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

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Abstract

The implementation of a new financial stability framework raises a number of issues. One of them is that research on the impact of macroprudential policies and their interaction with monetary policy is relatively recent, and requires deeper analysis. Using meta-analysis techniques, we present the results of a joint research project that evaluates the effectiveness of macroprudential tools in five Latin American countries (Argentina, Brazil, Colombia, Mexico and Peru). The use of granular credit registry data helps us disentangle loan demand from loan supply effects, and allows us to compare macroprudential tools that are very different in nature. The main conclusion of our study is that the macroprudential policies followed by our sample of countries have been quite effective in stabilising credit growth. This was particularly the case for policies employed for countercyclical purposes. Such policies acted in the same direction as monetary policy, suggesting complementarity in the use of policy tools. Last, we also found that policies affecting the level of prudential buffers (provisions and capital requirements) were particularly effective in limiting risks to the banking sector.

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

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1. Introduction

The recent Global Financial Crisis (GFC) has made it clear that the macroprudential or systemic dimension in 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. Many countries have gained valuable experience in the use of macroprudential policies but their implementation still raises a number of issues. One is the evaluation of the impact of macroprudential policies, especially when more than one tool is activated. Bearing that in mind, effectiveness should be analysed with respect to the specific goal macroprudential policies are designed to achieve, that is, to increasing the resilience of the financial system or, more ambitiously, taming financial booms and busts.

At the moment, the evidence on the impact of macroprudential policies is mixed and additional work is required before one can reach solid conclusions. For instance, recent evidence suggests that debt-to-income ratios and, probably to a lesser extent, loan-to-value ratios are relatively more effective than capital requirements as tools for containing asset growth (Claessens et al (2013)). Indeed, the recent activation of the Basel III countercyclical capital buffer 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 buffers is to increase the banking sector's resilience, not to smooth the credit cycle. Restraining the boom is perhaps no more than a welcome side effect of capital-related macroprudential tools (Drehmann and Gambacorta (2012)). Similarly Cohen and Scatigna (2016) show that banks met higher capital requirements in the aftermath of the global financial crisis through accumulation of retained earnings without sharply adjusting credit growth.

A second issue pertains to the varied 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 have 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 loan-to-value ratio caps only affect new borrowers (and usually only those that are highly leveraged). This argues in favour of capital buffers when the objective is to improve overall resilience. But loan-to-value ratios 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 studies point to their effectiveness in limiting excessive credit growth (Cerutti et al (2015), Bruno et al (2015)), 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 (2015)). Nevertheless, most of the evidence gathered so far has been obtained using aggregate data at country level or bank-level data (mostly from BankScope). 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 (2012)) and a study on the effects of reserve requirements in Uruguay (Dassatti and Peydro, 2014). Our paper tries to fill this gap by using in a comprehensive way loan level data, that are very helpful to disentangle loan demand from loan supply effects.

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 the 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 (2012), 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 loan-to-value or debt-to-income ratios 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 kinds of policy could have additional implications, especially in emerging market economies (EMEs), 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 would be critical (Freixas et al (2015)).

Another question that has not been fully answered is whether macroprudential and monetary policy instruments are complements or substitutes. On this issue, evidence obtained from the use of DSGE models[2] and empirical analysis suggests that monetary and macroprudential policies are complements rather than substitutes, although the results obtained vary by types 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)). 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 banking 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 at al (2016)). IMF (2013b) discusses a number of experiences in which macroprudential tools have been used in conjunction with monetary policy to produce successful results in terms of financial and monetary stability objectives. In

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

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 financial cycles, such as credit cycles, are very powerful, and then monetary and fiscal policies should also play a role (Borio (2014)). However, macroprudential instruments have been used so far with a variety of goals and it would be worth gaining further practical experience concerning their interaction with monetary policy instruments.

Finally, some recent studies analyse the effectiveness in a cross-country set up. Cerutti et al (2015) 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 nonbank finance, and in open economies that tend to allow borrowers to obtain funds from across the border. Cizel and others (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. Aiyar et al (2014) analyse the experience for the UK and find that capital requirements can be circumvented by foreign bank branches, that are not affected by regulation, or the shadow banking sector.

In order to improve our knowledge of 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 five countries (Argentina, Brazil, Colombia, Mexico and Peru) that made use of credit registry data. The analysis arising out of the joint project was completed by work conducted in three additional countries (Canada, Chile and United States) on the effects of specific policies using information on credit origination and borrower characteristics. The studies consider individual banks both domestic and foreign institutions (subsidiaries and branches).

Latin America is a good laboratory for the evaluation of the effectiveness of macroprudential tools, given that their use has a relatively long history (Jara et al (2009), Tovar et al (2012)).[3] Graph 1 shows that the vast majority (around 80%) of existing macroprudential tools have been applied in EMEs (see also Altunbas et al (2016)). Moreover, several Latin American countries 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 reasonably 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 had to face a major issue in comparing macroprudential 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 allowed us to estimate the relevance of

[3] Annex A gives details of the macroprudential tools for all the CCA countries.

different policy characteristics (or tools) in explaining the heterogeneity of policy effects.

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 allows us to carefully disentangle shifts in loan demand and supply shifts, and to insulate the impact of macroprudential tools on credit dynamics and banking sector risks. We also shed some light on the link between monetary and macroprudential policies. Our initiative is complementary to the International Banking Research Network (IBRN) where researchers from 15 central banks and 2 international organizations use confidential bank-level data to analyse the existence of cross-border prudential policy spillovers. By focusing on domestic credit our paper complements the IBRN analysis.

Our main results are the following. First, the macroprudential policies implemented by our sample of countries have been effective in dampening credit cycles and reducing banking sector risks. In particular, policies used countercyclically have been successful in reducing credit growth. This is in line with the IBRN results where interbank exposure limits, loan to-value-ratios and reserve requirements are the prudential instrument that most frequently spill over internationally through bank lending.

Second, macroprudential policies used as complements to monetary policy have had more significant effects on credit growth than any other kind of policy instrument. Third, macroprudential policies have helped reduce the procyclicality of credit and have acted as stabilising tools for the economy. Fourth, prudential policies directed at increasing the resilience of the banking sector (provisions and capital requirements) have been effective in reducing banking sector risk. By contrast, the effectiveness of macroprudential policies designed to dampen credit growth have had a more limited impact on the volume of loans but not on the overall accumulation of risk in the banking sector.

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

2. Empirical strategy

Credit register data are highly confidential. This means that it is not possible to pool the data in a unique data set and that it is necessary to run regressions at a country level. This does not allow the cross-sectional variability at the country level to be exploited but, on the other hand, 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. However, 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.

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). The fourth equation studies how risk (at the bank level) is influenced by macroprudential policies (Equation 4). These four equations aim at answering the following questions:

(i) Are macroprudential tools effective?

(ii) Are macroprudential policies substitutes for or complementary to monetary policy?

(iii) Are macroprudential policies countercyclical?

(iv) Are macroprudential policies effective in limiting bank credit risk?

Macroprudential tools and loan supply shifts

The first equation evaluates the impact of macroprudential tool at the loan level using the following regression:[4]

$$\Delta Log\ Credit_{bft} = \delta_f + \beta \Delta \text{Macro tool}_{t-1} + \gamma \Delta \text{Macro tool}_{t-1} * X_{bt-1} + \mu\ controls_{bft} + \theta_t + \varepsilon_{bft} \quad (1)$$

where $\Delta Log\ Credit_{bft}$ is the first difference in the logarithm of actual value of loans by bank b to firm f at time t. We include as explanatory variables the change in macroprudential tool lagged one period ($\Delta \text{Macro tool}_{t-1}$) and its interaction with a vector of bank-specific characteristics (X_{bt-1}). 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 bank-debtor relationship characteristics. Our main coefficients of interest are the vectors β and γ that indicate the change of credit induced by the changes in the specific macroeconomic tool.[5]

It is worth stressing that the test is limited at the moment to the short term impact but it is necessary to test also the impact after one year as some of the macroprudential tool that have a more structural nature could take time to propagate their effects.

The inclusion of interaction terms between macroprudential tools and bank-specific characteristics ($\Delta \text{Macro tool}_{t-1} * X_{bt-1}$) is essential for evaluating whether responses to macroprudential shock differ by type of bank (ie domestic vs versus

[4] 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.

[5] In the baseline we assume fixed effect by debtors and standard error clustered at the bank level. However, country papers are free to use other clustering approaches depending on the specific characteristics of their models.

foreign banks; well capitalised vs weakly capitalised banks; public vs private banks, large vs small banks; liquid vs illiquid banks etc). In this vector, we include indicators of capital, liquidity, size and funding structure. All bank-specific characteristics are taken at *t–1* to limit endogeneity issues.

This approach 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.[6] 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, small and less 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.

Interaction between monetary and macroprudential policies

In the second specification, we are especially interested in evaluating whether responses to prudential policies vary with monetary policy conditions. We test this introducing additional interaction terms by combining macroprudential dummies and monetary policy conditions (ie changes in the real money rate, Δr_t,), by estimating the following equation:

$$\Delta Log\ Credit_{bft} = \delta_f + \beta \Delta \text{Macro tool}_{t-1} + \gamma \Delta \text{Macro tool}_{t-1} * \Delta r_t + \delta \Delta r_t + \mu\ controls_{bft} + \theta_t + \varepsilon_{bft} \quad (2)$$

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 γ. The objective of this test is to evaluate if there are some complementarities or differential effects of macroprudential policies depending on the stance of monetary policy.

