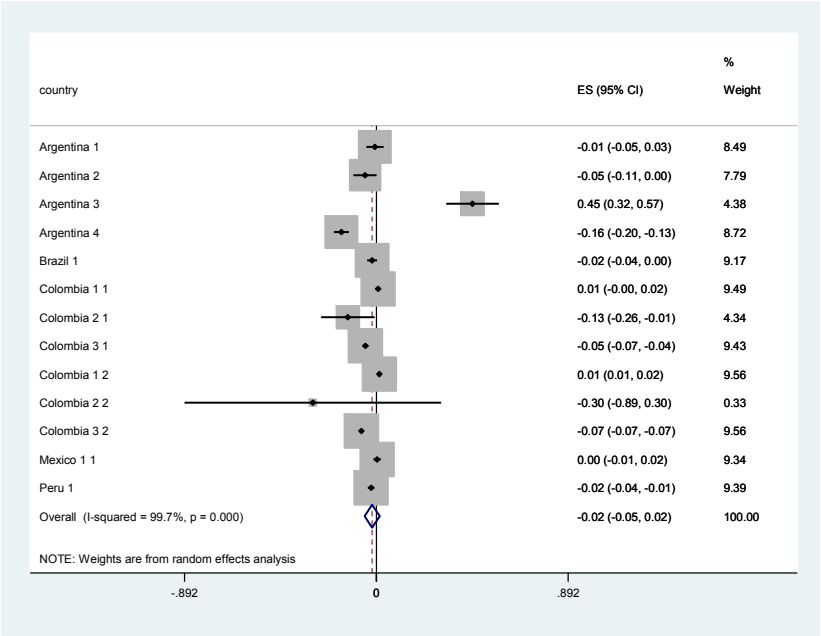


[1] The sample covers 1,047 macroprudential policy actions adopted in 64 countries (29 advanced and 35 emerging market economies). The database has been constructed using information in Kuttner and Shim (2016) and Lim et al (2013).

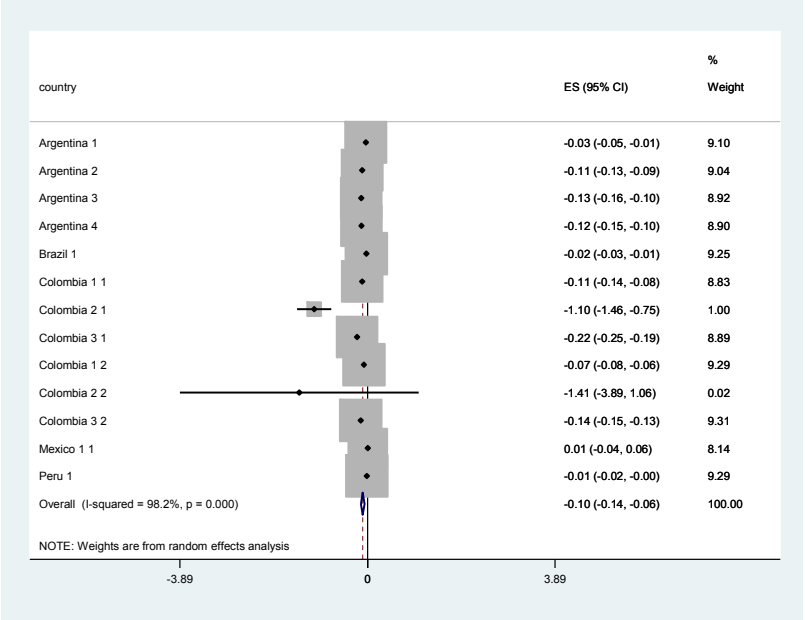
Sources: IMF; BIS.

Forest plot of the effects of MPP on credit growth controlling for bank characteristics (Equation 1) Graph 2

