Assessing the Effectiveness of Currency-Differentiated Tools: The Case of Reserve Requirements*

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This paper analyzes the benefits and side effects of foreign-currency-differentiated reserve requirements, a widely used tool to limit currency risks. Departing from the existing macroprudential policy literature that uses binary policy variables, we study the gap between foreign- and local-currency reserve requirement rates to isolate the impact of the currency differentiation net of volume effects. First, increasing the gap appears generally effective in reducing currency mismatches and dollarization in banks' balance sheets. Second, a higher gap is associated with a broader reduction of portfolio debt inflows and flows to non-banks. Third, we find little evidence of domestic or international circumvention.

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1. Introduction

The post-financial-crisis period has seen a proliferation of the use of macroprudential tools, designed to both mitigate the buildup of

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vulnerabilities and increase the resilience of the financial system. However, since the 2008 crisis, new vulnerabilities have emerged, such as the increasing foreign exchange (FX) debt by emerging market economies (EMEs) which has contributed to the rise of currency mismatches in banks' and corporates' balance sheets (Chui, Kuruc, and Turner 2018), as well as households (OECD 2017). These developments have restarted a debate on the role of the exchange rate in driving financial conditions and the appropriate toolkit to deal with large exchange rate swings (Carstens 2019). Targeted macroprudential tools may help on this front, when ensuring liquidity buffers for bad times or reducing the FX exposure of different actors. In fact, "currency-based measures" (CBMs), i.e., measures that apply less favorable treatment on the basis of the currency of an operation, have proliferated in the post-crisis period (Ahnert et al. 2021; de Crescenzio, Golin, and Ott 2015).[1] The few recent empirical studies on this category of policies point to their effectiveness in reducing credit growth (Fendoğlu 2017; Lepers and Mehigan 2019) or banks' FX exposure (Ahnert et al. 2021). On the other hand, CBMs may act de facto as measures hindering capital flows insofar as most of cross-border inflows are denominated in foreign currency (de Crescenzio, Golin, and Molteni 2017; Frost, Ito, and van Stralen 2020) or shift the risks from banks to other sectors (Ahnert et al. 2021). As such, it is important that costs and benefits of each measure are carefully assessed.

This paper contributes to these efforts by assessing the effectiveness of one of such tools, reserve requirements (RRs) applied to banks' liabilities, with a focus on foreign-currency-differentiated ones, providing the first comprehensive analysis of the costs and benefits of such instrument across a large sample of countries.

Reserve requirements are an interesting policy tool to study for several reasons: First, the use of reserve requirements with a macroprudential intent has gained significant traction in recent years. They have become an important part of the policy instruments used to lean against the wind, mitigating credit cycle, notably in the Latin American region (Lim et al. 2011; Terrier et al. 2011). This is even more the case for currency-differentiated RRs

[1]Beyond macroprudential measures, more drastic measures to reduce FX exposure have been used such as forced or voluntary loan conversion programs as seen in Eastern Europe (Fischer and Yeşin 2022).

(OECD 2019) imposing a higher rate on FX liabilities, as they may directly target currency mismatches and deposit and loan dollarization of the financial system—a common problem in several Latin American economies.

Second, the specific properties of reserve requirements—flexibility and experience—make them an appropriate countercyclical instrument (Agénor, Alper, and Pereira da Silva 2018; Landau 2018). Reserve requirements were indeed part of the policy response to the 2020 COVID-19 crisis in countries that had been experiencing significant outflows: FX reserve requirements were cut in several countries to ensure easier access to liquidity (OECD 2020).

Finally, from an empirical point of view, reserve requirements present several advantages over other macroprudential tools: they have been the most frequently used tool in the last decades (both in terms of cross- and within-country variation), allowing sufficient observations of policy adjustments to conduct meaningful econometric analyses, and are more easily comparable across countries than other tools.

Departing from traditional studies on effectiveness using binary indicators, we directly use reserve requirement *rates*, which enables us to separate a composition effect (gap between FX and LC rate) and a volume effect (average rate) and to provide economic magnitude for the impact of policy changes. Specifically, we test the impact of a change in the currency gap on a number of macroeconomic variables of interest.

First, we find that a higher gap between FX and local-currency (LC) reserve requirements appears effective in reducing currency mismatch and dollarization in banks' balance sheets, proxied by the share of banks' FX liabilities to total liabilities and the net FX position of the banking sector. We find that a 1 percentage point increase in the gap between FX and LC rates leads to a 0.1 and 1.6 percentage point decrease in these respective variables over one year, and reaching 0.15 and 2.9 in models controlling better for potential endogeneity.

Second, a higher gap appears to have a negative impact on capital inflows more broadly, notably inflows to non-banks and portfolio debt inflows. We find that a 1 percentage point increase in the gap between FX and LC rate leads to a reduction of portfolio debt inflow to GDP of 0.1 percentage point over a one-year horizon. The direction of the effect is in line with previous studies on the impact of currency-based measures on capital flows (Ahnert et al. 2021; de Crescenzio, Golin, and Molenti 2017; Frost, Ito, and van Stralen 2020; Lepers and Mehigan 2019), which however could not speak about the magnitude of the effect. An increase in the gap is also associated with lower capital inflows to non-banks, albeit of smaller magnitude.

Third, we find little evidence of domestic circumvention through higher international debt issuance by corporates or higher cross-border flows to corporates, nor international circumvention.

Controlling for endogeneity creating proxies for "exogenous" changes in reserve requirements, we find that all our previously significant results are confirmed and stronger evidence for the type of transmission mechanisms highlighted in our conceptual framework. We also test for evidence of non-linearity in the effect of changes in reserve requirement rates depending on the initial *level* of the rate: our baseline results are robust to the non-linearity hypothesis, while showing some evidence of non-linearity for some of the dependent variables.

Overall, this paper contributes to the broader literature on the effectiveness of macroprudential tools by providing a detailed analysis of benefits and potential externalities through domestic and international circumvention of currency-differentiated reserve requirements. It also represents, to our knowledge, the first study capturing the intensity of reserve requirements, hence adding to studies trying to get closer to intensity (Eller et al. 2020). Comparing our intensity-based results with results from a more classical binary policy indicator reveals significant differences, highlighting the necessity to better capture the intensity of policy measures in effectiveness studies.

Our results have important implications for policymakers: as for other macroprudential measures, there are important trade-offs in using differentiated reserve requirements. The measure appears to achieve several of its declared objectives, and in particular appears to be an effective tool against dollarization and currency mismatch. On the other hand, this paper finds that their use may also have broader indirect effects on capital flows and as such may have features of capital flow management measures.

The remainder of the paper is structured as follows: Section 2 describes the features and motivation of reserve requirements and a conceptual framework to explain possible channels; Section 3 presents the empirical model and the data used; Section 4 describes the results for the direct impact, and the domestic and international side effects. Section 5 presents robustness checks relative to endogeneity and non-linearity of the effect; Section 6 shows the importance of intensity-based measures compared with binary policy indicators. Section 7 concludes by presenting policy conclusions and outlining avenues for further research.

2. Reserve Requirements Inside Out

2.1 Features

Reserve requirements generally apply to deposit-taking institutions, to hold minimum reserves against their liabilities ("the reserve base"), usually in the form of balances at the central bank, the minimum reserves being calculated as a percentage of the targeted bank liabilities ("the reserve ratio").

Beyond this basic definition, there is a wide range of reserve requirements across countries, which arise from the numerous technical choices that have to be made in designing such tools. Apart from the ratio, central banks have to decide whether and to what extent the funds reserved at the central bank are remunerated, which are the eligible reserve assets (deposits, vault cash, T-bills), and what is the currency of maintenance of the reserves (any, local, or foreign currency) (see OECD 2019 and Gray 2011 for a detailed discussion).

Also, central banks have to decide the scope of liabilities that are covered by the reserve requirements: whether the reserves are required only on deposits, or on a broader category, or on the full scope of a bank's financial liabilities—including loans and debt securities. Authorities may also exempt some liabilities from reserve requirements: e.g., government deposits, acting therefore as a subsidy for that particular type of liability.

Ratios can be further differentiated depending on the maturity of such liabilities, e.g., charging a higher rate on more volatile, shorter-term liabilities.

Most importantly for the purpose of the present paper, reserve ratios may be differentiated depending on the currency denomination of the liabilities, with a lower or higher rate on foreign-currency liabilities than local-currency liabilities.

From a policymaker's perspective, one important benefit of reserve requirements is the relative ease of their use, in part because central banks have had decades of experience with reserve requirements when these tools were used as an integral part of the monetary policy toolkit and as micro-prudential buffers. In most places, the central bank has authority over the tool and can adjust the ratio rapidly and flexibly.

Our data on reserve requirements are sourced from the compilation efforts of Federico, Vegh, and Vuletin (2014), enhanced with an OECD survey to members (OECD 2019)[2] and complemented with country-specific research, which allow us to fully add, adjust, or extend the data in the case of Bulgaria, Croatia, Estonia, Iceland, Indonesia, Philippines, Russia, Slovenia, and Slovakia. The final sample used for our empirical analysis is an unbalanced panel of maximum 58 countries from 1999:Q1 to 2015:Q3. Country sample and quarterly adjustments in RR are displayed in Figure A.1 and Figure A.2 of the appendix.

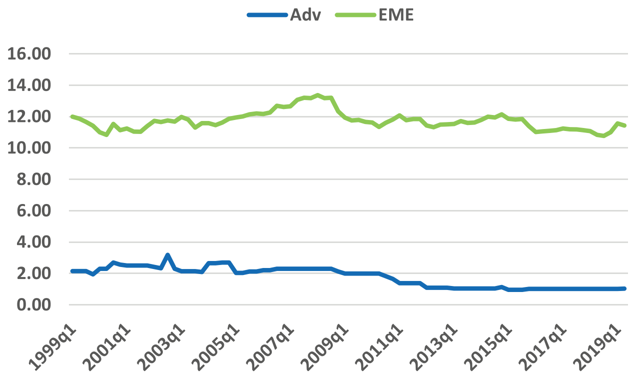
2.2 From Monetary to Macroprudential Objectives, the Changing Use of Reserve Requirements

Reserve requirements have been part of the monetary toolkit for a long time, as a complement to, if not a substitute for, monetary policy adjustment of the interest rates. In some countries they have been a key component of a financially repressed economy (McKinnon 1973). There has since been a significant evolution over time regarding the role of reserve requirements, which evolved from a purely monetary policy instrument to a policy tool with a diverse set of objectives and uses, including based on financial stability motivations.

Figure 1 illustrates average reserve requirements ratios in advanced economies (AEs) and EMEs since the 2000s, highlighting a clear divide between EMEs and AEs: their use has declined

[2]The survey was conducted in 2018 with all countries participating in the Advisory Task Force on the OECD Codes, which includes all OECD members, G-20 members, and selected emerging markets. Further information is presented in OECD (2019).

Figure 1. Average Reserve Requirement Ratio (1999–2019)



Note: Simple average of reserve requirement ratios. Advanced/Emerging classification based on IMF WEO groupings.
Source: Authors' calculations and data, notably based on Federico, Vegh, and Vuletin (2014) and its 2019 update and OECD (2019).

in AEs, with the level of the ratios going down as countries reduce significantly or repeal their reserve requirement framework. EMEs, on the other hand, have tended to use reserve requirements more actively, with an increasing trend in the run-up to the 2008 crisis, followed by a reduction post-2008, after which it oscillated around a more or less stable average. The difference in average ratios between the two groups is also striking, with 11 percent on average for EMEs and 1.5 percent for advanced economies.

Reserve requirements were first used for microprudential purposes. Initially, they were to ensure that banks held a certain proportion of liquid assets as a buffer. This prudential purpose is likely outdated, following implementation of a series of financial regulations, and notably the Basel framework.

