Reserve Requirement Policy and Interest Rate Spreads

Yuxuan Huang*

The George Washington University

JOB MARKET PAPER

This Version: November 15, 2019

(Draft – Please do not cite or circulate)

Reserve requirement changes have been a widely employed monetary policy and macroprudential tool in the last decades. Countries may choose this policy, which effectively changes the cost of deposit financing for banks, instead of an interest rate change, to avoid influencing capital flows and exchange rates. Such a nonmarket based policy tool can lead to distortionary macroeconomic effects by changing the relative cost of different financing options. Given both its widespread use and the potential to shape financial market outcomes, understanding its impact is important. This article adds new cross-country empirical evidence of the effects of reserve requirement changes on lending-deposit interest rate spreads based on a country-level panel dataset of 75 countries from 1980 to 2015. Demonstrating the impact on the spread is important as it highlights the impact of reserve requirement policies and how they can shape funding decisions. The theoretical framework indicates that the effects of reserve requirement rate changes on the interest rate spread depend on countries' financial market conditions, such as the level of financial market development. The empirical results show that raising reserve requirements on average widens the lending-deposit interest rate spread. Such impacts are dampened for countries with more developed financial markets. The impacts of reserve requirement changes on the interest rate spread are further confirmed by propensity score matching estimators that address the self-selection bias associated with reserve requirement hikes. The results are robust to different covariate measures and various treatment effect estimators.

JEL Classification: G28, E43, E52

***Key words*:** Reserve requirements, Interest rates, Central bank policy

*PhD candidate in Economics, the George Washington University. Email: yxhuang@gwu.edu. I am deeply grateful to my supervisor Jay Shambaugh for his constant guidance and support. I would like to extend my gratitude to Michael Bradley and Benjamin Williams for their insightful comments. I am grateful to Camilo Tovar for his invaluable advice. I also thank conference participants at GWU and the Western Economic Association annual conference for their comments. All remaining errors are my own.

1 Introduction

Reserve requirements — rules that banks hold a certain percentage of deposits in an account at the central bank — are a widely adopted policy instrument around the world. As documented in Gray (2011), over 90 percent of the world's central banks have a reserve requirement policy. Reserve requirements can be a microprudential tool to ensure banks hold sufficient liquidity to prepare for unexpected withdrawals of their deposits and other short-term liabilities (Brei and Moreno, 2018). They have also been used as a complementary conventional monetary policy tool and to control inflation and money aggregates (Agénor et al., 2018), especially in many emerging market economies.

After the recent global financial crisis, reserve requirement policy has been widely recognized as a prominent macro prudential instrument in both emerging markets and advanced economies. Unlike many industrial countries adopting a counter-cyclical monetary policy, developing countries often have acyclical monetary policy while pursuing a counter-cyclical reserve requirement policy. Over 70 percent of developing countries have been using reserve requirements counter-cyclically as a macroeconomic stabilization tool since 2004 (Federico et al., 2014). In advanced economies, central banks are again interested in policy related to reserve remuneration rates for financial stabilization purposes. For example, the United States' Federal Reserve moved to pay interest on excess bank reserves (IOER) beginning in October 2008 to prevent significant increases in bank credit during quantitative easing (Dutkowsky and VanHoose, 2018). Many recent theoretical studies also support the view that reserve requirement policy provides an additional degree of freedom for the Fed to expand its policy objectives (Kashyap and Stein, 2000; Reinhart and Rogoff, 2013; Ireland, 2014; Canzoneri et al., 2017).

The reserve requirement is a non-market-based policy tool that leads to distortionary effects in the financial system and even real effects in the economy. By increasing the gap between what savers can earn and borrowers must pay, a wider spread increases the cost of the financial system to the overall economy. Against this backdrop, this study aims to understand better the impact of countries changing reserve requirements. It provides new cross-country empirical evidence and contributes to the ongoing research on the macroeconomic effects of reserve requirement policy. Specifically, it focuses on the impact of changing the reserve requirement on the changes in the bank interest rate spread.

Although the main policy targets of adopting reserve requirements vary across countries and periods (Carvalho and Azevedo, 2008; Gray, 2011), they can be summarized in these three categories: a microprudential tool, a monetary policy tool, and a macroprudential tool. By design, a reserve requirement serves as a microprudential tool against banks' solvency and liquidity risks. It is often set as a minimum ratio that commercial banks or other depository institutions have to hold against their liabilities in central

banks. Central banks can also impose different reserve requirements for various bank liabilities or even across different regimes in the country. For example, Brazil has used heterogeneous reserve requirements across regions (Robitaille et al., 2011). China has also developed a dynamic reserve requirement system as discussed by Ma et al. (2013). The reserve requirements build up buffers for the commercial banks to ensure they have sufficient liquidity.

Reserve requirements can also serve as a supplementary monetary policy tool to control inflation or overheating asset markets. An increase in the minimum required reserve ratio would limit commercial banks' ability to convert their deposits into lending funds, which reduces the money multiplier. A decrease in the reserve requirement leads to the opposite consequence. It is also a cheaper way to achieve a policy target compared to open market operations (OMO) as it is often remunerated below market rates. Central banks in emerging market economies have been actively using reserve requirements as another important monetary policy tool in addition to the conventional policy interest rate. For example, China has developed a dynamic reserve requirement system over recent years and has used it intensively as a regular monetary policy tool (Fungáčová et al., 2016).

Reserve requirements are also widely used as one of the major macroprudential tools to achieve financial stability. According to the IMF's recent macroprudential survey report[1], fifty percent of the emerging market economies and developing countries are actively using reserve requirements for macroprudential purposes alone in the year 2017.

Emerging market economies often use reserve requirements counter-cyclically as a macroeconomic stabilization tool in place of monetary policy or to pursue financial stability (Federico et al., 2014; Agénor et al., 2018). They are reluctant to increase interest rates in response to credit booms in good times. Using interest rates to curb credit booms creates a policy dilemma and contradicts the contractionary policy stance as it will potentially attract more capital inflow with a higher deposit rate. Raising reserve requirements increases lending rates while avoiding a similar increase in deposit rates. To fight the recession in bad times, a lower interest rate is also not always effective for emerging market economies as it might lead to rapid currency depreciation which can cause problems for their exchange peg target[2]. In addition, Azis and Shin (2015) suggest that the rise in bank assets in some emerging markets was driven by surges in non-core liabilities associated with capital inflow. The growing share of non-deposit and other non-core liabilities makes it more difficult for interest rate policy to contain credit growth. They indicate the need to complement monetary policies by macroprudential measures to reduce the risk of financial vulnerability. One potential tool is the reserve requirement

[1]Data are obtained from IMF Macroprudential policy survey database: https://www.elibrary-areaer.imf.org/Macroprudential/Pages/Home.aspx

[2]These two situations are also called "fear of capital inflows" and "fear of free falling" in Federico et al. (2014).

for non-deposit liabilities which would raise the cost of non-deposit funding for banks and restrain the rapid growth of such liabilities during booms (Hahm et al., 2012).

As a versatile and widely adopted policy tool, reserve requirements bring many macroeconomic impacts. Understanding what policy targets this policy tool can achieve and at what cost when pursuing such targets is important when implementing reserve requirement policies. Research has shown a number of macroeconomic consequences from reserve requirement changes. Increases in reserve requirement rates have been documented to be associated with changes in many macroeconomic variables, such as investment and GNP (Loungani and Rush, 1995), exchange rate depreciation and an improved current account (Glocker and Towbin, 2015), credit and GDP growth (Tovar Mora et al., 2012; Fungáčová et al., 2016; Cuaresma et al., 2019) and banks' lending and deposit interest rates in some countries (Vargas et al., 2010, Reinhart and Reinhart, 1999; Alper et al., 2014). Some of these changes are the targets of policy. For example, the reserve requirement is a standard policy tool to control overheating credit growth in many emerging market economies. It raises the cost of deposit-based funding and reduces the money multiplier. However, some other macroeconomic impacts bring unwanted costs. The impact of changing reserve requirements is not the same as conventional short-term policy interest rates. As a non-market policy tool, the implementation of reserve requirement changes distorts the financial market as they are often unremunerated or remunerated below market rates. It acts as an implicit tax, which raises the marginal cost for commercial banks. If monetary tightening is performed through increasing reserve requirements, deposit rates can be affected and potentially decreased, especially when there are other funding source substitutes available. This might be inconsistent with the monetary stance, which is raising rates.

Changes in banks' lending-deposit interest rate spread are an essential part of the many macroeconomic consequences of reserve requirement policies. The documented impacts on countries' investment, savings, employment, credit, and economic growth are mostly transmitted through price changes in the banking sector where the reserve requirement policy is implemented. The lending-deposit rate spread serves as a good indicator of financial system efficiency. Focusing on changes in the spread gives us information on how reserve requirements might impact financial efficiency in general. Changes in banks' interest rate spreads also reflect the impacts of reserve requirement changes on financial stability. Raising reserve requirements changes banks' funding structures by making deposit-based funding more costly for banks and shifts them towards non-core liabilities, which are riskier. Such activities lead to higher lending rates as a result of cost increases in banks' liabilities, and lower deposit rates as banks rely less on deposit-based funding. Either scenario results in a larger interest rate spread. Looking at changes in the spread is also an important way to discern if reserve requirement changes are having impacts on the economy. When it comes to evaluating the impacts, other quantitative changes, such

as credit volume and economic growth, are more prone to endogeneity problems.

The main contributions of the present paper are: first, it provides new systematic empirical evidence for 75 countries from 1980 to 2015 of the effects of reserve requirement changes on lending-deposit interest rate spreads. Existing studies on similar topics, by contrast, tend to focus on a single country (Carvalho and Azevedo, 2008; Herrera et al., 2010) or on a small group of countries in a particular region (Tovar et al. 2012; Brei and Moreno, 2018). Second, by focusing on a single country or a region, most of the previous empirical studies lack the ability to incorporate the interaction of country-level characteristics into the analysis. With the cross-country panel dataset, I am able to test how other country-specific macroeconomic factors interact with the effectiveness of reserve requirements. Third, in addition to confirming correlations between changes in the reserve requirement rate and interest rate spread changes using panel regressions, this study further tests the potential causal effects using propensity matching estimators (PSM) and other treatment effect estimators. To the best of our knowledge, this is the first empirical study that confirms the treatment effect of reserve requirement policies on changes in the bank interest rate spread.

With the new cross-country dataset, I first estimate panel regressions and investigate the potential correlations between reserve requirement rates and interest rate spreads. To better understand how financial openness and financial market development play a role, additional interaction terms with these country-specific financial factors are also added into the regressions. The balance diagnostics result from the standardized mean difference (SMD) comparison suggests that the treatment of increasing reserve requirements is not randomly assigned. Against the existence of strong covariate imbalance, propensity score matching and other treatment effect estimators are further used to test the causal relations between the changes.

To preview the findings, regression results show that reserve requirements have on average a positive correlation with countries' lending-deposit interest rate spreads. However, this positive effect is dampened by a higher level of financial openness and more mature financial markets. This suggests that as a country's financial markets deepened, reserve requirement changes may be less impactful as a monetary policy tool. The propensity score matching estimators further confirm the causal relation that changes in reserve requirements lead to a larger lending-deposit interest rate spread. These results are robust to different matching algorithms and treatment effect estimators.

The remainder of the paper proceeds as follows. Section 2 reviews related literature on this topic and discuss how reserve requirements affect banks' pricing behaviors. Section 3 provides a theoretical model framework to illustrate the transmission mechanisms of the effects of changing reserve requirements on lending and deposit rates. Section 4 describes the data, empirical strategies and results. Extensions and robustness checks are reviewed in section 5. Section 6 concludes.

2 Literature review

The closest literature to this study is the cross-country empirical studies on the macroeconomic impact of the reserve requirement. Reinhart and Reinhart (1999) use data from ten developing countries sample and show that both deposit and lending rates respond to changes in reserve requirements. Using a novel dataset, Federico et al. (2014) analyze the use and cyclical properties of reserve requirements and find that they are used in emerging market economics frequently as a counter-cyclically macroeconomic stabilization tool, especially after 2004. The reserve requirement policy acts as a second instrument that substitutes for monetary policy in many developing countries. Tovar Mora et al. (2012) examine how reserve requirements influence real private bank credit growth in the five Latin American countries using a dynamic panel vector autoregression model. Their results suggest that reserve requirements and other macroprudential instruments have a moderate and transitory effect and play a complementary role in monetary policy. Vandenbussche et al. (2015) use data from 16 central and eastern European countries and find that changes in minimum CAR (capital requirement) and MRRs (marginal reserve requirement) have a significant negative impact on credit growth as well as housing price inflation. Brei and Moreno (2018)'s result based on bank-level data from seven Latin American countries shows that higher reserve requirements are associated with higher loan rates, whereas deposit rates remain unchanged during normal times and decrease during large capital inflows periods. Fendoğlu (2017) compiles an index of the macroprudential for 18 EMEs and suggests that tightening in domestic currency reserve requirements significantly reduces the impact of portfolio inflows on credit cycles. Cuaresma et al. (2019) use a Bayesian estimation framework and find that the reserve requirements have on average the expected negative but short-lived effect on the GDP growth. They instead find a robust long-run positive effect of past requirements on current credit growth after five years.