(a) Effect after three months



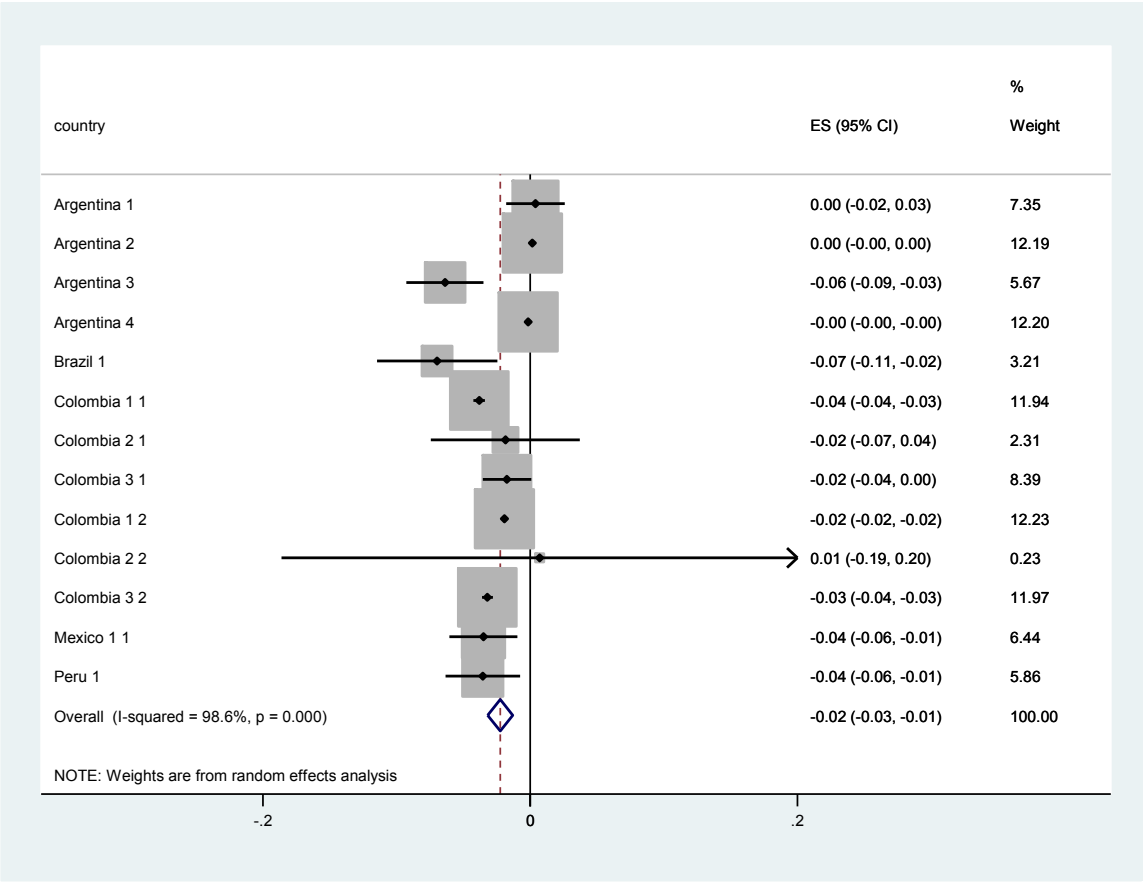
(b) Effect after one year



Note: The rows correspond to the analysed policies and the size of the grey squares represents the weights of each country observation. The x-axis represents the level of the coefficient and the country coefficients are embodied by black dots. Each point is crossed by a line which represents the confidence interval of the estimated value. The blue rhombus represents the estimated range of the effect using random effects analysis. Convention of policies evaluated: Argentina 1: Introduction of capital buffer; Argentina 2: tightening of capital buffer; Argentina 3: Introduction of limits on net global position; Argentina 4: tightening in the limits on net global position; Brazil 1: Use of reserve requirements; Colombia 1 1 introduction of dynamic provisioning system. Evaluation made on loans to firms; Colombia 2 1: requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to firms; Colombia 1 2 : introduction of dynamic provisioning. Evaluation made on loans to individuals; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to individuals; Mexico 1: Provisions on expected losses Peru 1: Introduction of dynamic provisioning system.

Forest plot of the sum of the interaction terms between monetary and macroprudential policies ($\sum_{j=1}^{4} \gamma_j$ in Equation 2)

