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Bank risk-taking in emerging economies: Empirical evidence and theory ☆

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ABSTRACT

This article empirically studies the impact of foreign shocks on bank risk-taking in emerging economies. We use a country panel model for the 2001–2017 period. Using several measures of bank risk-taking, financial openness and foreign debt participation, we find if anything that the lower the financial openness in an economy, the higher the likelihood that the foreign monetary policy rate increases bank risk-taking and that the foreign debt participation reduces bank risk-taking. To provide an intuition of these results, we develop a simple small open economy model with banks facing foreign borrowing limits and taking excessive risk. The novel result is that, when the foreign borrowing limit binds, a lower foreign interest rate reduces excessive bank risk-taking. Since the foreign borrowing limit binds, the lower foreign rate does not boost bank credit but reduces bank default probability, which diminishes bank incentives to take excessive risk. Similarly, greater access to the international credit markets reduces excessive bank risk-taking.

1. Introduction

As emerging economies become more integrated into the international credit markets, their banking systems' dependence on foreign funds becomes more important, which makes them more vulnerable to foreign shocks. For instance, Avdjiev et al. (2017), who split debt inflows into four borrowing sectors, government, central bank, banks, and corporates, show that the average banks' external debt as a share of total external debt for 34 emerging economies has been around 30% in the last two decades.[1] In addition, it is expected that the still undeveloped and small banking systems in the emerging economies will become more important and sophisticated.

In this context, it is crucial to monitor the banking system's exposure to the international credit market. Considering the large and volatile capital flows to emerging markets economies, it becomes imperative to study the effects of foreign shocks, such as foreign interest rates and access to the international credit market, on the risk-taking behavior of banks. For instance, large credit booms and capital inflows seem to be followed by a deep crisis (see, e.g., Benigno et al., 2015; Caballero, 2014). In particular, in an emerging economy like Peru, capital flows are strongly positively correlated with private credit growth and negatively correlated with an indicator of the quality of the banking system's loans. Although there has been a large amount of research into the impact of domestic policy rates on the degree of bank risk-taking, known as the "risk-taking channel" (term coined by Borio and Zhu, 2012), less attention has been devoted to studying the effects of foreign monetary policy and the access to foreign credit on excessive bank risk-taking.

In that sense, this paper aims to study empirically the effects of the foreign interest rate and access to the international credit market on excessive risk-taking by domestic banks. Also, we develop a simple model to provide an intuition of our empirical results.

In the empirical analysis, we perform a cross-country empirical study over the 2001–2017 period. Using different measures from the literature for bank risk-taking, financial openness and foreign debt participation, we find if anything that the lower the financial openness in an economy, the higher the likelihood that foreign debt participation reduces bank risk-taking and that foreign monetary policy rate increases bank risk-taking. In addition, we find that foreign debt participation increases the positive impact of the foreign interest rate on bank risk-taking. Interestingly, we find some evidence that the domestic policy rate might have a positive effect on bank risk-taking. And when assessing the implications of domestic debt participation on the effect of the domestic policy rate on bank risk-taking, results are not robust. Interestingly, we find evidence that after a contractionary

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[1] This number for the case of 25 advanced economies is 42%.

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monetary policy, countries that are more financially constrained are more willing to take more risk. In general, our empirical results seem robust for several measures of financial openness, foreign and domestic debt participation, bank risk-taking, and domestic and foreign interest rate.

In the theoretical analysis, we develop a two-period small partially open economy model with domestic banks, and domestic and foreign depositors. As commonly assumed in the literature, the foreign interest rate will be lower than the domestic interest rate. This encourages domestic banks to borrow from abroad. We assume banks face a limit on foreign borrowing. This limit on the aggregate external borrowing is emphasized in the emerging literature (see, e.g., Atkeson and Ríos-Rull, 1996; Bulow and Rogoff, 1989; Caballero and Krishnamurthy, 2001). As in those studies, here this type of constraint aims to capture any friction between the emerging economy and international creditors.

Two additional frictions in the model are bank limited liability and deposit insurance. Their interaction results in banks overestimating the marginal expected return of loans since they cannot internalize the effects of loans on the risk-insensitive deposit rates due to the deposit insurance. Since we assume diminishing marginal returns to capital, the aggregate credit and the bank risk-taking are going to be inefficiently high.[2] The model is parametrized by observing the 2001–2017 average data of small open economies.

The literature on risk-taking commonly suggests that a lower domestic interest rate increases bank risk-taking (see, e.g., Jiménez et al., 2014). In line with the empirical results,[3] when the foreign borrowing constraint binds, we find the same result for the domestic interest rate, but the opposite for the foreign interest rate. Interestingly, the model suggests that a lower foreign interest rate or a greater access to the international credit market reduces excess bank risk-taking and hence excess levels of bank loans. Since the foreign borrowing limit binds, banks' marginal debt is domestic and thus the foreign rate does not boost bank credit. Thus, for given bank loans the lower foreign interest rate reduces bank obligations and hence bank default probability, which in turn diminishes banks' incentives to take excessive risk. In other words, the overestimation of marginal benefits from banks' perspective is reduced, which in turn reduces excess bank loans.[4] Similarly, after a greater access to foreign fund, banks substitute expensive domestic debt for cheap foreign debt. This reduces bank default probability, which in turn reduces banks' incentives to take excessive risk. In this case of lower domestic interest rate, it reduces the marginal cost of loan funding and hence boosts bank credit. This higher credit increases bank default probability and indeed dominates the negative impact of the lower domestic rate on bank default probability. As a result, the lower domestic rate increases banks' default probability and banks' incentives to take excessive risk.

Also, as in the empirical results, the theoretical model suggests that foreign debt participation accentuates the negative effect on excessive bank risk-taking after a foreign rate cut. Similarly, domestic debt participation reduces the positive impact on excessive bank risk-taking after a domestic rate cut. This is in line with figure 6 from Dell'Ariccia et al. (2014), which shows a positive relationship between the domestic policy rate and bank risk-taking over a period of highly leveraged banks: 2007Q4 to 2009Q3.

This paper proceeds as follows: Section 2 presents the literature review. In Section 3 we develop the empirical analysis. Section 4 describes the theoretical model. In Section 5 we parametrize the model and report the numerical results. Finally, Section 6 concludes.

2. Literature review

This paper follows a branch of the banking literature that model the interaction of the limited liability and deposit insurance to explain the socially excessive bank risk-taking (see, e.g., Agur and Demertzis, 2012, 2019; Collard et al., 2017; De Nicolò et al., 2012). In contrast to Collard et al. (2017), however, bank default probability of banks is endogenous, which allows us to properly measure the effects of the interest rates on the excessive bank risk-taking.[5] This paper attempts to contribute to this branch of the literature by studying the effects of interest rates on the excessive bank risk-taking in an open economy.