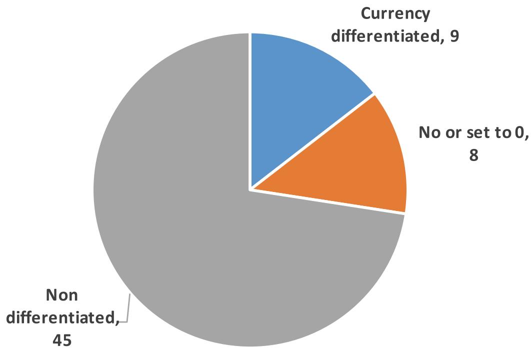
They were and are still used for monetary control purposes and adjusted, similarly to monetary policy, along the business cycle, e.g., to offset below-trend output growth (Federico, Vegh, and Vuletin 2014). The channel works through controlling reserves to affect credit growth, and indirectly amounts to a change in interest rates. Compared with central bank policy rate adjustments, however, raising reserve requirements is less likely to attract capital inflows if they incentivize banks to raise lending rates without raising deposit rates (Montoro and Moreno 2011). Indeed, all else equal, an increase in the reserve requirement ratio increases the effective funding cost of funding for banks with no actual change in the deposit rate. Recent research found evidence that reserve requirements indeed work that way, leading to higher lending rates. In contrast, raising policy rates leads to both higher lending and deposit rates, hence potentially attracting capital inflows by increasing carry trade opportunities (Brei and Moreno 2019). In addition, in contrast to interest rates, RRs may lead to exchange rate depreciation, which makes the balance sheet effects stronger and the tool more effective when firms borrow in foreign currency (Glocker and Towbin 2012a).

More recently, however, reserve requirements have started to be used with new objectives and following macroprudential considerations. As mentioned, reserve requirements affect credit growth and they may be used with a macroprudential intent to dampen credit cycles when used countercyclically (Agénor, Alper, and Pereira da Silva 2018; Glocker and Towbin 2012b; Mimir, Sunel, and Taşkin 2013). Studying theoretically the optimal mix of a typical short-term policy rate and reserve requirements in a policy rule that smooths out fluctuations in credit spreads over the cost of foreign borrowing, Mimir and Sunel (2019) finds that when the central bank finds it hard to use interest rates to lean against the wind for price-stability reasons, reserve requirements may be an effective additional tool to do so without forgoing substantial stabilization gains. Cantù et al. (2019) also find that tightening single reserve requirements limits the likelihood of financial distress. Beyond mitigating credit growth, they may also in theory be used as a countercyclical liquidity tool in ways that tools like the liquidity coverage ratio (LCR) and net stable funding ratio (NSFR) cannot (Landau 2018).

Introducing a maturity differentiation would also help address issues of maturity mismatches, insofar as banks would lengthen the maturity of their funding structures if shorter-term liabilities are taxed more.

Perhaps the most common way through which reserve requirements are and have been used as part of the policy toolkit for macroprudential purposes is through differentiation by currency. A number of central banks choose to impose higher reserve requirements on FX liabilities than on those in domestic currency. This

Figure 2. RR Currency Differentiation (2015)



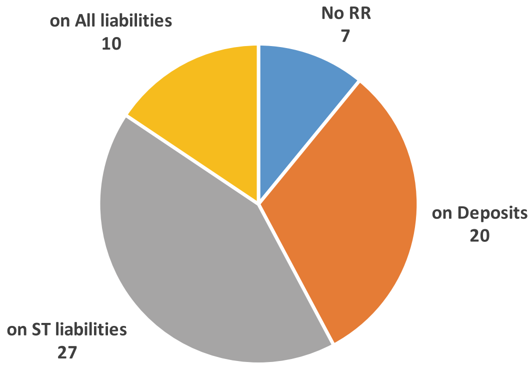
Note: The sample comprises the same sample as in Figure 1.
Source: Authors' calculations and data, notably based on Federico, Vegh, and Vuletin (2014) and OECD (2019).

policy choice is usually aimed at addressing country-specific issues, such as discouraging the use of FX in the economy, e.g., fighting dollarization, reducing currency risk in banks' balance sheets, and/or for the purpose of managing capital flows.

Figure 2 highlights the distribution of countries that have currency-differentiated reserve requirements, RR not differentiated by currency, and no or zero-rate reserve requirements. A vast majority of countries use low undifferentiated reserve requirements. Figure 3 highlights the distribution of countries which impose reserve requirements on deposit only, on short-term liabilities, with less than two-year original maturity, and on all liabilities. This heterogeneity in design may affect the below-described transmission channels for our expected effects, but the empirical test is beyond the scope of this paper and more suited for micro-data analysis.

Looking at the regional breakdown, FX-differentiated reserve requirements have been widely used in Latin America, with countries like Peru and Argentina raising in the post-2008 crisis period their FX reserve requirements above 50 percent or 40 percent, respectively. Countries like Brazil and Colombia adjust their undifferentiated reserve requirements, and countries like Chile and Mexico use a flat undifferentiated reserve requirement below 10 percent. Asian economies employ undifferentiated reserve requirements, with China and the Philippines using them in the range of 20 percent and other

Figure 3. Liabilities Included in the Reserve Base (2015)



Note: Numbers in data label refer to the number of countries.
Source: Authors' calculations and data.

economies in the region below 10 percent. In the group "Emerging Europe," Turkey, Russia, and Romania have been using differentiated reserve requirements, with the latter country raising it above 30 percent in the period preceding and following the 2008 crisis (Figure 4).

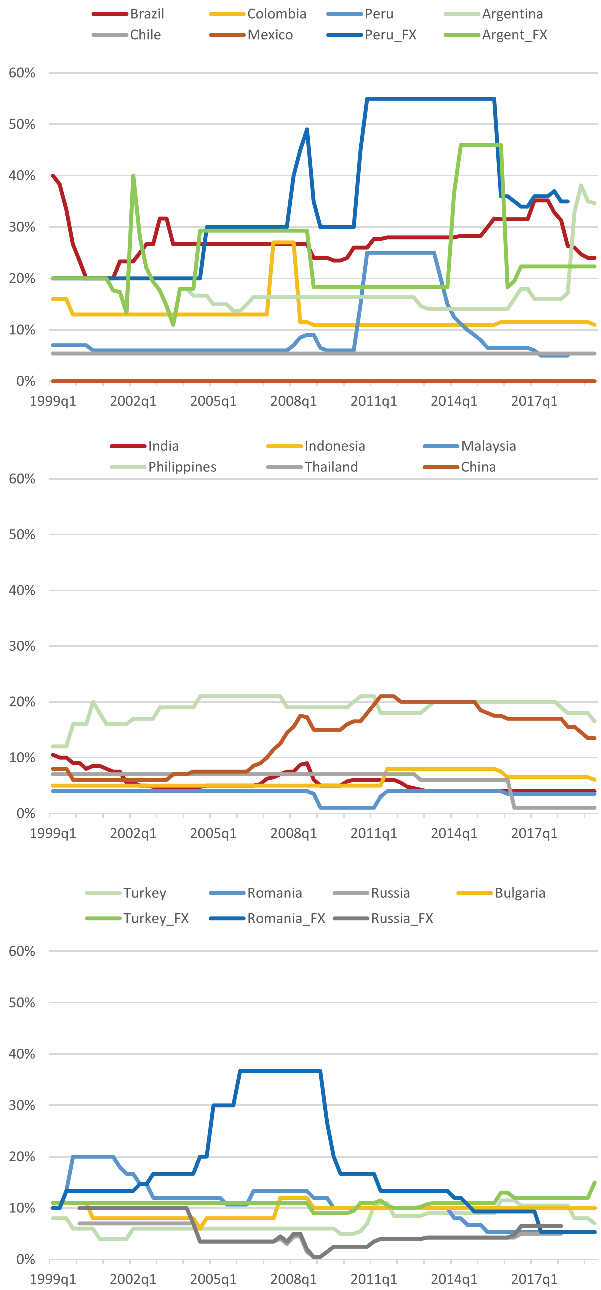
2.3 Costs and Benefits of Currency-Differentiated Reserve Requirements: A Conceptual Framework

2.3.1 Channels

Different reserve requirements may affect various financial stability outcomes through a number of channels (Figure 5).

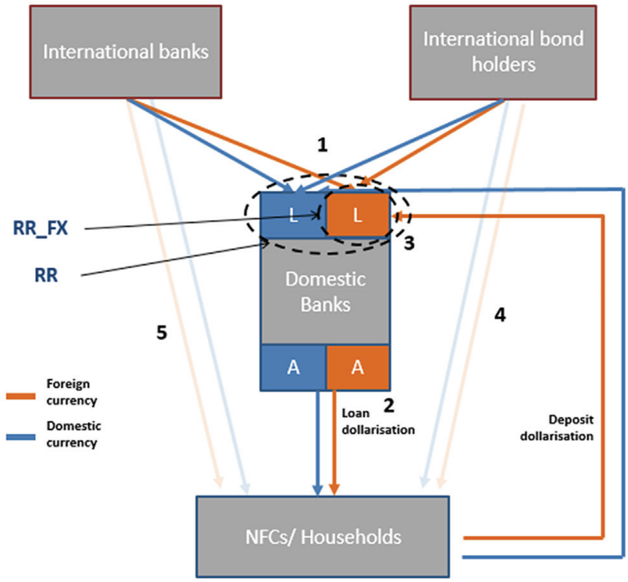
A core financial stability outcome is the capacity of reserve requirements to mitigate credit cycles. Single reserve requirements are reserve requirements with a single rate for all liabilities covered, which act akin to monetary policy rates and make funding for banks costlier across all liabilities covered by the requirements. This higher cost of funding would be the same whether these liabilities are to residents or non-residents. Through balance sheet effects, as the balance sheet of the bank shrinks, the asset side will also be affected, and like interest rates, higher reserve requirements should lead to reduced credit growth, notably to domestic households and

Figure 4. Regional Use of FX-Differentiated and Undifferentiated RR (1999–2019)



Source: Authors' calculations and data, based on Federico, Vegh, and Vuletin (2014) and its 2019 update and OECD (2019).

Figure 5. Stylized Transmission Channels



Note: The middle box represents a stylized bank balance sheet, with "A" = Assets, "L" = Liabilities. "NFCs" = Non-financial Corporates. "RR" = Single reserve requirements, "RR_FX" = Reserve requirements differentiated by currency. Numbers refer to expected channels which reserve requirements may affect and are described in the text of Section 2.3.

NFCs. This was most recently evidenced by Camors, Peydró, and Rodriguez-Tous (2019) who, thanks to firm-level and credit registry data, were able to test the impact on credit to the same firm, hence controlling for change in borrowers' characteristics.

When reserve requirements are differentiated by currency, with a higher ratio for FX liabilities than local-currency liabilities, they will affect the volume and composition of the liabilities. Funding in foreign currency specifically will be less interesting compared with local-currency funding because it is implicitly "taxed," incentivizing banks to shift their funding mix toward local-currency funding (channel numbered as 3 in Figure 5 on the liability side of the domestic banks). A composition effect reflected in a reduced share of FX liabilities to total liabilities would be expected. In addition, such differentiation may also affect the origin of funds, potentially dis-incentivizing external sources compared with domestic sources, insofar as cross-border capital movements are usually denominated in foreign currency and should thus have an impact on capital flows to domestic banks (channel 1 in Figure 5).

Through balance sheet effects, there will be less funding available to extend FX loans on the asset side, which may be reflected by a reduced share of FX loans or assets to total assets (channel 2 in Figure 5). Recent work, notably using credit registry or bank-level data, provides insights on some of the mechanisms: bank FX liabilities do feed credit dollarization (Özsöz, Rengifo, and Kutan 2015), with banks' non-core FX liabilities feeding credit dollarization three times more than core FX liabilities according to a study on Turkey (Yılmaz 2020).[3] The explanation may be related to the difference in maturity of non-core versus core liabilities, the latter of which tend to be significantly shorter.[4]

Overall, FX-differentiated reserve requirements are thus expected to help countries with issues of dollarization on both the asset and liability sides. They may also reduce currency mismatches, with a better balance between FX assets and FX liabilities, as FX liabilities are used to fund FX assets (difference between 2 and 3—FX assets minus FX liabilities of domestic banks in Figure 5).

2.3.2 Externalities

On the other hand, reserve requirements entail a number of externalities, which this paper also tests for. The basic cost of reserve requirements is that they effectively act as a distortive tax on bank funding (with differentiation imposing further disadvantages to specific operations). As such, they may move the activity and potential risk to non-regulated financial institutions, and may lead to financial disintermediation if calibrated excessively. The design of the reserve requirements is in this regard crucial, as banks will seek to use financial innovation to circumvent the requirement.

In the case of Brazil, Robitaille (2011) argues that the reserve requirements induced banks to devise alternative funding sources: large banks were able to create repos to substitute for time deposits,

[3]Traditional retail deposits are considered banks' core liabilities.