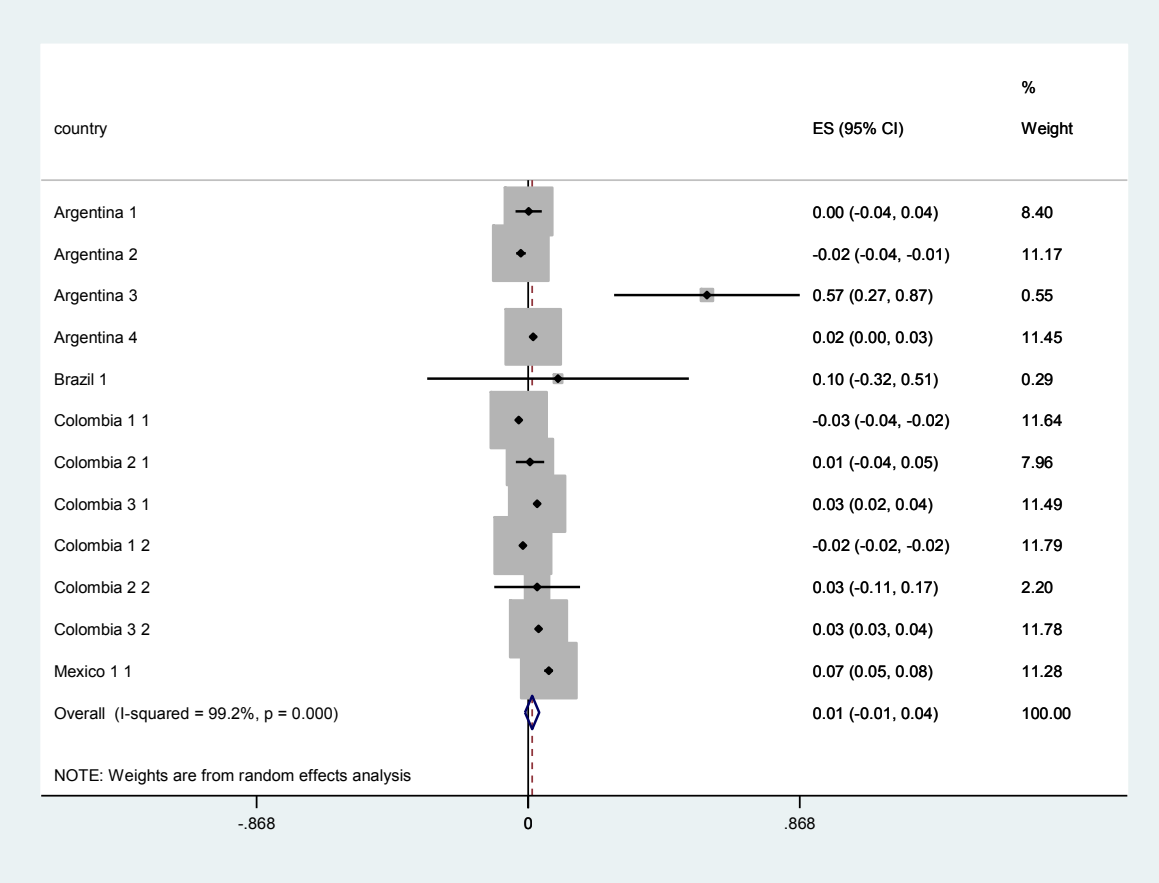
Graph 3



Note: The rows correspond to the analysed policies and the size of the grey squares represents the weights of each country observation. The x-axis represents the level of the coefficient and the country coefficients are embodied by black dots. Each point is crossed by a line which represents the confidence interval of the estimated value. The blue rhombus represents the estimated range of the sum of interactions using random effects analysis. Convention of policies evaluated: Argentina 1: Introduction of capital buffer; Argentina 2: tightening of capital buffer; Argentina 3: Introduction of limits on net global position; Argentina 4: tightening in the limits on net global position; Brazil 1: Use of reserve requirements; Colombia 1 1 introduction of dynamic provisioning system. Evaluation made on loans to firms; Colombia 2 1: requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to firms; Colombia 1 2: introduction of dynamic provisioning. Evaluation made on loans to individuals; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to individuals; Mexico 1: Provisions on expected losses. Peru 1: Introduction of dynamic provisioning system.

Forest plot of the interaction between macroprudential policy and business cycle conditions ($\sum_{j=1}^{4} \eta_j$ in Equation 3)

Graph 4



Note: The rows correspond to the analysed policies and the size of the grey squares represents the weights of each country observation. The x-axis represents the level of the coefficient and the country coefficients are embodied by black dots. Each point is crossed by a line which represents the confidence interval of the estimated value. The blue rhombus represents the estimated range of the effect using random effects analysis. Convention of policies evaluated: Argentina 1: Introduction of capital buffer; Argentina 2: tightening of capital buffer; Argentina 3: Introduction of limits on net global position; Argentina 4: tightening in the limits on net global position; Brazil 1: Use of reserve requirements; Colombia 1 1 introduction of dynamic provisioning system. Evaluation made on loans to firms; Colombia 2 1: requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to firms; Colombia 1 2: introduction of dynamic provisioning. Evaluation made on loans to individuals; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to firms; Mexico 1: Provisions on expected losses. Peru 1: Introduction of dynamic provisioning system.