This work is related to the group of papers devoted to studying the different channels through which monetary policy can affect bank risk-taking (see, e.g., Agur and Demertzis, 2012, 2019; Dell'Ariccia et al., 2014, 2016). They mainly suggest two channels: the *profit* channel and the *leverage* channel. According to the *profit* channel, a lower rate increases banks' profits at good states and reduces banks' incentives to take risk. The *leverage* channel suggests that the lower rate makes leverage less expensive. This means that the bank internalizes less of its risk-taking and increases its risk-taking incentives. Dell'Ariccia et al. (2014) conclude that when leverage is endogenous, low interest rates lead to higher bank risk-taking. However, if the leverage ratio is exogenous, the effect depends on the leverage level as follows: the higher the leverage, the higher the probability that a lower rate reduces bank risk-taking.[6] These channels are also captured in this paper, however, in the case of foreign monetary policy only the *profit* channel is relevant when the foreign borrowing limit binds. In contrast to Dell'Ariccia et al. (2014), this work focuses on excessive bank risk-taking. To this end, it builds a simple model to quantitatively measure this excessive risk-taking.

In addition, this paper is related to empirical studies of the risk-taking channel of the monetary policy, which typically suggests that excess bank risk-taking increases after a reduction in the policy rate. In Jiménez et al. (2014), using data from Spain, conclude that a lower short-term interest rate increases the level of risk of the loans. In the same way, Maddaloni and Peydró (2011) show that lending standards deteriorate after a reduction in the short-term interest rate. Here, under the calibration presented, we find similar results when considering the effects of the domestic interest rate, but the opposite for the foreign domestic rate. Recently, Chen et al. (2017), using panel data from more than 1000 banks in 29 emerging economies during 2000–2012, find that bank's riskiness increases when the monetary policy is eased.

Also, this work is related to the literature on the international transmission of the US monetary policy. Miranda-Agrippino and Rey (2020) find that a US monetary policy tightening produces a contraction of domestic credit and financial asset prices. Passari and Rey (2015) find that there is a co-movement of gross capital flows, bank leverage, credit creation and risky asset prices; and that indices of market fear as VIX co-move negatively with credit and leverage growth. Bruno and Shin

[2] In this work bank risk-taking involves the volume of the bank credit and not the type of the credit as in Collard et al. (2017). This is in line with current literature, particularly, the monetary policy literature that commonly views excessive bank risk-taking in terms of the aggregate volume of credit (see, e.g., Borio and Zhu, 2012).

[3] The foreign borrowing constraint captures the financial openness of a country.

[4] Indeed, these smaller bank loans reduces even more bank default probability, which creates bank incentives to reduce again excess bank risk-taking and thus excess bank loans, etc.

[5] Collard et al. (2017) develops an extension that incorporates the risk-taking channel of the monetary policy. By construction, a lower domestic rate increases the excessive bank risk-taking.

[6] Dell'Ariccia et al. (2014) assume banks' limited liability and asymmetric information, depositors cannot observe ex-ante the bank's risk-taking level. It also studies the effects of different degrees of deposit insurance. Reinforcing (Dell'Ariccia et al., 2014)' theoretical results, an empirical work using the Federal Reserve's survey of terms of business lending over the period 1997 to 2011 performed by Dell'Ariccia et al. (2016) concludes that the negative relationship between bank risk-taking and short-term interest rates is less pronounced for periods of low bank capital.

(2015) find that contractionary US monetary policy decreases cross-border flows and produces a decline in the leverage of international banks. And in a dollarized economy like Bolivia, Ioannidu et al. (2015) find that a lower US policy rate increases bank risk-taking. In contrast, this work provides a different result in the sense that after a US monetary policy tightening, domestic bank credit and excessive risk-taking might increase. In addition, capital flows are negatively correlated with bank credit. The reason is that in this framework the US interest rate and capital flows do not have a direct impact on bank lending costs.

Finally, this paper is also related to the literature that studies capital inflow and the probability of a financial crisis (see, e.g., Benigno et al., 2015; Caballero, 2014). Caballero (2014) suggests that surges in inflows increase crisis probability even in the absence of lending booms. Here, this paper complements this literature by suggesting a mechanism by which capital inflows bonanzas might reduce the probability of a banking crisis. In addition, as in the capital control literature, which suggests that capital account openness has a positive effect on firms' credit rating (see, e.g., Prati et al., 2012), this paper suggests that greater access to foreign markets reduces excess bank risk-taking.

3. Empirical analysis

In the empirical analysis, we aim to answer the following research questions:

1. What are the implications of the financial openness, on the impact of the participation of foreign borrowing on bank risk-taking?
2. What are the implications of the financial openness and foreign debt participation, on the impact of the foreign monetary policy rate on bank risk-taking?
3. What is the impact of the domestic policy rate on bank risk-taking and the role of domestic funding participation on this impact?

We propose one specification to answer each of our previous questions. We perform a cross-country analysis at an annual frequency. Before we turn to the empirical model, we describe the data used.

3.1. Data description

We propose several measures of bank risk-taking, country openness, and bank foreign debt participation, used in the literature. As measures of bank risk-taking, we consider: (i) Bank z-score (Z_SCORE).[7] In particular, a higher z-score suggests a lower probability of default of a country's banking system. (ii) Bank regulatory capital to risk-weighted assets (CA_RWA). A lower ratio might increase bank incentives to take excessive risk, in addition that banks have less capacity to absorb unexpected shocks.[8] (iii) Banking crisis indicator ($CRISIS$). It takes two values, 0 if there is not a banking crisis and 1 if there is a baking crisis.[9] (iv) Volatility of stock prices (SP_Vol).[10] A higher volatility might suggest more bank risk-taking. (v) Bank nonperforming loans to gross loans ratio (NPL). A higher ratio suggests more bank risk-taking.[11]

As measures of the financial openness in a country, we use: (i) Overall index of capital controls on both inflows and outflows (KA).[12] The indicator goes from 0, representing no restrictions, to 1, representing restrictions on all types of international transactions. This is based on the *de jure* information. (ii) Foreign assets and liabilities to GDP ratio (AL_GDP).[13] This could be considered a *de facto* measure.

As measures of bank foreign debt participation, we consider: (i) Outstanding international private debt securities to total debt securities (international and domestic) FD_TD.[14] (ii) The external debt stock to GNI ratio FD_GNI.[15] (iii) The bank credit to bank deposits ratio CRE_DEP.[16] (iv,v) From the International Financial Statistics of the IMF, we built up two additional proxies of bank foreign debt participation.[17] Our first proxy is the liabilities to non-residents to total deposits (FD_DEP).[18] Our second proxy is the liabilities to non-residents to claims on private sector (FD_CLAIMS). We expect that the foreign debt participation is positively related to these two indicators. (vi) Foreign liabilities to GDP ratio (L_GDP).[19]

We use the information of policy rates (POL_RATES). Since our previous variables are available mainly in annual frequency, we take the average within each year to compute our policy rate series. For the foreign policy rate, we might use the policy rates of the US, UK or EA. However, since these rates are lower bound, we use the shadow interest rates from Wu and Xia (2016, 2017). This is because the shadow rates give us a better idea of the stance of the monetary policy.