In particular, we can construct a formal test of complementarity/substitutability between monetary and macroprudential policies taking the first derivative of equation (2) with respect to changes in macro tool and monetary policy, respectively:

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta \text{Macro tool}_{t-1}} = \beta + \gamma \Delta r_t$$

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta r_t} = \delta + \gamma \Delta \text{Macro tool}_{t-1}$$

Since β, δ 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 coefficient γ. Each policy will reinforce the other

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

(ie the two policies are complements) if $\gamma < 0$. By contrast, if a macroprudential policy tightening reduces the effectiveness of a monetary policy tightening (ie the two policies are substitutes) and we should observe $\gamma > 0$.

Macroprudential policies over the cycle

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

$$\Delta Log\ Credit_{bft} = \delta_f + \beta \Delta Macro\ tool_{t-1} + \lambda \Delta LogGDP_t + \eta \Delta Macro\ tool_{t-1} * \Delta LogGDP_t + \mu\ controls_{bft} + \theta_t + \varepsilon_{bft} \quad (3)$$

In order to evaluate procyclicality in the use of macroprudential tools we can calculate the first partial derivative of Equation (3) with respect to changes in macroprudential tools and changes in real GDP growth:

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta \text{Macro tool}_{t-1}} = \beta + \eta \Delta LogGDP_t$$

$$\frac{\partial \Delta Log\ Credit_{bft}}{\partial \Delta LogGDP_t} = \delta + \eta \Delta \text{Macro tool}_{t-1}$$

Given the positive correlation between credit and the level of economic activity, the expected sign of δ is positive. Macroprudential tools could be used to smooth the cycle and therefore a desirable property of macroprudential tools (at least in some cases) could be to attenuate such credit procyclicality. Following this line of reasoning, if we observe a tightening in a specific macroprudential tool that is associated with a reduction of amplification of the business cycle, the total effect of a change in GDP growth on credit dynamic should be lower. In other words, if $\gamma < 0$, the specific macroprudential tool would help to reduce credit procyclicality.

Effect on bank risk-taking

In general, most of the macroprudential policies aim at containing systemic risk that is by nature endogenous. By applying macroprudential tools, policymakers aim to restrict bank risk-taking and the probability of a financial crisis. This means that, ideally, we should be able to evaluate how macroprudential policies influence a bank's contribution to system-wide risk.

Despite recent improvements in constructing measures of systemic risk (for instance Tarashev, Tsatsaronis and Borio (2015) proposed a methodology using the Shapley Value as a measure of risk attribution for banking institutions), it was not feasible to construct a common measure among the countries analysed in this study. In the meta-analysis results obtained using a dependent variable, we have therefore considered a proxy for systemic risk based on non-performing loans. In particular we used the following equation:

$$\Delta Log\ NPL_{bft} = \delta_f + \beta \Delta \text{Macro tool}_{t-1} + \mu\ controls_{bft} + \theta_t + \varepsilon_{bft} \quad (4)$$

where $\Delta Log\ NPL_{bft}$ is the change in the logarithm of actual value of non-performing loans by bank *b* to debtor *f* over a given period after the introduction or change in a macroprudential tool.

Meta-analysis techniques

In order to summarise the results obtained at the country level, we used 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 (2016) summarise by means of meta-analysis the results of a multi-study initiative of the IBRN to study cross-border prudential policy spillovers. As mentioned in the introduction, our analysis focusing on the effects of macroprudential policies on domestic lending represents a complementary experiment.

In our case, each observation is related to the evaluation of a macroprudential policy on different dimensions of credit (ie credit growth and bank risk indicator). We analysed the estimated effects in the four equations presented above. In Table 2, we report the macroprudential tools evaluated by country papers using the common approach.

In a first step using meta-analysis, we are able to estimate a range of the effect of macroprudential policies on credit along different dimensions (eg credit growth, bank risk). 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 groups. 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.

Data issues

In the construction of a common approach, we used a common definition of variables and the same frequency. In particular, we used bank-level data at the quarterly frequency to match them with macro controls (GDP, current account deficit etc) and in order to keep the size of the database to a minimum. 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 ($\Delta Macro\ tool_t$) 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 (Cerutti et al (2015), Altunbas, Binici and Gambacorta (2016); Akinci and Olmstead-Rumsey (2015); Buch et al (2016)). It does not weight for the intensity of the change in the macroprudential tool but it simplifies the comparison of macroprudential tools.

Indeed the macroprudential tools analysed in this paper have a different nature, in the sense that they tend to be more complicated 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 (some 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 and 2.[7]

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 are more focused on dampening the cycle. In that respect, the effects of specific macroprudential tools on credit growth and bank risk can be different. Claessens et al (2013) distinguish 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 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 countercyclically to dampen an expected credit boom or credit crunch[8]– are identified with the acronym *cyclical*. Macroprudential tools with a more structural objective which are intended to increase the resilience of the financial sector, using capital or provisioning requirements, are identified with the acronym *structural*.[9]

[7] 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, Correa and Lee (2016) aim at evaluating recent changes introduced by Comprehensive Capital Analysis and Review, the Dodd-Frank stress tests and Leveraged Lending Guidance. Allen et al (2016), 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, Alegria, Alfaro and Córdova (2016) estimate the effect of loan to value in the housing loan market originating from an unexpected Chilean central bank statement concerning housing price dynamics.

[8] 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.

[9] 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

For consistency, all variables have been expressed in real terms. In some cases results have been carefully checked to take into account different estimations for loans expressed in different currencies (see Levin et al (2016)). The results of this paper show that the change 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). Some studies (Gomez et al (2016)) also include a securitisation activity dummy (equal to 1 if the bank is active in the securitisation market); and return on assets (ROA).[10] Specific effects on credit could originate from regulation. Gomez et al (2016) 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 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.[11]

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 a sector*time

methodology for the calculation of banking provisions in Mexico; and (iv) the introduction and (v) the tightening of a capital buffer and profit reinvestment mechanism in Argentina.

[10] The analysis of this characteristic is important because, while one may question the exogeneity of policies at the national level for domestic banks, it is more difficult to argue that policy measures implemented abroad are influenced by the activities of specific foreign banks in that country.

[11] 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.

dummy. Some papers (eg Barroso et al (2016)) control for different kinds of fixed effect by firm, firm*time, bank and bank*time. In addition to the panel methodology, these authors also employed diff-in-diff to evaluate the effects of policy shocks on the variables of interest. Levin et al (2016) also use random effects to evaluate if their results are robust. In general, the results are robust to different specifications.

3. Results

In order to assess the general effectiveness of macroprudential policies on credit and risk, we employed meta-analysis techniques to summarise country results. In particular, we used the coefficients obtained by the country groups from Argentina, Brazil, Colombia, Mexico and Peru from the regressions (1)–(4) described in Section 2. These models could slightly differ from those used in the specific papers but are directly comparable between countries. For each equation, we have 14 observations (ie coefficients).[12] Four of these observations correspond to the coefficients reported by Argentina (four policies,[13] one kind of loan), one for Brazil (one policy, one kind of loan), six coefficients reported by Colombia (three policies for two kinds of loan[14]), two for Mexico (one policy, two kinds of loan[15]) and finally one for Peru (one policy, one kind of loan). The estimated range of the effect of macroprudential tools combines the information of the reported coefficients and their respective standard error. These countries evaluated different kinds 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).

Even if our paper focuses on the meta-analysis of the results obtained using a common protocol, we also refer to the results of country studies on the effect of macroprudential policies on lending and bank risk. The country papers of the joint project and their main characteristics are summarised 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 use 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).

[12] This number can change slightly in some cases depending on the information reported by country groups.

[13] 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 policies.

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

[15] A group of estimations for credits denominated in local currency and the other for loans in foreign currency.

We anticipate that the way in which macroprudential policies are differentiated is quite relevant when explaining the differences among the estimated effects. To control for this, we grouped policies in different categories depending on the purpose of the specific tools. In particular, using the categorisation presented in Claessens et al (2013), we differentiate policies with the clear aim of dampening the cycle (*cyclical*) from those with the aim of increasing the financial sector's resilience using capital or provisioning requirements (*structural)*.

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 are complements of monetary policy if the sign of the interaction between the policies (detected by the coefficient γ 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. We have constructed a dummy variable that takes the value of one for policies that satisfy these conditions.[16] Regarding the interaction of macroprudential policies and business cycle conditions, based on equation 3, we identified policies that help to reduce the procyclicality of credit if: $\gamma < 0 < \delta$.[17]

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 find that the range of the calculated mean effect among estimations is significantly negative for policies that were used for countercyclical purposes (*cyclical*) (Table 4). We find that a tightening in countercyclical macroprudential policy is associated with a reduction in credit growth of 6–12%.