Different types of macroprudential tool in the Americas

Table 1

Type of instrument	Measures	Frequency of use (percent)	Tightening measures	Loosening measures
	(1)	(2)	(3)	(4)
a. Enhancing Resilience (1)	38	22		
Capital requirement/Risk weights (RW)/ Limits on dividend distribution	21	12.1	17	4
Provisioning requirement (Prov)	9	5.2	9	0
Liquidity ratios	8	4.6	7	1
b. Dampening the cycle (2)	135	78		
Changes in reserve requirement (RR)	108	62.4	53	55
Net open position (NOP)	9	5.2	4	5
Changes in LTV, DTI limits	13	7.5	9	4
Limits on credit growth or lending to specific sectors	2	1.2	1	1
Foreign currency lending limits	3	1.7	3	0
Total	***173***	***100***	***45***	***16***

Note: (1) We follow the classification in Claessens et al (2013) with respect to the objectives of macroprudential policies. According to them, in reviewing the goals of various types of macroprudential policies, it is useful to classify measures in four groups. The first two groups are aimed at reducing the occurrence and consequences of cyclical financial risks, by respectively either (1) dampening the expansionary phase of the cycle, or (2) reinforcing the resilience of the financial sector to the adverse phases of the cycle. The database has been constructed using information in Kuttner and Shim (2016) and Lim et al (2013). The information includes the following countries: Argentina, Brazil, Canada, Chile, Colombia, Mexico, Peru, United States and Uruguay.

Macroprudential policies reported for meta-analysis by country groups Table 2

Instrument	Country	Description	Authority responsible for the measure	Objective of the policy (classification used by Claessens et al (2013))*
1. Capital buffer and profit reinvestment	Argentina	Authorities established that any financial institution could redistribute profits through dividends as long as its regulatory capital after dividends are paid is at least 75% above the regulatory minimum capital requirement. This measure was introduced in 2010, with 30% threshold of regulatory capital requirement over which profits may be distributed; it was further increased to 75% in 2012.	Central bank	Enhancing resilience (introduction) and dampening the cycle (tightening)
2. Foreign currency net global position	Argentina	To limit currency mismatches of banking institutions, a limit in the difference between assets and liabilities denominated in foreign currency was introduced in 2014, with a 30% threshold of regulatory capital and then lowered (tightened) to 20% in September that year.	Central bank	Dampening the cycle (tightening)
3.Reserve requirements	Brazil	Brazil has been active in the use of reserve requirements. Different scenarios are considered (i) the release of reserves in 2008–09 in response to the liquidity squeeze following the global financial crisis; (ii) the reversal of the policies in 2010–11 in the context of high capital inflows and associated credit growth; and (iii) the renewal of stimulus during 2012–14 in response to perceived weakness of economic activity and credit growth.	Central bank	Dampening the cycle
4.Dynamic provisioning regime	Colombia	Inspired by the Spanish system, a new provisioning regime with countercyclical considerations for commercial loans began in July 2007.	Supervisor	Enhancing resilience
5.Deposit requirement on external loans	Colombia	Almost simultaneously with the establishment of a marginal reserve requirement on deposits, the central bank adopted a requirement on short term external loans of 40% with a holding period of six months.	Central Bank	Dampening the cycle
6.Marginal reserve requirement on banking deposits	Colombia	In response to an episode of excessive credit growth, in May 2007 the central bank established a marginal reserve requirement of 27% on current accounts, 12.5% for saving accounts and 5% for term deposits with a maturity lower than 18 months.	Central bank	Dampening the cycle
7.Changes in provisioning	Mexico	From a backward-looking scheme of provisions, the authorities introduced a new provisioning methodology designed to increase the accuracy of provisions including expected losses considerations. It was introduced in 2009, 2011 and 2014 for different types of loan.	Supervisor	Enhancing resilience
8.Dynamic provisioning	Peru	To reduce the procyclical behaviour of credit, a dynamic provisioning scheme was introduced in 2008.	Supervisor	Enhancing resilience

* According to this paper, in reviewing the goals of various types of macroprudential policies, it is useful to classify measures in four groups. The first two groups are aimed at reducing the occurrence and consequences of cyclical financial risks, by respectively either (1) dampening the expansionary phase of the cycle, or (2) reinforcing the resilience of the financial sector to the adverse phases of the cycle. The paper also considers a third group that includes those prudential policies directed to dispelling the gestation of cycles and a fourth group of policies which is aimed at risks arising from interconnectedness and tries to ensure the internalisation of spillovers. These two types of policies are not analysed in this paper.

Effects of macroprudential policies on credit growth after three months. Meta-analysis of estimated coefficient of MPP on credit growth

Table 3

	Eq.1	Eq.1 cyclical	Eq1 capital	Eq.2	Eq.2 cyclical	Eq.2 capital	Eq.3	Eq.3 cyclical	Eq.3 capital	ALL	ALL cyclical	ALL capital
Q (1)	1033***	105.3***	94.87	4415***	53.6***	32.9***	241.5***	37.2***	24.85***	5691.0***	1273***	333.15***
Degrees of freedom	12	6	5	12	6	5	12	6	5	37	20	16
I^2 (2) (%)	98.8	99.2	94.7	99.7	88.8	84.8	95.4	66.7	85.5	99.3	99.7	92.3
τ^2 (3)	0.0014	0.0015	0.0010	0.0034	0.0006	0.0002	0.0035	0.0069	0.004	0.0019	0.0008	0.0011
Random-effects mean (4)	**-0.057*** **	**-0.094*** **	**-0.027***	-0.020	**-0.072*** **	-0.002	**-0.036***	**-0.108*** **	-0.021	**-0.042*** **	**-0.084*** **	-0.019
95% conf.int	-0.081 to -0.0034	-0.129 to -0.060	-0.055 to 0.001	-0.055 to 0.015	-0.099 to -0.046	-0.017 to 0.012	-0.077 to 0.006	-0.189 to -0.027	-0.053 to 0.004	-0.058 to -0.025	-0.101 to -0.067	-0.054 to 0.010