[4]In the case of Turkey, the average maturity of FX deposits held at Turkish banks is less than 3 months, while it is as high as 68 months for syndicated loans (Yılmaz 2020).

while smaller banks were forced to increase risky loan portfolio sales. A recurrent finding in the literature on circumvention of macroprudential policy is that as macroprudential tools are usually applied to banks, the market gap may be filled by other financial institutions not covered by the policy (Aiyar, Calomiris, and Wieladek 2012) and reserve requirements are expected to be no different.

If one focuses on credit to the private non-financial sector, notably domestic NFCs, four types of institutions may theoretically fill the gap left by banks: (i) domestic non-bank financial institutions, (ii) foreign branches when they are not covered by the reserve requirements, (iii) cross-border loans from foreign banks (depicted in channel 5), or (iv) international bond issuance (depicted in channel 4).[5]

With regards to FX exposure, the recent analysis by Ahnert et al. (2021) demonstrates a transfer of the FX exposure and currency risk from banks to non-financial corporates. Banks reduce their exposure, but at the same time non-financial corporates increase FX debt issuance. Insofar as FX reserve requirements are expected to affect domestic FX credit growth to NFCs, a similar shift to international FX debt issuance by NFCs can be expected (channel 4).

Finally, there may also be changes in the composition of credit portfolios of affected banks: there is recent evidence that, while bank credit diminishes when reserve requirements are increased, banks concentrate their portfolio in riskier firms (Camors, Peydró, and Rodriguez-Tous 2019).

This paper analyzes and quantifies the impact of FX-differentiated reserve requirements along these expected direct and indirect channels.

3. Empirical Model and Data

Specifically, we seek to estimate the response of variables of interest to *changes* in reserve requirement rates (either the local-currency ones or the foreign-currency ones).

[5] The relative strength of such channels would depend on the size of these different institutions and sectors in each country, as well as their participation in global capital flows. Non-bank financial institutions of advanced economies are, for instance, much more developed and integrated in the global financial system than the ones of emerging economies.

A major limitation of the existing literature on CBMs is the reliance on binary variables such as tightening/easing variables, to measure policy changes.[6] A limitation of such an approach is that such binary variables fail to capture the intensity of policy changes: a tightening of an LTV (loan-to-value) cap from 100 to 80 percent would be coded exactly the same as a tightening from 100 to 60 percent. This creates two problems: first, it provides no guidance on the optimal amount by which to change policy; and second, it would underestimate the impact of a one-off large change versus a series of small changes.[7] These issues have led the most recent literature to move away from aggregate indices towards policy-specific studies, being able to capture the intensity of the tool while providing a more precise identification of the transmission channels. These studies have so far focused on LTV ratios, which are comparable across countries (Alam et al. 2019; Richter, Schularick, and Shim 2019).

Our data enable us to capture the intensity of reserve requirements and hence to provide information on the economic magnitude of the effects.

Let us consider the following model:

$$\begin{aligned}\Delta Y_{it} = \alpha &+ \sum_{k=0}^{3} \beta_{1,k} \left(\Delta RR^{F}_{i,t-k} - \Delta RR^{L}_{i,t-k}\right) \\ &+ \sum_{k=0}^{3} \beta_{2,k} \Delta \text{average} RR_{i,t-k} \\ &+ \sum_{k=0}^{3} \gamma_{L,k} RBM_{i,t-k} + \sum_{k=0}^{3} \gamma_{F,k} CBM_{i,t-k} \\ &+ \sum_{k=0}^{3} \gamma_{L,k} MPM_{i,t-k} + \Gamma X_{i,t-1} + \delta_i + \delta_T + e_{it}. \qquad (1)\end{aligned}$$

[6] For example, when a policy is tightened, an indicator-type variable takes the value +1; when policy is loosened, it takes −1; and if it there is no change, it takes 0.

[7] A few papers have tried to get closer to the intensity of policies: an early attempt is Vandenbussche, Vogel, and Detragiache (2015) and Eller et al. (2020), which tries in a study on Central and Eastern Europe to quantify the strength of different macroprudential tools.

The dependent variable ΔY_{it} represents the *change* in one of the many variables exposed in our conceptual framework in Section 2.3 on which reserve requirements may have an impact.

Changes in the reserve requirement rates are given by $\Delta RR^{L}_{i,t-k}$, $\Delta RR^{F}_{i,t-k}$ with the L and F superscripts representing the rates on local-currency or foreign-currency liabilities. While a model adding separately changes in these two rates would provide information on the effectiveness of increasing the rate of RR_L or RR_F in isolation, the economic rationale for the adjustment in currency-differentiated RR relies on the idea of the size of the gap between foreign- and domestic-currency liabilities and not on both rates separately. Increasing the gap $\left(\Delta RR^{F}_{i,t-k} - \Delta RR^{L}_{i,t-k}\right)$ will be the key criterion for creditors for a shift away from FX funding to local-currency funding.

This said, by simply looking at the differential, we overlook instances where the gap remains the same but reserve requirement rates are increased (or decreased) overall. The change in the overall average level of reserve requirements will have an impact on our outcome variables, which we ought to capture. We thus include the change in the average reserve requirement rate in the economy as an additional variable ($\Delta \text{average}RR_{i,t-k}$) capturing all changes in levels, including from single reserve requirements. Overall, we thus narrow the diversity of reserve requirements in our country sample to three categories, three "rates": the rates on local- or foreign-currency liability for currency-differentiated RRs and the simple average reserve requirement rate. When RRs are further differentiated by the maturity of the liabilities, the average is computed.[8] The following model makes it easier to grasp the benefits of differentiated RR and to interpret the results.

[8]We recognize that, in practice, the binding character of a reserve requirement framework depends on the relative financing structure of each bank and that, as a result, a simple average is not ideal (an average weighted by the relative share of each type of liabilities would be necessary). This is the case at the country level but also within each country at the bank level (global banks versus small local banks will have different funding structures). For simplicity, due to data constraints on even country-level funding structures and in light of the important diversity of reserve requirements settings across countries, we take a simple average.

All variables are indexed by i and t, identifying country and quarter, respectively.

The policy controls $RBM_{i,t-k}$, $CBM_{i,t-k}$, and $MPM_{i,t-k}$ represent adjustments in residency-based measures (RBMs), currency-based measures (CBMs), and other macroprudential measures (MPMs) which are all policies that may have an impact on our outcome variables. All of these variables are coded as +1 for each tightening or introduction of measure during the quarter, and −1 for each easing or removal of a measure during the quarter. Values may be higher than 1 and smaller than −1 in case several measures have been taken in the same policy category in the same quarter. The data mostly come from OECD work: our data on capital controls/residency-based measures is from a new data set collected in Lepers and Mehigan (2019); currency-based measures and other macroprudential tools (MPMs) are from Alam et al. (2019).

We also add a series of country-specific controls $X_{i,t-1}$, which have been found in previous literature to be important drivers of our outcome variables. Our baseline control variables for all regressions Baseline controls include real GDP growth (year on year) to capture the domestic business cycle, the domestic interest rate to capture the domestic monetary policy stance,[9] and the growth in the real effective exchange rate to capture appreciation and depreciation dynamics.[10] As there are important differences in the various dependent variables we test, we add two additional dependent-variable-specific controls: For all cross-border capital flow variables, we include the change in sovereign ratings as in Ahnert et al. (2021) to capture country risk. For FX exposure in bank balance sheets (FX loans share, FX liability share, and net FX positions), we include a measure of inflation volatility,[11] taken as the standard deviation of the difference between the log CPI over the last eight quarters, which is an important determinant of dollarization. We lag all of our control variables by one quarter to limit endogeneity issues.

[9]We include the domestic interest rate as levels rather than change. Dickey-Fuller tests confirm that this has no unit root and can thus be included as is, consistent with Kuttner and Shim (2016). This is preferable because a large part of our sample hasn't seen many monetary policy changes.

[10]We also test exchange rate volatility instead of exchange rate changes, without changes to the results.

[11]We thank the anonymous reviewer for this suggestion.

All variables are described in detail in Table A.1 in the appendix. Summary statistics for our dependent, policy, and control variables are provided in Table A.2. All continuous variables have been symmetrically winsorized at the 2 percent level to limit outliers.

The choice of the lag structure for our policy variables is also worth discussing. While there has not been any previous study on the specific time after which a change in reserve requirement will have an impact, we expect banks to react quickly to changes in reserve requirements. We choose to assess the impact of reserve requirements over a year's time and thus a [t,t–3] lag structure. Such lag structure was also chosen in recent studies on currency-based measures (Ahnert et al. 2021). While capturing the delay in the effectiveness of a policy over a reasonable time period, it also eases interpretation of the results. We take a similar lag structure for our other policy variables (CBM, RBM, MPM).

In addition, the specification includes country and year fixed effects δ_i and δ_T. The fixed-effect regression approach was chosen because it helps us towards isolating the effect of the policy change on the variable of interest by controlling for confounding sources of variation. We thus control for consistent country-specific differences in the outcome variables and for time-specific differences in the outcome variables, such as a widespread drop in NFC debt issuance during the financial crisis. The estimated coefficient on the policy change measure thus captures the extent to which variation in the outcome that is not due to country-specific or time-specific factors can be explained by the change in policy. The coefficient β_1 is interpreted as the magnitude of a change in the outcome variable in response to an increase in the difference between the FX and local-currency reserve requirement rate of 1 percentage point. Year fixed effects were chosen over quarter fixed effects to limit the number of variables in the regression, already important with the lag structures of the policy variables. The error term is clustered by country but is assumed independent across countries.[12]

There may be a simultaneity bias: the coefficients $\beta_{1,k}$ and $\beta_{2,k}$ may be picking up the response of policy to changes in the variables

[12]We do not include a lagged dependent variable, as tests did not display significant persistence of our outcome variables; its inclusion does not change the results.

of interest. This is somewhat addressed by our lag structure—we control for the effect of policy change within the last year (covering four quarters). We address the endogeneity issue more formally in the robustness section by conducting a two-step regression framework. Other models were considered, such as inverse propensity weighting (IPW) used in Alam et al. (2019) and Richter, Schularick, and Shin (2019)[13] or dynamic and system GMM approaches,[14] but none allowed us to address the simultaneity bias and relax the assumption that policy responds with a lag without introducing alternative assumptions deemed undesirable.

4. Results

4.1 Direct Effect on Outcomes Variables

Following the conceptual framework outlined in Section 2.3, we first test the effectiveness of reserve requirements on a series of variables which may be targeted by policymakers adjusting reserve requirements.

[13]As noted by Jordà and Taylor (2016), IPW does not address simultaneity bias. IPW will reduce the risk of bias due to the omission of other important explanatory variables from the model. It is akin to the inclusion of control variables in a regression, with the benefit of being non-parametric and the limitation that it can only be used where the explanatory variable is categorical. While controlling for omitted-variable bias is important, we prefer in our baseline model to control for omitted-variable bias by simply testing various control variables in the main specification since a key contribution of our paper is to use a non-categorical explanatory variable.

[14]We did not use dynamic and system GMM approaches, often used to address simultaneity in panel applications, for two reasons. First, our data structure is such that the panel dimension N (the number of countries) and the time dimension T (the number of quarters) are similar and reasonably large, while GMM methods are intended for data sets with large N and small T (Blundell and Bond 2000). When T is relatively large, as is the case in our data, there is an instrument proliferation problem which biases the GMM coefficient estimates towards the non-instrumented panel estimates and causes statistical tests for mis-specification to be weak (Roodman 2009). The second problem is with the lag structure. GMM requires that lagged values of the explanatory variable do not affect the outcome, but we assume that reserve requirement changes can affect outcome variables with up to four quarters' lag. One could use the fifth lag and earlier as instruments for the first lag, but the strong persistence of the explanatory variable required to justify that assumption may itself contribute to the dynamic GMM weak instrument problem (Blundell and Bond 2000) and imply a violation of the additional condition required for system GMM (Roodman 2009).

Our outcome variables are the following: (i) total inflows to domestic banks; (ii) the change in the share of FX loans to total assets; (iii) the change in the share of FX liabilities to total liabilities; (iv) the change in the net FX position of the banking sector.[15] Dickey-Fuller panel unit-root tests confirm all variables are stationary.[16]

Results are displayed in Table 1. For ease of interpretation of the results, we also summarized the lag coefficients following Ahnert et al. (2021) by taking the sum of the coefficients of the four lags [t,t–3] and test whether the sum of all four coefficients is significantly different from zero (p values instead of standard errors are displayed in the table for reserve requirements coefficients, and italic is used to differentiate from other coefficients). Such method allows us to summarize the information provided by the four separate coefficients.