By contrast, we do not find that prudential policies aimed at raising additional buffers through capital requirements or provisioning (*structural*) have an average significant effect on credit growth. These results are the same for the three equations and also when we combine all the observations together (Table 4, right-hand panel). The same results can be summarised visually by means of "forest plots" (see Annex C). Each graph reports the coefficients found by country studies for different equations. The aggregate estimated effect is represented by a red line accompanied by the respective confidence interval (blue rhombus). For example, in Graph C1, which includes all the policies, we detect no clear negative correlation between macroprudential policies and bank lending growth. However, this is detected when the focus is on countercyclical policies only (Graph C2). A similar pattern can be seen

[16] The policies that satisfied those conditions were: (i) the implementation and (ii) tightening of the capital buffer in Argentina; (iii) the tightening of the restrictions on global currency mismatch positions in Argentina; and (iv) the deposit requirement for external loans in Colombia; and (iv) reserve requirements in Brazil. In the tables, this variable is identified as "Complementarity with monetary policy".

[17] The policies that satisfied those conditions were (i) tightening of the capital buffer in Argentina; (ii) tightening of the foreign currency net global position; (iii) the reserve requirement on external loans in Colombia; and (iv) the change in the provisioning system in Mexico. In the tables, this variable is identified as "Business cycle relationship".

if we compare the results of equation (3) in Graphs C3 and C4, which controls for the interaction of macroprudential policies and the business cycle.

The analysis of the forest plots indicates a high level of heterogeneity in many of the estimations, and therefore the above results should be read with caution. To this end, the usual second step in meta-analysis is to identify some pattern in the variability among results using meta-regressions (see Annex B for details).

In Table 5, we report the results of meta-regressions for the estimations on credit growth. The overall findings confirm that tools employed for countercyclical purposes (*cyclical*) have a significant negative effect on lending supply. However, in this case we find that policies that directly affect the capital levels (*structural*) of financial institutions tend to depress credit growth. However, it is worth noticing that the coefficients reported for the policies with countercyclical purposes (*cyclical*) are always larger in all the specifications.

All these results are confirmed in the country papers for Argentina, Brazil, Colombia, Mexico and Peru, even when alternative specifications or additional institutional characteristics are controlled for. Interesting results are also obtained by Allen et al (2016), who evaluate the effects of prudential tools such as changes in limits on LTV and DTI on demand for mortgage contracts in Canada. In particular, they find that LTV constraints are effective in influencing mortgage demand, while tools that aim to apply repayment constraints, such as amortisation and debt-service limits, are on average not binding. The US paper found that the macroprudential use of stress tests with regulatory purposes had a significant effect on the supply of riskier loans.[18]

To verify that banks behave differently, according to their characteristics, we analyse the sign and significance of the interaction terms between prudential policies and bank characteristics in equation (1). Overall, we detect no clear pattern for bank size and liquidity. There is some evidence that lending supply reacts differently for banks with a different level of risk and capitalisation (Brazil and Colombia).[19] The limited significance of the standard indicators used in the bank lending channel literature could be due to high levels of capital and liquidity ratio typically maintained by banks in emerging countries to protect themselves against external shocks. Indeed, significant effects of capitalisation are detected when the capital buffer is calculated with respect to bank-specific targets as banks can have different levels of risk-aversion.[20]

[18] In particular, the US paper evaluated recent changes introduced by the Comprehensive Capital Analysis and Review (CCAR), the Dodd-Frank Act stress tests and Leveraged Lending Guidance on the credit supply. Calem, Correa and Lee (2016) find that stress tests on US banks had negative effects on the share of jumbo mortgage originations and approval rates on such loans at CCAR banks.

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

[20] 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

The only bank-specific characteristic that turned out to be highly significant in explaining different behaviour among banks is their funding composition, represented by the ratio between deposits and total bank funding (Table 6). In particular, we find that banks with more deposits in proportion to their total liabilities tend to cut back credit by less in response to a macroprudential measure. For other bank characteristics (capital, liquidity and size), we find no clear pattern.

This is an interesting result, as bank funding composition was found to have been an important influence on the bank lending channel during the global financial crisis. The deposit to total liabilities indicator is typically used to measure a bank's contractual strength. Banks that have a large deposit base will adjust their deposit rates to a lesser degree (and less quickly) than do banks whose liabilities mainly comprise variable-rate bonds that are directly affected by market movements (Berlin and Mester (1999)). Intuitively, this should mean that, in view of menu costs, it is more likely that a bank will adjust its terms for passive deposits if there is a change in the terms of its own alternative form of refinancing (ie bonds). Moreover, a bank will refrain from changing deposit conditions because, if the ratio of deposits to total liabilities is high, even small changes to their price will have a huge effect on total interest rate costs. In contrast, banks that depend relatively more on bonds than deposits for funding will come under greater pressure because their costs will increase in line with market rates.

Our result accords with the fact that a key transmission channel of the crisis was the dislocation in bank funding markets. Amiti et al (2016) find that banks which relied more on wholesale funding and cross-currency swaps found themselves unable to roll over their positions during the most severe quarters of the crisis. These results are in line with Gambacorta and Marques (2011), who find that the proportion of deposit funding was a key element in assessing banks' ability to withstand adverse shocks. The results seem also match the finding of the IBRN study (see Buch and Goldberg, 2016). For example, spillovers of interbank exposure limits through foreign bank affiliates differ in degree across banks not only in relation to banks' illiquid asset shares but also with respect to deposit shares, and internal capital market positions with their parent banks.

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

A preliminary assessment of the link between the effectiveness of macroprudential policy in conjunction with monetary policy is provided in Table 7. In particular, we find that prudential policies that are used as complements of monetary policy have larger negative effects on credit growth than other types of measure. In other words, macroprudential policies tend to be more effective in tackling credit cycles when they are accompanied with the use of countercyclical monetary policy. This result is robust to the inclusion of country fixed effects.

al (2004) and Brei and Gambacorta (2014, equation 1) for estimating a bank capital equation and calculating the deviation of the actual bank capital ratio from the fitted value (residual).

In order to further explore these interactions, we estimate an additional set of equations using the dummy variable indicating complementarity between monetary and macroprudential policy as the dependent variable.[21] As explanatory variables, we included: (i) the distinction of type of prudential policy (*cyclical* and *structural*); (ii) country effects and (iii) the variable of the business cycle relationship.

The overall results presented in Table 8 suggest that the level of complementarity between monetary and macroprudential policies is conditioned to the types of policy that are implemented. On the one hand, policies with countercyclical objectives (*cyclical*) tend to be positively associated with the probability of exhibiting a positive level of complementarity with monetary policy. In contrast, policies that affect capital levels (*structural*) do not exhibit such an effect. Additionally, we found a positive relationship between the policies that are used in a countercyclical way with respect to the business cycle and the probability that the policy is used as a complement of monetary policy. In other words, policies that help to reduce the procyclicality of credit tend to be complements of monetary policy.

Regarding the interaction of macroprudential and monetary policy, country papers find that both policies tend to be complements. In other words, the effects of a tightening in one policy tend to be reinforced by the effect of the other. Some evidence of this complementarity was found in Barroso et al (2016). In the same direction, Gomez et al (2016) report that the monetary and macroprudential policy stances have been used historically in the same direction in Colombia.

The evidence that policies which are used countercyclically (with respect to the business cycle) have a significant effect on credit growth is less clear. We found a significant effect (at a 90% confidence level) only in the specification that includes country fixed effects (Table 7, final column). Additional evidence is obtained from the country papers. Levin et al (2016) find that the change in provisioning system in Mexico is countercyclical especially for banks that use their own rules (eg through internal models). In the same direction, Gomez et al (2016) found that, when the macroprudential policy stance is tightened in Colombia, the expansionary effects of economic growth on credit are reduced, thus dampening the procyclicality of loan growth.

The effects of macroprudential policies on bank risk

The ultimate goal of macroprudential policies should be to reduce systemic risks. Even if it is possible to calculate measures of systemic risk at the bank level (eg using EDF, COVAR), it is not possible to detect a common methodology for those countries involved in the exercise. Nevertheless, three countries (Argentina, Colombia and Mexico) estimated the coefficients for the proposed equation 4 that evaluate the impact of macroprudential policies on a proxy for bank risk given by the growth of non-performing loans (NPL). Even if this can be considered as an ex-post measure of credit risk, it is natural to expect that the risk-taking decisions of banks could be related to posterior loan quality behaviour.

The results of meta-analysis (Table 9) and meta-regressions (Table 10) for the effects of macroprudential tools on non-performing loans suggest that, on average, prudential policies have significant effects on bank risk. However, and more importantly, this result is driven mainly by policies aimed at increasing the banking

[21] This variable takes the value of 1 if the values reported for δ, γ in equation 2 are both negative.

sector's resilience: the ranges of expected effects using random meta-analysis are clearly negative only for this type of policy (Graph C6 in Annex C). We confirm this result with a meta-regression analysis estimating the levels of the reported coefficients in function of different characteristics. We find that policies classified in the group of capital and provisioning tools (*structural*) exhibit a more negative effect on non-performing loans than other types of policy. In particular, the tightening of a macroprudential policy designed to enhance the banking sector's resilience reduces the growth of non-performing loans by 2–6% (Table 9). By contrast, we find no evidence that policies with a countercyclical aim (*cyclical*) have on average any effect on bank risk indicators (Tables 9 and 10).