Finally, in our regressions, we use some macroeconomic and banking variables as controls. We control for the development of the banking credit market or financial depth using the bank credit to GDP ratio (CRE_GDP), for the income level with the real GDP per capita ($RGDPPC$), for the business cycle conditions using the current and lagged real GDP per capita growth rate ($RGDPPCG$), see Jimenéz et al. (2013), for the trade openness using imports and exports to GDP ratio (XM_GDP). We control for profitability using the return on assets after

[7] It captures the probability of default of a country's commercial banking system. It is estimated as (ROA+(bank equity/bank assets))/sd(ROA); sd(ROA) is the standard deviation of ROA. This measure is traditionally used in banking literature, see, e.g., Dias (2021), Brana et al. (2019) and Laeven and Levine (2009).

[8] In other words, while banks do not have much to lose, they might gain a lot if take a lot of risk. There are theoretical and empirical literature that positively relate bank risk-taking and the capital ratio, see, e.g., Acosta-Smith et al. (2020) and Dell'Ariccia et al. (2014, 2016).

[9] This is constructed by Laeven and Valencia (2020). This banking crisis measure has been widely used in the literature, for example, Nguyen et al. (2022), which extends the systemic banking crises database by Laeven and Valencia (2020), and Eberhardt and Presbitero (2021).

[10] Stock price volatility is the average of the 360-day volatility of the national stock market index.

[11] This is another indicator typically used as bank risk-taking measure on banking literature, see e.g., Jimenéz et al. (2013) and Delis Manthos and Kouretas (2011). The drawback of this measure is that it looks more like an ex-post measure.

[12] This index is offered by Fernández et al. (2016). The authors also provide indices of capital controls on only capital inflows and only capital outflows. The overall index of capital controls is constructed as the average of the indices of capital controls on inflows and outflows. These indices are widely used in the literature, see, e.g., Caballero and Fernández (2019), Demirgüç-Kunt et al. (2016) and Erten et al. (2021).

[13] This is the cross-border assets and the cross-border liabilities to GDP ratio built from the database (Lane and Milesi-Ferretti, 2017). In fact, the sum of foreign assets (FA) and foreign liabilities (FL) over GDP has been proposed as a measure of *de facto* financial openness by Lane and Lane and Milesi-Ferretti (2011, 2017). This cross-country database has been used by several authors, see e.g., Calomiris Charles and Chen (2022) and Iñaki and Turnovsky (2022).

[14] The amount of International private debt securities covers long-term bonds and notes and money market instruments placed on international markets. The amount of domestic private debt securities covers data on long-term bonds and notes, commercial paper and other short-term notes, issued in domestic markets.

[15] We might argue that the bank foreign debt participation is positively related to the external debt to GNI ratio.

[16] We might claim that the higher this ratio, the higher the likelihood of a higher participation of foreign debt on bank credit funding.

[17] These proxies are built using the balance sheet of other depository corporations (ODC). The ODC sector represents depository institutions, excluding the central bank, that issue liabilities included in the national definition of broad money.

[18] Total deposits are transferable and other deposits included in broad money of ODC.

[19] This is the cross-border liabilities to GDP ratio from Lane and Milesi-Ferretti (2017).

Table 1
Summary statistics.

	N	Period	Obs.	Mean	SD.	Min	Max
Measures of bank risk-taking							
Z_SCORE_{it}	182	1996–17	3908	13.40	8.62	0.02	96.68
CA_RWA_{it} (%)	139	1998–17	2110	16.66	5.41	1.75	48.60
$CRISIS_{it}$	214	1970–17	10 257	0.04	0.21	0.00	1.00
SPI_VOL_{it}	88	1990–17	2020	21.30	13.34	2.39	141.60
NPL_{it} (%)	137	1998–17	2097	7.25	7.61	0.00	74.10
Measures of financial openness							
KA_{it}	100	1995–17	2300	0.38	0.34	0.00	1.00
AL_GDP_{it} (%)	209	1970–15	7755	1369	12,381	5	276,033
Measures of bank foreign debt participation							
FD_TD_{it} (%)	46	1990–17	1030	43.74	26.33	0.82	99.84
FD_GNI_{it} (%)	128	1970–19	5267	56.22	63.97	0.00	1233.10
FD_DEP_{it} (%)	167	2001–20	3167	18.88	16.89	0.00	93.35
FD_CLAIMS_{it} (%)	167	2001–20	3167	49.74	181.03	0.00	2866.75
CRE_DEP_{it} (%)	177	1960–17	8363	98.81	73.96	1.14	2861.06
L_GDP_{it} (%)	209	1970–15	7768	676	6167	1	158,949
Policy rates							
POL_RATES_{it} (%)	106	1990–20	2274	7.36	10.34	−0.50	149.25
$SHADOW\_US_t$ (%)		1990–20	31	2.44	2.73	−2.74	7.60
$SHADOW\_ECB_t$ (%)		2004–20	17	−1.08	3.67	−7.38	3.81
$SHADOW\_UK_t$ (%)		1990–20	31	2.15	5.34	−7.23	14.41
Controls							
$LERNER_{it}$	80	1996–14	2353	0.26	0.16	−1.61	1.53
ROA_{it} (%)	181	1996–17	3870	1.37	2.25	−29.12	65.84
CRE_GDP_{it} (%)	225	1960–19	10 271	35.81	32.85	0.00	308.98
$RGDPPC_{it}$ (const 2010 US$)	247	1960–19	11 935	11,043	17,716	132	196,061
$RGDPPCG_{it}$ (%)	251	1961–19	11 920	2.07	5.54	−64.99	140.37
XM_GDP_{it} (%)	234	1960–19	10 689	71.96	50.38	0.00	860.80

SD.: Standard deviations. Sources: Global Financial Development Database (GFDD), World Development Indicators, World Bank; International Financial Statistics, IMF. Fernández et al. (2016), Laeven and Valencia (2020), and Lane and Milesi-Ferretti (2017). N: number of countries. Obs.: number of country-year observations.

taxes (ROA), and control for the banking competition level using the Lerner index ($LERNER$). Higher values of the Lerner index indicate less bank competition.[20]

Table 1 reports the main statistics of our variables. The average of the capital to risk-weighted assets is 17 with a standard deviation of 5. The mean of the banking crisis indicator suggests that in the 1970–2017 period the average probability of being in a banking crisis in a year is 4%. The mean non-performing loans ratio is 7.25%, with a volatility of 7.61% and with an extremely high value of 74.10%.