Regarding controls, GDP growth is generally associated with higher flows and NFC debt issuance, as is an increase in sovereign ratings. Interest rate displays little statistical significance for any of our dependent variables. Finally, depreciation of the effective exchange rate is associated with an overall increase in the share of FX loans and FX liabilities in bank balance sheets, in line with expectations. The respective effects of macroprudential, currency-based, and capital control measures deserve detailed explanations and more precise identification strategy beyond the scope of this paper and have been discussed by a wide literature (e.g., Frost, Ito, and van Stralen 2020). They are used here to control policy actions that may be simultaneous with reserve requirement changes, which would otherwise bias our estimates.

Looking at the effects of changes in the differential (the gap) between FX and local-currency-denominated reserve requirements in Table 1, on the currency composition of bank balance sheets, we find that an increase in the gap between FX and local-currency reserve requirements reduces the share of FX liabilities to total liabilities

[15]Because data are collected from different sources, the size of the sample and the countries included vary across regression and hence coefficients are not comparable across regressions. We note this caveat while choosing to include each time the largest sample. We control for specific countries driving the results across regressions in the robustness checks.

[16]The share of FX loans to total loans and the share of FX liabilities to total liabilities in levels would otherwise have been non-stationary.

Table 1. Direct Effect of Changes in Reserve Requirements

Dependent Variable	CB_tobanks_Flows (1)	Δ FX_loans_share (2)	Δ FX_liab_share (3)	Δ Net_FX_pos_FSI (4)
Gap (ΔRR_F-ΔRR_L)	0.004	–0.140	–0.000	**–1.232*****
	0.806	0.418	0.994	0.002
Gap (ΔRR_F-ΔRR_L) (t–1)	–0.011	–0.079	**–0.078***	0.252
	0.689	0.451	0.055	0.108
Gap (ΔRR_F-ΔRR_L) (t–2)	0.012	–0.113	–0.026	–0.340
	0.658	0.302	0.615	0.237
Gap (ΔRR_F-ΔRR_L) (t–3)	–0.006	–0.040	0.002	**–0.308***
	0.844	0.364	0.926	0.089
Gap (ΔRR_F-ΔRR_L) sum coef [t;t–3]	*–0.001*	*–0.372*	***–0.102******	***–1.628******
p value of sum test	*0.989*	*0.365*	***0.009***	***0.010***
Δaverage RR sum coef [t;t–3]	*0.050*	*0.615*	*0.134**	*0.253*
p value of sum test	*0.649*	*0.408*	*0.093*	*0.466*
CBM sum coef [t;t–3]	*5.6*	*–10.291*	*–7.62***	*1.655*
p value of sum test	*0.181*	*0.144*	*0.021*	*0.831*
RBM_inf sum coef [t;t–3]	*–2.987*	*–3.9*	*–0.118*	*2.104*
p value of sum test	*0.229*	*0.160*	*0.865*	*0.230*
MPM sum coef [t;t–3]	*15.978***	*4.227*	*0.338*	*12.65**
p value of sum test	*0.036*	*0.249*	*0.870*	*0.093*
GDP Growth (t–1)	0.069**	–0.033	–0.033	–0.004
	0.023	0.379	0.231	0.970
Int. Rate (t–1)	–0.022	–0.003	–0.001	0.105
	0.559	0.950	0.969	0.345
Exchange Rate Growth (t–1)	1.712	3.032**	1.148**	0.222
	0.261	0.018	0.038	0.900
Δ Sovereign Rating (t–1)	0.164			
	0.145			
Inflation Volatility (t–1)		–5.935	–17.101***	–28.462
		0.525	0.000	0.291
Constant	–0.058	0.533	0.975**	–1.450***
	0.889	0.502	0.047	0.001
Country FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Observations	2,744	887	1,025	797
R-squared	0.100	0.053	0.069	0.053
Number of ifs_code	49	25	29	35

Note: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors clustered at country level. Italic text displays the sum of the coefficients for all four policy lags, and the p-value of the sum test is displayed below rather than the standard errors as for the other coefficients in this table.

(column 3), strongly significant at the 1 percent level. Differentiated reserve requirements also appear very effective in reducing the net FX position ratios (column 4), again significant at the 1 percent threshold. Specifically, a 1 percentage point increase in the gap between FX and LC rate leads to a 0.1 percentage point reduction in the share of FX loans to total loans and a 1.6 percentage point reduction in the net FX position over a year's time (four quarters).[17] The coefficient on the share of FX loans is negative but insignificant (column 2). Reserve requirements are a liability-side measure and would only affect the asset side through balance sheet effects, which are thus indirect and may not be necessarily well captured through aggregate cross-country analysis like these.

On the cross-border side, the coefficient on total capital inflows to domestic banks is negative, as expected, but not statistically significant (column 1). Data availability prevents us from splitting cross-border bank financing between local and foreign currency, as the relevant Bank for International Settlements data cover only a limited number of countries using FX RRs, and hence we prefer not to use the currency split. This may explain the lack of significance, as our conceptual framework expects a cut in cross-border funding in FX but not in LC.

Overall, introducing the differentiation in the rates seems to match the intended effects by central banks: we see a shift away from FX liabilities (significant but not materially large) and a significantly lower overall FX position, and hence a lower mismatch.

4.2 Domestic Side Effects

Next, we turn to the identification of potential externalities, unintended effects, and evidence of circumvention of changes in FX reserve requirements.

We test seven outcome variables: (i) the change in the issuance of international debt by NFCs; (ii) capital inflows to non-banks;

[17] As we work with country-level data, as for our other variables, our outcome variable is the net FX position of the banking sector as a whole. There may obviously be heterogeneity in the net FX position of individual banks, which is not captured by the aggregate variable and by our results here. Firm-level analysis could identify heterogeneous effect of reserve requirements across banks.

(iii) total capital inflows across the three most volatile asset classes (portfolio equity, portfolio debt, other investment/credit flows);[18] and (iv) two measures of exchange rate deviation from trend. Dickey-Fuller panel unit-root tests confirm again that all variables are stationary.[19] Results are presented in Table 2.

We find that an increase in the gap is generally associated with a reduction in capital inflows (columns 2–4), with all coefficients being negative over a year time. An increase in the gap significantly decreases cross-border flows to non-banks after one and two quarters, equity inflows at time t, and portfolio debt inflows after one and two quarters. The summary coefficient over a year's time is only significant for portfolio debt inflows: specifically, a 1 percentage point increase in the gap leads to a reduction of portfolio debt inflow to GDP of 0.1 percentage point. There is no statistically significant impact on credit (bank loans) inflows. As FX reserve requirements often cover bonds, but not interbank lending nor equity, the stronger result on portfolio debt flows may not be surprising.

FX reserve requirements do not seem to have an impact, either, on exchange rate deviation from long-term trends (three or five years). However, further research using more sophisticated measures of exchange rate misalignments, notably deviations from model-based equilibrium exchange rate, could be done.[20]

Finally, we find little evidence of circumvention of FX reserve requirements, i.e., with the private sector getting more funding from abroad (columns 1 and 2) if it cannot receive the FX funds from domestic banks. Unlike Ahnert et al. (2021), who study a much broader set of currency-based measures, we do not find evidence of higher international debt issuance of corporates, and as mentioned there is at times a negative rather than positive effect on inflows to non-banks (column 2). These negative coefficients appear as a side effect, as according to our conceptual framework (Section 2.3), the

[18] By "inflows" we refer to non-resident flows, i.e., the net incurrence of liabilities to non-residents. To account for the persistence in capital flows, we also try models with lagged dependent variable as regressor and the results do not change.

[19] The issuance of international debt by NFCs in levels would otherwise have been non-stationary.

[20] Loeffler (2015) finds that single reserve requirements represent an efficient tool to depreciate the exchange rate.

Table 2. Indirect Effect of Changes in Reserve Requirements

	NFC Debt Growth (1)	CB_tononbanks_ Flows (2)	Equity Flow (3)	Portfolio Debt Flow (4)	Credit Flow (5)	ER Dev 3Y (6)	ER Dev 5Y (7)
Gap (ΔRR_F-ΔRR_L)	0.000	0.007	**–0.011***	0.003	0.033	–0.050	–0.358
	0.881	0.588	0.090	0.913	0.232	0.735	0.311
Gap (ΔRR_F-ΔRR_L) (t–1)	0.002	**–0.020****	–0.007	**–0.045****	–0.024	0.198	–0.358
	0.507	0.040	0.322	0.037	0.584	0.221	0.412
Gap (ΔRR_F-ΔRR_L) (t–2)	0.002	**–0.013***	–0.004	**–0.031****	–0.028	0.426	–0.214
	0.423	0.097	0.581	0.023	0.287	0.102	0.549
Gap (ΔRR_F-ΔRR_L) (t–3)	**–0.006***	0.002	0.001	–0.021	0.021	0.474	–0.097
	0.067	0.766	0.808	0.250	0.576	0.108	0.759
Gap (ΔRR_F-ΔRR_L) sum coef [t;t–3]	*–0.002*	*–0.024*	*–0.021*	***–0.094****	*0.002*	*1.048*	*–1.027*
p value of sum test	*0.785*	*0.391*	*0.263*	***0.073***	*0.983*	*0.108*	*0.475*
Δ average RR sum coef [t;t–3]	*0.001*	*0.041**	*–0.010*	*0.074*	*–0.068*	*–0.674*	*–0.205*
p value of sum test	*0.941*	*0.077*	*0.698*	*0.244*	*0.557*	*0.254*	*0.508*
CBM sum coef [t;t–3]	*0.307*	*–0.307*	*0.643*	*–1.426*	*1.087*	*19.801*	*28.607*
p value of sum test	*0.266*	*0.891*	*0.501*	*0.710*	*0.868*	*0.443*	*0.325*
RBM_inf sum coef [t;t–3]	*–0.055*	*–0.046*	*0.494*	*–0.84*	*–2.037*	*2.92*	*2.785*
p value of sum test	*0.354*	*0.948*	*0.149*	*0.415*	*0.193*	*0.755*	*0.798*
MPM sum coef [t;t–3]	*0.121*	*3.492*	*0.826*	*4.529*	*17.681***	*–11.878*	*–6.412*
p value of sum test	*0.418*	*0.242*	*0.634*	*0.443*	*0.042*	*0.543*	*0.797*
GDP Growth (t–1)	0.002**	0.038***	0.028	0.019	0.066	0.431**	0.235
	0.026	0.000	0.186	0.531	0.199	0.023	0.184
Int. Rate (t–1)	0.001	0.005	–0.005	–0.026	0.062	–0.225	0.601
	0.398	0.648	0.476	0.301	0.211	0.252	0.236
Exchange Rate Growth (t–1)	0.009	0.537	–0.315	0.825	0.369		
	0.764	0.225	0.267	0.236	0.786		
Δ Sovereign Rating (t–1)		0.122***	0.022	0.213**	0.097		
		0.007	0.437	0.024	0.662		
Constant	0.022	–0.091	0.669***	0.445	0.162	0.253	–3.303
	0.276	0.541	0.002	0.142	0.821	0.881	0.293
Country FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Observations	2,826	2,744	2,676	2,677	2,736	2,715	2,336
R-squared	0.048	0.091	0.031	0.054	0.090	0.076	0.090
Number of ifs_code	51	49	48	48	49	51	51

Note: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. Standard errors clustered at country level. Italic text displays the sum of the coefficients for all four policy lags, and the p-value of the sum test is displayed below rather than the standard errors as for the other coefficients in this table.

direct effect of a higher RR gap should lower capital inflows to banks, but not to non-banks. We may have expected a positive coefficient if NFCs seek to get the FX financing they cannot get from domestic banks directly cross-border.[21]

Overall, our results on side effects highlight two main conclusions: first, FX reserve requirements appear to affect overall cross-border inflows beyond a simple reduction of domestic banks' external financing. This is consistent with the earlier above-mentioned literature on the impact of currency-based measures on overall capital flows, and provides more specific evidence of an impact of FX reserve requirements on flows. Secondly, while many studies have highlighted important circumvention of macroprudential tools, we do not see evidence of circumvention in the case of FX reserve requirements on the variables studied here.