The above results are also in line with the findings of country papers that adopt a more refined approach. For instance, Aguirre and Repetto (2016) find that the use of prudential policies are associated with a subsequent reduction of the growth of non-performing loans in Argentina. Similarly, Gomez et al (2016) found that the introduction of some policies in Colombia was effective in reducing the growth of non-performing loans and also affected the cost of lending. In particular, a tightening in the macroprudential policy stance is associated with a larger decrease in credit for riskier borrowers, which shows that macroprudential policies had significant effects on the risk-taking channel. Likewise, Barroso et al (2016) find that Brazil's use of reserve requirements affected access to credit in particular for riskier borrowers. In fact, they find that banks avoid riskier firms in the aftermath of policy changes. During tightening phases, when there is credit contraction, riskier firms tend to receive less credit.

Communication issues are also relevant to the use of macroprudential tools and the potential impact on bank risk-taking. That is, the way such measures are explained can make a difference. In fact, the US paper finds not only that the 2013 Supervisory Guidance on Leveraged Lending and subsequent 2014 FAQ notice (which clarified expectations on the Guidance) had a significant impact on syndicated lending, but it also indicates that the share of speculative-grade term-loan originations fell markedly at regulated banks only after the FAQ notice. Another case highlighting the importance of communication, and specifically the role of the analysis and public statements of the central bank regarding various issues, is described in the Chilean paper. The latter evaluates the impact of warnings issued by the Central Bank of Chile in its Financial Stability Report (FSR) about possible risks in the housing market. The analysis finds that these warnings had a significant effect on LTVs (in the high-end range), suggesting that the announcements had a significant impact on bank risk decision-making.

4. Conclusions

The impact of macroprudential policies on credit and banking sector risk 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 uses loan-level information that is normally available only to bank regulators and supervisors. This is, to our knowledge, the first paper that uses granular cross-country data under a common protocol for the identification of the

effectiveness of macroprudential tools. Given that, for confidentiality reasons, it was not possible to pool the data sets, we used meta-analysis techniques to compare the results.

The main results of this study are the following:

First, the macroprudential policies adopted by a sample of Latin American countries have been successful in dampening credit cycles and reducing banking sector risk. In particular, policies used for countercyclical purposes have been highly effective in reducing credit growth. Bank-specific characteristics also influenced the impact of macroprudential policies on credit. For example, the supply of credit originated by banks with more stable forms of funding (ie with higher ratios of deposits relative to other liabilities) was less affected by the introduction or tightening of macroprudential policies. In addition, some of the contributions from participating countries 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, we found that macroprudential policies used as complements to monetary policy were more effective in dampening credit growth than other types of instrument. This seems to indicate that prudential policies should be used as complements to monetary policy.

Third, we uncovered evidence that macroprudential policies have been used countercyclically with respect to the business cycle and helped to stabilise the economy. This is in line with the country contributions, which showed that the macroprudential policy stance was negatively related to GDP growth (Colombia). Bank-specific provisioning practices could help to explain this link (Mexico).

Fourth, prudential policies directed at increasing the resilience of the banking sector (provisions and capital requirements) have been effective in reducing banking sector risk. By contrast, the effectiveness of macroprudential policies designed to dampen credit growth have had a more limited impact on the volume of loans but not on the overall accumulation of banking sector risk. This last result should be checked by considering a larger horizon for the effects of capital policies that – given the more structural nature – could take more time to produce effects, especially on lending. This is left for the next version of the paper.

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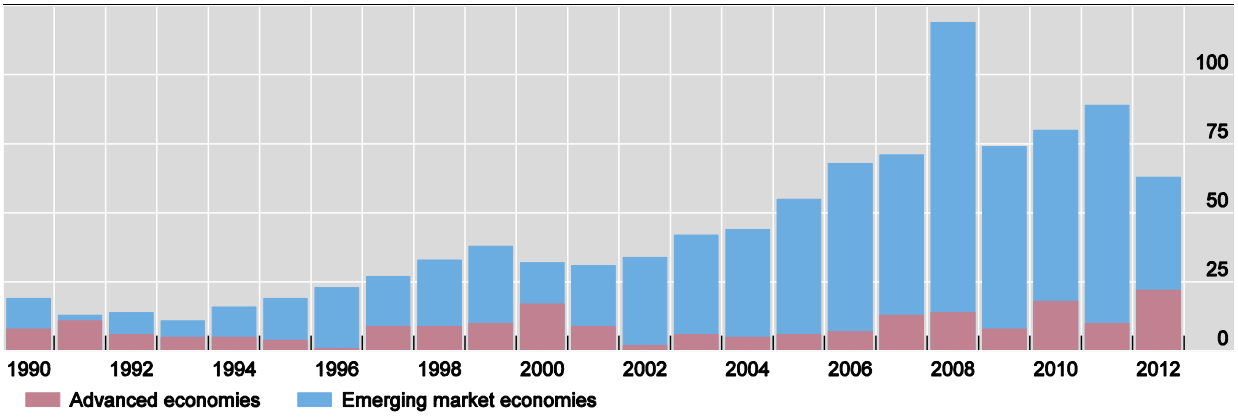
Graphs and tables

Use of macroprudential measures over time[1]

Graph 1

Number of macroprudential policy actions



[1] The sample covers 1,034 macroprudential policy actions adopted in 64 countries (29 advanced and 35 emerging market economies). The database has been constructed using information in Kuttner, K N and I Shim (2013) Lim, C H, I Krznar, F Lipinsky, A Otani, and X Wu (2013).

Sources: IMF; BIS. Altunbas et al (2016).

Different types of macroprudential tools 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)	29	49	22	9
Capital requirement/Risk weights (RW)	14	24	9	4
Provisioning requirement (Prov)	3	5	3	0
Limits on dividend distribution	7	12	6	4
Liquidity ratios	5	8	4	1
b. Dampening the cycle (2)	23	39	20	8
Changes in reserve requirement (RR)	8	14	7	4
Net open position (NOP)	6	10	6	0
Changes in LTV, DTI limits	8	14	6	3
Limits on credit growth or lending to specific sectors	0	0	0	0
Requirement on external borrowing operations	1	7	1	1
c. Dispelling gestation of cycle (3)	7	12	7	0
Levy or tax on specific assets and/or liabilities	4	7	4	0
Official warnings on specific vulnerabilities	2	3	2	0
Adjustments to lending standards	1	2	1	0
Total	***59***	***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. A third group (3) includes these prudential policies directed to dispelling the gestation of cycles. They also include a fourth group which is aimed at risks arising from interconnectedness and tries to ensure the internalisation of spillovers. We did not include that fourth category since the policies evaluated are not directly linked with those purposes.

Summary of results of country papers

Table 2

Authors	Country	Period	Macroprudential tools analysed	Main results
1. H Aguirre and G Repetto	Argentina	2009-2014	i) Introduction and tightening of a capital buffer (CB) ii) Foreign currency net global position (FGP)	Changes in CB and FGP are effective in reducing credit cycles. In addition, the introduction and tightening of these policies had a significant effect on the behaviour of non-performing loans.
2. J Barroso, B Van Doonik, C Cinelli and R Barbone	Brazil	2008-2015	i) Reserve requirements (RR)	RR tightening had a negative effect on credit, especially to riskier loans. Higher liquidity and capital ratio of banking institutions reduce the impact of RR. Evidence of complementarities among RR and monetary policy (the tightening in one policy reinforces the effects of the other).
3. E Gómez, A Lizarazo, J Mendoza and A Murcia	Colombia	2006-2009	i) Dynamic provisioning system (DP); ii) Countercyclical reserve requirement (CRR); iii) External borrowing reserve (EBR)	DP and CRR had a negative effect on credit growth, while the effect of the three tools on both the cost of credit and the riskiness of banks differs between policies. 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. Evidence of complementarities in the use of monetary policy and macroprudential policies.
4.G Levin, C López and F López-Gallo	Mexico	2009-2015	i)Banking provisions based on expected losses (PR)	The implementation of PR reduced credit growth. The effect is larger in loans denominated in local currency than in dollar denominated credits. The use of internal methodologies for calculating banking provisions reduces the impact of that policy on credit growth.
5.M Cabello, J Lupu and E Minaya	Peru	2004-2014	i)Dynamic provisioning system (DP) ii)Conditional reserve requirement on deposits in foreign currency (CR)	DP had a significant effect on credit growth. CR had a significant effect on the share of loans denominated in foreign currency which helped to stimulate the de-dollarisation process in Peru.
6.J Allen, T Grieder, B Peterson and T Roberts	Canada	2005-2014	i)Changes in Loan to Value Limits for mortgages (LTV); ii) Changes in repayment constraints (REP)	LTV constraint is effective in influencing mortgage demand, while tools directed at the repayment constraint (REP), such as amortisation and debt-service limits, are on average not binding.
7.A Alegría, A Alfaro and F Córdova	Chile	2012-2014	i) Warnings of the CB regarding real estate prices.	The 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. Different responses between private and state owned banks.
8.D Godoy de Araujo, J Barroso and R Barbone	Brazil	2012-2014	i) Introduction of LTV limits for certain subsidised loans (LTV)	LTV cap caused individuals more likely to borrow with high LTV to make higher down payments. However, these individuals also borrow more in housing credit lines that circumvent that regulation.
9.P Calem, R Correa and SJ Lee	United States	2011, 2013, 2014	i) Comprehensive Capital Analysis and Review bank stress tests (CCAR); ii) Supervisory Guidance on Leverage Lending and subsequent FAQ period that clarified expectations on the Guidance (SGLL).	CCAR stress test in 2011 had negative effects on the share of jumbo mortgage originations and approval rates on such loans. Banks with worse capital positions were impacted more negatively. SGLL, particularly during the period of subsequent FAQ notice, had a negative effect on the share of speculative-grade term-loan originations.