Regarding our measures of openness, the mean of the overall capital controls index is nearly below 0.5, and the foreign assets and liability to GDP ratio is 1368%, with a relatively high standard deviation of almost ten times its mean.

Regarding our measures of bank foreign debt participation, the international debt securities to total debt has a mean of 43.74% in the 1990–2017 period; and a volatility of 26.33%; however, the number of observations across countries is smaller than our other measures. The mean of external debt stock to GNI is 56.22% in the 1970–2019 period, with a volatility similar to its mean. The means of the liabilities to non-residents to total deposits and the liabilities to non-residents to claims to private sector in the 2001–2020 period are 18.88% and 49.74%, respectively. Finally, the bank credit to deposits ratio has a mean of 98.81% in the 1960–2017 period, and the foreign liabilities to GDP ratio reports a mean of 676% in the 1970–2015 period.

The policy rates have an average of 7.36% in the 1990–2020 period, with an important volatility of 10.34%, and an extreme value of 149%. The shadow policy rate of the US shows a mean of 2.44% in the 1990–2020 period, with a minimum value of −2.74% and a maximum value of 7.60%. It is important to work with the shadow value in order to capture that monetary policy ease associated with the −2.74%. The shadow value policy rate of the UK has a mean of 2.15% in the period 1990–2020, with a minimum value of 7.23%. A younger shadow policy rate is the Euro Area policy rate that has a mean of −1.08% in the 2004–2020 period.[21]

It is important to mention that for our analysis we omit extreme values.[22] The time period analyzed spans from 2001 to 2017. This is in order to avoid the capital flow crisis in the emerging economies during the nineteens, and due to available information of our bank risk-taking measures. We use ordinary least squares (OLS) to estimate the parameters in a linear regression panel model among country and time dimensions.

3.2. Foreign debt dependence and bank risk-taking

The following panel specification is to assess the implications of the financial openness, on the impact of the participation of foreign borrowing on bank risk-taking:

$$RT_{it} = \alpha_i + \beta_1 FD_{it} + \beta_2 OP_{it} FD_{it} + \beta_3 OP_{it} + \beta_4 CRTL_{it} + \epsilon_{it},$$

where the i subscript refers to a country and the t subscript refers to a sample year; RT_{it} denotes our measure of bank risk-taking, FD_{it} is our measure of foreign debt participation, OP_{it} is our measure of financial

[20] It is defined as the difference between output prices and marginal costs (relative to prices). Prices are calculated as total bank revenue over assets, whereas marginal costs are obtained from an estimated translog cost function with respect to output.

[21] Our control variables also present important variability. For example, the return on assets has a mean of 1.37% and a standard deviation of 2.25%, and the credit to GDP ratio shows a mean of 35.81% and a volatility of 32.85%. The mean of the real GPD per capita growth yields 2.07%, while the real GDP per capita has a mean of US$ 11,043 (constant 2010) . Finally, the exports and imports to GDP ratio has a mean of 72%.

[22] We choose data such that $Z - SCORE_{it} \leq 57$, $CA\_RWA_{it} \leq 42\%$, $SPI\_VOL_{it} \leq 110$, $NPL_{it} \leq 50\%$, $AL\_GDP_{it} \leq 2000\%$, $FD\_TD_{it} \leq 100\%$, $FD\_GNI_{it} \leq 360\%$, $FD\_DEP_{it} \leq 100\%$, $FD\_CLAIMS_{it} \leq 100\%$, $CRE\_DEP_{it} \leq 800\%$, $L\_GDP_{it} \leq 2000\%$, $POL\_RATES_{it} \leq 50\%$, $-0.4 \leq LERNER_{it} \leq 1.3$, $-20\% \leq ROA_{it} \leq 20\%$, $CRE\_GDP_{it} \leq 300\%$, $-25\% \leq RGDPPCG_{it} \leq 48\%$, $XM\_GDP_{it} \leq 400\%$.

Table 2
FD_{it} : liabilities to non-residents to claims on private sector, FD_CLAIMS, OP_{it}: overall index of capital controls, KA.

RT	Z-score		CA to RWA		Banking crisis		SPI Vol		NPL ratio	
	1	2	3	4	5	6	7	8	9	10
FD	−0.065***	−0.072***	−0.057	−0.072**	0.048***	0.086**	0.008	0.052	−0.087*	−0.080**
	(0.020)	(0.021)	(0.040)	(0.035)	(0.016)	(0.036)	(0.055)	(0.053)	(0.052)	(0.035)
FD*OP	0.092**	0.104**	0.039	0.097	−0.025	0.046	0.215	0.145	0.065	−0.065
	(0.041)	(0.040)	(0.075)	(0.067)	(0.030)	(0.091)	(0.218)	(0.194)	(0.154)	(0.152)
OP	−2.025	−3.198*	0.238	−4.276	2.077	5.966	2.563	8.167	1.514	1.442
	(1.602)	(1.909)	(4.183)	(2.760)	(1.493)	(3.933)	(5.044)	(9.423)	(5.211)	(3.690)
CRE_GDP		−0.025**		−0.024*		0.098***		0.060*		0.011
		(0.011)		(0.014)		(0.023)		(0.032)		(0.028)
ln(RGGPDPC)		0.361		−1.784		−2.452		−18.159***		−12.511***
		(1.277)		(2.025)		(2.319)		(5.304)		(3.821)
RGGPDPCG		0.005		−0.058*		−0.416***		−0.797***		−0.083
		(0.027)		(0.034)		(0.090)		(0.172)		(0.064)
RGGPDPCG(−1)		−0.026		−0.082***		−0.049		−0.103		−0.169***
		(0.022)		(0.030)		(0.064)		(0.091)		(0.060)
ROA		0.171		0.133		−0.158		−0.672		−0.595*
		(0.106)		(0.091)		(0.106)		(0.526)		(0.352)
LERNER		6.971***		5.788***		−5.116*		−5.261		−9.534**
		(1.924)		(1.887)		(2.987)		(4.185)		(3.867)
Observations	1326	952	1080	809	467	337	890	654	1061	797
R-squared	0.029	0.111	0.019	0.100			0.019	0.251	0.019	0.299
N	84	78	78	71	29	26	62	60	77	71
F test (ρ-value)	0.0149	0.000714	0.357	0.000827	0.0104	0	0.572	4.69e−09	0.276	2.96e−10

We cluster the standard errors (in parentheses) by country level. For banking crisis indicator as our bank risk-taking measure, we use a logistic regression model.
*Statistically significant at 10%.
**Statistically significant at 5%.
***Statistically significant at 1%.

openness. It captures the idea that the foreign borrowing constraint might or might not bind. $CRTL_{it}$ is the set of variables that allow us to control for the business cycle, the banks' profitability, financial depth and bank competition. We include country fixed effects α_i to control for unobservable country characteristics constant over time, and ϵ_{it} is a random error that has a normal distribution.