4.3 International Externalities

As shown in the previous section, FX reserve requirements have the potential to reduce capital flows and hence be used as capital flow management measures. A substantial literature has highlighted that capital flow management measures may lead to capital flow deflection to similar or neighboring economies (Forbes, Fratzscher, and Straub 2015; Giordani et al. 2017; Pasricha 2017). Specifically, deflection has usually been identified in the following way: if country A and country B are economically similar, the introduction of a control in country A will reduce capital inflows from C to A and deflect capital flows towards country B, which has not introduced barriers. In this section, we seek to extend our baseline model to test for the potential of similar capital flow deflection dynamics following adjustments of FX reserve requirements.

We follow the empirical approach used in recent work on capital flow deflection by Gori, Lepers, and Mehigan (2020) to test the existence of such international spillover. In particular, we add to our baseline regressions on capital flows a variable (the "spillover

[21] One explanation for this result may be the negative signal that such adjustments send to international investors. In the case of adjustments of capital controls, Forbes et al. (2016) show that a measure need not actually be binding on international investors for them to reduce investment in the country. This would be consistent with the small size of the coefficient.

variable"), which represents the sum of tightening actions in FX reserve requirements in similar economies.

Each FX RR adjustment is weighted by how similar a country is to the country adjusting RR and hence the most likely to receive more inflows. The choice of an adequate weighting scheme is not trivial: here countries' similarity is defined based on the correlation between capital inflows to both countries.[22] This implies the use of a continuous weighting scheme in which the set of weights are defined by the time-varying bilateral correlation coefficient between the inflow of capital in the tightening country and another country.[23] Specifically, the weights are computed on a rolling basis over the past eight quarters' capital inflows to both countries. The resulting spillover variable enters the regression with a lag.

Results are displayed in Table A.3 in the appendix. We start by testing potential spillovers effects of FX RR tightening on total inflows to GDP after one quarter (columns 1–2) and do not find any effect for either the full country sample or an EME sample (capital flow deflection following capital controls has been mainly a feature of EMEs according to the recent literature). Neither do we find any spillover two, three, or four quarters after a RR tightening (columns 4–6), or within a year's time (column 7). Using fixed time correlations as weights rather than time-varying weights does not change the results (column 3). Changing the dependent variable to test for spillover effects on specific asset classes, we do not find evidence for any flow (foreign direct investment, FDI; equity; debt; credit) (columns 8–11).

Overall, under this empirical specification, we don't find evidence of international spillovers in the form of capital flow deflection to similar economies after adjustments in FX RR, unlike traditional

[22]The economic rationale of this choice lies in the idea that if capital inflows to two distinct countries co-move in relation to each other, this underlines similarity in the two countries' assets in the eyes of international investors. Gori, Lepers, and Mehigan (2020) argue that this measure is more effective in measuring similarity among two countries than alternatives based on location (as assets even in nearby countries may have different investment characteristics) or fundamentals (as fundamentals are often unable to explain asset price dynamics).

[23]All negative inflow correlations to 0. The idea is to eliminate from the set of similar countries all economies whose capital inflow is negatively correlated with the one of the tightening countries, and whose policy shift would otherwise be added with negative sign (thus subtracted) from the spillover variable.

capital flow management tools. RR are targeted at domestic banks, which may be bearing the full cost of the measure rather than shifting it to international lenders/investors.

5. Robustness Checks

5.1 Alternative Method to Control for Endogeneity

We test whether some of our baseline results may not be affected by simultaneity bias whereby it is not the policy change driving changes in the outcome variables, but the policy that actually responds to ongoing macroeconomic developments. Policy adjustments are likely endogenous to the variables they try to target. As shown in Rojas, Vegh, and Vuletin (2020) for reserve requirements specifically, endogeneity concerns are real and may bias studies on their effectiveness.[24] While our lag structure should mitigate the concern, it may not fully address it.

We closely follow the innovative technique used in Ahnert et al. (2021) in their study of currency-based measures. It seeks to estimate more "exogenous" policy shocks, thereby removing the potential for endogenous adjustments. The approach relies on a two-stage regression framework, with a first stage estimating the likelihood of a policy change from a range of variables describing the macroeconomic and financial context of the country and likely to be followed by policymakers. It then regresses the baseline, replacing the policy variables with the residuals obtained from the first stage (i.e., the variation of the policy changes that is not explained by macro-financial variables).

We regress both the change in the FX RR gap and the change in the average level of the RR on a range of variables which policymakers are likely to look at for deciding a policy change, namely the lagged GDP growth to control for the business cycle, exchange rate change, bank credit growth for the credit cycles, various measures of inflows in the economy, and the main outcome variables of our

[24] In a recent paper, Rojas, Vegh, and Vuletin (2020) use the narrative approach of Romer and Romer (2010) to identify exogenous reserve requirement changes based on press releases and other reports of central banks introducing these changes. They achieve this for three countries, and this method would not be suitable for the large number of countries that we have.

baseline. This should control for the possible motivations for RRs: business cycle smoothing, exchange rate management, capital flow management, macroprudential intent. We also add the lagged level in the gap and lagged average RR to control for potential mean-reverting dynamics (if the rate or gap is historically high, it is more likely to be brought down to "normal"). We also control for the contemporaneous change in interest rates by the central bank to control for interaction between the two tools in a monetary policy setting.

The two regressions for the first stage can be described as follows:

$$\left(\Delta RR^F - \Delta RR^L\right)_{it} = \alpha + \omega\left(RR^F - RR^L\right)_{it-1} + \Gamma X_{i,t-1} + \delta_i + \delta_T + e_{it} \tag{2}$$

$$\Delta \text{average}RR_{it} = \alpha + \mu \text{ average}RR_{it-1} + \partial X_{i,t-1} + \delta_i + \delta_T + e_{it}. \tag{3}$$

Results for the gap are displayed in Table A.4 in the appendix. While mean-reverting dynamics are confirmed (i.e., wider gap in the previous quarter reduces the chance of an increase), there does not appear to be any obvious driver of RR adjustments in our macro-financial variables. This is consistent with the nascent literature explaining policy changes, which finds it hard to match real drivers and expected targets. While institutional and political variables are expected to play a non-negligible role in driving changes—e.g., central bank independence—they are irrelevant for the present exercise, which simply seeks to construct a measure of policy change that is exogenous to our outcome variables in the first place.

The absence of strong results for any macro-financial variables in our setting may in itself reduce reverse-causality concerns, but we go ahead with a second stage for the variables we are concerned about: we select the model in column 2 as our baseline—in the absence of strong result for any specific variable, we prefer to select a model with the largest country sample.

We plug the residuals from this model back into our baseline model, replacing our RR variables, keeping the specification with four lags of the policy variable:

$$Y_{it} = \alpha + \sum_{k=0}^{3} \beta_{1,k} RR\_\widehat{gap\_residuals}_{it} + \sum_{k=0}^{3} \beta_{2,k} RR\_\widehat{av\_residuals}_{it} + \Gamma X_{i,t-1} + \delta_i + \delta_T + e_{it}. \tag{4}$$

Table 3 displays the results. We not only find that our previously significant results are typically confirmed in this model (a larger gap leading to lower FX liability share, lower net FX positions, and lower flows to non-banks and lower portfolio debt flows); we also find additional significant coefficients for some of the lags in line with our conceptual framework, e.g., a negative coefficient at the third lag for cross-border flows to domestic banks.

The significant coefficients in the baseline are also typically more significant both in terms of and statistical and economic significance: the reduction in the net FX position is now 2.3 percentage points over a year's time for a 1 percent increase in the gap and the reduction in the FX liability share at 0.15. Both coefficients are more significant, well below the 1 percent threshold.[25] The reduction in portfolio debt inflows is also higher at 0.2 but moves slightly above the 10 percent threshold.

We further find a positive (and significant at 5 percent threshold) coefficient regarding the exchange rate deviation from a three-year trend. Instead of driving exchange rates towards undervaluation, this seems to have the opposite effect of strengthening the currency; but again note, however, that deviation from trend represents a crude proxy for exchange rate misalignment.

Overall, results from the "exogenous policy shock" model confirm our baseline findings while reducing reverse-causality concerns.

5.2 Does the Effect of Changes in Reserve Requirements Depend on the Initial Level of the Rate?

The effect of a change in reserve requirements could well depend on the initial level of the reserve requirements. If it is already very high, a small change may not make a big difference, or on the other hand it could also be hypothesized that because the reserve requirements are very tight, a small change would make a larger difference.

[25] As a robustness check, we also compute residuals from a first-stage model that includes the lagged change in the FX liability share as an additional control (at the detriment of losing observations), and results from the second stage are almost identical.

Table 3. Direct and Indirect Effect: The Residual Method

Dependent Variable	CB_tobanks_Flows (1)	Δ FX_loans_share (2)	Δ FX_liab_share (3)	Δ Net_FX_pos_FSI (4)	NFC Debt Growth (5)
Residual from Gap Reg	–0.043	–0.148	–0.030	**–1.515*****	0.003
	0.316	0.486	0.443	0.000	0.268
Residual from Gap Reg	–0.052	–0.099	–0.053	0.207	0.004
(t–1)	0.106	0.472	0.138	0.232	0.335
Residual from Gap Reg	–0.014	–0.137	**–0.096*****	–0.532	0.003
(t–2)	0.688	0.294	0.001	0.133	0.303
Residual from Gap Reg	**–0.089****	–0.050	0.036	**–0.448***	**–0.009***
(t–3)	0.047	0.274	0.135	0.056	0.072
sum coef [t;t–3]	*–0.198*	*–0.434*	***–0.143******	***–2.288******	*0.001*
p value of sum test	*0.157*	*0.388*	***0.003***	***0.002***	*0.964*
Residual from Average	0.066	0.329	0.041	–0.043	–0.000
RR Reg	0.181	0.478	0.187	0.664	0.868
Residual from Average	0.056	0.165	0.115	0.038	0.000
RR Reg (t–1)	0.179	0.403	0.145	0.748	0.912
Residual from Average	–0.001	0.153	0.029	0.475	–0.000
RR Reg (t–2)	0.986	0.335	0.328	0.327	0.915
Residual from Average	0.006	–0.036	–0.044	0.203	0.000
RR Reg (t–3)	0.883	0.576	0.204	0.342	0.957
Policy Controls	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y
Country and Year FE	Y	Y	Y	Y	Y
Observations	2,490	808	882	694	2,430
R-squared	0.100	0.053	0.068	0.060	0.060
Number of ifs_code	47	24	25	32	45

(*continued*)

Table 3. (Continued)

Dependent Variable	CB_tononbanks_Flows (6)	Equity Flow (7)	Portfolio Debt Flow (8)	Credit Flow (9)	ER Deviation 3Y (10)	ER Deviation 5Y (11)
Residual from Gap Reg	–0.002	–0.002	–0.039	–0.026	0.209	–0.358
	0.928	0.825	0.356	0.652	0.216	0.449
Residual from Gap Reg	**–0.033****	–0.001	**–0.054****	–0.028	**0.585*****	–0.395
(t–1)	0.026	0.899	0.040	0.618	0.005	0.449
Residual from Gap Reg	–0.013	0.005	**–0.047***	–0.042	**0.910***	–0.251
(t–2)	0.249	0.714	0.081	0.359	0.053	0.563
Residual from Gap Reg	**–0.029***	0.001	–0.048	–0.087	**0.787***	–0.027
(t–3)	0.067	0.949	0.219	0.206	0.056	0.943
sum coef [t;t–3]	*–0.077*	*0.003*	*–0.188*	*–0.183*	***2.491*****	*–1.031*
p value of sum test	*0.110*	*0.956*	*0.119*	*0.344*	***0.016***	*0.557*
Residual from Average	0.036**	–0.012	0.038	0.011	–0.007	–0.269
RR Reg	0.023	0.404	0.231	0.871	0.953	0.260
Residual from Average	0.020	–0.003	–0.002	–0.038	–0.750*	0.019
RR Reg (t–1)	0.172	0.742	0.933	0.467	0.100	0.858
Residual from Average	0.008	–0.021	0.017	–0.011	–0.510	0.240
RR Reg (t–2)	0.492	0.237	0.603	0.844	0.194	0.241
Residual from Average	0.001	–0.008	–0.011	–0.041	–0.164	0.160
RR Reg (t–3)	0.910	0.557	0.615	0.370	0.510	0.459
Policy Controls	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y
Country and Year FE	Y	Y	Y	Y	Y	Y
Observations	2,490	2,430	2,431	2,490	2,450	2,146
R-squared	0.092	0.037	0.065	0.091	0.098	0.087
Number of ifs_code	47	46	46	47	48	48

Note: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors clustered at country level. Italic text displays the sum of the coefficients for all four policy lags, and the p-value of the sum test is displayed below rather than the standard errors as for the other coefficients in this table.