Apart from above, much research has been focusing within a single country. Reserve requirement changes are suggested to have significant impacts on real economic activities in the United States. An increase in reserve requirements ought to be followed by declines in output and investment (Loungani and Rush, 1995). Reduction in the reserve requirement increases loans and leads to employment growth (Fang, 2017). For Brazil, the empirical studies from both macroeconomic and bank-level data support the bank lending channel as the primary transmission mechanism for reserve requirement policy (Glocker and Towbin, 2015; Becker et al., 2017). Brazilian bank stock returns have also been affected by reserve requirement changes, which implies that the associated cost of the required reserve has not been fully passed through to bank's clients (Carvalho and Azevedo, 2008). Empirical evidence from Columbia suggests that reserve requirements have worked effectively to stabilize credit cycles and control credit growth (Gómez et al.,

2017). They have also been effective in strengthening the pass-through from the policy rate to deposit and lending interest rates (Herrera et al., 2010). China is another country that heavily relies on reserve requirement policy. It has developed a dynamic reserve requirement system over the years and used reserve requirements for macroprudential purposes and as a cheaper substitute for open market operations (Ma et al., 2013; Klingelhöfer and Sun, 2019). For some other emerging markets, Alper et al. (2018) identify a new "liquidity channel" as the short-term borrowing from the central bank is not a close substitute for deposits in Turkey. Increases in reserve requirement put upward pressure on deposit interest rates as it decreases banks' liquidity. Dassatti Camors et al. (2019) following a difference-in-differences approach and identify the negative impact of tightening reserve requirements on banks' lending to firms.

From a theoretical perspective, Bhattacharya et al. (1997) demonstrate that changes in (apparently) nonbinding reserve requirements can have significant, real effects using a monetary growth model. Chang et al. (2019) build a two-sector DSGE model of the Chinese economy to demonstrate that increasing the required reserve ratio acts as a tax on SOE activity and reallocates resources to private firms, raising aggregate productivity. They suggest the reserve requirement adjustments affect the overall credit supply but can also lead to the reallocation of credit and capital. Evidence shows that increases in reserve requirements raise off-balance-sheet lending, which typically benefits China's more productive private sector.

Recent analytical studies have been focusing on investigating the interaction between reserve requirement policy and conventional interest rate policy in a general equilibrium framework. Areosa et al. (2013) compare the impact of short-term interest rate and reserve requirement ratio in a dynamic stochastic equilibrium model (DSGE) and find that two policies have the same qualitative effects on GDP inflation and investment, but the impact is higher for interest rate policy. Glocker and Towbin (2012) integrate reserve requirements into a small open-economy DSGE framework. Their result indicates that reserve requirements can support the price stability objective only if financial frictions are important. Escudero et al. (2014) evaluate a policy rule incorporating both interest rate and legal reserve requirements as monetary policy instruments. They suggest the policy rate is more effective in reducing inflation when the reserve requirement is solely directed at achieving financial stability. More recent theoretical work also has a similar conclusion that the use of a counter-cyclical macroprudential instrument in addition to the policy rate improves welfare. Leduc and Natal (2017) examine the optimal monetary policy by incorporating macroprudential policies in a DSGE model. Their results suggest reserve requirements dampen the endogenous feedback loop on credit growth and lead to near price stability. Medina et al. (2018) study interactions between monetary and macroprudential policies in a model with nominal and financial frictions. The use of a counter-cyclical macroprudential instrument in addition to the policy rate improves

welfare and has important implications for the conduct of monetary policy. Some other studies focus more on the macroprudential role of the reserve requirement. The overall conclusions suggest the reserve requirement policy is effective as a macroeconomic stabilization role, which can alleviate financial volatility and mitigate exogenous shocks to the economy (Tavman, 2015; Mimir et al., 2013; Agénor and da Silva, 2016; Agénor et al., 2018).

This paper connects to another trend of early literature studying the determinants of bank interest margins dates back to 1980s. The literature on this topic explains the interest margin using bank/industry characteristics and other risk factors. The reserve requirement ratio has been considered as one of the independent variables in these studies. Ho and Saunders (1981) construct the pioneering model of bank interest margin determinants. They mainly explain the interest rate margin with competition and interest rate risk. This model is further extended by introducing different types of credit and deposits (Allen, 1988) and for credit default risk (Angbazo, 1997). Wong (1997) builds a firm-theoretical model and demonstrates how cost, regulation, credit risk, and interest rate risk conditions jointly determine the optimal bank interest margin decision. Saunders and Schumacher (2000) apply the Ho and Saunders model to six selected European countries and the US and decompose bank margins into a regulatory component, a market structure component, and a risk premium component. Using a cross-section dataset in 2003, Gelos (2009) suggests Latin America has higher interest rates, less efficient banks, and larger reserve requirements than other regions, and these factors have a significant impact on spreads.

To summarize the above literature, the general conclusions from the previous studies are: (i) Reserve requirements are generally used as a counter-cyclical macroprudential tool or a secondary monetary policy instruments to stabilize the economy. (ii) As required reserves are often unremunerated or remunerated below market rates, usage of reserve requirements is associated with cost and might introduce financial distortion and disintermediation, including effects on credit growth, output, and interest rate spreads. (iii) Bank interest rate spreads are affected by bank competition, operating costs, and different risk factors.

This paper adds to the literature by providing broader cross-country evidence of the effectiveness of reserve requirement policy from demonstrating its impacts on interest rate spread. Previous empirical studies above are mostly focusing on a single country or a small group of countries in a region. With cross-country data, the study also shows new evidence on how country-specific characteristics can play a role in affecting reserve requirements' impacts on interest rate spread. Last and most importantly, in addition to showing the correlations between reserve requirements and interest rate spread changes in a broader cross-country setting, I further provide robust casual inference between changes of reserve requirement and interest rate spreads using various treatment effect estimators.

3 A Simple Theoretical Framework

The change in reserve requirement can have potential impacts on lending-deposit interest rate spreads. If the reserve requirements are remunerated below market interest rates, which is common in many countries, it acts as an implicitly tax on banks' deposits and reduces banks' net interest margins. As profit-maximizers, banks have the incentive to compensate for this additional cost through adjustments in either pricing strategy or funding structure. Potential funding substitute for deposits (core liability) are various non-core liabilities including repos, bank debt securiteis, bank liabilities to foreign creditors and etc. If such alternative funding sources are available, banks may shift its funding demand from deposits towards these non-core liability options when facing an increase in reserve requirement. Against this situation, Banks are motivated to pass the cost of increasing reserve requirements to their customers by either through the revenue side (increasing the lending rates), cost side (decreasing the deposit rates) or both. However, as argued in Antoniades (2019), non-core liabilites and deposits are often not perfect substitutes given different funding risks and costs. Substitutability becomes lower if the country's financial market is less developed. In many emerging markets economies, deposits and other funding sources are imperfect substitutes. In this case, the effect of increasing reserve requirements on banks' deposit rates is ambiguous. On the one hand, increases in required reserve increase the cost of deposit as a source of funding. Banks may decrease their demand for deposits, and deposit rates decrease. On the other hand, higher reserve requirements reduce available funds for bank loans and put pressure on banks' liquidity positions. If no perfect substitutes exist, banks would have to raise the deposit rate to attract more funds.

In this section, I construct below a discrete-time economy model similar to the banking sector framework described in Dutkowsky and VanHoose (2017). Additionally, a potential non-core liability is added into the model as an alternative funding source for the commercial banks. The banking sector provides financial intermediary service between the household and firms. Table 1 displays the simplified banks' balance sheet. On the asset side, there are loans extended by the banks and reserves obliged to put in the central bank. The liability side consists of deposits from households and non-core liabilities.

Table 1: Simplified commercial bank balance Sheet

Assets	**Liabilities**
Reserves	Deposits
Loans	Wholesale funding
	International borrowing

Suppose the representative banks maximize their profits by only choosing their loan supply, deposit demand and funding demand from alternative funding sources. The bank's profit in each period:

$$Max\ E_0 \sum_{t=0}^{\infty} \beta^t \pi_t,$$

where

$$\pi_t = R_t^L L_t + \rho_t D_t - R_t^D D_t - R_t^B B_t - \frac{\theta}{2} B_t^2$$
$$where \quad R_t^L > 1, R_t^D > 1, R_t^B > 1,$$
$$\theta > 0, 0 < \rho_t < 1$$

subject to resource constraint:

$$L_t + \rho_t D_t = D_t + B_t \tag{1}$$

The commercial banks gain profit at the end of each period, provide deposit product D_t to the households at the gross interest rate of R_t^D and lend to the firm owners L_t at the rate of R_t^L. B_t is a type of non-core liability, which is another funding source for the commercial banks. The interest rate R_t^B is set exogenously by the creditor. To characterized that non-core liabilities are often not a perfect substitute for deposits in many countries, I add an additional quadratic adjustment term $\frac{\theta}{2}B^2$ to differentiated non-core liabilities from household deposits. The adjustment cost parameter θ is higher for countries with less developed financial markets and financial systems. ρ_t is the reserve requirement ratio set by the central bank. As long as $\rho_t > 0$, the bank cannot convert all the deposits into loans. The profit-maximizing conditions for loans, deposits, alternative funding, and the shadow marginal profit (λ_t) are the following:

$$R_t^L = \lambda_t \tag{2}$$

$$R_t^D - \rho_t + = (1 - \rho_t)\lambda_t \tag{3}$$

$$R_t^B + \theta B_t = \lambda_t \tag{4}$$

$$D_t + B_t - L_t - \rho_t D_t = 0 \tag{5}$$

To solve for market interest rates, the public demands for bank loans and public supply for deposits are set as exogenous conditions as in Dutkowsky and VanHoose (2018). M^D

and M^L are the exogenous components of deposit supply and loan demand.

$$D_t^s = M^D + \alpha^D R_t^D \tag{6}$$

$$L_t^d = M^L - \alpha^L R_t^L \tag{7}$$

In response to reserve requirement rate hikes, commercial banks could either change their price strategy in the loan market or deposit market or both. Here I solve banks' decision on loan and deposit market separately by fixing the aggregate level of the other market.[3] The solution for bank loan supply can be obtained by combining the optimal conditions and the bank resource constraint. To derive the loan supply function, note first substituting (4) into (5) for B_t, (2) into (5) for λ_t, and rearranging yields the well-behaved loan supply function in equation (8) which is positively related to the loan interest rate. Note that I assume D_t to be a fixed amount of $\bar{D}$ when solving the optimization problem for the loan market.

$$L_t^s = \frac{1}{\theta} R_t^L + \frac{\theta\bar{D}(1-\rho_t) - R_t^B}{\theta} \tag{8}$$

From there, substituting the loan supply into the exogenous public loan equation, the equilibrium loan interest rate is presented in equation (9).

$$R_t^L = \frac{[M^L - \frac{\theta\bar{D} - \theta\bar{D}\rho_t - R_t^B}{\theta}]}{[\alpha^L + \frac{1}{\theta}]} \tag{9}$$

$$\frac{\partial R_t^L}{\partial \rho_t} = \frac{\theta\bar{D}}{1 + \alpha^L\theta} > 0 \tag{10}$$

$$\frac{\partial[\frac{\theta\bar{D}}{1+\alpha^L\theta}]}{\partial\theta} = \frac{1}{(1+\alpha^L\theta)^2} > 0 \tag{11}$$

Equation (8) shows that the loan supply function is a well-behaved upward sloping cure, which is positively related to the Loan interest rate. The non-core liability interest rate R_t^B is negatively related to loan supply since it increases the bank funding cost. Similarly, the increase in reserve requirement ratio ρ_t decreases the total deposit that banks can convert to supplies of loans. Thus increasing reserve requirement ratio would decrease banks' loan supply and result in a higher loan interest rate by shifting the supply curve to the left. The comparative statics in equation (10) confirms the positive impact of the reserve requirement rate on the bank loan interest rate. Taking the additional partial derivative with respect to θ, Equation (10) shows that this positive effect is positively correlated with the quadratic cost parameter. The comparative statics suggests