Macroprudential policies reported for meta-analysis by country groups Table 3

Instrument	Country	Description	Objective of the policy (classification used by Claessens et al, 2013)*
1. Capital buffer and profit reinvestment	Argentina	In order to increase the level of capital of banks, the 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.	Enhancing resilience (introduction) and dampening the cycle (tightening)
2. Foreign currency net global position	Argentina	This rule was established as a mechanism to limit currency mismatches of banking institutions. It was defined as the difference of assets and liabilities denominated in foreign currency. The limit was introduced in 2014, with a 30% threshold of regulatory capital and then lowered (tightened) to 20% in September that year.	Dampening the cycle (tightening)
3.Reserve requirements	Brazil	Brazil has been active in the use of reserve requirement as a tool of dampen credit cycles. Different scenarios are the following: (i) the release of reserves in 2008-2009 in response to the liquidity squeeze following the global financial crisis; (ii) the reversal of the policies in 2010-2011 in the context of high capital inflows and associated credit growth; and (iii) the renewal of stimulus during 2012-2014 in response to perceived weakness of economic activity and credit growth.	Dampening the cycle
4.Dynamic Provisioning regime	Colombia	Inspired in the Spanish system, a new provisioning regime with countercyclical considerations for commercial loans began in July 2007. The methodology for calculating the individual provision consists of estimating two components (procyclical and countercyclical). Depending on the financial condition of the institution (based on individual indicators) the formulas to calculate the provisioning level differ. Thus, by tying the counter-cyclical buffer triggers to bank-specific variables, it allows institutions facing difficulties to smooth their provisioning expenses, independent of overall economic conditions.	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. This measure had the purpose of containing a potential substitution from local to external borrowing.	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. The requirement was lately unified for the first two types of deposits at 27%.	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 kinds of loan.	Enhancing resilience
8.Dynamic Provisioning	Peru	To reduce the procyclical behaviour of credit, this scheme was introduced in 2008. The definition of accumulation and de-accumulation of provisions is defined based on the dynamics of aggregate economy (GDP growth).	Enhancing resilience

* 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. A third group (3) includes these prudential policies directed to dispelling the gestation of cycles. They also include a fourth group which is aimed at risks arising from interconnectedness and tries to ensure the internalisation of spillovers.

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

Table 4

	Eq.1	Eq.1 cyclical	Eq1 structural	Eq.2	Eq.2 cyclical	Eq.2 structural	Eq.3	Eq.3 cyclical	Eq.3 structural	ALL	ALL cyclical	ALL structural
Q (1)	97***	6.85***	3.75	7080***	4317***	911***	5081***	1500***	511***	14475***	7703***	1563***
Degrees of freedom	13	6	6	13	6	6	12	6	6	40	20	19
I^2 (2) (%)	86.6	12.3	0.3	99.8	99.9	99.3	99.8	99.6	99.1	99.7	99.7	98.8
τ^2 (3)	0.0101	0.0002	0.000	0.0031	0.0067	0.0009	0.0064	0.0030	0.0030	0.0042	0.0049	0.0011
Random-effects mean (4)	-0.002	**-0.031*** **	-0.01	-0.004	**-0.096*** **	-0.007	-0.029	**-0.115*** **	-0.003	-0.012	**- 0.088*** **	-0.009
95% conf.int	-0.066 to 0.063	-0.058 to -0.003	-0.049 to 0.022	-0.034 to 0.026	-0.157 to -0.036	-0.032 to 0.017	-0.073 to 0.015	-0.155 to -0.074	-0.049 to 0.044	-0.034 to 0.010	-0.12 to -0.056	-0.028 to 0.009

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, Higgins et al. (2003) 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)	**-0.1421*** **(0.074)**	**-0.139*** **(0.0652)**	**-0.40***** **(0.1009)**	**-0.416**** **(0.1210)**	**-0.29***** **(0.072)**	**-0.32***** **(0.0694)**	**-0.28***** **(0.0485)**	**-0.299***** **(0.04928)**
Capital instrument (2)	-0.1045 (0.074)	-0.1039 (0.0652)	**-0.291**** **(0.1060)**	**-0.280*** **(0.1210)**	**-0.134*** **(0.0720)**	-0.116 (0.0694)	**-0.17***** **(0.0486)**	**-0.164***** **(0.04928)**
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2 (percent)	18.8	23.3	52.7	36.9	59	62.9	47.6	50.2
Joint test for significance of all variables	1.89	1.24	8.01***	2.22	8.78***	5.92**	17.19***	6.96***
Number of observations	14	14	14	14	13	13	41	41

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. (3) We identified with a dummy variable those policies that in the country estimations exhibited simultaneously a negative sign of monetary policy on credit and a negative interaction between the macroprudential tool and the changes in monetary policy in the Equation 2, suggesting the existence of complementarities between the policies. (4) We identified with a dummy variable those policies that simultaneously exhibited a positive sign between the GDP growth and the credit growth and a negative sign in the interaction between the macroprudential policies and GDP growth in Equation 3. This condition suggests the presence of significant effects of macroprudential tools in reducing credit procyclicality. ***,** and * denote significance at the 1%,5% and 10%, respectively.

Meta-analysis of estimated coefficient of the interaction between macroprudential policy and deposit ratio

Table 6

	All equations	Countercyclical policies (cyclical)	Capital policies (structural)
Q (1)	1706***	117***	787***
Degrees of freedom	12	5	6
I^2 (2)	99.3%	95.7%	99.2%
τ^2 (3)	0.0061	0.002	0.0106
Random-effect mean (4)	0.029	**0.065*** **	-0.010
95% confidence interval	-0.018 to 0.076	0.025 to 0.104	-0.099 to 0.079

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, Higgins et al. (2003) 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. The effect of the policies that are used in conjunction with monetary policy Table 7

Explanatory variables:	Dependent variable: Estimated effect of macroprudential policy on credit growth							
	Eq 1	Eq 1	Eq 2	Eq 2	Eq3	Eq3	ALL	ALL
Cyclical instrument (1)	**-0.1421*** **(0.074)**	**-0.1393*** **(0.0652)**	**-0.3485**** **(0.1223)**	**-0.2574*** **(0.1187)**	**-0.2412**** **(0.0768)**	**-0.272**** **(0.0847)**	**-0.26***** **(0.064)**	**-0.236***** **(0.058)**
Structural instrument (2)	-0.1045 (0.074)	-0.1039 (0.0652)	**-0.2723**** **(0.1050)**	**-0.2061*** **(0.1012)**	-0.1133 (0.0704)	-0.1017 (0.07041)	**-0.124***** **(0.049)**	**-0.104**** **(0.0439)**
Complementarity with monetary policy (3)			-0.0746 (0.0960)	**-0.2330*** **(0.1034)**			**-0.1235*** **(0.0705)**	**-0.255***** **(0.06647)**
Business cycle relationship (4)					-0.07314 (0.0575)	-0.0548 (0.0600)	0.0713 (0.0684)	**-0.1387*** **(0.0724)**
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2 (percent)	18.8	23.3	51.4	60.7	61.1	62.0	53.4	67.5
Joint test for significance of all variables	1.89	1.24	5.42**	3.75*	7.09***	4.8**	8.84***	9.63***
Number of observations	14	14	14	14	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. (3) We identified with a dummy variable those policies that in the country estimations exhibited simultaneously a negative sign of monetary policy on credit and a negative interaction between the macroprudential tool and the changes in monetary policy in the Equation 2, suggesting the existence of complementarities between the policies. (4) We identified with a dummy variable those policies that simultaneously exhibited a positive sign between the GDP growth and the credit growth and a negative sign in the interaction between the macroprudential policies and GDP growth in Equation 3. This condition suggests the presence of significant effects of macroprudential tools in reducing credit procyclicality. ***,** and * denote significance at the 1%,5% and 10%, respectively.