To test this, we rerun our baseline, this time scaling our variable of interest (the change in the FX RR gap) by the initial average level of reserve requirements (at time t–1).

Formally, the new specification reads as follows:

$$Y_{it} = \alpha + \sum_{k=0}^{3} \beta_{1,k} \left(\frac{\Delta RR\_Gap_{i,t-k}}{Av\_RR_{i,t-k-1}} \right) + \sum_{k=0}^{3} \beta_{2,k} \Delta \text{average} RR + \Gamma X_{i,t-1} + \delta_i + \delta_T + e_{it}. \quad (5)$$

If $\beta_{1,k}$ displays higher statistical significance under this specification than under the baseline, we can conclude that the impact of changes in the FX RR gap on our specific outcome variable Y_{it} is non-linear and, specifically, that the higher the initial average rate, the lower the impact of a change in the gap. We considered other empirical strategies, such as interacting with a dummy variable representing a high initial RR or a low one, similar to the Alam et al. (2019) study on LTV caps, but such technique creates threshold effects around the decided cut-off. Interacting directly with the average RR level removes such issue, but we find that the inclusion of interaction terms leads to the loss of too many degrees of freedom. Table A.5 in the appendix displays the new results, comparing the coefficients from the baseline and the coefficients from Equation (5).

Regarding direct effects, the coefficients are more significant for the FX liability share, but only slightly. The coefficient is, on the other hand, less significant in the case of the net FX position, moving below the 1 percent significance threshold.

There are also some differences regarding coefficients on indirect variables. Portfolio debt flows become substantially more significant, moving from 7 percent almost to the 1 percent significance level, suggesting non-linearity there. Finally, the coefficient on the deviation from the three-year trend becomes significant at the 10 percent level.

These results provide slight evidence of non-linearity with regards to the FX liability share, more marked evidence for portfolio debt flows, and to some extent for the exchange rate deviation from the three-year (3Y) trend. Specifically, it supports the null hypothesis that the higher the initial average rate, the lower the impact of a change in the gap. It also provides reassurance that our baseline results are not significantly changed when controlling for potential non-linear effects.

6. The Value of Intensity-Based Measures

In this final empirical section, we seek to illustrate the value of intensity-based measures like ours compared with the easing/tightening binary variables used in the literature by creating binary +1/–1 variables for our reserve requirements data (one for the rate on local-currency liabilities, one for foreign currency, one for undifferentiated single reserve requirements) and running the same model separately with our continuous/intensity variables and our binary ones.

The baseline model used in the previous section used the concept of gap (differential between the FX-RR rate and the LC-RR rate). As binary variables do not capture information on the size of the change, they are mostly silent regarding an increase or decrease of the gap. In the spirit of comparability with previous models using binary variables used in the literature, we now estimate the following model:

$$\begin{aligned} Y_{it} = \alpha &+ \sum_{k=0}^{3} \beta_{L,k} \Delta RR_{i,t-k}^{L} + \sum_{k=0}^{3} \beta_{F,k} \Delta RR_{i,t-k}^{F} \\ &+ \sum_{k=0}^{3} \beta_{S,k} \Delta RR_{i,t-k}^{S} + \sum_{k=0}^{3} \gamma_{R,k} RBM_{i,t-k} \\ &+ \sum_{k=0}^{3} \gamma_{C,k} CBM_{i,t-k} + \sum_{k=0}^{3} \gamma_{M,k} MPM_{i,t-k} \\ &+ \Gamma X_{i,t-1} + \delta_i + \delta_T + e_{it}. \end{aligned} \tag{6}$$

We thus replace our variables of interest, replacing the gap between FX and LC rate with separate variables capturing change in the FX rate, change in the LC rate, or change in the single reserve requirement rate in the case of undifferentiated reserve requirements.

We split the results between our "direct" outcome variables and our "indirect" outcome variables. Results are summarized in Table 4 and Table 5.

Table 4. The Direct Effect of Reserve Requirements: Intensity-Based Measures vs. Easing/Tightening Binary Variables

Dependent Var.:	**Inflows to Banks**		**Δ FX Loans Share**		**Δ FX Liab Share**		**Δ Net FX Position**	
	Rates	**Binary**	**Rates**	**Binary**	**Rates**	**Binary**	**Rates**	**Binary**
RR Variable Type	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Δ RR FX Liabilities	0.029	**0.399***	–0.003	0.064	0.013	0.064	**–1.474*****	–2.396
	0.159	0.086	0.897	0.574	0.584	0.814	0.000	0.261
Δ RR FX Liabilities (t–1)	0.005	–0.057	0.004	0.033	–0.011	0.262	**0.290****	1.028
	0.779	0.806	0.949	0.917	0.753	0.345	0.042	0.245
Δ RR FX Liabilities (t–2)	0.001	0.166	–0.046	0.113	–0.021	0.011	–0.237	–0.060
	0.978	0.396	0.222	0.679	0.648	0.957	0.216	0.938
Δ RR FX Liabilities (t–3)	–0.006	–0.056	–0.028	–0.066	0.003	0.046	–0.175	**–0.675***
	0.796	0.613	0.568	0.588	0.872	0.768	0.155	0.079
sum coef [t;t–3]	*0.029*	*0.452*	*–0.073*	*0.144*	*–0.016*	***0.383****	***1.596*****	*–2.103*
p value of sum test	*0.66*	*0.50*	*0.59*	*0.80*	*0.56*	***0.01***	***0.00***	*0.37*
Δ RR LC Liabilities	0.022	0.039	0.105	0.053	–0.041	0.030	0.347	1.740
	0.342	0.778	0.307	0.709	0.591	0.803	0.307	0.251
Δ RR LC Liabilities (t–1)	0.032	0.132	0.084	0.433	**0.200*****	**0.383*****	0.010	–1.784
	0.480	0.565	0.323	0.177	0.002	0.002	0.951	0.153
Δ RR LC Liabilities (t–2)	–0.029	–0.117	**0.122***	0.319	0.078	**0.157****	**0.419****	0.602
	0.414	0.389	0.093	0.226	0.183	0.044	0.032	0.208
Δ RR LC Liabilities (t–3)	–0.004	–0.047	0.058	0.145	0.012	–0.179	0.067	0.718
	0.912	0.671	0.203	0.380	0.517	0.294	0.617	0.150
sum coef [t;t–3]	*0.021*	*0.007*	*0.369*	***0.95****	***0.249****	***0.391****	***0.843****	*1.276*
p value of sum test	*0.88*	*0.99*	*0.17*	***0.09***	***0.06***	***0.08***	***0.05***	*0.29*

(*continued*)

Table 4. (Continued)

Dependent Var.:	**Inflows to Banks**		**Δ FX Loans Share**		**Δ FX Liab Share**		**Δ Net FX Position**	
	Rates	**Binary**	**Rates**	**Binary**	**Rates**	**Binary**	**Rates**	**Binary**
RR Variable Type	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Δ Single RR	0.045	0.111	0.787	2.599	**0.079*****	0.275	–0.124	–0.372
	0.571	0.691	0.363	0.234	0.005	0.216	0.499	0.565
Δ Single RR (t–1)	0.040	0.072	0.472	1.946	0.102	0.284	–0.158	–0.755
	0.578	0.797	0.261	0.276	0.288	0.570	0.614	0.442
Δ Single RR (t–2)	0.060	0.195	0.530	2.680	0.037	0.172	0.731	1.509
	0.541	0.426	0.294	0.223	0.565	0.671	0.379	0.233
Δ Single RR (t–3)	0.064	0.298	–0.136	–0.519	–0.046	0.279	0.393	2.165
	0.399	0.294	0.506	0.540	0.520	0.358	0.375	0.186
sum coef [t;t–3]	*0.209*	*0.676*	*1.653*	*6.706*	*0.172*	*1.01*	*0.842*	*2.547*
p value of sum test	*0.49*	*0.43*	*0.30*	*0.21*	*0.18*	*0.13*	*0.29*	*0.18*
Policy Controls	Y	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y
Country and Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2,744	2,744	887	887	1,025	1,025	797	797
R-squared	0.101	0.101	0.117	0.102	0.076	0.068	0.064	0.035
Number of ifs_code	49	49	25	25	29	29	35	35

Note: $*p < 0.10$, $**p < 0.05$, $***p < 0.01$. Standard errors clustered at country level. Italic text displays the sum of the coefficients for all four policy lags, and the p-value of the sum test is displayed below rather than the standard errors as for the other coefficients in this table.

Table 5. The Indirect Effect of Reserve Requirements: Intensity-Based Measures vs. Easing/Tightening Binary Variables

Dependent Var.:	NFC Debt Growth		Inflows to Non-banks		Equity Inflows		Debt Inflows		Other Inflows		ER Deviation 3Y		ER Deviation 5Y	
	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary
RR Variable Type	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Δ RR FX	0.000	0.050	0.028	0.165	–0.010	–0.065	0.028	0.065	0.038	0.406	0.093	4.201	–0.546	–2.090
Liabilities	0.955	0.126	0.141	0.119	0.188	0.198	0.420	0.628	0.319	0.277	0.631	0.143	0.258	0.421
Δ RR FX	0.003	0.015	–0.014	–0.027	–0.003	0.047	**–0.033*****	–0.044	–0.035	0.136	–0.084	**2.491***	–0.420	–1.296
Liabilities (t–1)	0.461	0.404	0.148	0.633	0.734	0.615	0.002	0.681	0.395	0.695	0.507	0.050	0.363	0.569
Δ RR FX	0.001	**0.024****	**–0.011***	0.025	–0.005	**–0.090****	–0.014	0.087	–0.040	0.051	0.257	**4.274***	–0.165	0.324
Liabilities (t–2)	0.446	0.046	0.090	0.648	0.493	0.049	0.315	0.322	0.111	0.641	0.139	0.090	0.607	0.795
Δ RR FX	**–0.006***	0.002	0.000	0.023	0.001	0.034	–0.014	0.034	0.007	–0.027	**0.448***	5.042	–0.024	1.173
Liabilities (t–3)	0.085	0.948	0.954	0.687	0.840	0.622	0.261	0.721	0.882	0.844	0.058	0.221	0.940	0.157
sum coef [t;t–3]	*–0.002*	*0.091*	*0.003*	*0.186*	*–0.017*	*–0.074*	*–0.033*	*0.142*	*–0.03*	*0.566*	*0.71*	*16.01*	*–1.16*	*–1.89*
p value of sum test	*0.80*	*0.15*	*0.91*	*0.37*	*0.44*	*0.69*	*0.48*	*0.67*	*0.77*	*0.45*	*0.16*	*0.13*	*0.45*	*0.76*
Δ RR LC	–0.002	–0.043	0.015	0.094	0.013	0.032	0.025	**0.191*****	–0.031	–0.319	0.214	0.921	0.073	0.592
Liabilities	0.705	0.137	0.207	0.258	0.134	0.514	0.455	0.006	0.264	0.132	0.208	0.336	0.743	0.559
Δ RR LC	–0.004	0.014	**0.034****	0.053	**0.017***	**0.125****	**0.087*****	0.109	0.020	0.031	–0.532	–0.024	0.194	1.183
Liabilities (t–1)	0.395	0.457	0.012	0.438	0.052	0.042	0.004	0.255	0.710	0.888	0.181	0.979	0.465	0.547
Δ RR LC	**–0.007*****	**–0.033****	0.020	–0.049	0.012	–0.009	**0.075****	0.054	0.025	0.022	–0.738	–0.693	0.207	0.318
Liabilities (t–2)	0.001	0.019	0.108	0.569	0.122	0.828	0.014	0.572	0.487	0.875	0.144	0.560	0.579	0.878
Δ RR LC	0.004	–0.008	–0.002	0.010	0.011	0.036	**0.058****	0.059	**–0.062****	–0.030	–0.608	2.169	0.225	1.073
Liabilities (t–3)	0.161	0.749	0.848	0.897	0.182	0.516	0.024	0.583	0.033	0.873	0.153	0.243	0.592	0.626
sum coef [t;t–3]	*–0.009*	***–0.07*****	***0.067****	*0.108*	***0.053*****	*0.184*	***0.245******	*0.413*	*–0.048*	*–0.296*	*–1.664*	*2.373*	*0.699*	*3.166*
p value of sum test	*0.21*	***0.00***	***0.07***	*0.55*	***0.05***	*0.10*	***0.00***	*0.16*	*0.70*	*0.55*	*0.16*	*0.59*	*0.52*	*0.65*