[3]If solve them simultaneously; the general equilibrium result would depend on the price elasticities (lending and deposit rates) of the two markets.

the positive impact of hiking reserve requirements on the loan interest rate is higher if the country is less financially developed

If banks consider changing deposit rate in response to reserve requirement changes, The bank deposit demand can be obtained by first substituting (4) into (5) for B, (3) into (5) for λ, and similarly assume $L = \bar{L}$ when solving the optimization problem in the deposit market for banks.

$$D_t^d = \frac{\theta(1-\rho_t)\bar{L} + \rho + R_t^B(1-\rho_t) - R_t^D}{\theta(1-\rho_t)^2} \tag{12}$$

Substitute the deposit demand into the exogenous public deposit supply equation, the equilibrium deposit interest rate:

$$R_t^D = \frac{\rho_t + \theta(1-\rho_t)\bar{L} + (1-\rho_t)R_t^B - \theta(1-\rho_t)^2\bar{D}}{1+\theta(1-\rho_t)^2\alpha^D} \tag{13}$$

$$\frac{\partial R_t^D}{\partial \rho_t} = \frac{2\theta(1-\rho_t)(\rho_t + \theta(1-\rho_t)\bar{L} + (1-\rho_t)R_t^B)\alpha^D}{(1+\theta(1-\rho_t)^2\alpha^D)^2} + \frac{1-\theta\bar{L} - R_t^B + 2\theta(1-\rho_t)\bar{D}}{1+\theta(1-\rho_t)^2\alpha^D} \tag{14}$$

The overall effect of reserve requirement changes on deposit rate changes is ambiguous, as shown in the comparative statics in equation (14). Here we have two channels. Substitution channel: Higher reserve requirements lower the deposit rates through direct intermediation cost. Increasing the reserve requirement increases the cost of funding the loan supply through deposits. If there exist other alternative funding substitutes, banks would reduce their demand for deposits and shift their funding source to other substitutes. Such action leads to a lower deposit interest rate. Liquidity channel: The reserve requirement hikes may result in lower funds that can be converted into loans. To resolve deterioration in the liquidity position and satisfy the loan demand, banks would potentially increase their deposit rate to attract more deposits, especially if the costs of alternative funding sources are still higher even after the reserve requirement hike. In our model, if the costs of using wholesale market funding or international borrowing as loan funding sources are higher compared to the deposit even after the increase in reserve requirement, banks would still compensate for the loss in funding from deposits and increase the deposit interest rate. This ambiguous outcome in deposit rates has also been discussed in Herrera et al. (2010); Herrera et al. (2018).

4 Data and Empirical analysis

4.1 Data and variables

The data used in this study are yearly unbalanced panel-data for 75 countries from 1980 to 2015. It consists of 21 Advanced countries and 54 emerging market economies and developing countries[4]. The data of reserve requirement rates combines the dataset from Federico et al. (2014) and data from Global Economic Data, Indicators, Charts Database (CEIC) and central banks. The interest rate spread is defined as a country's lending rates − deposit rates. The data for deposit interest rates and lending interest rates are mainly from IFS, CEIC. The financial openness indicator uses the financial account openness index from Chin and ito (2011). The financial development index, capital inflow data, inflation rates, GDP, country classifications are obtained from IFS, WDI, and CEIC.

Measuring countries' openness in financial account transactions have been extremely difficult for many reasons (Eichengreen, 2001; Chinn and Ito, 2006). The financial openness indicator used in this study is from the one proposed by Chinn and Ito (2006, 2008). It has an extensive coverage which encompasses the period of 1970-2016 for 182 countries, which matches well with the panel data in this study. The Chinn-Ito index (Kaopen) is a dejure financial openness measure based on countries' cross-border financial activities reported in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The index is currently updated to 2016 with a range from -1.91 to 2.36. This study uses the normalized Chin-Ito index with a range between zero and one. By construction, higher values in the index indicate more open financial accounts.

The financial development indicator used in this paper is the Financial Development Index created by IMF (Svirydzenka, 2016). Following the multi-dimensional approach to defining financial development in Cihak et al. (2012), the index has six sub-indices that cover different aspects from both financial institutions and financial markets. This index also has a wide coverage for 183 countries from 1980 to 2016 to match the panel needed in this study.

To define capital inflow surge periods, there exists two broad types of approach. One is using country-specific or region-specific cut-off, which uses information from all sample periods. Reinhart and Reinhart (2008) use a cut-off of 20th percentile for the net capital inflow over GDP ratio. Ghosh et al. (2014) define an observation to be a surge period if it lies both in the top 30th percentile of the country's own distribution and also in the top 30th percentile of the entire sample's distribution. The other type of inflow surge measure used more often recently is based on comparing the deviations from its rolling trend. Forbes and Warnock (2012) define the surge as the annual increase in gross inflows that is more than one standard deviation above the five-year rolling average. Cardarelli

[4]Country group classification used in this paper is based on IMF World Economic Outlook (WEO) country group classification

et al. (2010) identify the surges as the net private capital flows/GDP (NPCIR) exceed its backward-looking HP filtered trend by one standard deviation or the NPCIR exceeds the 75th percentile of the distribution of NPCIRs for the region over all sample periods. As discussed in Ghosh et al. (2014), the country-specific cut-off measures can ensure the exceptionally large capital inflow periods are always coded as surges. However, the methods use deviations from rolling trends may take better account of drifts in the inflow volatility along their trends.

To better capture the persistence of surge periods along the trend, I follow Powell and Tavella (2012) to employ a backward-looking Hodrick-Prescott (HP) filter using only past inflows-to-GDP ratio data[5]. Specifically, The HP filter is applied to the first five observations of each country and add subsequent years on a rolling basis. Medians of the difference between the inflow/GDP ratios and their trends are calculated for the observations that are above the trend. As in equation (15), A period is identified as an inflow surge episode if the associated inflow/GDP ratio minus the trend is greater than the above median for that country.

$$Surge_{i,t} = \begin{cases} 1, & if \quad dif_{i,t} > median(dif_{i,t} > 0)_{t=1}^{T} \\ & , where \quad dif_{i,t} = \left(\frac{inflow}{GDP}\right)_{i,t} - trend_{i,t}^{inflow} \\ 0, & otherwise \end{cases} \tag{15}$$

As discussed earlier, the reserve requirement policy has also been used as a supplement monetary policy to stabilize the price level. Countries enduring higher-than-normal increases in inflation would be more likely to hike the reserve requirement rate to curb their inflation pressure. A similar dummy variable $Inf_{i,t}^{inc}$ is defined in equation (16) to capture countries' irregular increased inflation periods by comparing them to their previous periods' inflation rolling trends [6]. The same backward looking HP filter is applied to the inflation series of each country. I identify a certain year t has a higher-than-normal increase in inflation if the deviation of inflation from its trend is larger than one historical standard deviation.

$$Inf_{i,t}^{inc} = \begin{cases} 1, & \text{if} \quad inf_{i,t} > trend_{i,t}^{inf} + s.d.(inf_{i,t})_{1}^{t} \\ 0, & otherwise \end{cases} \tag{16}$$

Figure 1 top panel presents the cross country simple average value of the reserve requirement ratio and the borrowing-lending interest rate spread by for emerging market

[5]Following Cardarelli et al. (2010), here I use a smoothing parameter of 1000 to determine the trend. The HP filter result is also robust to other values of the smoothing parameter.

[6]I also test different measures of capital inflow surges and higher-than-normal inflation periods using the definition in equation (15) to measure increased inflation periods or using definition in equation (16) to define capital inflow surges. The empirical results are similar. The correlations of the dummy variables under different definitions are summarized in Table (19)

and developing economies (EMDE) and advanced economies group (AE). Over the entire sample periods, the EMDE group has, on average, a higher level of reserve requirement rate of around 10.51 while the average level of reserve requirement for the AE group is 2.53. The gap between the two groups become relatively stable after the year 1995. For the lending-deposit interest rate spread in the bottom panel, the EMDE group again has a higher average interest rate spread compared to the AE group after the year 1985. The entire sample average lending-deposit interest rate spread is 6.03 for the EMDE group and 3.81 for the AE group.

Figure 2 bottom panel shows that the average values of the lending-deposit interest rate spread and the reserve requirement ratio have a similar evolving trend for most of the sample periods. Both series have spikes around the 1990s, 1996, and during the 2008 global financial crisis periods. They both have a growing trend from the early 2000s towards 2009 and decrease after. The similarity in the movement of two series motivates further investigation on their relationships. Figure 3 provides some individual country evidence on the co-movements of reserve requirement rates and bank interest rate spreads. The three countries on the top row are emerging market economies, and the three on the bottom are from the advanced country group. All six countries show a similar trend of the two series in most of the sample periods

4.2 Cross-country panel regressions

4.2.1 Regression models

In this section, I first assess the relationship between countries' lending-deposit interest rate spreads and reserve requirement ratios through cross-country panel regressions. The benchmark cross-country panel regression models are specified in equation (17). The dependent variable $Spread_{i,t}$is the lending-deposit interest rate spread for country i at year t. The independent variables include reserve requirement rates $RR_{i,t}$, the financial development index $Findev_{i,t}$, the financial openness index $Kaopen_{i,t}$ and their interaction terms with reserve requirement rates. Equation (18) presents an augmented model which adds some additional country-specific control variables into the regression model: $Infinc_{i,t}$ is the country higher-than-normal increased inflation period dummy. $Surge_{i,t}$ is another dummy variable indicating countries' experiencing capital inflow surge as defined in the above section. The last variable is the nominal GDP growth rate, $GDPgr_{i,t}$. All regression models also include the country fixed effect α_i and year fixed effect δ_t.

$$Spread_{i,t} = \beta_1 RR_{i,t} + \beta_2 Findev_{i,t} + \beta_3 Kaopen_{i,t} + \theta_1 RR_{i,t} \times Findev_{i,t} + \theta_2 RR_{i,t} \times Kaopenv_{i,t} + \alpha_i + \delta_t + \epsilon_{i,t} \tag{17}$$

$$Spread_{i,t} = \beta_1 RR_{i,t} + \beta_2 Findev_{i,t} + \beta_3 Kaopen_{i,t} + \theta_1 RR_{i,t} \times Findev_{i,t} + \theta_2 RR_{i,t} \times Kaopen_{i,t} + \phi_1 Infinc_{i,t} + \phi_2 Surge_{i,t} + \phi_3 GDPgr_{i,t} + \alpha_i + \delta_t + \epsilon_{i,t} \quad (18)$$

The variables used in the above regressions are the level values of the corresponding variables. As the main interest in this study is to investigate whether changes in countries' reserve requirement rates lead to changes in lending-deposit interest rate spread. I also test the same model specification using the first-order differences of the variables, as shown in equation (19).

$$\Delta Spread_{i,t} = \beta_1 \Delta RR_{i,t} + \beta_2 \Delta FD_{i,t} + \beta_3 \Delta OP_{i,t} + \theta_1 \Delta RR_{i,t} \times FD_{i,t} + \theta_2 \Delta RR_{i,t} \times OP_{i,t} + \phi_1 \Delta Infinc_{i,t} + \phi_2 \Delta Surge_{i,t} + \phi_3 \Delta GDPgr_{i,t} + \alpha_i + \delta_t + \epsilon_{i,t} \quad (19)$$

Although higher reserve requirements lead to higher lending rate while having an ambiguous effect on deposit rates as discussed in section 3, the magnitude of change on lending rates have been proved to be the dominated one. The correlation between reserve requirements and lending-deposit interest rate spreads is expected to be positive. The coefficients of financial development and financial openness denote the direct effects on interest rate spreads and are both expected to be negative.

The financial development index denotes the matureness of a country's financial sector. If a country has a more developed financial system, the financial intermediary cost such as information frictions, adjustment costs are lower. A more developed financial market also presents a more competitive market where the profit margin is lower. Both of these factors contribute to a lower lending-deposit interest rate spread. Similarly, a more opened financial account brings more foreign competition into the domestic market by allowing entry of foreign investment and foreign banks, which help increase the efficiency and reduce the spread between lending rates and deposit rates.

The interaction terms of reserve requirements with financial account openness and financial development index are added into the regression to capture the roles of these two country-specific macroeconomic conditions in reserve requirement' effects on the spreads. In general, a higher degree of financial openness and a more developed financial system would reduce the effectiveness of reserve requirement policy and dampen its effects on the interest rate spread. With a more mature financial market, domestic residents have more investment and saving vehicles while banks also have more funding sources that can act as substitutes for deposits. Thus bank interest rates are less affected.