Notes: (1) The *Q* Measure evaluates the level of homogeneity/heterogeneity among studies. It is calculated as the weighted squared difference of the estimated effects with respect to the mean. The statistical distribution of this measure follows a χ^2 distribution. The null hypothesis of the test assumes homogeneity in the effect sizes. (2) This percentage represents the magnitude of the level of heterogeneity in effect sizes and it is defined as the percentage of the residual variation that it is attributable to between study heterogeneity. It is defined as the difference between the *Q* measure and the degrees of freedom divided by the *Q* measure. Although there can be no absolute rule for when heterogeneity becomes important, Harbor and Higgins (2008) tentatively suggest adjectives of low for I^2 values between 25% and 50%, moderate for 50%-75% and high for values larger than 75%. (3) τ^2 is a measure of population variability in effect sizes. It depends positively on the observed heterogeneity (Q measure) and its difference with respect to the degrees of freedom. Given the expected value of Q measure under the null hypothesis of homogeneity is equal to the degrees of freedom; a homogeneous set of studies will result in this statistic equal to cero. Under the presence of heterogeneity this estimate should be different from cero. (4) It corresponds to the weighted average of coefficients reported in different estimations. The weights are calculated considering the sampling fluctuation of each effect size (standard error per reported coefficient) and estimated population variance of effect sizes (τ^2). ***,** and * denote significance at the 1%,5% and 10%, respectively.

Effects after one year of macroprudential policies on credit growth. Meta-analysis of estimated coefficient of MPP on credit growth

Table 4

	Eq.1	Eq.1 cyclical	Eq1 capital	Eq.2	Eq.2 cyclical	Eq.2 capital	Eq.3	Eq.3 cyclical	Eq.3 capital	ALL	ALL cyclical	ALL capital
Q (1)	663***	61.8***	123.01***	200.4***	86.5***	31.1***	99.5***	26.3***	39.84***	1784***	434***	573.5***
Degrees of freedom	12	6	5	12	6	5	12	6	4	37	20	16
I^2 (2) (%)	98.2	98.2	95.9	94	93.1	83.9	88.9	77.2	90	97.9	95.4	98.8
τ^2 (3)	0.0039	0.0054	0.0017	0.0008	0.0017	0.0002	0.0010	0.0029	0.0005	0.0024	0.0033	0.0010
Random-effects mean (4)	**-0.098*** **	**-0.150*** **	**-0.056*** **	**-0.042*** **	**-0.068*** **	**-0.031*** **	**-0.065*** **	**-0.115*** **	**-0.054*** **	**-0.072*** **	**-0.125*** **	**-0.047*** **
95% conf.int	-0.149 to -0.072	-0.215 to -0.086	-0.090 to -0.021	-0.060 to -0.024	-0.105 to -0.032	-0.043 to -0.018	-0.091 to -0.040	-0.178 to -0.053	-0.075 to -0.033	-0.114 to -0.060	-0.158 to -0.091	-0.063 to -0.031

Notes: (1) The *Q* Measure evaluates the level of homogeneity/heterogeneity among studies. It is calculated as the weighted squared difference of the estimated effects with respect to the mean. The statistical distribution of this measure follows a χ^2 distribution. The null hypothesis of the test assumes homogeneity in the effect sizes. (2) This percentage represents the magnitude of the level of heterogeneity in effect sizes and it is defined as the percentage of the residual variation that it is attributable to between study heterogeneity. It is defined as the difference between the *Q* measure and the degrees of freedom divided by the *Q* measure. Although there can be no absolute rule for when heterogeneity becomes important, Harbor and Higgins (2008) tentatively suggest adjectives of low for I^2 values between 25% and 50%, moderate for 50%-75% and high for values larger than 75%. (3) τ^2 is a measure of population variability in effect sizes. It depends positively on the observed heterogeneity (Q measure) and its difference with respect to the degrees of freedom. Given the expected value of Q measure under the null hypothesis of homogeneity is equal to the degrees of freedom; a homogeneous set of studies will result in this statistic equal to cero. Under the presence of heterogeneity this estimate should be different from cero. (4) It corresponds to the weighted average of coefficients reported in different estimations. The weights are calculated considering the sampling fluctuation of each effect size (standard error per reported coefficient) and estimated population variance of effect sizes (τ^2). ***,** and * denote significance at the 1%,5% and 10%, respectively.