(*continued*)

Table 5. (Continued)

Dependent Var.:	NFC Debt Growth		Inflows to Non-banks		Equity Inflows		Debt Inflows		Other Inflows		ER Deviation 3Y		ER Deviation 5Y	
	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary	Rates	Binary
RR Variable Type	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Δ Single RR	–0.001	0.009	0.013	0.081	**–0.030***	–0.048	0.034	0.212	0.024	–0.540	–0.335	–0.725	–0.329	–0.918
	0.697	0.256	0.617	0.442	0.083	0.555	0.110	0.263	0.824	0.235	0.154	0.333	0.132	0.372
Δ Single RR (t–1)	–0.000	0.008	–0.010	–0.073	0.000	**0.166***	–0.030	–0.131	–0.029	–0.124	–0.294	–0.957	–0.098	–0.620
	1.000	0.327	0.379	0.196	0.990	0.085	0.111	0.462	0.622	0.730	0.180	0.161	0.576	0.466
Δ Single RR (t–2)	0.005	0.012	–0.004	0.021	–0.015	–0.007	0.015	0.242	0.052	0.235	0.011	0.042	0.123	0.243
	0.475	0.255	0.882	0.744	0.296	0.862	0.631	0.214	0.564	0.471	0.946	0.935	0.274	0.670
Δ Single RR (t–3)	**0.005****	0.001	–0.015	–0.072	0.005	–0.080	–0.027	–0.235	0.069	0.490	0.209	0.250	0.145	–0.313
	0.032	0.901	0.430	0.281	0.686	0.245	0.407	0.183	0.436	0.244	0.134	0.629	0.514	0.654
sum coef [t;t–3]	*0.009*	***0.03****	*–0.016*	*–0.043*	*–0.04*	*0.031*	*–0.008*	*0.088*	*0.116*	*0.061*	*–0.409*	*–1.39*	*–0.159*	*–1.608*
p value of sum test	*0.17*	***0.04***	*0.73*	*0.77*	*0.32*	*0.77*	*0.90*	*0.84*	*0.72*	*0.95*	*0.55*	*0.51*	*0.78*	*0.55*
Policy Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country and Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2,826	2,826	2,744	2,744	2,676	2,676	2,677	2,677	2,736	2,736	2,715	2,715	2,336	2,336
R-squared	0.051	0.053	0.091	0.092	0.031	0.031	0.055	0.055	0.091	0.091	0.080	0.119	0.091	0.087
Number of ifs_code	51	51	49	49	48	48	48	48	49	49	51	51	51	51

Note: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors clustered at country level. Italic text displays the sum of the coefficients for all four policy lags, and the p-value of the sum test is displayed below rather than the standard errors as for the other coefficients in this table.

First, we find that our previous results on the change in the gap and underlying channels are all confirmed in this new model with a split between the rate on FX liabilities, the rate on local-currency-denominated liabilities, and the rate on single reserve requirements. Furthermore and interestingly, it is changes in the LC rate relative to the FX one that affect most of our dependent variables with more channels identified than in our baseline regressions: increases in the LC rate lead to a statistically significant increase over a year's time in the FX liability share, in the net FX position, and in inflows to non-banks, equity inflows, and debt inflows. Changes in FX rate typically move dependent variables in the symmetrically opposite direction but display less statistical significance throughout.

Second, the comparison between the results using a binary policy indicator versus our intensity-based measure of reserve requirements rate strongly highlights the need to consider the intensity of measures. There appear to be very significant differences between the two policy indicators. The main difference lies in the significance of the results, e.g., a binary indicator does not pick up a statistically significant reduction in the net FX position or a reduction in capital flows to non-banks from a decrease in LC rate or an increase in the FX rate. Conversely, there are also cases where a binary indicator may be potentially misleading, with statistically significant effects not captured with the intensity-based measure. Notably, the results of a decrease in the RR ratio on LC liabilities on the higher issuance of NFC debt abroad highlighted in Ahnert et al. (2021) is found significant using a binary policy variable but not using intensity-based measures.

7. Policy Implications and Possible Areas of Future Work

This study offers a detailed assessment of the impact of currency-differentiated reserve requirements: it provides new evidence for policymakers regarding the benefits and externalities of such a tool, by quantifying the impact of an increase in the gap between FX and local-currency reserve requirements on key target variables.

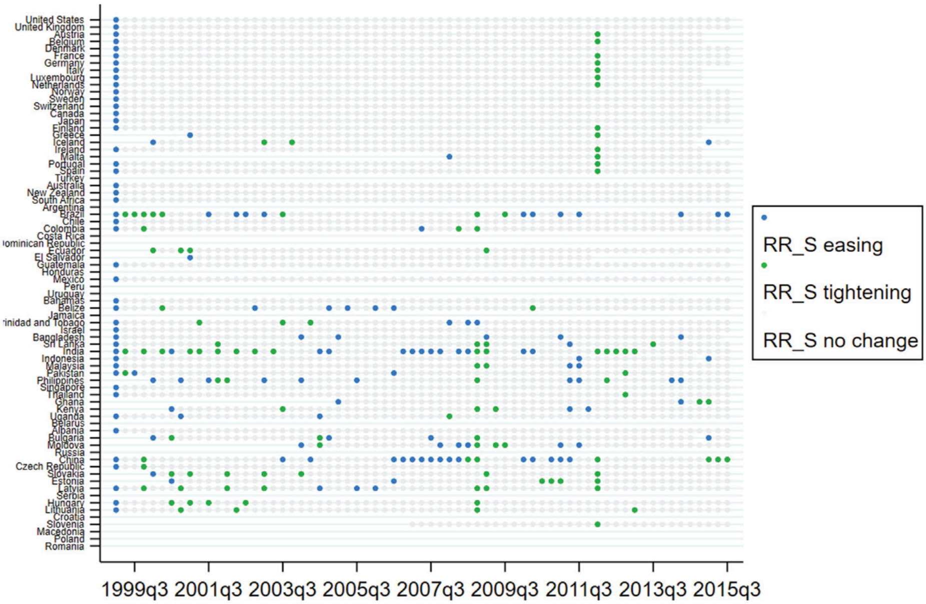
From a policy perspective, the paper points to their usefulness in reducing dollarization and currency mismatches in the banking sector without an obvious shifting of risk to other sectors or other countries. However, policymakers should be mindful of the effects that such measures may have on capital flows more broadly. While currency-differentiated reserve requirements may be effective macro-prudential tools, in certain cases they may share the features of capital flow management measures to be analyzed in the context of international frameworks on capital flow management such as the OECD Capital Movements Code and the IMF Institutional View.

From a methodological perspective, this paper shows the limitations of using binary variables when conducting analytical studies on the effectiveness of macro-prudential tools. Therefore, where possible, policymakers are advised to assess the effectiveness of their tools capturing the intensity of the measure. When using binary variables, researchers should be mindful of the limitations that such quantitative studies may have. As experience grows, and consequently the number of policy observations that regressions are based on, it is advisable to study in details other macro-prudential tools with intensity-based coding.

Finally, further work should be done on precisely identifying the transmission channels. Work using banks' balance sheet data could be a welcome avenue for future research, which would enable both a closer identification of transmission channels as well as heterogeneous effect of reserve requirements across different types of banks, likely hidden in the country-level data that this paper has been using.

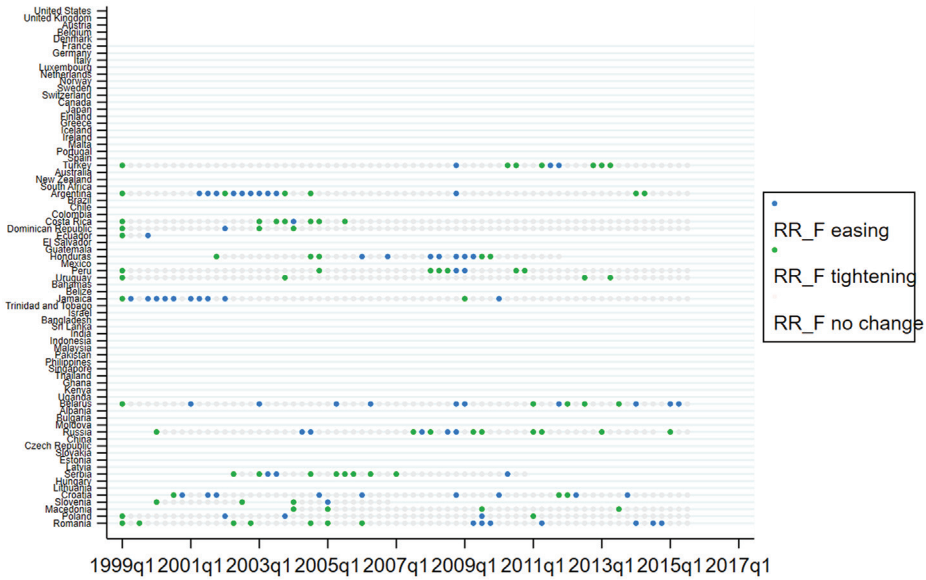
Appendix. Supplementary Materials

Figure A.1. Adjustments in Single Reserve Requirements



Note: Zero for all countries which don't have single reserve requirements.

Figure A.2. Adjustments in Reserve Requirements on FX Liabilities



Note: Zero for all countries which don't differentiate RR by currency.

Table A.1. Variable Descriptions

Variables		
Indicators	**Description**	**Data Source**
Reserve Requirements	Average of the rates for reserve requirements on local-currency liabilities and on foreign-currency liabilities. The differential is computed as the difference between the FX and the LC rate.	Fernandez et al. (2015), OECD (2019), authors' collection for individual countries
Financial Policy Adjustments (Currency-based measures, residency-based measures, and macroprudential measures)	Easing adjustment or removal of the measure is coded as –1 and introduction or tightening adjustment is coded as +1. Description of the policies included under the broad policy types is described in Lepers and Mehigan (2019).	Lepers and Mehigan (2019) based on de Crescenzio, Golin, and Molteni (2017) and Alam et al. (2019)
Exchange Rate Appreciation	Computed year on year. Real effective exchange rate.	BIS exchange rate data
Exchange Rate Deviation from Trend	Computed as the deviation from three- or five-year trends (12 or 20 quarters).	BIS
Inflation Volatility	Computed as the standard deviation over eight quarters of the difference of the log CPI.	IMF IFS
Domestic Interest Rate		IMF IFS, BIS
NFC Debt Growth	International debt issuance by domestic NFC. Year-on-year growth.	BIS
Share of FX Loans to Total Loans		IMF IFS, ECB SDW, national central banks, bilateral exchanges[†]
Share of FX Liabilities to Total Liabilities		IMF IFS, ECB SDW, national central banks, bilateral exchanges

Table A.1. (Continued)

Variables		
Indicators	**Description**	**Data Source**
GDP Growth		IMF IFS, OECD
Net Open Position in Foreign Exchange to Capital		IMF FSI
Sovereign Ratings	Foreign-currency long-term sovereign ratings.	Fitch
Capital Flows	Portfolio debt, portfolio equity, other flows, FDI flows. Net incurrence of liabilities to non-residents. All our flow variables are divided by annual GDP as we interpret the effectiveness of RR changes over four quarters but we calculate the four-quarters moving average of annual GDP to avoid sharp changes from Q4 to Q1.	IMF BoP
Inflows to Banks	Claims from BIS reporting banks to bank sector in the counterpart countries. FX/break-adjusted change.	BIS LBS‡
Inflows to Non-banks	Claims from BIS reporting banks to non-bank sector in the counterpart countries. FX/break-adjusted change.	BIS LBS

† The BIS locational banking statistics does not allow us to have a complete picture of the share of FX assets and liabilities, as countries have been reporting banks' local-currency liabilities to residents only since 2012:Q2. Before, only the cross-border position was reported.

‡ We use the perspective of the counterpart countries, which provides us data on sectoral breakdown: it represents claims from BIS reporting banks to specific sectors in the counterpart countries. We get the cross-border flows to the bank and non-bank sector of the counterpart country. For this we do not have the currency breakdown; however, it allows to increase the size of the country sample substantially. As we are interested in the change/flow rather than the stocks, we take the FX/break-adjusted change calculated by the BIS, which is better than a change in stocks that do not capture exchange rate developments.