The additional increased inflation period indicators, inflow surge indicators, and the GDP growth rates variables are the factors that not only encourage the implementation of reserve requirement policy but also have direct effects on the interest rate spread. Higher-than-normal inflation and overheating economy may both suggest a broader economic uncertainty, which prompts the banks to compensate for the risks by raising the interest rate spread. Demirgüç-Kunt and Huizinga (1999) provide some evidence on the positive correlation between interest margins and inflation rates. The coefficients of increased inflation and GDP growth are expected to be positive. Capital inflow surges are expected to have a negative impact on the lending-deposit rate spread as the massive influx of foreign capital provides additional liquidity to the domestic market and reduce the cost borrowing.

4.2.2 Regression results

Table 4 and Table 5 present panel regression estimation results for level regressions in equation (17), equation (18) and first-order difference regression in equation (19). In each table, The first column reports the results for univariate regression with only the reserve requirements or the first difference of reserve requirements as the independent variable (Column 1). In Column 2, two domestic financial market conditions related variables, the financial market development indicator and financial openness indicator, along with their interaction terms with reserve requirements, are added into the regressions. Column 3 incorporate more independent variables. Column 4 reports the result of the specification in equation (17). Column 5 presents results of the full specification of the augmented regression model in equation (18) All specifications include both country fixed effects and year fixed effects and are estimated using standard errors clustered in the country level.

Estimates in Table 4 show that the coefficients of reserve requirements are significant at the 95 percent confidence interval and positively correlated with the lending-deposit interest rate spread in all specifications. Results in column 2-5 suggest both financial development level indicators and financial openness indicators have a strong negative correlation with the interest rate spread. This suggests that countries with a higher financially developed market or a higher degree of financial openness would have, on average, a lower lending-deposit interest rate spread. The interaction term between the financial market development indicator and the reserve requirement rate is negative and significant. This suggests the impact of reserve requirements on the interest rate spread is higher if countries have a less developed financial market. Although, as shown in Figure 4, the effect of reserve requirement on the interest rate spread becomes negative when the FD increased to some higher levels, such negative effects are not statistically significantly different from zero, when running regressions of the sample above 75 percentile of the financial development index variable. In columns 4-5, the coefficients on GDP growth

have the expected sign but are not statistically significantly different from zero. The inflow surge periods are negatively significant at the 95 percent confidence interval and suggest the interest spread of our sample is, on average 0.3 percentage point lower during the large capital inflow period, which is consistent with the theories above. The increased inflation periods indicator has negative signs and is not statistically significantly different from zero. The results for the first difference regression in Table 4 show a similar sign. However, the coefficients of financial openness and inflow surge binary indicators are no longer significant.

The analysis suggests that the reserve requirement has, on average, a positive impact on the lending-deposit interest rate spread. From the results of column 5 of Table 4, one percentage point increase in reserve requirements is correlated with around 0.16 percentage point increase in the interest rate spread while the average value of spread in the estimation sample is 5.38 percentage point. Similarly, in Table 5 a one percentage point increase in the changes of reserve requirement is on average correlated with 0.22 percentage point increase in the changes of interest rate spread while the mean and the standard deviation of $\Delta Spread$ are around -0.12 percentage point and 1.39 percentage point for the whole sample.

4.3 The treatment effect estimation

4.3.1 The propensity score matching methodology

The results from the above regression models are to test the correlations between changes in reserve requirement rates and changes in the lending-deposit interest rate spreads. As discussed by Gelman and King (1990), standard regression techniques work well if the underlying model is linear and the treated group (the group of observations receiving policy changes) and the untreated group (the group of observations not receiving policy changes) are balanced (having similar characteristics on the covariates). If not, then matching is a better choice as it ensures us comparing similar individuals to have more reliable estimated effects. The data sample in this paper, as I will show later, have substantial differences between the treated and untreated observations. To further explore the treatment effect of the reserve requirement policy. I adopt the propensity score matching (PSM) method in estimating the treatment effect of an increase in the reserve requirement ratio on interest rate spreads.

Propensity score matching has become an important and popular approach in many social science studies estimating causal treatment effects (Thoemmes and Kim, 2011). First introduced into empirical social science study by Rosenbaum and Rubin (1983) and Rosenbaum and Rubin (1985), PSM provides an alternative way to help alleviate endogeneity, confounders problems, and mitigate selection bias from the non-random nature of observational data. To calculate the unbiased causal effects, one needs to address the

endogeneity problem, which commonly exists in observational studies. The non-random sample selection is a special case of the omitted variable problem, which can cause the endogeneity problem (Li, 2013). The PSM approach reduces the selection bias by separating the process of reducing endogeneity and the final outcome analysis. Comparing to standard regression techniques, it has additional advantages as it does not require assumptions of a particular functional form of the relationship between covariates and the outcome. So it does not rely on regression assumptions such as a linear relationship between dependent and independent variables or serially non-correlated errors as the linear regression methods (Cushman and De Vita, 2017). In our case, there is no particular reason to expect that the effects of reserve requirement changes on the bank interest rate spreads are linear, so matching methods can potentially yield better results and help us identify the causal effects between the reserve requirement changes and interest rate spread changes.

To estimate the propensity score matching model, I proceed in three steps. First, the treatment variable of increases in reserve requirement is constructed. Second, using a group of covariates, the propensity to adopt a tightening reserve requirement is estimated. Third, countries that have similar propensity scores are compared using different matching algorithms, to analyze the impact of an increase in reserve requirement on lending-deposit interest rate spread.

The article's main objective is to evaluate the treatment effect of hiking reserve requirement on lending-deposit interest rate spread; thus, I define a binary variable $RRUP_{i,t}$ as the treatment variable for the policy of increasing reserve requirement in equation (20). Here I drop the periods where countries having decreased the reserve requirements since I am only focusing on the scenarios of hiking reserve requirement rates. I refer to countries having increased reserve requirements in a year as the treated group, whereas countries keeping reserve requirements unchanged in a year as the control group. The outcome variable is the first-order difference in the lending-deposit interest rate spread, i.e., $\Delta Spread$, the changes in the spread.

$$RRUP_{i,t} = \begin{cases} 1, & \text{if} \quad RR_{i,t} > RR_{i,t-1} \\ 0, & \text{if} \quad RR_{i,t} = RR_{i,t-1} \end{cases} \tag{20}$$

The interested outcome here is the Average Treatment Effect on the Treated (ATT), which is measured as:

$$ATT = E[Y_i^1 - Y_i^0 | RRUP_i = 1] = E[Y_i^0 | RRUP_i = 1] - E[Y_i^0 | RRUP_i = 1] \tag{21}$$

where Y_i^1 is the value of outcome variable if country i increase reserve requirement rate. Y_i^0 is the value of the outcome variable when the country i keeps its reserve requirement rate unchanged. $Y_i^1 | RRUP_i = 1$, therefore, is the outcome value observed in the data

for country i that has increased its reserve requirement rate. $Y_i^0|RRUP_i = 1$ is the outcome value that would have been observed if the same country i had not increased its reserve requirement rate. Equation (21) gives an unbiased estimate of the ATT between the outcome of increasing reserve requirement rate and the outcome if they had kept it unchanged for the treated group of countries. In practice, however, the latter outcome cannot be observed in the data, which creates an identification problem. The ATT would be the same as comparing the difference between the treatment group and the control group if the treatment is randomly assigned among the countries. The selection bias would become zeros in such cases.

The intuition of adopting PSM methodology to address this issue is to mimic a randomized experiment. It mitigates the identification and selection bias by creating a counterfactual group of countries similar to the treatment group in terms of observable characteristics but does not increase reserve requirements. In this case, the ATT will then be computed as in equation (22), where X is a set of observable country-specific characteristics. $p(X)$, defined in equation (23), is the conditional probability of assignment to a particular treatment given a vector of observed covariates or called the propensity score (Rosenbaum and Rubin, 1983).

$$ATT = E[Y_i^1|RRUP_i = 1, p(X)] - E[Y_i^0|RRUP_i = 1, p(X)] \tag{22}$$

$$p(X) = Pr[RRUP_i = 1|X] \tag{23}$$

In addition to the propensity score estimates, another influential step is the matching criterion. To ensure the robustness of the PSM results, I apply five different propensity score matching algorithms, which include the nearest neighbor matching, the five-nearest neighbor matching, the kernel matching, the radius matching, and the local-linear matching algorithms. The nearest neighbor matching pairs each observation in the treated group with an observation from the control group based on the nearest propensity score. Five-nearest neighbor matching follows similar logic but matches each individual with five specified individuals from the other treatment level. The radius matching is also similar to the nearest-neighbor matching as it specifies the maximum propensity score distance when choosing the matching pairs. And it helps to avoid the potential bad matches from the nearest-neighbor type matching if the distance is far away. The Kernel matching (KM) and local linear matching (LLM) are non-parametric matching estimators that use weighted averages of individuals in the control group to construct the counterfactual outcome (Caliendo and Kopeinig, 2008).

4.3.2 The Logit regression and covariates

To estimate the propensity score, it is common in practice to use either a Logit or a Probit model. Here I estimate the likelihood of a country implementing reserve requirement hike using a logistic model shown in Eq.(24). The independent variable in Eq.(24) is the log-odds of the country increases reserve requirement ratio ($RRUP_{i,t} = 1$). The covariates consist of both domestic financial, macroeconomic factors such as financial development index, increased inflation period indicator, advanced economy dummy, and GDP growth rate, and international financial factor like financial openness (Chinn-ito index) and capital inflow surge indicator defined in the previous section.

$$ln\frac{Prob(RRUP_{i,t}=1)}{1-Prob(RRUP_{i,t}=1)} = \beta_0 + \beta_1 Findev_{i,t} + \beta_2 Kaopen_{i,t} + \beta_3 Infinc_{i,t} + \beta_4 Surge_{i,t} + \beta_5 Adv_{i,t} + \beta_6 GDPgr_{i,t} \quad (24)$$

Table 6 displays the estimation result of the logistic model. All covariates proposed above are significant at the 90 percent confidence interval and having consistent signs in explaining countries' reserve requirement hikes as discussed before. The negative coefficients of financial development and financial openness suggest that countries with more developed financial systems and financial openness are less likely to implement reserve requirement policy. Comparing to advanced economies, emerging market economies and developing countries change reserve requirement rates more frequently. For other domestic factors, having a higher-than-normal increase in inflation increase a country's probability to hike the reserve requirement rate for inflation control purpose. Similarly, the positive coefficient of GDP growth rate indicates that countries may have been using reserve requirement tightening to cool down overheating economic growth through bank credit expansion channel. Lastly, the estimates also show that countries have been tightening reserve requirements against massive capital inflow since it serves as an additional policy instrument to solve the dilemma when countries want to pursue both price stability and financial stability targets.

The PSM also requires the matching results to satisfy the balancing hypothesis. The balancing test results shown in Table 7 compare the treated and untreated groups before and after the matching. The top panel displays the detailed comparisons results of all covariates for the nearest neighbor matching method[7]. From the test results on top, all covariates exhibit no significant difference between the treated and control group after the nearest neighbor matching applied and also the total number of off support observations for each matching method. The bottom panel shows the mean bias comparison between

[7]The covariate balancing test results are similar for 5-nearest neighbor match, radius matching, Kernel matching, and local-linear matching methods.

the matched and unmatched samples for the nearest neighbor matching, five nearest neighbor matching, kernel matching, radius matching, and local linear matching. The sizeable mean bias of 55.5 for the unmatched sample indicates the existence of selection bias. However, all five match methods have successfully reduced the bias to much smaller values ranging from 4.0 to 4.9. The overall results in Table 7 show that all matching methods significantly remove the difference between treated and untreated groups. The same balance test results are also shown in the dot chart of covariate imbalance in terms of standardized percentage differences of each covariate in Figure 5. The test results suggest the treatment assignment in this study, the policy decision to raise reserve requirement rates, is not random. The bias comparisons of matched and unmatched samples further confirm the importance of using treatment effect estimators instead of panel regressions for causal inference. The last column in the bottom panel indicatest that only two observations are off support when applying radius matching, and three are off support for the kernel matching method. All else methods have zero off support observations.

4.3.3 Propensity score matching results

Table 8 summarizes the propensity score matching results of all five matching methods. As shown in the third row of the table. The average treatment effects, computed as the differences between treated and control groups, are all positive and significant at the 99 percent confidence interval. These results of the average treatment effects on the treated (ATT) confirm that the impacts of reserve requirement hikes on changes of interest rate spread are positive. From the first two rows in the table, the average value of the interest rate spread for the treated group is 0.21, which suggests the lending-deposit interest rate spreads increase when there are reserve requirement hikes. For the control group, the average values of the interest spread changes are negative in the samples without reserve requirement changes. On the magnitude of the ATT across different matching methods, all of them are in a similar magnitude. The local-linear matching has the smallest ATT value of 0.908, while the largest ATT is 1.046 from the Kernel matching. The ATT of the nearest neighbor suggests countries on average have a 1.022 percentage point more increase in the lending-deposit interest rate spread when adopting a tighten reserve requirement policy. For the kernel matching, the ATT result suggests the interest spread brought by the reserve requirement hike increases 0.908 percentage point more compared to the situation without changes in reserve requirements. The overall results of average treatment effects on the treated form Table 10 confirm the positive impact of reserve requirements on lending-deposit rates is statistically and economically significant. Moreover, the results are robust across different match methods.