Effects of macroprudential policies on credit growth. Meta-regression

Table 5

Explanatory variables:	Dependent variable: Estimated effect of macroprudential policy on credit growth							
	Eq 1	Eq 1	Eq 2	Eq 2	Eq3	Eq3	ALL	ALL
Countercyclical instrument (1)	-0.0712 (0.0640)	**-0.0791*** **(0.0347)**	**-0.2631**** **(0.0869)**	**-0.2949**** **(0.1032)**	**-0.3616**** **(0.1417)**	**-0.3848***** **(0.1385)**	**-0.2251***** **(0.0577)**	**-0.2450***** **(0.0617)**
Capital instrument (2)	0.0163 (0.0639)	0.01814 (0.0351)	**-0.1777*** **(0.08391)**	-0.1766 (0.1032)	**-0.2911*** **(0.1481)**	-0.2911 (0.1540)	**-0.1381***** **(0.0573)**	**-0.1257***** **(0.0605)**
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2 (percent)	9.16	91.7	46.7	12.4	33.1	38.0	31.7	25.1
Joint test for significance of all variables	1.58	5.09**	4.94**	1.54	3.43*	2.53	7.74***	3.05***
Number of observations	13	13	13	13	13	13	39	39

Note: (1) We identified with a dummy variable the policies employed with countercyclical purposes. To this group we included: (i) the increase in capital buffers requirements requirement, (ii) the increase in the limits on external borrowing position, both employed in Argentina in 2012; (iii) the imposition of marginal reserve requirements; and iv) the obligation of a deposit requirement on external loans, both employed in Colombia in 2007. (2) We identified with a dummy variable those instruments that have effects on the capital of banking institutions. To this group belong the following policies: (i) the establishment and (ii) the tightening in capital buffers that took place in Argentina in 2010 and 2012, respectively; iii) the introduction of a dynamic provisioning system in Colombia and (iv) in Peru and finally (v) the changes in provisioning requirements that took place in Mexico. (***,** and * denote significance at the 1%,5% and 10%, respectively.

Effectiveness of macroprudential policy conditional on monetary policy and business cycle. Meta-regression

Table 6

Explanatory variables:	Dependent variable: Sum of coefficients of the interaction terms between macroprudential and monetary policy		Dependent variable: Sum of coefficients of the interaction terms between macroprudential policy and changes in GDP	
Countercyclical instrument (1)	-0.0127 (0.0120)	-0.0095 (0.0125)	-0.0656 (0.0186)	-0.0880 (0.0298)
Capital instrument (2)	-0.0096 (0.0129)	-0.0098 (0.0121)	-0.0769 (0.0494)	**-0.0546*** **(0.0272)**
Country effects	No	Yes	No	Yes
Adjusted R^2 (percent)	6.4	7.1	90.1	84.3
Joint test for significance of all variables	0.8	1.07	10.56***	2.44
Number of observations	13	13	13	13

Note: (1) We identified with a dummy variable the policies employed with countercyclical purposes. To this group we included: (i) the increase in capital buffers requirements requirement, (ii) the increase in the limits on external borrowing position, both employed in Argentina in 2012; (iii) the imposition of marginal reserve requirements; and (iv) the obligation of a deposit requirement on external loans, both employed in Colombia in 2007. (2) We identified with a dummy variable those instruments that have effects on the capital of banking institutions. To this group belong the following policies: (i) the establishment and (ii) the tightening in capital buffers that took place in Argentina in 2010 and 2012, respectively; (iii) the introduction of a dynamic provisioning system in Colombia and (iv) in Peru and finally (v) the changes in provisioning requirements that took place in Mexico. (***,** and * denote significance at the 1%,5% and 10%, respectively.

Panel estimation vs weighted OLS. Effects after one year

Table 7

Instrument	Country	Panel estimation	Weighted OLS
1. Capital buffer and profit reinvestment	Argentina	-0.1086*** (0.0115)	-0.0546* (0.0319)
2. Foreign currency net global position	Argentina	-0.1244*** (0.0141)	-0.2559*** (0.0893)
3.Reserve requirements	Brazil	-0.0209** (0.0064)	-0.0039 (0.0062)
4.Dynamic Provisioning regime	Colombia	-0.1068*** (0.015)	-0.3683*** (0.0714)
5.Deposit requirement on external loans	Colombia	-1.1044*** (0.1813)	-0.9769*** (0.5172)
6.Marginal reserve requirement on banking deposits	Colombia	-0.2173*** (0.01421)	-0.2006** (0.018)
7.Changes in provisioning	Mexico	-0.0508*** (0.0076)	-0.1356* (0.0812)
8.Dynamic Provisioning	Peru	-0.0122*** (0.0052)	-0.0484** (0.0196)

Note: ***,** and * denote significance at the 1%,5% and 10%, respectively.