Estimation of the probability of complementarity between monetary and macroprudential policy

Table 8

Explanatory variables	Dependent variable: Probability of complementarity between macroprudential and monetary policy(1)					
	I	II	III	IV	V	VI
Cyclical (2)	**0.75** **(0.3398)**	**0.6818*** **(0.3265)**			0.5060 (0.3987)	0.2142 (0.3804)
Structural (3)	0.25 (0.3398)	0.3181 (0.3265)			0.1445 (0.3645)	0.2142 (0.2994)
Business cycle relationship (4)			**0.55**** **(0.2006)**	**0.647**** **(0.199)**	0.3493 (0.2969)	**0.5714*** **(0.292)**
Country effects	No	Yes	No	Yes	No	Yes
Adjusted R^2(percent)	24.9	36.5	22.34	58.4	23.43	49.2
Joint test for all covariates	3.16*	2.49	4.45*	5.20**	2.3	2.93*
Number of observations	14	14	13	13	13	13

Note: (1) We identified with a dummy variable those policies that in the country estimations exhibited simultaneously a negative sign of monetary policy on credit and a negative interaction between the macroprudential tool and the changes in monetary policy in the Equation 2, suggesting the existence of complementarities between the policies. This dummy variable is used as the dependent variable in these specifications. (2) 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. (3) 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. (4) We identified with a dummy variable those policies that simultaneously exhibited a positive sign between the GDP growth and the credit growth and a negative sign in the interaction between the macroprudential policies and GDP growth in Equation 3. This condition suggests the presence of significant effects of macroprudential tools in reducing credit procyclicality. ***,** and * denote significance at the 1%,5% and 10%, respectively.

Meta-analysis of estimated coefficient of the effect of macroprudential policies on bank risk

Table 9

	All equations	Countercyclical policies (cyclical)	Capital policies (structural)
Q (1)	2705***	1895***	389***
Degrees of freedom	11	5	5
I^2 (2)	99.6%	99.7%	98.7%
τ^2 (3)	0.0010	0.0010	0.0006
Random-effect mean (4)	**-0.020****	-0.010	**-0.039*****
95% confidence interval	-0.038 to -0.002	-0.035 to 0.015	-0.060 to -0.017

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, Higgins et al. (2003) 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.

Meta regression of the effects of macroprudential policies on bank risk

Table 10

Explanatory variables:	Dependent variable: The estimated effect of macroprudential policy on bank risk							
	I	II	III	IV	V	VI	VII	VIII
Cyclical instrument (1)	-0.0038 (0.01978)	-0.0037 (0.0129)					0.01844 (0.02563)	0.00643 (0.0172)
Structural (2)	**-0.038*** **(0.0197)**	**-0.04***** **(0.0129)**					-0.0304 (0.02084)	**-0.0404**** **(0.0132)**
Complementarity with monetary policy (3)			-0.012 (0.018)	0.0024 (0.0182)			-0.0215 (0.0280)	0.02500 (0.0193)
Business cycle relationship (4)					-0.009 (0.018)	-0.0023 (0.0164)	-0.03304 (0.02046)	-0.03304 (0.02046)
Country effects	No	Yes	No	Yes	No	Yes	No	Yes
Adjusted R^2 (percent)	24.6	74.6	-3.81	23.4	-9.7	23.4	23.2	71.5
Joint test for significance of all variables	2.8	6.65**	NA	1.82	NA	1.82	1.87**	5.12**
Number of observations	12	12	12	12	12	12	12	12

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. (3) We identified with a dummy variable those policies that in the country estimations exhibited simultaneously a negative sign of monetary policy on credit and a negative interaction between the macroprudential tool and the changes in monetary policy in the Equation 5, suggesting the existence of complementarities between the policies. (4) We identified with a dummy variable those policies that simultaneously exhibited a positive sign between the GDP growth and the credit growth and a negative sign in the interaction between the macroprudential policies and GDP growth in Equation 6. This condition suggests the presence of significant effects of macroprudential tools in reducing credit procyclicality. ***,** and * denote significance at the 1%,5% and 10%, respectively.

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.

Instruments that participants evaluated in the national papers.

Other possible instruments to evaluate but not considered in the network

Annex B Meta-analysis techniques

Meta-analysis techniques are very helpful when studies are not perfectly comparable but evaluate the same or a quite related question. The main purpose of the meta-analysis is to better exploit the information of a set of estimations on a specific problem. These techniques are especially used in medical and 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 kind 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 our case since we have different sources of heterogeneity.

We employed therefore 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 kind of estimation considers not only the level of variation for each specific estimated coefficient (as it was done under the fixed-effect approach) but also the level 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 kind 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 kind of estimations, a great level of heterogeneity among studies, or as in our case, among country estimations. The performed country estimations in our exercise are not the exception on this. 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 kind 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 kind 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).

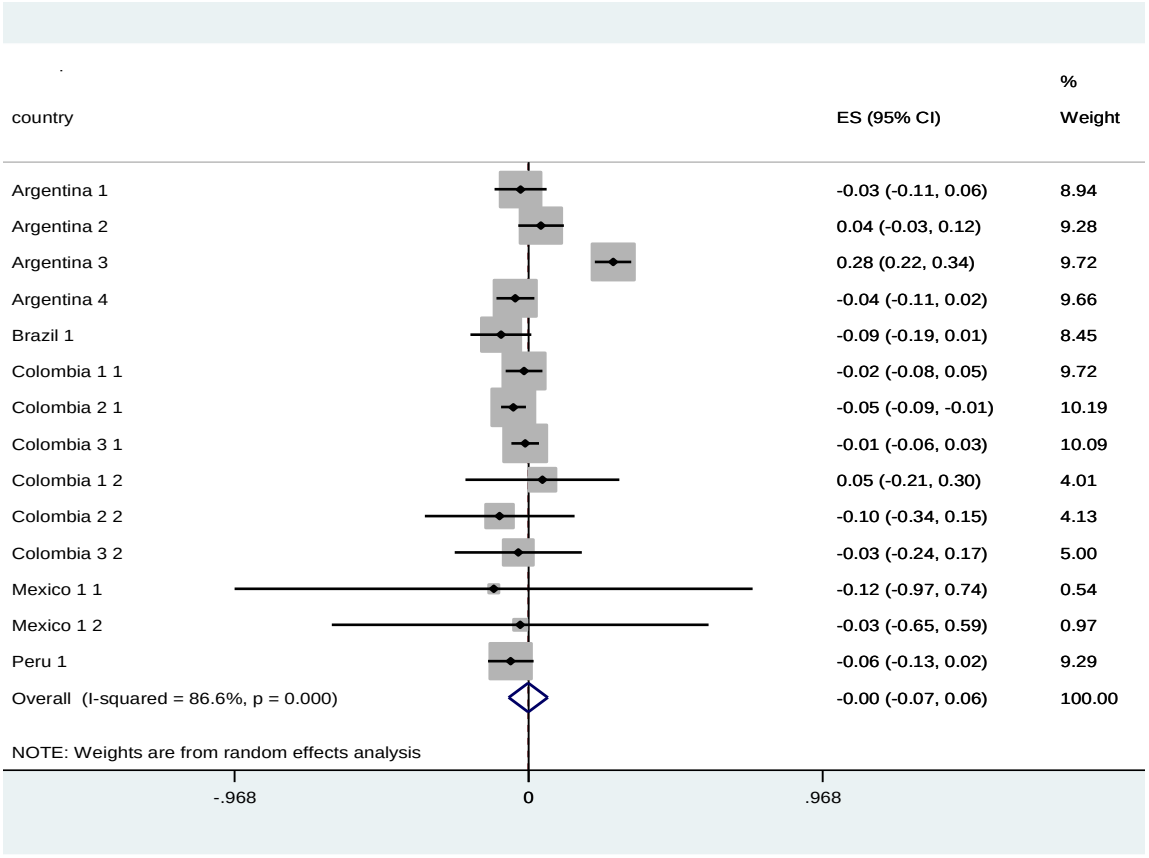
Meta-regressions are similar in essence to OLS regressions, in which an outcome variable is predicted according to the values of one or more explanatory variables (Higgins and Green, 2011). In our case the dependent variable is the effect estimate of macroprudential tools on the different dimensions 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 estimates how the macroprudential effect in each subgroup differs from a nominated reference subgroup.