4.3.4 Comparison with regression models

To compare the propensity score matching results to linear regression models. I estimate a modified version of the previous regression model by dropping the interaction terms and replacing the reserve requirement variable with the treatment variable $RRUP$. Table 9 reports the linear regression results. In column 3 of Table 9, the coefficient of $RRUP$ suggests the overall sample difference between the periods has an increase in reserve requirement, and the other periods is around 0.7 percentage, which is smaller compared to the previous propensity score matching results via various matching methods.

I also test the exact panel regressions in the previous section for the propensity score matching sample, which excludes periods of decreasing reserve requirement. Table 10 and 11 reports the estimation results for levels and changes of the variables, which are both similar to the full sample estimations in Table 4 and 5 in their coefficient signs and statistical significance. However, the PSM sample exhibits a larger effect of reserve requirement changes on the changes in interest rate spreads.

5 Robustness check

In this section, I investigate the extent to which the previous results are robust to different treatment effect estimators, measures of prices, financial openness, financial development indicators, and also potential sub-sample instabilities.

5.1 Different treatment effect estimators

In addition to the treatment effect estimation based on propensity score matching, four alternative treatment effect estimators are estimated as a robustness check for ATT results. Table 12 shows the average treatment effects for the treated group using nearest-neighbor matching (NNM), Inverse-probability weighting (IPW), Regression adjustment (RA), and Inverse-probability-weighted regression adjustment estimators (IPWRA). Note that the NNM estimator here is different from the nearest neighbor matching algorithm in the previous table. It is a non-parametric treatment effect estimator in the sense that no explicit functional form for either the outcome model or the treatment model is specified. Unlike using an estimated propensity score, the NNM estimator determines the "nearest" by using a weighted function of the covariates for each observation. The RA estimators use means of predicted outcomes for each treatment level to estimate each potential-outcome means. It also relies on a specific functional form to obtain conditional means of the outcome model. The IPW estimator, however, requires no specific assumption of the functional form for the outcome model. It uses the inverse probability of an individual receives a treatment level as the weight to estimate means

of the potential outcomes. The last estimator IPWRA is a doubly robust estimator first derived in Wooldridge (2007), also known as "Wooldridge's double-robust" estimator. IPWRA requires model estimations for both treatment status prediction and outcome prediction. It obtains the parameters in the outcome model using the inverse-probability weights from the treatment status estimation.

All the estimated ATT results from the four different treatment effect estimators in Table 11 show positive and significant results at the 99 percent confidence interval except for IPW result (significant at 90% confidence interval). The outcomes of nearest-neighbor matching, Inverse-probability weighting, and Inverse-probability-weighted regression adjustment estimators are significant at the 99 percent confidence interval. The magnitude of the ATTs ranges from 0.739 to 2.293, which is similar to the results obtained from the propensity score estimators in Table 10. This confirms the effects of tightening reserve requirements on bank interest rate spreads are positive and robust to different treatment effect estimators.

5.2 Alternative measures of financial openness and financial development

As another robustness check, I examine alternative measures of countries' financial openness and financial development. For the financial openness measure, the capital control index from Fernández et al. (2016) (FKRSU index) is used in this robustness check. Two traditional indicators, the ratios of private credit to GDP, which assesses the size, development of countries' financial sector, are applied to the models.

The FKRSU index is first proposed by Schindler (2009), updated, and extended in Fernández et al. (2016). It is *de jure* measure of capital control for ten asset categories in 100 countries during 1995-2013. Like the Chinn-Ito financial account openness index, FKRSU index is also built on the analysis of IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). The main index used here is an average of twenty sub-indicators that describe restrictions from both capital inflow and outflow. The index ranges from 0 to 1, with 1 representing the presence of a restriction and 0 representing no restriction. To measure financial development, I use two alternative measures: domestic credit to the private sector (% of GDP) and domestic credit to the private sector by banks (% of GDP). The first one denotes the financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits, and other accounts receivable. It has been a traditional indicator of financial development used in many research articles studying finance and growth (Levine et al., 2000; Levine, 2005; Djankov et al., 2007). The second ratio is very similar to the first one but only take into account the credit provided by

other depository corporations (deposit-taking corporations except for central banks)[8].

Table 13 and 14 present the full specification of panel regression estimations of column (5) in Tables 4 and 5 for both the levels and changes of the variables using the alternative measures mentioned above. The first and second columns replace the Financial development index (FD) with the two new private credit to GDP ratios and keep the Chinn-Ito index as the measure for financial openness. Column 3 keeps the FD index but applies the FKRSU index to measure countries' financial openness. Column 4 and 5 show the regression results using combinations of both new measures. The overall results of Table 13 and Table 14 are consistent with the main results in Table 4 and 5. All specifications in Table 13 and 14 have positive coefficients for the changes of reserve requirement rate and negative coefficients of the interaction terms of financial requirement and financial development, which are the same as the one in Table 4 and 5. Only the coefficients in column 2 are not statistically significant. The overall results in Table 13 confirm the positive correlations between reserve requirement changes and changes in lending-deposit interest rate spread. The negative and significant interaction terms for financial development indicator and reserve requirement rate again suggest the positive correlation of reserve requirement with interest rate spread is lower if countries have a more mature financial system.

For the robustness check in the propensity score matching, Table 15 reports the result of logit regressions for propensity score estimations. The results in all specifications have consistent signs with the result in Table 6. Being an advanced country, having a higher degree of financial development and openness reduces a country's chance to implement reserve requirement policy, while countries are more likely to hike reserve requirements during periods of irregular increased inflation, massive capital inflow or overheating economic growth. On the statistical significance, the inflow surge indicator is not statistically significantly different from zero in column (1) and (2), but they have the expected signs. Table (16) presents the estimation results of propensity score matching using alternative measures with different matching algorithms. All results show positive treatment effects, and most of them are significant at the 95 percent confidence interval. The only estimation that is not statistically significant is the nearest neighbor matching result for specification (5). All other treatment effect estimations in Table (16) are significant at 95% confidence interval and ranging from 0.73 to 1.03, which are similar in magnitude to the main results in Table 10. The overall results of the robustness check of propensity score matching confirm that increases in the reserve requirement ratio lead to a higher lending-deposit interest rate spread.

[8]For detail information on the domestic credit to private sector variables, see metadata of World Development Index database: https://databank.worldbank.org/source/world-development-indicators

5.3 Rosenbaum Bounds robustness test

As argued by Rosenbaum (2002), if there are unobserved variables that simultaneously affect assignment into treatment and the outcome variable, a hidden bias might arise to which matching estimators are not robust. Heckman and Navarro-Lozano (2004) and Heckman and Vytlacil (2007) also bring up a similar discussion of the potential bias caused by unobserved factors. To test for the robustness of the previous treatment effect estimator against potential unobserved factor bias, I further apply the Rosenbaum bounds test to the nearest neighbor matching, NN-5 matching, kernel matching, radius matching, and local linear matching propensity score estimators.

The Bootstrapped Rosenbaum bounds tests for the different matching method estimators generate similar results. Table 17 presents the results for Rosenbaum's bounding for the nearest neighbor PSM estimator. The first column is the different critical level of Γ, the forth to the seventh column display the upper $(+)$ and lower bound $(-)$ of the new t-statistics and confidence intervals which account for the hidden bias problem in the matching case. Under the assumption of no hidden bias ($\Gamma = 1$), the significance levels (p-values) in the first two columns both show significance at 99 percent confidence intervals, which is consistent with the main PSM estimation result. As the critical level of Γ increases, the lower bound significance levels (sig-) becomes more significant, which reject the hypothesis the treatment effect is underestimated. The upper bound significance levels ($sig+$) grow larger for increasing values of Γ. But it is still significant at 95 percent confidence intervals for a 1.5 Γ, which suggests the PSM is not overestimated. The overall result of the Rosenbaum bounds test suggests the main propensity score matching estimates are robust to an unobserved variable, which causes the odds ratio of treatment assignment to differ between the treatment and comparison groups by a factor of 1.5 or smaller.

5.4 Bayesian propensity score matching

This section presents another robustness check for the propensity score matching result by considering the estimation uncertainty in estimating the propensity score. As defined in the methodology, propensity score matching is conducted in two steps: the first step is to estimate the propensity scores. The second step is to match the sample based on the estimated propensity scores and make comparisons. The propensity scores estimated in the first step, however, always have some degree of measurement uncertainty as we do not know the exact treatment assignment mechanism. Abadie and Imbens (2016) derive adjustments for propensity score matching estimators of ATE and ATET. They argue that treating the estimated propensity score as it was the true propensity score for estimating the variance of the ATE estimator leads to conservative confidence intervals that need to be adjusted downwards. However, confidence intervals that are either too

large or too small for the ATET estimator depending on the data generating process. Following a similar approach, An (2010) develops a Bayesian counterpart of propensity score regression (BPSR) and matching estimators (BPSM).

I follow the Baysian propensity score matching method in An (2010) and estimate the ATT on the same sample using both propensity score matching and Bayesian propensity score matching. Both estimations are implemented via the "IUPS" Package in R[9]. The number of iterations and posterior samples for the BPSM estimation are 5000 and 100, respectively. The estimates are reported in Table (18). The ATT estimates of BPSM still show statistical significance at 95% confidence interval level even as the standard error corrected by BPSM is larger compared to the one in regular PSM estimation. The result again confirms the reliability of the propensity score matching estimates.

6 Conclusion

The main aim of the present study is to identify the effects of reserve requirement hikes on banks' lending-deposit interest rate spread. Based on a country level panel dataset of 75 countries from the year 1980 to 2015, this paper documents new cross-country evidence that there are positive correlations between the reserve requirement changes and lending-deposit interest rate changes. More importantly, such changes are also affected by country-specific financial conditions like financial development level. The effects of reserve requirement ratio changes on the interest rate spread are more significant if the country has a less developed financial market and system.

Furthermore, to mitigate the selection bias and covariate imbalance found in the data, this study employs propensity score matching estimators with different matching algorithms and confirms the causal relation that reserve requirement hikes on average lead to a larger lending-deposit interest rate spread. The impact brought by the reserve requirement hike on the interest rate spread is statistically and economically significant. These findings are robust to other commonly used treatment effect estimators and different measures of financial openness and financial development levels. The overall result in this paper is consistent with many previous studies on an individual country or a region.

This study highlights the important role of reserve requirements as a supplementary monetary policy and macroprudential policy tool in many countries. The cross-country empirical evidence confirms the effectiveness of reserve requirements as an additional policy tool with its impact on the interest rate spread. Understanding such impacts and their interaction with country-specific characteristics are also essential for creating sound policies for macroprudential and monetary purposes. Also, countries in different economic situations should consider implementing the reserve requirement policy discretely as its

[9]The IUPS package and its reference manual can be found in: https://cran.r-project.org/web/packages/IUPS/index.html

effects on the interest rate spread change with financial market development. The results justify the policy action of many emerging market economies use reserve requirements to curb domestic credit growth while also preventing capital inflow surges since it is more effective in emerging and developing countries where the financial development levels are relatively low. If the banking sector can easily alleviate the pressure from reserve requirement hikes by substituting deposits with other funding sources, reserve requirement changes will have little impact on the bank interest rates and other aspects of the economy. This is consistent with the empirical pattern of using reserve requirements documented in Federico et al. (2014). Lastly, the impact of reserve requirement on interest rate spread also warns countries about the trade-offs of using reserve requirement policy as it can potentially reduce financial intermediation and increase the cost of credit.