Estimated effect of macroprudential polices on credit growth using difference in difference analysis

Table 8

Country	Instrument	Counterfactual used	Effect on credit growth	Comments
Argentina	Introduction of the capital buffer and the limit on foreign currency holdings.	The evaluated policies did not apply to all the intermediaries. The counterfactual is based on this categorisation.	-3.4% for the capital buffer and -4.8% for the introduction of the limit on foreign currency holdings	Time window of six months before and after the implementation of each rule.
Brazil	Changes in reserve requirements	Based on the levels of reserve requirements that banks would have constituted assuming that each requirement was enacted one month before.	For the intensive margin the impact is -0.77% (November 2008) and -1.32% (March 2010). For the extensive margin the effect is -0.54 and -0.67%, respectively.	Monthly data. They evaluated an easing in reserve requirements in November 2008 and a tightening in such requirements in March 2010
Colombia	Introduction of dynamic provisioning system and the marginal reserve requirement.	Based on the levels of provisions and reserve requirements that banks would have constituted assuming that each requirement was enacted one year before.	-0.97% for provisioning and -0.80% for reserve requirements	The values of the elasticities are calculated assuming an increase in 1% in the ratio between provisions for the introduction of dynamic provisions, and an increase of 10bp in the ratio between reserve and total liabilities. One-year window was employed

Note: Country teams of Mexico and Peru did not report this analysis.

Annex A: Macroprudential instruments in CCA countries

Instrument	Argentina	Brazil	Canada	Chile	Colombia	Mexico	Peru	United States
Capital-based instruments								
Countercyclical capital buffers	No	No	No	No	No	No	No	No
Limits on Leverage	No	No	No	No	No	No	No	No
Dynamic Provisioning	No	No	No	No	**Yes (2007)**	**Yes (2011) (provision on expected losses)**	**Yes (2008)**	No
Limits on dividend distribution	**Yes (2010, 2012 conservation buffer)**	No	No	No	*Yes (2008)*	No	No	*Yes, CCAR (2011, 2012, 2013, 2014)*
Other capital-based tools	*Yes (2004, 2007, 2012 changes in risk weights for specific operations)*	**Yes (Change of risk weights for some housing loans and some auto and payroll loans)**	No	No	*Yes (increase in the LGD of some consumer loans in 2011 and temporary provision for entities with high NPL growth in 2012).*	No	*Yes (on specific operations 2010, 2012)*	**Yes, SCAP (2009), DFA Stress tests (2013, 2014)**
Liquidity-based instruments								
Countercyclical reserve requirements	*Yes (but not countercyclical)*	**Yes (2008, 2009, 2011, 2012)**	No	No	**Yes (2007)**	No	**Yes. (2010, 2011)**	No
Liquidity ratios	*Yes (2008)*	*Yes. Liquidity measures and capital flow tax to ease funding problems of banks that lend to firms.*	No	*Yes*	*Yes (2008)*	*Yes*	*Yes (1997, 2012)*	No
Limits on non-core liabilities	No	No	No	No	No	No	No	No
Asset-based instruments								
LTV and DTI limits	*Yes (LTV for mortgages)*	**Yes. Establishment of LTV caps for some housing loans.**	**Yes (2004, 2007, 2008, 2010, 2011, 2012)**	No	*Yes (1999)*	No	*Yes*	*Yes (2014) (Dodd Frank)*
Limits on credit growth	No	No	No	No	*Yes*	No	No	No
Limits on exchange rate risk	**Yes (limits on net foreign currency position of FI)**	*Yes (2007)*	No	*Yes*	*Yes (2005)*	*Yes (1997)*	*Yes (2010-2011)*	No
Limits on derivatives	*Yes*	*Yes (2011)*	No	No	*Yes (2007)*	*Yes (2001)*	*Yes (2011)*	No
Other asset-based instruments	No	No	No	No	No	No	No	**Yes (2013) (Leveraged Lending Guidance)**

Note: The number in brackets indicates the year of modification or use of macroprudential instrument. Macroprudential tools that have been evaluated in this project by country teams are indicated in bold.

Annex B: Meta-analysis techniques

Meta-analysis techniques are very helpful when studies are not perfectly comparable but evaluate the same or a closely related question. The main purpose of the meta-analysis is to better exploit the information of a set of estimations for a specific problem. These techniques are especially used in medical sciences for summarising the effect of specific treatments or policies on a population of individuals. The unit of analysis is commonly a study in which a specific coefficient is estimated. There are two usual approaches that are used depending on the type of information employed and also on the question to be answered: "fixed" and "random effects" estimations.