When considering the overall index of capital controls as our financial openness measure and, in general, for all our measures of bank foreign debt participation (except for the external debt to GNI ratio) we find that the higher the financial openness (i.e., the lower the KA), the lower the likelihood that a higher foreign debt participation leads to a lower bank risk-taking.[23] If we use the liabilities to non-residents to claims to private sector ratio as our foreign debt participation measure, in Table 2, this result is statistically significant for z-score.

Numerically, for the latter case, an increase of one standard deviation of the liabilities to non-residents to claims on private sector (49.74%) leads on average to a reduction of 2.0 (= 0.104 ∗ $\overline{OP}$ ∗ 49.74) in the z-score, which has a sample mean of 13.40. However, the impact for countries with a KA one standard deviation above its mean is 3.7 (= 0.104 ∗ 0.72 ∗ 49.74).

In addition, in Table 2, when considering the z-score or the capital to RWA ratio as our bank risk-taking measure (column 1 & 2), we find that for a financially open economy ($KA = 0$), foreign debt is positively associated with bank risk-taking; however, for a financially closed economy ($KA = 1$), foreign debt decreases bank risk-taking. However, in Table 2 if we use the banking crisis indicator and the stock price volatility as our bank risk-taking measures, previous results hold for a financially open economy ($KA = 0$), while we find the opposite results for a financial closed economy ($KA = 1$). When using the NPL ratio, results hold for a financially closed economy, while we find the opposite results for a financially open economy.

In addition, in Table 2 we find that financial depth is positively associated with bank risk-taking; while income level, bank profitability and competition are negatively associated with bank risk-taking. And current and lagged GDP growths are positively associated with bank risk-taking when using z-score and capital to RWA as bank risk-taking measures, and are negatively associated when using banking crisis indicator, stock price volatility and NPL as risk-taking measures. This latter might provide some evidence that z-score and capital to RWA are better measures of bank risk-taking.

3.3. Foreign policy rate and bank risk-taking

The following panel specification is to assess the implications of the financial openness and foreign debt participation, on the impact of the foreign monetary policy rate on bank risk-taking:

$$RT_{it} = \alpha_i + \beta_1 r_t^f + \beta_2 FD_{it} r_t^f + \beta_3 OP_{it} r_t^f + \beta_4 OP_{it} + \beta_5 CTRL_{it} + \epsilon_{it},$$

where r_t^f is foreign interest rate. It could be the US policy rate, the ECB policy rate or the UK policy rate.[24]

In general, when considering the overall index of capital controls as our financial openness measure, we find that foreign policy rate increases bank risk-taking for all our bank risk-taking measures, except when considering the NPL ratio. For example, Table 3 reports the results for the bank credit to deposits ratio as our foreign debt participation measure. In that case only for the capital to RWA ratio (columns 3 y 4) result is statistically significant. Numerically, an increment in 100 bps of the US shadow rate reduces the capital to RWA ratio on average in 18 bps (= 0.007 + 0.003 ∗ $\overline{FD}$ − 0.327 ∗ $\overline{OP}$).

[23] Similarly, when considering the foreign liabilities and assets to GDP as our financial openness measure and, in general, for all our measures of bank foreign debt participation (except for the external debt to GNI ratio), we find that the higher the financial openness (i.e. the higher the foreign assets and liabilities to GDP ratio) the lower the likelihood that a foreign debt participation reduces bank risk-taking. See, for example, in table 7 the regression results, for the case of the liabilities to non-residents to claims on private sector as our bank foreign debt participation measure.

[24] RT_{it}, FD_{it} and OP_{it} were already defined. $CRTL_{it}$ groups the same set of variables as in Section 3.2 and the relationship already found between our controls and our risk-taking measures holds.

Table 3
FD_{it}: bank credit to deposits, CRE_DEP; OP_{it}: overall index of capital controls, KA.

RT	Z-score		CA to RWA		Banking crisis		SPI Vol		NPL ratio	
	1	2	3	4	5	6	7	8	9	10
FD	0.009	0.008	−0.018*	−0.023***	−0.001	0.007	0.000	−0.000	0.019**	0.018*
	(0.008)	(0.009)	(0.010)	(0.008)	(0.016)	(0.016)	(0.018)	(0.027)	(0.009)	(0.010)
SHADOW_US	−0.060	−0.004	−0.242***	−0.007	0.036	−0.116	0.116	−0.044	−0.339***	−0.273*
	(0.064)	(0.124)	(0.073)	(0.159)	(0.103)	(0.245)	(0.200)	(0.420)	(0.089)	(0.157)
FD*SHADOW_US		−0.000		−0.003***		0.000		−0.002		−0.001
		(0.001)		(0.001)		(0.002)		(0.003)		(0.001)
OP*SHADOW_US		−0.103		0.327		0.684		1.569***		0.372
		(0.161)		(0.202)		(0.465)		(0.483)		(0.336)
OP		0.553		−2.619		5.895***		6.768		2.997
		(1.641)		(1.739)		(2.206)		(5.432)		(3.534)
CRE_GDP	−0.040***	−0.039***	−0.007	−0.001	0.064***	0.075***	0.050	0.046	0.048***	0.048***
	(0.013)	(0.014)	(0.013)	(0.015)	(0.024)	(0.025)	(0.034)	(0.036)	(0.014)	(0.014)
ln(RGGPDPC)	2.544	2.460	−0.352	0.281	−0.279	−1.647	−7.836	−5.106	−21.257***	−20.530***
	(2.327)	(2.351)	(2.094)	(2.066)	(2.665)	(2.711)	(4.926)	(4.860)	(2.915)	(3.156)
RGGPDPCG	−0.003	−0.004	−0.068**	−0.077**	−0.370***	−0.373***	−0.744***	−0.765***	0.029	0.021
	(0.029)	(0.029)	(0.032)	(0.034)	(0.084)	(0.084)	(0.162)	(0.162)	(0.049)	(0.050)
RGGPDPCG(−1)	−0.007	−0.008	−0.072***	−0.070***	−0.058	−0.042	−0.153	−0.179*	−0.098*	−0.106**
	(0.023)	(0.022)	(0.027)	(0.026)	(0.061)	(0.063)	(0.105)	(0.104)	(0.050)	(0.051)
ROA	0.337	0.334	0.168	0.187	−0.369**	−0.359*	−1.361**	−1.206**	−1.063***	−1.021***
	(0.211)	(0.207)	(0.145)	(0.141)	(0.179)	(0.194)	(0.644)	(0.580)	(0.189)	(0.211)
LERNER	5.096**	5.160**	2.392	2.847*	−2.639	−4.786*	3.070	1.070	−3.170	−3.954*
	(2.082)	(2.100)	(1.498)	(1.477)	(2.629)	(2.880)	(5.320)	(4.428)	(1.977)	(2.137)
Observations	1013	1013	860	860	336	336	759	759	858	858
R-squared	0.091	0.091	0.121	0.164			0.209	0.237	0.466	0.476
N	88	88	82	82	27	27	70	70	82	82
F test (ρ-value)	0.00164	0.000961	2.42e−07	2.04e−08	0	0	1.56e−05	7.83e−08	0	0

We cluster the standard errors (in parentheses) by country level. For banking crisis indicator as our bank risk-taking measure, we use a logistic regression model.
*Statistically significant at 10%.
**Statistically significant at 5%.
***Statistically significant at 1%.