Annex C Visual summary of meta-analysis techniques results

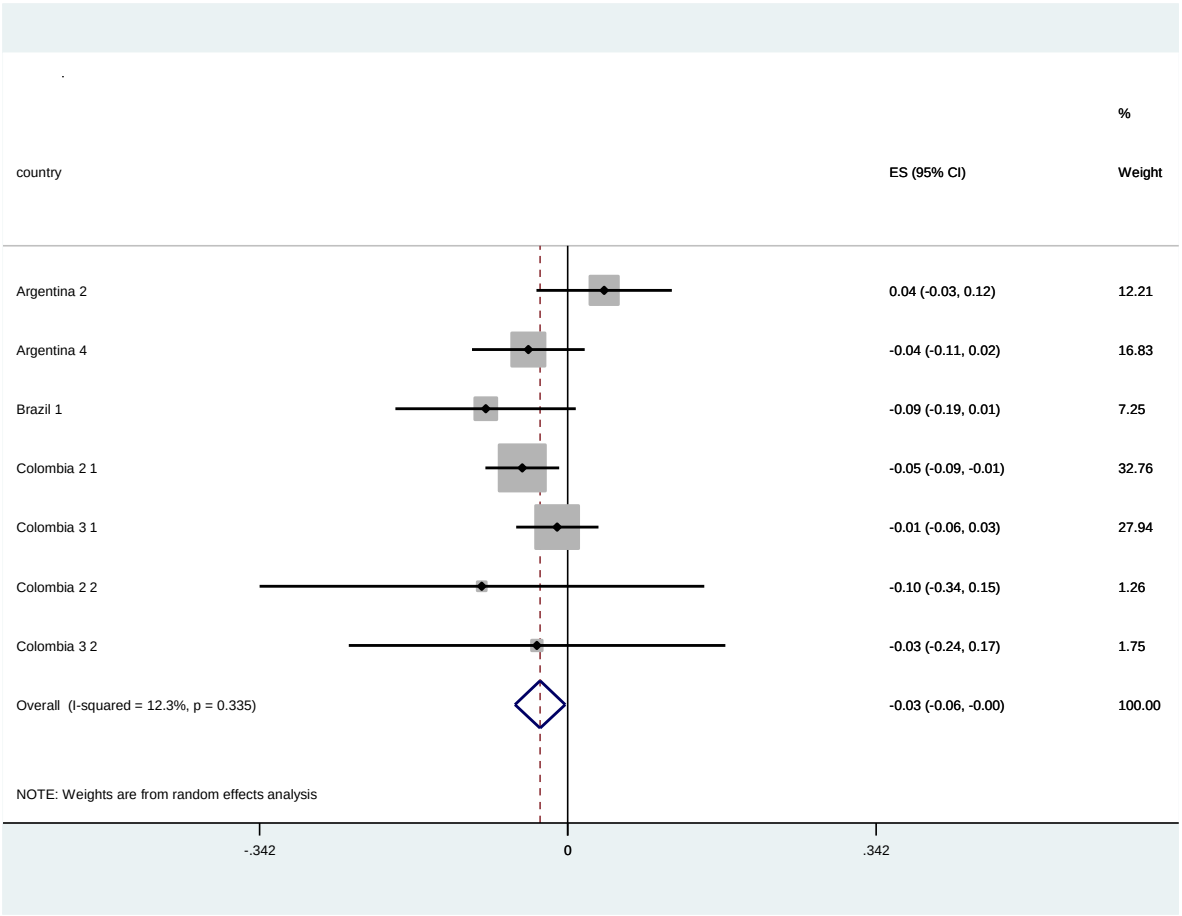
Forest plot of the effects of MPP on credit growth controlling for bank characteristics. All policies — Graph C1



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 individuals; Colombia 2 1: requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to individuals; Colombia 1 2 : introduction of dynamic provisioning. Evaluation made on loans to firms; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to firms; Mexico 1: Provisions on expected losses. Evaluation for loans denominated in local currency; Mexico 2: Provisions on expected losses. Evaluation for loans denominated in foreign currency. Peru 1: Introduction of dynamic provisioning system.

Forest plot of the effects of MPP on credit growth controlling for bank characteristics. Only countercyclical policies

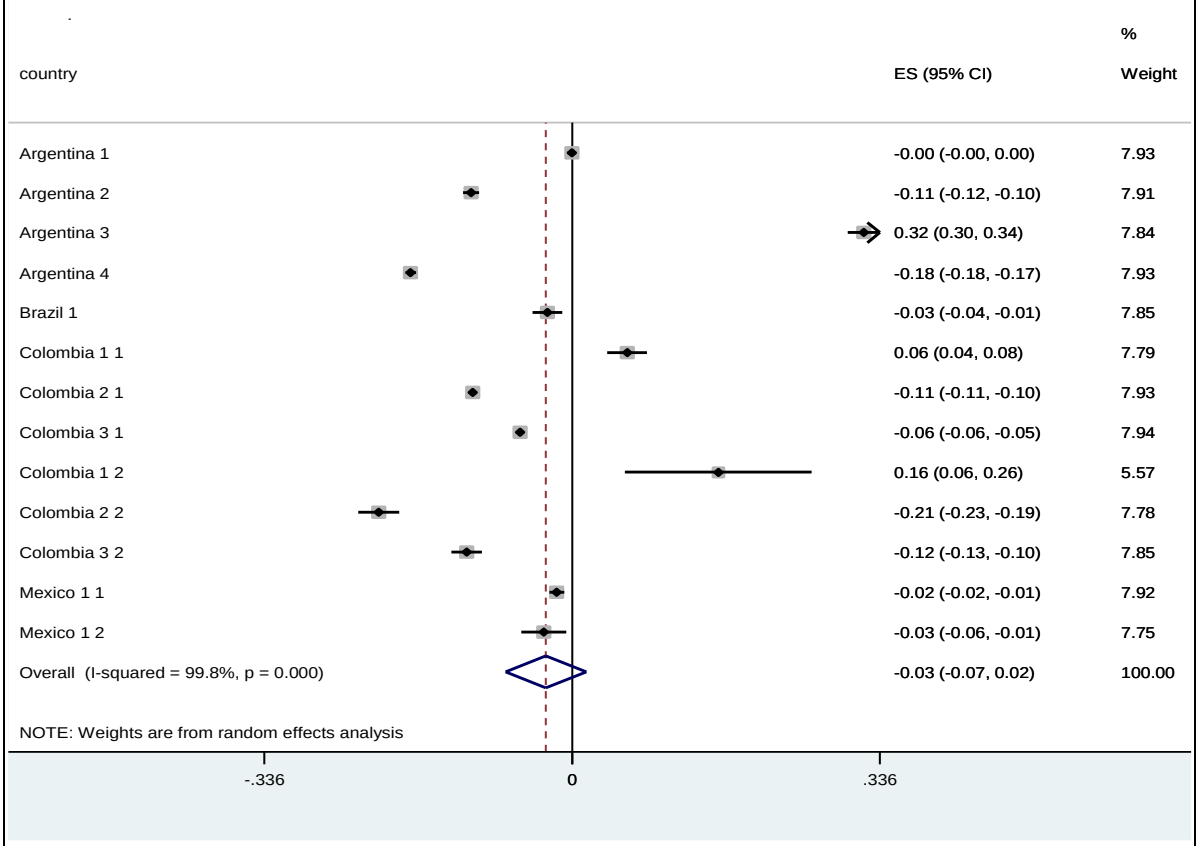
Graph C2



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 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 2 1: requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to individuals; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to firms.

Forest plot of the effects of MPP on credit growth controlling by relationship with business cycle. All policies

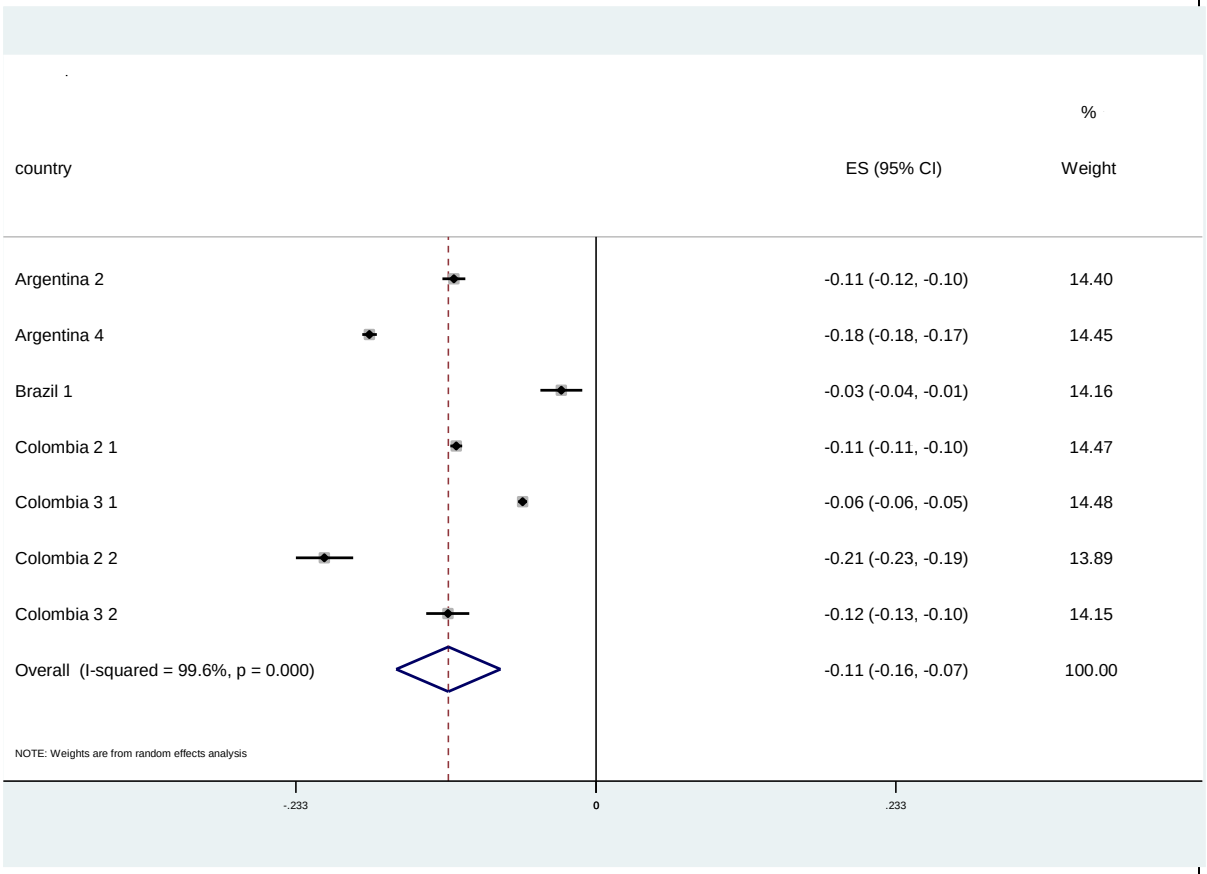
Graph C3



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 individuals; Colombia 2 1: requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to individuals; Colombia 1 2 : introduction of dynamic provisioning. Evaluation made on loans to firms; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to firms; Mexico 1: Provisions on expected losses. Evaluation for loans denominated in local currency; Mexico 2: Provisions on expected losses. Evaluation for loans denominated in foreign currency. Peru 1: Introduction of dynamic provisioning system.