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Appendix

Table 2: Country list

	Advanced economies (AE)	Emergeing market economies / Developing countries (EMDE)	
	Australia	Albania	Poland
	Canada	Armenia	Qatar
	Czech Republic	Azerbaijan	Romania
	France	Bahamas	Russian Federation
	Germany	Bahrain	South Africa
	Greece	Bangladesh	Sri Lanka
	Iceland	Bolivia	Tajikistan
	Israel	Bosnia and Herzegovina	Thailand
	Japan	Botswana	Trinidad and Tobago
	Lithuania	Bulgaria	Tunisia
	Latvia	Chile	Uganda
	New Zealand	China	Ukraine
	Norway	Colombia	Uruguay
	Portugal	Costa Rica	Venezuela
	Singapore	Croatia	Vietnam
	South Korea	Dominican Republic	Yemen
	Spain	Egypt	
	Sweden	Georgia	
	Switzerland	Guatemala	
	United Kingdom	Honduras	
	United States	Hungary	
		India	
		Indonesia	
		Jamaica	
		Kenya	
		Lebanon	
		Macedonia	
		Malaysia	
		Mexico	
		Moldova	
		Mongolia	
		Nepal	
		Nicaragua	
		Nigeria	
		Oman	
		Pakistan	
		Panama	
		Philippines	
Total numbers of countries	21	54	

Figures and tables

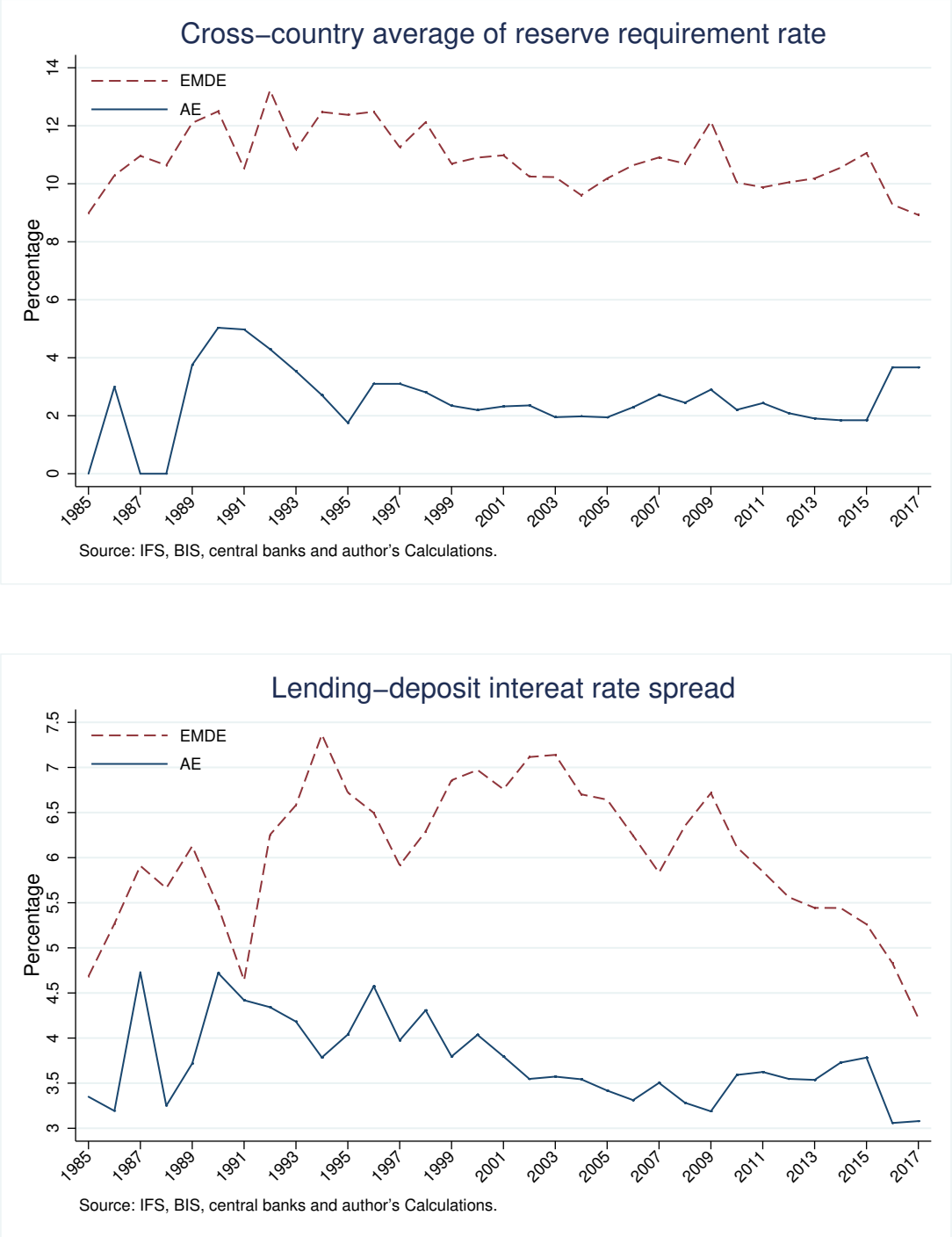

Figure 1: Cross-country average of RR ratio and deposit-lending rate spread

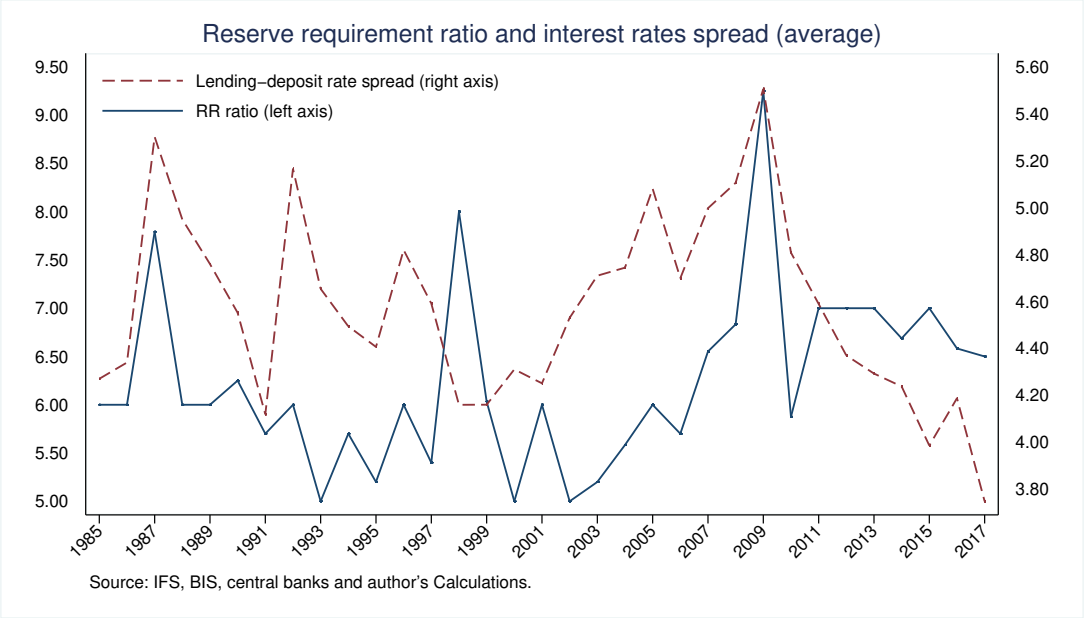

Figure 2: Cross-country average of RR ratio and deposit-lending rate spread, cross-country average

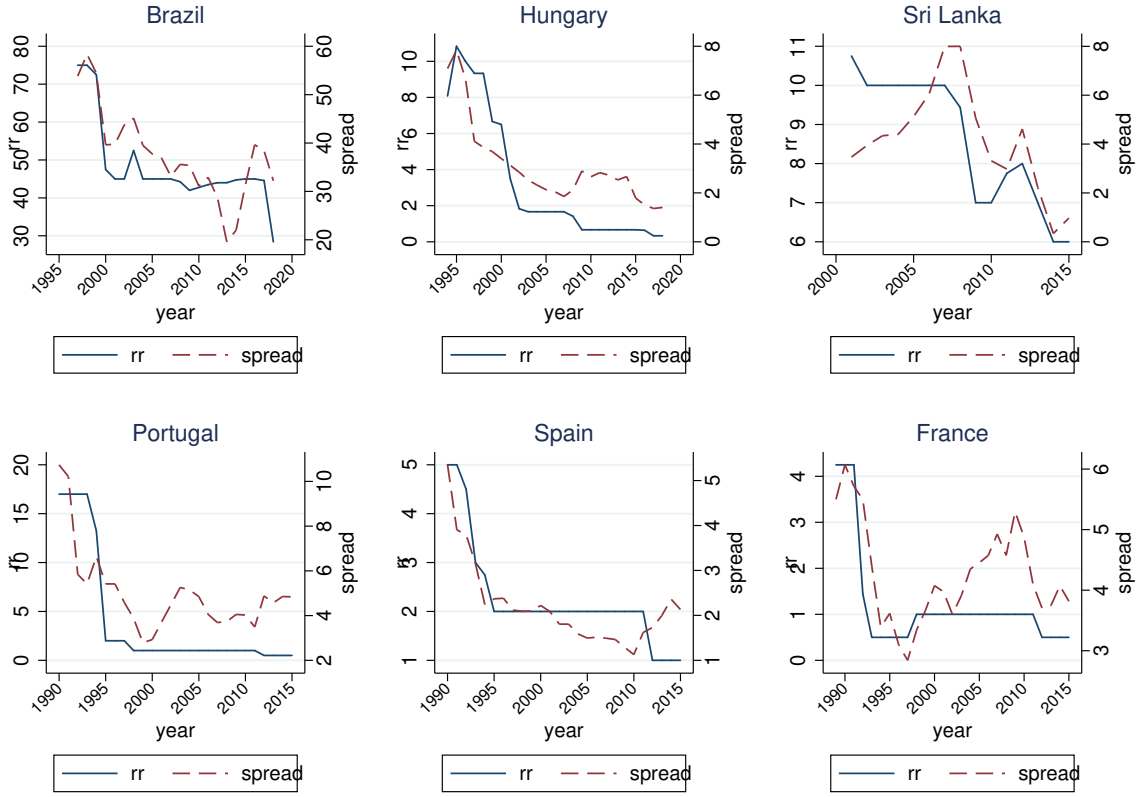

Figure 3: Cross-country average of RR ratio and deposit-lending rate spread, individual countries