In Table 3 when considering the capital to RWA ratio as the bank risk-taking measure (column 4), we find that the foreign debt participation increases the positive impact of foreign rate on bank risk-taking.[25] In particular, for a country with a credit to deposit ratio one standard deviation above is mean, the impact on the capital to RWA ratio of a 100 bps increase of the US shadow rate is −40 bps and hence more negative.

In addition, we find that the financial openness diminishes the positive impact of the foreign policy rate on bank risk-taking, for all our foreign debt participation measures and for all our risk-taking measures (except the capital to RWA ratio). However, only the coefficient for the stock price volatility is statistically significant. Quantitatively, after an increase of 100 bps of the US shadow rate the impact on the stock price volatility, for countries with a KA one standard deviation below its mean, is 0.53% smaller.

We find similar results when using the ECB policy rate or the UK policy as the foreign interest rate measures.[26] Results are robust when considering the foreign assets and liabilities to GDP as our financial openness measure.[27]

3.4. Domestic policy rate and bank risk-taking

The following panel specification is to assess the impact of the domestic policy rate on bank risk-taking and the role of domestic funding participation on such impact:

$$RT_{it} = \alpha_i + \beta_1 r^d_{it} + \beta_2 DD_{it} r^d_{it} + \beta_3 OP_{it} r^d_{it} + \beta_4 OP_{it} + \beta_5 CTRL_{it} + \epsilon_{it},$$

where r^d_{it} is the policy rate, DD_{it} is our measure of domestic funding dependence. For the latter, we use our measures of bank foreign debt participation. The higher the foreign debt participation, the lower the dependence on domestic funding.[28] We consider the interaction of the financial openness measure (OP_{it}) and the domestic policy rate (r^d_{it}) captures banks' ability to move to foreign debt after a rise in the domestic policy rate. Intuitively, the domestic policy rate might have a stronger negative impact on bank risk-taking if the ability to move to cheap foreign debt is smaller due to a lower financial openness.

Interestingly, when considering the overall index of capital controls as our financial openness measure, we find that the domestic policy rate might have a positive and significant effect on bank risk-taking.[29] In principle, it goes against our intuition. However, not surprisingly this might provide some evidence that there are also frictions between banks and domestic depositors and hence that there exists a domestic

[25] However, when considering the liabilities to non-residents to total deposits as our foreign debt participation measure and the banking crisis indicator or the stock price volatility as our bank risk-taking measures, we find the opposite results.

[26] We omit the omitting euro area countries when working with the ECB policy rate, and omit England when working with the UK policy rate. Notice that in our study period (2001–2017) the correlation between the US and ECB policy rates is 0.56, while the correlation between the US and UK policy rates is 0.83. It seems thus that the US and UK policy rates are more synchronized. Table 9 in Appendix A reports the case of having the ECB and UK policy rates as our foreign rate measures and the bank credit to deposit ratio as our bank foreign bank debt participation measure. Interestingly, according to Tables 3, 9, the impact of the ECB policy rate on bank risk-taking (z-score and capital to RWA ratio) is stronger than the impact of the US and UK policy rates.

[27] See for example, table 8 in Appendix A, where we consider the bank credit to deposit ratio as our foreign debt participation measure and the US policy rate as the foreign interest rate.

[28] RT_{it}, FD_{it} and OP_{it} were already defined. $CRTL_{it}$ groups the same set of variables as in Section 3.2 and the relationship already found between our controls and our risk-taking measures holds.

[29] This result is robust with or without controls.

Table 4
DD_{it} : bank credit to deposits, CRE_DEP; OP_{it}: overall index of capital controls, KA.

RT	Z-score		CA to RWA		Banking crisis		SPI Vol		NPL ratio	
	1	2	3	4	5	6	7	8	9	10
DD	0.010	−0.002	−0.017	−0.019	0.000	0.017	0.005	−0.008	0.013	0.027**
	(0.008)	(0.013)	(0.010)	(0.013)	(0.021)	(0.025)	(0.016)	(0.032)	(0.008)	(0.013)
POL_RATE	0.075	−0.111	−0.121**	−0.236**	0.222**	−0.242	0.056	−0.092	−0.187**	−0.166
	(0.045)	(0.096)	(0.059)	(0.099)	(0.096)	(0.233)	(0.182)	(0.247)	(0.078)	(0.178)
DD*POL_RATE		0.001		0.000		0.003		0.001		−0.001
		(0.001)		(0.001)		(0.002)		(0.001)		(0.001)
OP*POL_RATE		0.230*		0.214		0.750**		0.103		0.211
		(0.134)		(0.177)		(0.337)		(0.345)		(0.355)
OP		−1.562		−1.659		6.343*		6.670		3.759
		(1.756)		(1.675)		(3.499)		(4.916)		(6.468)
CRE_GDP	−0.032***	−0.029**	−0.006	−0.005	0.071**	0.068**	0.046	0.049	0.039**	0.030**
	(0.012)	(0.012)	(0.012)	(0.011)	(0.029)	(0.031)	(0.031)	(0.030)	(0.015)	(0.013)
ln(RGGPDPC)	0.797	0.889	2.923*	3.188**	6.536	10.214*	−12.389**	−12.526**	−17.502***	−16.895***
	(2.761)	(2.816)	(1.555)	(1.409)	(5.066)	(5.433)	(4.973)	(4.772)	(3.794)	(3.937)
RGGPDPCG	0.002	0.004	−0.105***	−0.096**	−0.574***	−0.695***	−1.178***	−1.178***	−0.071	−0.059
	(0.030)	(0.031)	(0.034)	(0.037)	(0.116)	(0.140)	(0.132)	(0.137)	(0.049)	(0.056)
RGGPDPCG(−1)	−0.027	−0.021	−0.083***	−0.074**	−0.128	−0.169	−0.336***	−0.344***	−0.167***	−0.149**
	(0.028)	(0.029)	(0.028)	(0.031)	(0.095)	(0.108)	(0.095)	(0.096)	(0.053)	(0.057)
ROA	0.218	0.230	0.031	0.033	−0.547**	−0.621**	−1.270*	−1.167**	−1.155***	−1.120***
	(0.191)	(0.180)	(0.167)	(0.171)	(0.263)	(0.269)	(0.655)	(0.566)	(0.225)	(0.258)
LERNER	6.638***	6.260**	4.582**	4.224**	−2.801	−4.448	0.347	−1.834	0.083	−1.515
	(2.474)	(2.518)	(1.792)	(1.627)	(3.458)	(3.773)	(5.475)	(4.370)	(2.132)	(2.417)
Observations	757	757	665	665	296	296	615	615	656	656
R-squared	0.076	0.084	0.159	0.169			0.343	0.351	0.432	0.455
N	69	69	65	65	24	24	58	58	65	65
F test (ρ-value)	0.0103	1.26e−05	8.82e−07	2.31e−07	0	0	0	0	0	2.63e−10