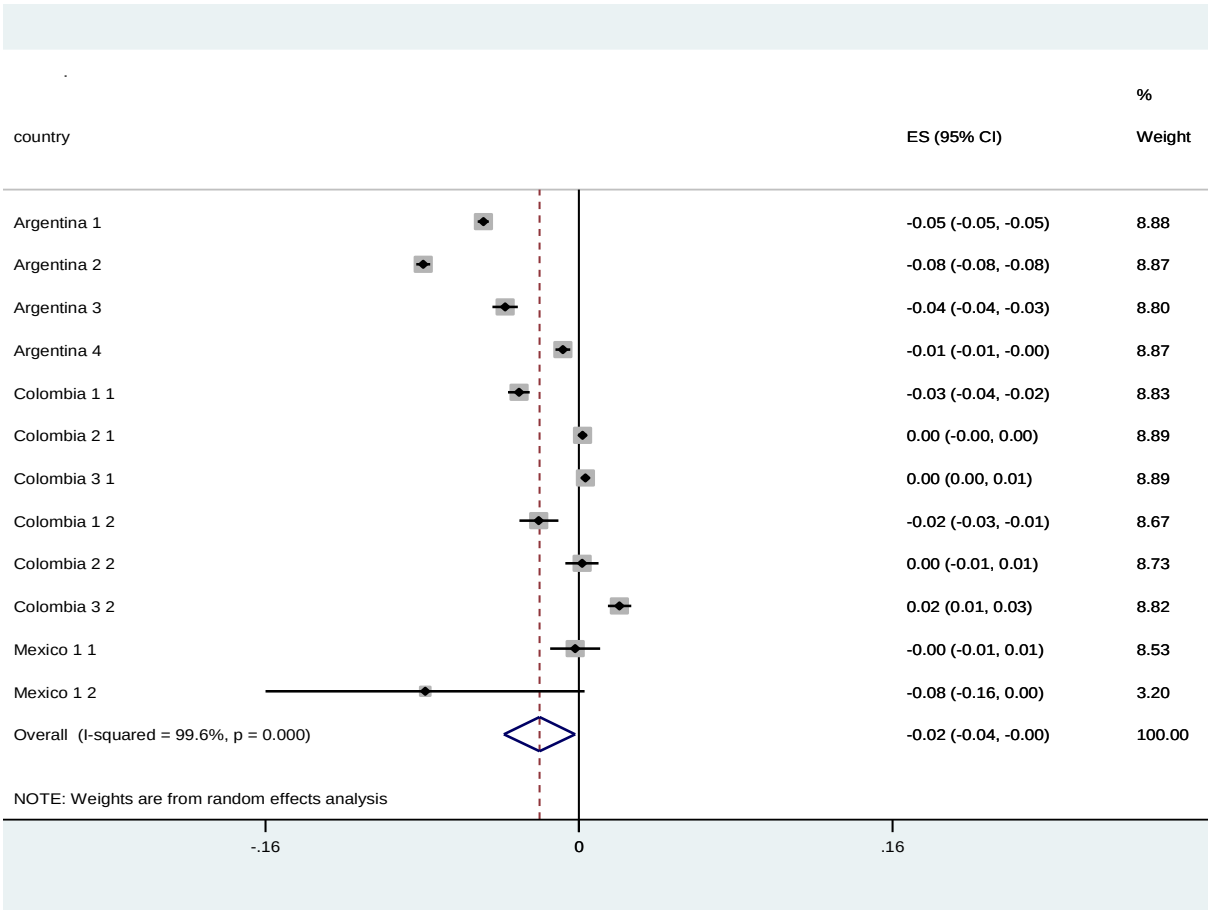
Forest plot of the effects of MPP on credit growth controlling by relationship with business cycle. Only countercyclical policies

Graph C4



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 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 2 1: requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to individuals; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to firms.

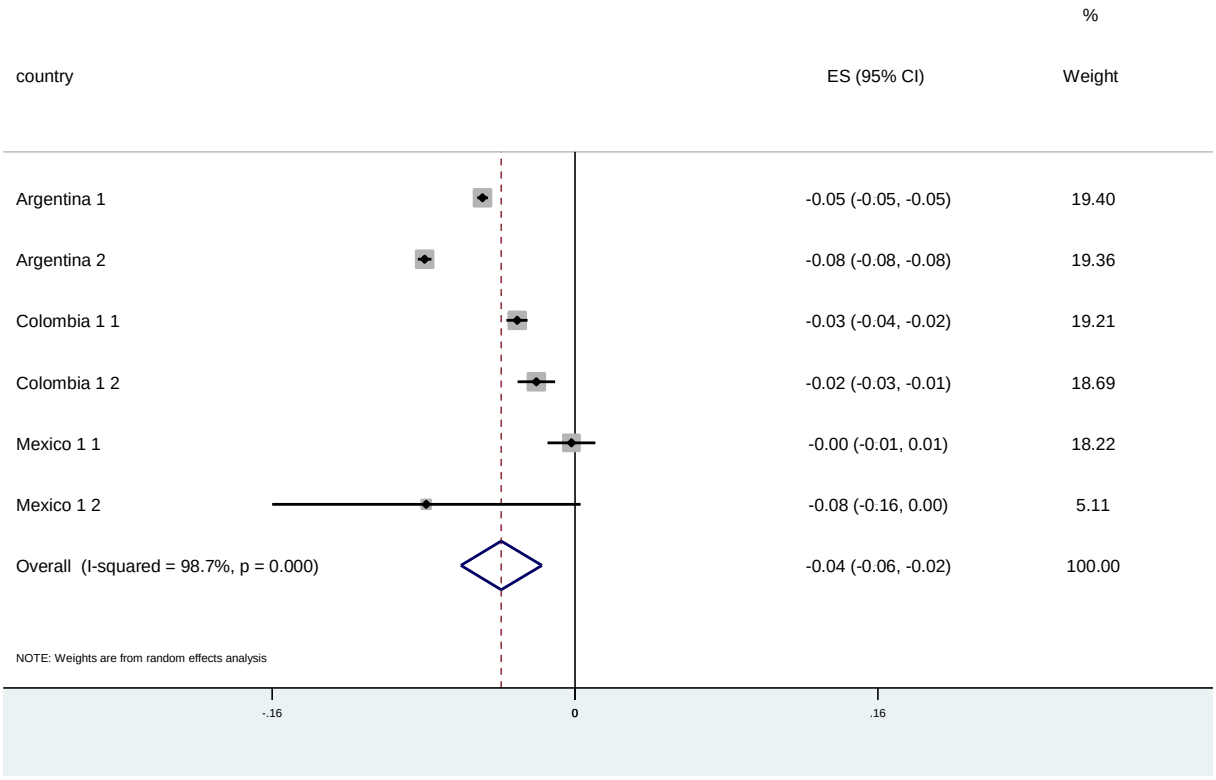
Forest plot of the effects of Macroprudential policies on bank risk. All policies Graph C5



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; Colombia 1 1 introduction of dynamic provisioning system. Evaluation made on loans to individuals; Colombia 2 1: requirement on external borrowing. Evaluation made on loans to individuals; Colombia 3 1 Marginal reserve requirements. Evaluation made on loans to individuals; Colombia 1 2 : introduction of dynamic provisioning. Evaluation made on loans to firms; Colombia 2 2 requirement on external borrowing. Evaluation made on loans to firms; Colombia 3 2 Marginal reserve requirements. Evaluation made on loans to firms; Mexico 1: Provisions on expected losses. Evaluation for loans denominated in local currency; Mexico 2: Provisions on expected losses. Evaluation for loans denominated in foreign currency.

Forest plot of the effects of Macroprudential policies on bank risk. Only policies with structural purposes

Graph C6



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; Colombia 1 1 introduction of dynamic provisioning system. Evaluation made on loans to individuals; Colombia 1 2 : introduction of dynamic provisioning. Evaluation made on loans to firms; Mexico 1: Provisions on expected losses. Evaluation for loans denominated in local currency; Mexico 2: Provisions on expected losses. Evaluation for loans denominated in foreign currency.