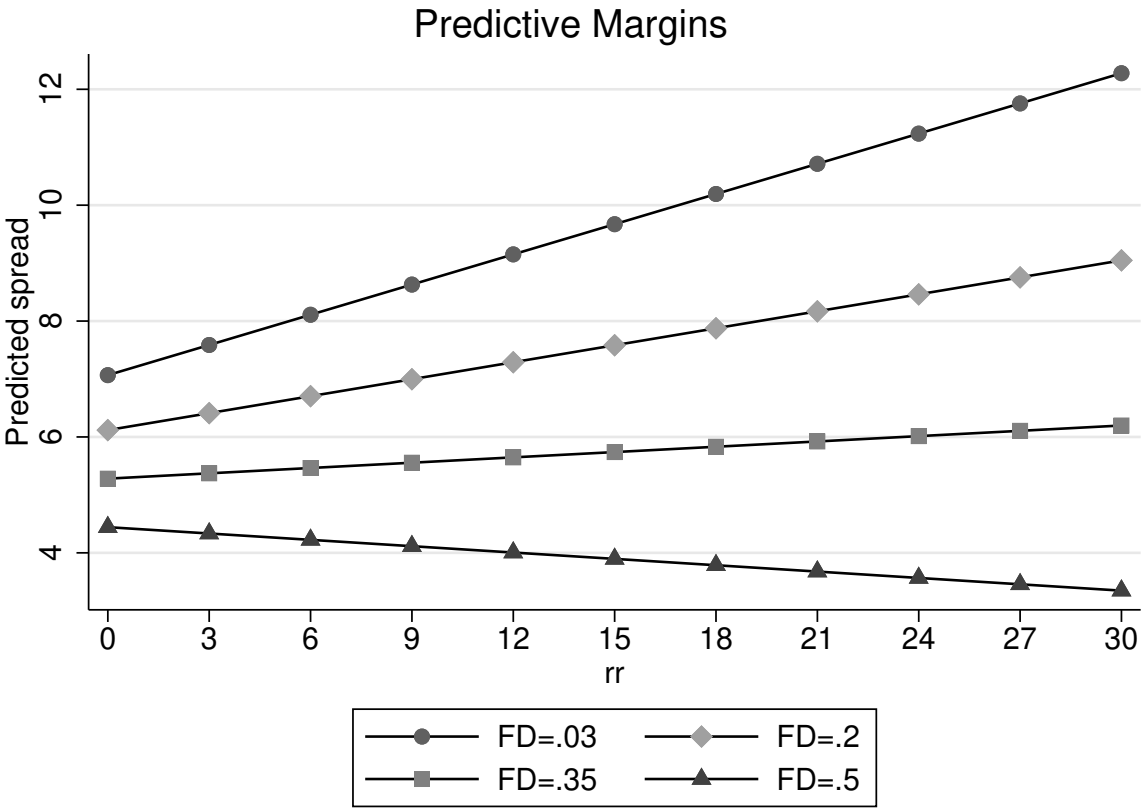

Figure 4: Predictive margins of RR

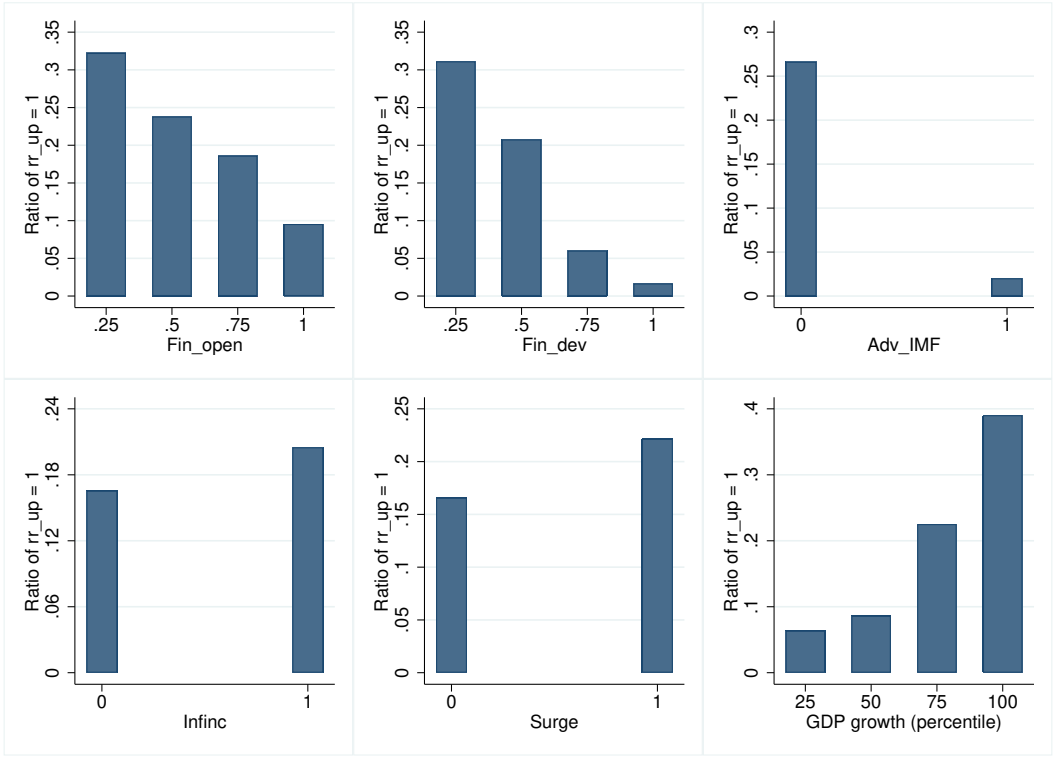

Figure 5: Proportion of observations with $RRUP = 1$ within covariates

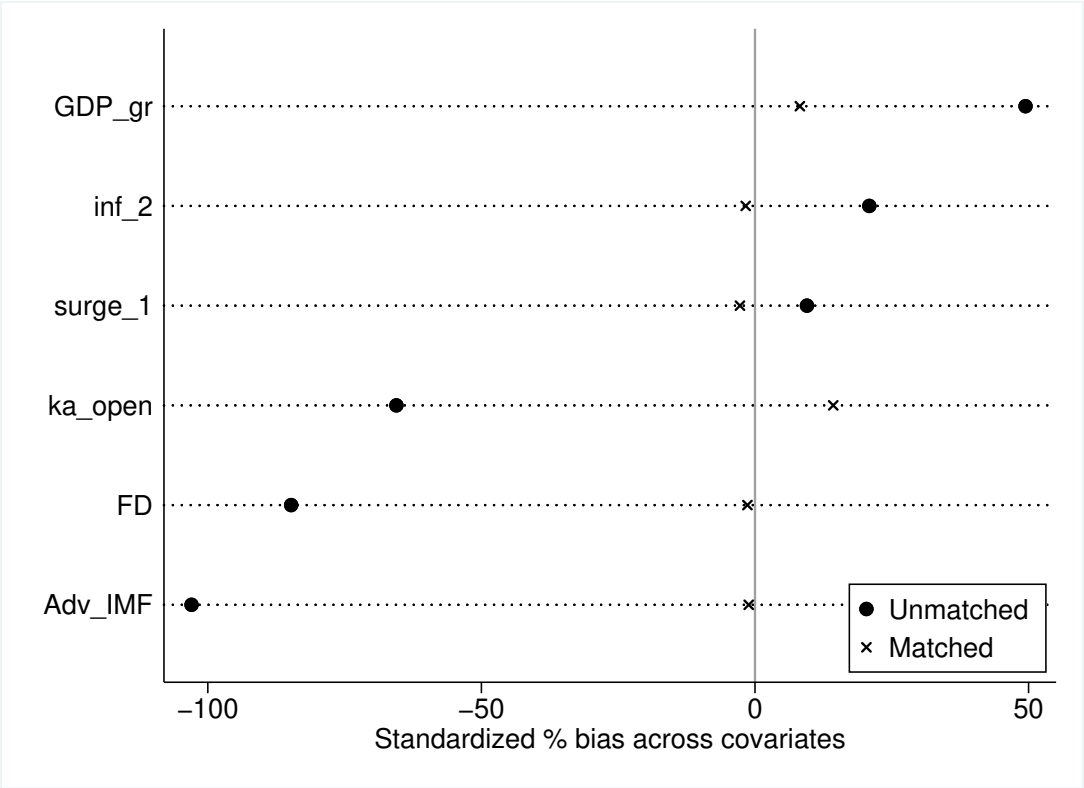

Figure 6: Covariate imbalance in terms of standardised percentage differences (nearest neighbor matching)

Table 3: Summary statistics

	Obs.	Mean	S.D.	Min	P5	P25	P50	P75	cP95	Max
Spread	1306	5.384	2.985	1.170	1.785	3.127	4.647	6.994	11.429	16.192
rr	1306	8.111	6.967	0.000	0.000	3.000	6.000	12.000	21.000	30.000
Findev	1306	0.400	0.212	0.036	0.128	0.237	0.351	0.523	0.835	0.981
Kaopen	1306	0.631	0.347	0.000	0.166	0.301	0.699	1.000	1.000	1.000
GDPgr	1306	10.783	7.353	-0.219	1.877	5.461	9.215	14.371	25.255	44.719
Δ*Spread*	1242	-0.122	1.385	-13.375	-2.167	-0.520	-0.058	0.305	1.650	8.837
Δ*rr*	1242	-0.109	1.528	-15.000	-2.250	0.000	0.000	0.000	1.667	11.250
Δ*Findev*	1242	0.007	0.028	-0.113	-0.037	-0.006	0.005	0.020	0.055	0.185
Δ*Kaopen*	1242	0.009	0.080	-0.534	-0.060	0.000	0.000	0.000	0.060	0.594
Δ*GDPgr*	1242	-0.247	7.788	-87.464	-10.331	-2.573	-0.018	2.329	9.309	47.290

Table 4: Cross-country panel regression: levels

	Spread	Spread	Spread	Spread	Spread
Reserve requirements	0.060**	0.054**	0.158**	0.050*	0.155**
	(0.028)	(0.026)	(0.067)	(0.027)	(0.068)
Financial development		-7.504***	-5.753**	-7.321***	-5.581**
		(2.534)	(2.408)	(2.515)	(2.387)
Financial openness		-0.954*	-1.395*	-0.940*	-1.358*
		(0.494)	(0.757)	(0.478)	(0.770)
RR x Fin_dev			-0.445**		-0.447**
			(0.207)		(0.207)
RR x Fin_open			0.053		0.050
			(0.059)		(0.060)
Increased inflation				-0.031	-0.025
				(0.157)	(0.154)
Inflow surge				-0.311**	-0.311**
				(0.137)	(0.134)
GDP growth				0.007	0.009
				(0.015)	(0.014)
Constant	6.756***	8.417***	8.055***	8.323***	7.923***
	(0.992)	(1.186)	(1.286)	(1.263)	(1.371)
Country FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	1306	1306	1306	1306	1306
R2	0.748	0.764	0.766	0.770	0.772
adj. R2	0.724	0.741	0.743	0.748	0.749

Clustered standard errors in parentheses
* p<0.1, ** p <0.05, *** p <0.01

Table 5: Cross-country panel regression: changes

	d_Spread	**d_Spread**	**d_Spread**	**d_Spread**	**d_Spread**
d_Reserve requirements	0.074**	0.074**	0.213***	0.075**	0.223***
	(0.035)	(0.033)	(0.072)	(0.034)	(0.071)
d_Financial development		-7.242***	-3.223	-7.188***	-2.994
		(1.883)	(1.989)	(1.913)	(1.932)
d_Financial openness		0.264	-0.634	0.315	-0.570
		(0.582)	(0.655)	(0.582)	(0.670)
d_RR x Fin_dev			-0.680***		-0.707***
			(0.195)		(0.187)
d_RR x Fin_open			0.090		0.089
			(0.083)		(0.082)
d_ Increased inflation				-0.104	-0.098
				(0.109)	(0.110)
d_Inflow surge				-0.064	-0.086
				(0.071)	(0.068)
d_GDP growth				-0.002	-0.004
				(0.008)	(0.008)
Constant	0.275	0.260	0.286	0.231	0.245
	(0.513)	(0.496)	(0.505)	(0.494)	(0.502)
Country FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	1242	1242	1242	1242	1242
R2	0.106	0.123	0.137	0.125	0.139
adj. R2	0.017	0.034	0.048	0.034	0.048

Clusterd standard errors in parentheses
* p <0.10, ** p <0.05, *** p <0.01

Table 6: Estimation of propensity scores: a logistic regression

	RRUP
Fin_dev	-1.278**
	(0.626)
Fin_open	-0.671***
	(0.244)
Inf_high	0.593***
	(0.162)
Adv_IMF	-2.283***
	(0.442)
Surge	0.309*
	(0.173)
GDP_gr	0.032***
	(0.007)
Constant	-0.975***
	(0.293)
N	1,174
Pseudo R2	0.193

Clustered standard errors in parentheses
* p <0.10, ** p <0.05, *** p <0.01

Table 7: Common support and balancing test

	Unmatched (U) Matched (M)	**Mean: Treated group**	**Mean: Control group**	**t-statistics**	$p > \|t\|$
Fin_dev	U	0.291	0.452	-10.330***	0.000
	M	0.291	0.294	-0.220	0.829
Fin_open	U	0.472	0.691	-8.840***	0.000
	M	0.472	0.424	1.580	0.115
inf_high	U	0.504	0.401	2.900***	0.004
	M	0.504	0.513	-0.180	0.855
Adv_IMF	U	0.029	0.408	-11.700***	0.000
	M	0.029	0.034	-0.260	0.794
Surge	U	0.324	0.280	1.330	0.185
	M	0.324	0.336	-0.290	0.771
GDP_gr	U	19.748	9.344	9.280***	0.000
	M	19.748	18.022	0.760	0.450
		Mean bias	**Off support Obs.**		
Nearest neighbor:	U	55.5	0		
	M	4.9			
5-nearest neighbor:	U	55.5	0		
	M	6.6			
Kernel:	U	55.5	3		
	M	4.6			
Radius:	U	55.5	2		
	M	4.0			
Local-linear:	U	55.5	0		
	M	4.9			

Table 8: Propensity score matching results for five matching methods

	Nearest neighbor	**5-nearest neighbor**	**Kernel**	**Radius**	**Local-linear**
Treated	0.334	0.334	0.365	0.364	0.334
Untreated	-0.688	-0.630	-0.714	-0.684	-0.574
ATT	1.022***	0.964***	1.079***	1.049***	0.908***
S.E.	(0.329)	(0.234)	(0.201)	(0.198)	(0.329)
Treated Obs.	238	238	238	238	238
Untreated Obs.	936	936	936	936	936
N	1,174	1,174	1,174	1,174	1,174

Robust standard errors in parentheses
* p<0.10, ** p<0.05, *** p<0.01

Table 9: Comparison with PSM: Linear regressions

	d_Spread	**d_Spread**	**d_Spread**
RRUP	0.663**	0.782**	0.717**
	(0.291)	(0.322)	(0.305)
Fin_dev		0.893**	1.085***
		(0.350)	(0.351)
Fin_open		-0.110	-0.048
		(0.185)	(0.224)
Increased inflation			0.019
			(0.142)
Inflow surge			-0.135
			(0.124)
GDP growth			0.011
			(0.014)
Constant	-0.329***	-0.657***	-0.858**
	(0.084)	(0.189)	(0.329)
N	1174	1174	1174
R2	0.016	0.024	0.031
adj. R2	0.015	0.021	0.026