Table A.2. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Gap (ΔRR_F-ΔRR_L)	4,611	0.0178428	1.059108	−26.5	18.34667
Δ Average RR	4,611	−0.016628	1.0795	−20.5	26.66667
Share of FX Loans	1,093	24.53647	18.61165	0.4874488	74.05593
Share of FX Liabilities	1,212	28.69709	19.06401	0.493115	79.63947
Net FX Position (% Capital)	1,496	2.501967	16.33829	−53.41409	59.88136
Growth of NFC International Debt	3,414	0.0309675	0.1035836	−0.141645	0.4869565
Equity Flows to GDP	3,050	0.6799856	2.907258	−0.917113	18.20209
Debt Flows to GDP	3,047	0.7709214	2.053976	−4.011715	9.145951
Other Flows to GDP	3,115	1.164403	4.4197	−8.224331	19.82228
Inflows to Non-banks	3,531	0.2963567	1.317996	−2.813571	5.726814
Inflows to Banks	3,531	0.4824458	3.223528	−8.62071	12.5931
Real ER Deviation from 3Y Trend	3,294	0.0524328	7.491084	−145.2603	22.99722
Real ER Deviation from 5Y Trend	2,862	0.3922434	8.322114	−87.33316	29.39366
Interest Rate	4,409	5.87029	5.460344	0.05	26
ER Growth	4,841	−5.16E-05	0.064751	−0.167171	0.1703383
Real GDP Growth	3,647	3.824683	4.353704	−7.034104	14.43261
Inflation Volatility	4,468	0.0157891	0.0232994	6.74E-06	0.3114145
Sovereign Ratings	3,652	20.82229	5.804296	0	28

Table A.3. Testing for International Spillovers Following Tightening in FX Reserve Requirements

Dependent Variable	Total Inflows to GDP (1)	Total Inflows to GDP (2)	Total Inflows to GDP (3)	Total Inflows to GDP (4)	Total Inflows to GDP (5)	Total Inflows to GDP (6)	Total Inflows to GDP (7)	FDI Inflows to GDP (8)	Portfolio Equity to GDP (9)	Portfolio Debt to GDP (10)	Credit Inflows to GDP (11)
Dep. Var. (t–1)	0.423***	0.269***	0.422***	0.352***	0.322***	0.325***	0.352***	0.232***	0.559***	–0.445***	0.112***
	(0.006)	(0.011)	(0.006)	(0.005)	(0.006)	(0.007)	(0.006)	(0.001)	(0.005)	(0.042)	(0.018)
log_VIX	–0.056+	–0.007***	–0.064	–0.059	–0.060	–0.057	–0.057+	0.001	–0.024	–0.019*	–0.022**
	(0.035)	(0.002)	(0.044)	(0.041)	(0.039)	(0.039)	(0.035)	(0.004)	(0.022)	(0.011)	(0.011)
Inflation (t–1)	–0.019***	0.002	–0.016**	–0.027***	–0.030***	–0.015*	–0.031+	0.014	–0.012	–0.005	–0.024+
	(0.007)	(0.005)	(0.007)	(0.009)	(0.010)	(0.008)	(0.019)	(0.019)	(0.011)	(0.005)	(0.015)
GDP Growth (t–1)	0.001	0.001***	0.001	0.001	0.002+	0.002**	0.001	0.001***	–0.001	–0.000	0.002***
	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
Interest Rate (t–1)	–0.000	–0.000	–0.000	–0.000	–0.000	0.000	–0.000	0.000*	–0.000	–0.000	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
RBM_inf on Respective Flows (t–1)	0.004	0.003	0.004	0.001	0.003	0.000	–0.002	0.001*	0.002	0.000	–0.002
	(0.007)	(0.002)	(0.008)	(0.007)	(0.007)	(0.006)	(0.006)	(0.001)	(0.002)	(0.001)	(0.002)
RR Gap Spillover (t–1)	–0.002	0.000					–0.001	–0.001	–0.000	–0.000	0.000
	(0.002)	(0.000)					(0.002)	(0.001)	0.000)	(0.001)	(0.002)
RR Gap Spillover (t–2)				–0.000			–0.000				
				(0.001)			(0.001)				
RR Gap Spillover (t–3)					–0.000		–0.001				
					(0.003)		(0.002)				
RR Gap Spillover (t–4)						0.006	0.005*				
						(0.004)	(0.003)				
RR Gap Spillover (t–1) (Fixed Corr.)			–0.003+								
			(0.002)								
Observations	2,235	651	1,851	2,188	2,141	2,094	1,962	2,228	2,179	2,175	2,228
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Country Sample	All	EME	All	All	All	All	All	All	All	All	All

Note: $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Standard errors clustered at country level. The RR gap spillover variable is computed as the weighted sum of tightening actions in FX reserve requirements in other countries, with the weights representing the similarity between the two countries, proxied by the correlation of inflows to both countries.

Table A.4. First-Stage Regressions (drivers of RR adjustments)

Dependent Variable	Change in RR Gap (FX – LC)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Gap (ΔRR_F-ΔRR_L) (t–1)	**–4.681*** **	**–4.681*** **	**–4.697*** **	**–4.679*** **	–4.092	**–4.545*** **	**–4.660*** **	**–4.360*** **	**–4.629** **
	0.007	0.007	0.007	0.007	0.121	0.010	0.005	0.001	0.029
Δ Interest Rate	0.096	0.096	0.096	0.096	0.359	0.238	0.231	0.224	0.105
	0.197	0.197	0.197	0.198	0.199	0.181	0.185	0.177	0.130
GDP Growth (t–1)	0.010	0.010	0.011	0.010	–0.029	0.010	0.012	0.012	–0.000
	0.432	0.432	0.436	0.438	0.172	0.839	0.796	0.771	0.942
Exchange Rate Growth (t–1)	–0.074	–0.074	–0.072	–0.075	**–0.865***	0.112	0.184	0.133	–0.261
	0.841	0.841	0.845	0.837	0.066	0.889	0.798	0.864	0.385
Credit Growth (t–1)	0.003	0.003	0.003	0.003	0.011	0.005	0.005	0.004	0.000
	0.257	0.257	0.259	0.257	0.376	0.317	0.318	0.322	0.973
Total Inflows to GDP (t–1)	–0.000	–0.000							
	0.160	0.160							
Port. Debt Inflows to GDP (t–1)			–0.005		–0.007	–0.005	–0.001	0.001	0.000
			0.434		0.275	0.367	0.847	0.913	0.907
Other Inflows to GDP (t–1)				–0.001					
				0.368					
Net FX Position (t–1)					0.004				
					0.236				
Δ FX_loans_share (t–1)						–0.008			
						0.417			
Δ FX_liab_share (t–1)							0.018		
							0.196		
FX_liab_share (t–1)								0.000	
								0.982	
NFC Debt Growth (t–1)									–0.009
									0.962
Constant	–0.105	–0.105	–0.110	–0.106	–0.290	0.141	0.076	0.090	–0.007
	0.321	0.321	0.313	0.316	0.312	0.516	0.714	0.862	0.897
Observations	2,704	2,704	2,638	2,704	766	804	878	902	2,490
R-squared	0.045	0.045	0.046	0.045	0.287	0.118	0.111	0.104	0.046
Number of ifs_code	49	49	48	49	37	24	26	26	44

Note: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. Standard errors clustered at country level. Model run with country and year fixed effects. The dependent variable is the change in the RR gap (continuous).

Table A.5. Non-linear Models

	CB_tobanks_Flows		**FX_loans_share**		**FX_liab_share**		**Net_FX_pos_FSI**	
Dependent Variable	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**
Gap (ΔRR_F-ΔRR_L)	0.004	–0.000	–0.140	–0.024	–0.000	–0.001	**–1.232*** **	**–0.180** **
	0.806	0.597	0.418	0.421	0.994	0.821	0.002	0.024
Gap (ΔRR_F-ΔRR_L) (t–1)	–0.011	–0.003	–0.079	–0.015	**–0.078***	–0.011	0.252	0.011
	0.689	0.540	0.451	0.474	0.055	0.142	0.108	0.447
Gap (ΔRR_F-ΔRR_L) (t–2)	0.012	0.002	–0.113	–0.020	–0.026	–0.009	–0.340	–0.035
	0.658	0.740	0.302	0.331	0.615	0.193	0.237	0.415
Gap (ΔRR_F-ΔRR_L) (t–3)	–0.006	–0.002	–0.040	–0.011	0.002	–0.001	**–0.308***	**–0.063** **
	0.844	0.758	0.364	0.219	0.926	0.737	0.089	0.044
sum coef [t;t–3]	*–0.001*	*–0.003*	*–0.372*	*–0.07*	***–0.102**** ***	***–0.022**** ***	***–1.628**** ***	***–0.267**** **
p value of sum test	*0.989*	*0.785*	*0.365*	*0.366*	***0.009***	***0.000***	***0.010***	***0.041***
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2,744	2,744	887	887	1,025	1,025	797	797
R-squared	0.100	0.100	0.053	0.053	0.069	0.069	0.053	0.050
Number of ifs_code	49	49	25	25	29	29	35	35

(*continued*)

Table A.5. (Continued)

	NFC Debt Growth		CB_tononbanks_Flows		Equity Flow		Portfolio Debt Flow	
Dependent Variable	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**
Gap (ΔRR_F-ΔRR_L)	0.000	0.000	0.007	0.001	**–0.011***	–0.001	0.003	0.002
	0.881	0.997	0.588	0.158	0.090	0.255	0.913	0.129
Gap (ΔRR_F-ΔRR_L) (t–1)	0.002	0.000	**–0.020****	**–0.004****	–0.007	–0.002	**–0.045****	**–0.009****
	0.507	0.763	0.040	0.035	0.322	0.200	0.037	0.014
Gap (ΔRR_F-ΔRR_L) (t–2)	0.002	0.000	**–0.013***	**–0.002***	–0.004	–0.001	**–0.031****	**–0.007*****
	0.423	0.436	0.097	0.092	0.581	0.470	0.023	0.006
Gap (ΔRR_F-ΔRR_L) (t–3)	**–0.006***	–0.001	0.002	–0.000	0.001	0.001	–0.021	–0.004
	0.067	0.225	0.766	0.969	0.808	0.613	0.250	0.176
sum coef [t;t–3]	*–0.002*	*–0.001*	*–0.024*	*–0.005*	*–0.021*	*–0.003*	***–0.094****	***–0.018*****
p value of sum test	*0.785*	*0.798*	*0.391*	*0.107*	*0.263*	*0.423*	***0.073***	***0.015***
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2,826	2,826	2,744	2,744	2,676	2,676	2,677	2,677
R-squared	0.048	0.046	0.091	0.091	0.031	0.031	0.054	0.054
Number of ifs_code	51	51	49	49	48	48	48	48

(*continued*)

Table A.5. (Continued)

Dependent Variable	Credit Flow		ER Dev. 3Y		ER Dev. 5Y	
	Baseline	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**	**Baseline**	**Scaled by Av_RR**
Gap (ΔRR_F-ΔRR_L)	0.033	0.002	–0.050	–0.003	–0.358	–0.060
	0.232	0.191	0.735	0.591	0.311	0.267
Gap (ΔRR_F-ΔRR_L) (t–1)	–0.024	–0.001	0.198	0.043	–0.358	–0.054
	0.584	0.865	0.221	0.124	0.412	0.483
Gap (ΔRR_F-ΔRR_L) (t–2)	–0.028	–0.006	0.426	**0.091****	–0.214	–0.029
	0.287	0.209	0.102	0.049	0.549	0.680
Gap (ΔRR_F-ΔRR_L) (t–3)	0.021	–0.002	0.474	**0.092***	–0.097	–0.010
	0.576	0.770	0.108	0.070	0.759	0.870
sum coef [t;t–3]	*0.002*	*–0.007*	*1.05*	***0.223****	*–1.03*	*–0.15*
p value of sum test	*0.983*	*0.652*	*0.108*	***0.056***	*0.475*	*0.551*
Country FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	2,736	2,736	2,715	2,715	2,336	2,336
R-squared	0.090	0.090	0.076	0.078	0.090	0.089
Number of ifs_code	49	49	51	51	51	51

Note: *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. Standard errors clustered at country level. Italic text displays the sum of the coefficients for all four lags, and the p-value of the sum test is displayed below rather than the standard errors as for the other coefficients in this table.

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