We cluster the standard errors (in parentheses) by country level. For banking crisis indicator as our bank risk-taking measure, we use a logistic regression model.
*Statistically significant at 10%.
**Statistically significant at 5%.
***Statistically significant at 1%.

borrowing limit that could be binding.[30] For example, when considering the bank credit to deposits ratio as our domestic debt participation measure, Table 4, if we use any of our bank risk-taking measures (except the NLP ratio) we find that the domestic policy rate has on average a positive impact on bank risk-taking, but this result is statistically significant only for the capital to RWA ratio and the banking crisis indicator.

Numerically, when considering the capital to RWA ratio as our risk-taking measure, an increase of 100 bps of the domestic policy leads to a reduction of 16 bps ($= 0.236 - 0.000 * \overline{DD} - 0.214 * \overline{OP}$) in the capital to RWA ratio. However, if we use the NPL ratio, the impact is negative as typically suggested by the literature but it is not statistically significant.[31]

Furthermore, compared to the foreign policy rate, the positive effect (if any) of the domestic policy rate on bank risk-taking could be quantitatively smaller. For example, a 100 bps increase in the domestic policy rate reduces the capital to RWA ratio by 12 bps (column 3, Table 4) while a similar rise in the US policy rate decreases the capital to RWA ratio in 24 bps (column 3, Table 3). This suggests, in line with the literature, that the borrowing constraint is relatively stronger on foreign borrowing.[32]

When assessing the implications of the domestic debt participation on the effect of the domestic policy rate on bank risk-taking, results are neither statistically significant nor robust. For example, when considering the bank credit to deposit ratio as our domestic debt dependence, Table 4, and the Z-score or the capital to RWA ratio or the NPL ratio as our risk-taking measure, we find that the higher the domestic debt participation (i.e., the lower the bank credit to deposits ratio), the less negative the impact of the domestic policy rate on bank risk-taking. However, if we consider the banking crisis indicator or the stock price volatility, the results are the opposite.

In Table 4 when assessing the implications of financial openness and considering the banking crisis indicator, the stock price volatility and the NPL ratio, as our risk-taking measures, we find that the impact of the domestic policy rate on bank risk-taking is less positive (or more negative) for a financially open economy (i.e., $KA = 0$).[33] However, this is statistically significant with the banking crisis indicator. Interestingly, this might suggest that after a contractionary monetary policy, countries that are more financially open, are more willing to take more risk after a domestic rate reduction.[34]

3.5. Robustness and endogeneity

We perform additional robustness exercises. In particular, we propose a specification that includes both the domestic and foreign policy rates. These are presented in tables 11–12 in Appendix B.

Table 11 presents the results including simultaneously both policy rates. In part B, we consider a domestic policy rate that is orthogonal to the foreign policy rate. This is to better capture domestic policy rate shocks. The orthogonal domestic rate is obtained after removing the variation that can be explained by the foreign policy rate. In general, results hold, but the significance levels diminish, especially in part A of table 11. Finally, we present table 12 that reports the regressions with time-fixed effects, so the foreign policy rate is absorbed. Results still hold.

[30] In other words, as in the case of binding foreign borrowing limit when the domestic borrowing limit binds, the domestic interest rate might increase excessive bank risk-taking.

[31] Results are similar when considering the foreign assets and liabilities to GDP as our financial openness measure.

[32] In other words, the frictions between foreign depositors with domestic banks are stronger than the friction between domestic depositors with domestic banks.

[33] This result holds when using the liabilities to non-residents to total deposits, the liabilities to non-residents to claims to private sector and the foreign liabilities to GDP as our domestic funding dependence measures.

[34] Results are similar when considering the foreign assets and liabilities to GDP as our financial openness measure.

In contrast to the foreign interest rate and the foreign debt participation, which can be considered exogenous, the domestic policy rate at the contemporaneous level might generate an endogeneity issue. Part A in table 10 in Appendix A we run the regressions with the lagged domestic policy rate. Qualitatively, results hold. Similarly, results are robust if we include the persistence of the endogenous variable, see part B.

As a final exercise, not reported here, we run regressions using the overall inflow restrictions index (KAI) y the overall outflow restrictions index (KAO); and the results are qualitatively and quantitatively similar. This is due to the very high correlation between these three indices.

4. The two-period open economy model

We develop a two-period model with a continuum of measure one of identical domestic financial intermediaries (banks), domestic firms, domestic investors (domestic households), and foreign investors. Domestic households own banks and firms. Domestic and foreign investors make domestic and foreign deposits, respectively, into banks, and domestic investors supply labor to firms. Banks use identical exogenous initial equity and deposits to issue risky loans to firms. Firms use loans to purchase capital that in combination with labor is used for goods production.[35]

There are two key assumptions: limited liability faced by banks and deposit insurance. In order to capture the fact that the risk-free interest rate in emerging economies is higher than in developed economies, it is assumed that the opportunity cost of domestic investors is higher than the opportunity cost of foreign investors.

In addition, we assume that banks have borrowing limits only on foreign debt. This constraint seeks to capture the level of financial openness, that we study in our empirical model and that is measured by the overall restriction index and the foreign assets and liabilities to GDP ratio. The tighter this limit, the higher the likelihood that the constraint binds and hence the smaller the financial openness. From a theoretical point of view, this can be motivated by informational problems between banks and depositors and by asymmetric information among domestic and foreign depositors (see, e.g., Coval and Moskowitz, 2002; Choe et al., 2001).

For simplicity, we also make the following assumptions: households and firms do not have access to the international credit market, which makes the economy partially open; banks can, without cost, identify if a depositor is domestic or foreign; depositors invest in risky assets only through banks; all the agents are risk-neutral; banks are not able to issue equity. Since firms and banks are identical, there is only one type of risky bank loan. These simplifying assumptions will not affect the main results of the model. Further, the deposit insurance is funded by the government through lump-sum taxes on domestic households.

The timing of the model is as follows: At $t = 0$ investors make bank deposits and banks fund their risky lending activities with deposits and an exogenous initial equity, and firms purchase capital with bank loans. At $t = 1$ the outcome of goods production is realized. Since banks have limited liability, they transfer non-negative dividends to domestic households.[36] Hence, each time that at $t = 1$ banks' obligations are higher than banks' revenues from risky loans, banks are not able to fully repay depositors and thus banks default and the deposit insurance is activated so that depositors are fully repaid.