Clustered standard errors in parentheses
* p<0.1, ** p <0.05, *** p <0.01

Table 10: Cross-country panel regression: levels (PSM sample)

	Spread	**Spread**	**Spread**	**Spread**	**Spread**
Reserve requirements	0.090*	0.088*	0.285**	0.053	0.211**
	(0.051)	(0.051)	(0.133)	(0.037)	(0.095)
Financial development		-5.945**	-3.635	-5.734**	-3.700
		(2.695)	(2.522)	(2.728)	(2.555)
Financial openness		-1.015*	-1.155	-0.649	-1.014
		(0.568)	(1.134)	(0.571)	(1.046)
RR x Fin_dev			-0.825**		-0.701*
			(0.406)		(0.373)
RR x Fin_open			0.034		0.053
			(0.090)		(0.077)
Increased inflation periods				-0.469	-0.382
				(0.293)	(0.265)
Inflow surge periods				-0.195	-0.205
				(0.133)	(0.136)
GDP growth				0.064***	0.060**
				(0.024)	(0.023)
Constant	6.846***	8.645***	8.069***	7.399***	7.060***
	(1.051)	(1.095)	(1.514)	(1.260)	(1.541)
Country FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	1174	1174	1174	1174	1174
R2	0.832	0.836	0.845	0.857	0.863
adj. R2	0.813	0.817	0.826	0.840	0.846

Clustered standard errors in parentheses
* p<0.1, ** p <0.05, *** p <0.01

Table 11: Cross-country panel regression: changes (PSM sample)

	d_Spread	**d_Spread**	**d_Spread**	**d_Spread**	**d_Spread**
d_Reserve requirements	0.290**	0.287**	0.782***	0.277**	0.740***
	(0.125)	(0.123)	(0.259)	(0.117)	(0.246)
d_Financial development		-7.268***	0.683	-5.926***	1.244
		(2.478)	(2.777)	(2.044)	(2.779)
d_Financial openness		0.475	2.277	0.407	2.239
		(0.860)	(1.907)	(0.877)	(1.980)
d_RR x Fin_dev			-1.335**		-1.219**
			(0.542)		(0.497)
d_RR x Fin_open			-0.177		-0.178
			(0.194)		(0.197)
d_ Increased inflation				0.048	0.034
				(0.159)	(0.161)
d_Inflow surge				-0.164**	-0.186***
				(0.068)	(0.070)
d_GDP growth				0.026***	0.023***
				(0.008)	(0.007)
Constant	-0.020	-0.072	-0.055	0.129	0.122
	(0.591)	(0.555)	(0.605)	(0.593)	(0.630)
Country FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	1156	1156	1156	1156	1156
R2	0.154	0.162	0.186	0.182	0.203
adj. R2	0.059	0.065	0.091	0.085	0.107

Clusterd standard errors in parentheses
* p <0.10, ** p <0.05, *** p <0.01

Table 12: Robustness check: other treatment effect estimators

	NN-5	**IPW**	**RA**	**IPWRA**
ATT	0.739***	2.293*	1.141***	1.173***
	(0.211)	(1.190)	(0.292)	(0.295)
Treated Obs.	238	238	238	238
Untreated Obs.	936	936	936	936
N	1,174	1,174	1,174	1,174

Robust standard errors in parentheses.
* p <0.10, ** p <0.05, *** p <0.01

Table 13: Robustness check: alternative financial openness and financial development measures, panel regressions

	(1)	(2)	(3)	(4)	(5)
	Fin_dev: Domestic credit/GDP Fin_open: Chinn-Ito index Spread	**Fin_dev: Domestic bank credit/GDP Fin_open: Chinn-Ito index Spread**	**Fin_dev: Financial development index (IMF) Fin_open: FKRSU index Spread**	**Fin_dev: Domestic credit/GDP Fin_open: FKRSU index Spread**	**Fin_dev: Domestic bank credit/GDP Fin_open: FKRSU index Spread**
RR	0.107*	0.096	0.252***	0.133*	0.132*
	(0.061)	(0.059)	(0.092)	(0.069)	(0.068)
RR x Fin_dev	-0.001*	-0.001	-0.701**	-0.002*	-0.002**
	(0.001)	(0.001)	(0.308)	(0.001)	(0.001)
Fin_dev	-0.008	-0.014*	-3.062*	-0.005	-0.004
	(0.006)	(0.008)	(1.702)	(0.005)	(0.005)
RR x Fin_open	0.092	0.095	0.145	0.185	0.187
	(0.076)	(0.076)	(0.120)	(0.134)	(0.134)
Fin_open	-1.592*	-1.635*	0.682	0.203	0.306
	(0.890)	(0.847)	(0.791)	(0.850)	(0.825)
Increased inflation	-0.135	-0.096	-0.220	-0.226	-0.213
	(0.139)	(0.143)	(0.184)	(0.187)	(0.188)
Inflow surge	-0.247**	-0.241*	-0.270*	-0.246	-0.226
	(0.123)	(0.122)	(0.141)	(0.149)	(0.147)
GDP growth	0.008	0.008	0.021	0.025	0.026
	(0.015)	(0.015)	(0.019)	(0.021)	(0.020)
Constant	6.003***	6.238***	5.511***	4.527***	4.300***
	(0.795)	(0.804)	(0.864)	(0.593)	(0.577)
Country FE	Y	Y	Y	Y	Y
N	1119	1127	852	798	806
R2	0.773	0.775	0.810	0.811	0.809
Adj. R2	0.755	0.756	0.793	0.793	0.791

Clusterd standard errors in parentheses.
* p<0.10, ** p<0.005, *** p<0.01

Table 14: Robustness check: alternative financial openness and financial development measures, panel regressions

	(1)	(2)	(3)	(4)	(5)
	Fin_dev: Domestic credit/GDP **Fin_open: Chinn-Ito index** **d_Spread**	**Fin_dev: Domestic bank credit/GDP** **Fin_open: Chinn-Ito index** **d_Spread**	**Fin_dev: Financial development index (IMF)** **Fin_open: FKRSU index** **d_Spread**	**Fin_dev: Domestic credit/GDP** **Fin_open: FKRSU index** **d_Spread**	**Fin_dev: Domestic bank credit/GDP** **Fin_open: FKRSU index** **d_Spread**
d_RR	0.247***	0.250***	0.231***	0.157***	0.156***
	(0.071)	(0.069)	(0.086)	(0.046)	(0.047)
d_RR x Fin_dev	-0.001	-0.001*	-0.357**	-0.001	-0.001*
	(0.001)	(0.001)	(0.173)	(0.001)	(0.001)
d_Fin_dev	0.004	0.005	0.014	0.003	0.005
	(0.005)	(0.005)	(0.949)	(0.005)	(0.005)
d_RR x Fin_open	-0.047	-0.047	0.048	0.087	0.091*
	(0.068)	(0.068)	(0.065)	(0.053)	(0.053)
d_Fin_open	0.710	0.693	-0.350	-0.394	-0.570
	(0.663)	(0.658)	(0.564)	(0.523)	(0.557)
d_Increased inflation	0.002	0.004	0.009	0.005	0.005
	(0.053)	(0.053)	(0.052)	(0.055)	(0.055)
d_Inflow surge	-0.047	-0.056	-0.030	-0.033	-0.044
	(0.043)	(0.044)	(0.055)	(0.058)	(0.059)
d_GDP growth	-0.006	-0.006	-0.004	-0.005	-0.005
	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Constant	-0.224***	-0.223***	-0.192***	-0.203***	-0.201***
	(0.010)	(0.009)	(0.010)	(0.010)	(0.009)
Country FE	Y	Y	Y	Y	Y
N	987	994	741	696	703
R2	0.139	0.138	0.147	0.145	0.143
Adj. R2	0.056	0.055	0.055	0.047	0.045

Clusterd standard errors in parentheses.
* p<0.10, ** p<0.005, *** p<0.01

Table 15: Robustness check: alternative financial openness and financial development measures, estimation of propensity scores: logit regressions

	(1)	(2)	(3)	(4)	(5)
	Fin_dev: Domestic credit/GDP **Fin_open: Chinn-Ito index**	**Fin_dev: Domestic bank credit/GDP** **Fin_open: Chinn-Ito index**	**Fin_dev: Financial development index (IMF)** **Fin_open: FKRSU index**	**Fin_dev: Domestic credit/GDP** **Fin_open: FKRSU index**	**Fin_dev: Domestic bank credit/GDP** **Fin_open: FKRSU index**
	RR_up	RR_up	RR_up	RR_up	RR_up
Fin_dev	-0.011***	-0.010***	-2.117**	-0.014***	-0.014***
	(0.003)	(0.004)	(0.895)	(0.004)	(0.005)
Fin_open	-0.689***	-0.648***	0.763**	0.722**	0.722**
	(0.253)	(0.250)	(0.354)	(0.338)	(0.340)
Inf_high	0.506***	0.565***	-2.117**	0.722**	1.061***
	(0.170)	(0.168)	(0.895)	(0.338)	(0.220)
Adv_IMF	-3.944***	-4.041***	0.763**	-2.489***	-3.542***
	(1.017)	(1.018)	(0.354)	(0.781)	(1.037)
Surge	0.267	0.266	0.745***	0.632**	0.438*
	(0.181)	(0.180)	(0.278)	(0.282)	(0.226)
GDP_gr	0.034***	0.037***	0.027**	0.023*	0.067***
	(0.007)	(0.007)	(0.013)	(0.013)	(0.014)
Constant	-0.913***	-1.017***	-2.282***	-2.114***	-2.259***
	(0.269)	(0.273)	(0.368)	(0.343)	(0.349)
N	1105	1112	827	790	797
Pseudo R2	0.220	0.222	0.279	0.267	0.274

Standard errors in parentheses.
* p<0.10, ** p<0.05, *** p<0.01

Table 16: Robustness check: propensity score matching

			Nearest neighbor	5-nearest neighbor	Kernel	Radius	Local-linear
(1)	Fin_dev: Domestic credit/GDP Fin_open: Chinn-Ito index	**ATT**	0.959***	0.986***	0.914***	0.877***	0.966***
			(0.267)	(0.252)	(0.208)	(0.206)	(0.267)
		N	1,105	1,105	1,105	1,105	1,105
(2)	Fin_dev: Domestic bank credit/GDP Fin_open: Chinn-Ito index	**ATT**	0.849**	0.927***	0.913***	0.859***	0.957**
			(0.362)	(0.256)	(0.204)	(0.201)	(0.362)
		N	1,112	1,112	1,112	1,112	1,112
(3)	Fin_dev: Financial development index (IMF) Fin_open: FKRSU index	**ATT**	0.837**	1.031**	0.840**	0.843***	0.916**
			(0.407)	(0.299)	(0.250)	(0.241)	(0.407)
		N	827	827	827	827	827
(4)	Fin_dev: Domestic credit/GDP Fin_open: FKRSU index	**ATT**	0.836***	0.935***	0.809***	0.884***	0.966**
			(0.419)	(0.308)	(0.255)	(0.248)	(0.419)
		N	790	790	790	790	790
(5)	Fin_dev: Domestic bank credit/GDP Fin_open: FKRSU index	**ATT**	0.450	0.725**	0.816***	0.867***	0.950***
			(0.335)	(0.284)	(0.247)	(0.241)	(0.335)
		N	797	797	797	797	797

Robust standard errors in parentheses.
* p<0.10, ** p<0.005, *** p<0.01

Table 17: Robustness check: Rosenbaum bounds for reserve requirement hike treatment Effects

Γ	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1.000	0.000	0.000	0.467	0.467	0.257	0.706
1.100	0.000	0.000	0.397	0.542	0.193	0.795
1.200	0.001	0.000	0.337	0.611	0.134	0.887
1.300	0.003	0.000	0.278	0.678	0.081	0.975
1.400	0.012	0.000	0.230	0.741	0.032	1.061
1.500	0.034	0.000	0.185	0.809	-0.014	1.147
1.600	0.078	0.000	0.141	0.873	-0.058	1.224

Table 18: Standard error comparsion: PSM vs. BPSM

	PSM	BPSM
ATT estimates	0.869***	0.869**
S.E.	0.270	0.403

Standard errors in parentheses
* p <0.10, ** p <0.05, *** p <0.01

Table 19: Different definitions of inflow surge and increased inflation periods

	Definition 1 (Eq. 15)	**Definition 2 (Eq. 16)**	**Correlation coefficient**
Capital inflow surges	387	205	0.624***
Inreased inflation periods	372	294	0.658***

Standard errors in parentheses
* p 0.10, ** p 0.05, *** p 0.01