Under the presence of homogeneous effect sizes, which means that there is low level of variability in the estimated coefficients, we could employ a fixed effects approach in which the estimated effect of any policy corresponds to the average of coefficients weighted by their respective standard deviation. In the case of macroprudential policy evaluation, if we were evaluating the same policy with a similar population, we could employ this method. Nevertheless this is not the case here since we have different sources of heterogeneity.

We therefore employed a random effects methodology in which the objective is to try to model the unexplained heterogeneity of effects. Random effects models conceptualise the population of effect sizes as falling along a distribution with both mean and variance, but beyond variance due to sampling fluctuations of individual studies (Card (2016)). In other words, this type of estimation considers not only the level of variation for each specific estimated coefficient (as was done under the fixed-effect approach) but also the level of variability of estimated coefficients among the studies (or country estimations in our case).

The first step for performing a random effects meta-analysis is precisely to estimate the level of heterogeneity among effect sizes. This is constructed using the squared weighted sum of the difference between the estimates and its average. This statistic is commonly called the Q measure. In our case the value of this statistic is quite high, in many cases rejecting the null hypothesis of homogeneity under a χ^2 statistical distribution (Table 3), suggesting a large level of heterogeneity among estimates for the four considered equations.

The second step is to estimate the population variability in effect sizes (τ^2). There are different methodologies to estimate this parameter, but the simplest one uses the observed heterogeneity (total variability) and the expected variability given the standard errors of the coefficients. This statistic depends positively on Q and negatively on the number of studies (ie country estimations) or degrees of freedom.

The third step is to use this estimate of population variability to provide random-effects weights of effect sizes. This type of estimation considers two sources of imprecision of estimates: population variability and sampling fluctuation. The weights of each coefficient are defined as the inverse of the sum of the sampling standard error and the population variability.

All these elements together allow an expected range of different coefficients to be calculated. It is important to highlight that the purpose of a meta-analysis random effect calculation is not to estimate an expected value but a range.

More formally, given a certain level of variability of the country effects, we could expect that the true effects of a macroprudential policy, θ_i, varies between

estimations by assuming that they have a normal distribution around a mean effect, θ. In that sense, the effect could be represented in the following way:

$y_i|\theta_i \sim N(\theta_i, \sigma_i^2)$, where $\theta_i \sim N(\theta, \tau^2)$

So, $y_i \sim N(\theta_i, \sigma_i^2 + \tau^2)$

As it was mentioned above, under this approach there are two sources of variance that are estimated: (i) the variance around the mean of the estimated effect and (ii) the between-study variance.

The main result of this estimation corresponds to a range in which the expected value of the effect of a macroprudential tool in which a specific dimension of credit (ie credit growth or bank risk) could be located.

It is common to observe in this type of estimation a great level of heterogeneity among studies, or as in our case, among country estimations. The country estimations in our exercise are no exception. It is natural to expect a higher level of heterogeneity since we are combining not only different countries but also different types of policy.

When the estimated coefficients are quite diverse, increasing the uncertainty of an average effect, one common alternative is to try to explain the differences in the results using statistical estimations. This approach is called meta-regression analysis. This type of analysis is commonly employed on study-level summary data that investigate the extent to which statistical heterogeneity between results of multiple studies can be related to one more characteristics of the studies.

The meta-regression allows for such residual heterogeneity (between-study variance) by assuming that the true effects follow a normal distribution around the linear predictor. In that line, the meta-regression can be formally defined in the following way:

$y_i|\theta_i \sim N(\theta_i, \sigma_i^2)$, where $\theta_i \sim N(x_i\beta, \tau^2)$

So, $y_i \sim N(x_i\beta, \sigma_i^2 + \tau^2)$

where β is the vector of estimated effects of study characteristics. This type of equation is estimated by weighted least-squares, in which the weight of each estimated coefficient depends inversely of its variance and corresponds to the inverse of the sum of two types of deviations (σ^2, τ^2).

Meta-regressions are similar in essence to OLS regressions, in which an outcome variable is predicted according to the values of one or more explanatory variables (Higgins and Green (2011)). In our case the dependent variable is the effect estimate of macroprudential tools on the different dimensions of credit and the explanatory variables are characteristics of studies that might influence the size of intervention effect.

The regression coefficient obtained from the meta-regression analysis describes how the outcome variable (the effect of macroprudential policy) changes with a unit increase in the explanatory variable. As some of our dependent variables are categorical variables in most cases (dummy variables), the regression coefficients estimate how the macroprudential effect in each subgroup differs from a nominated reference subgroup.

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