At $t = 0$ the representative firm purchases capital, K_0, funded by bank loans, L_0, that are demanded to banks, $L_0 = K_0$. Firms use capital and labor, H_1, demanded at $t = 1$ for the production of goods, Y_1, using a Cobb–Douglas technology,

$$Y_1 = Z_1(K_0)^{\alpha}(H_1)^{1-\alpha},$$

where $0 < \alpha < 1$, i.e., we assume diminishing marginal returns to capital, and Z_1 is the multiplicative aggregate shock to productivity. We assume Z_1 has a lognormal distribution, $ln(Z_1) \sim N(\mu_z, \sigma_z^2)$. F is the cumulative density function and f is the probability density function of Z_1. Firm's profits at $t = 1$ are,

$$\Pi_1 = (1-\delta)K_0 + Y_1 - R_1^L L_0 - W_1 H_1,$$

where $\delta < 1$ is the capital depreciation rate, R_1^L is the lending interest rate. In order to have risky loans, it is assumed that R_1^L is state-contingent. Since there is an infinite number of firms, they take prices as given. The demand of loans of firms is found by maximizing the discounted value of future profits at $t = 0$, $\mathbb{E}_0\{\beta\Pi_1\}$, where $L_0 = K_0$.[37] The first order condition for K_0 is,

$$0 = \mathbb{E}_0\left\{\beta(R_1^K - R_1^L)\right\},$$

where $R_1^K = 1 - \delta + \alpha Z_1(K_0)^{\alpha-1}(H_1)^{1-\alpha}$ is the marginal productivity of capital. At $t = 1$ the productivity level is realized and firms demand labor until the marginal product of labor equals the wage, i.e., $W_1 = (1-\alpha)Z_1(K_0)^{\alpha}(H_1)^{-\alpha}$. We assume a non-negative condition for the realized profits, i.e., $0 \leq \Pi_1$. This implies that the first order condition for capital yields $R_1^K = R_1^L$. For simplicity, it is assumed that households supply inelastically one unit of labor. Then, in equilibrium the lending rate (bank loans demand curve) yields,

$$R_1^L = 1 - \delta + \alpha Z_1(L_0)^{\alpha-1}. \tag{1}$$

The problem of the representative domestic household is straightforward. Since this is risk-neutral, it maximizes the domestic utility that has the following form: $U_0 = C_0 + \beta E_0\{C_1\}$, where C_0 and C_1, respectively, denote the household's consumptions at $t = 0$ and $t = 1$, subject to the budget constraints at $t = 0$, $C_0 = Y_0 - D_0 + \Pi_0$, and at $t = 1$, $C_1 = \bar{R}_0^D D_0 + \Pi_1 + W_1 - T_1$, where β, Y_0, D_0, $\bar{R}_0^D$, Π_0, Π_1 and T_1, respectively, denote the household's exogenous discount factor, an exogenous initial endowment, the domestic deposits, the gross rate of return on domestic deposits, the banks' dividends at $t = 0$, the banks' dividends at $t = 1$, and the government's lump-sum taxes.[38]

In the benchmark equilibrium (unlimited liability), domestic deposits are risk-free and hence their gross rate of return is going to be the same as the gross rate of return on the government bonds, R_0^B, which it is assumed to be risk-free, i.e., $\bar{R}_0^D = R_0^B$. More importantly, under limited liability, the equilibrium condition $\bar{R}_0^D = R_0^B$ still holds since domestic deposits are fully protected by deposit insurance. Since domestic utility is linear on D_0 and to avoid any corner solution, it is assumed $R_0^B = \frac{1}{\beta}$. Hence, households are indifferent to the amount they deposit in banks. It follows that the deposit supply facing banks is perfectly elastic at the interest rate of R_0^B.

Notice that the model is in real terms and we implicitly assume that there is a one-to-one relationship between nominal and real interest rates. It is worth mentioning that due to the simplicity of the model, results might be interpreted with caution.

The representative bank funds its risky loans, L_0, with domestic deposits, D_0, foreign deposits D_0^F, and an exogenous initial equity, N_0. This is,

$$L_0 = D_0 + D_0^F + N_0. \tag{2}$$

[35] It is assumed the initial equity is exogenous without abstracting too much from reality since it is well known that to raise new equity is a long-term process and if the bank is going to face binding capital requirements, it will mainly reduce loans rather than increase equity.

[36] In this two-period model, the bank's dividends are identical to bank profits at $t = 1$.

[37] Since firms are owned by risk-neutral domestic households, we multiply Π_1 by the impatient parameter.

[38] In equilibrium Π_0 captures the net cash flow at $t = 0$. In particular, at $t = 0$ banks invest in a risky project the amount of K_0 (negative cash flow), they receive domestic deposits, D_0 (positive cash flow), and also receive foreign deposits, D_0^F (positive cash flow). In other words, in equilibrium $\Pi_0 = -K_0 + D_0^F + D_0$.

We assume foreign investors have an exogenous opportunity cost of R_0^F such that, $R_0^F < R_0^B$, where R_0^F can be interpreted as the gross return of safe foreign government bonds. Since foreign deposits are also fully protected by deposit insurance and foreign investor are risk-neutral, the bank also faces a perfectly elastic supply of foreign debt at the interest rate R_0^F.[39] We further assume the following exogenous borrowing constraint on foreign debt,

$$D_0^F \leq \phi, \tag{3}$$

where $\phi > 0$ is an exogenous parameter. Regarding this assumption, we state the following: First, this foreign borrowing limit can arise due to some informational frictions that might exist between the domestic bank and foreign creditors, but this paper does not model these frictions explicitly.[40] Further, we assume that this friction is independent of the credit risk and hence of the default probability of banks (driven by fundamentals). This implies that this friction exists even with the presence of deposit insurance. In other words, this friction is not related to the government's ability but to its willingness to honor the insurance.

Second, this borrowing limit on only foreign debt captures the plausible assumption that the borrowing limit is tighter on foreign borrowing than on domestic borrowing, i.e., that foreign debt requires relatively more collateral or that this collateral is relatively less available compared with the domestic one (see, e.g., Caballero and Krishnamurthy, 2001). Here, for simplicity, it is assumed an ad-hoc borrowing limit on only foreign borrowing. This is explained because domestic depositors might have more ability than foreign investors to enforce the domestic government to honor their obligations.

The "home bias" puzzle might support this assumption, since it argues that home equity preferences can be explained by information asymmetries between domestic and foreign investors. Coval and Moskowitz (2002) state that investors may have easier access to information about the companies located near them. Local investors can talk to employees, managers, and suppliers of the firm, all of whom may provide them with an information advantage. Choe et al. (2001) find evidence that domestic individual investors have a short-lived private information advantage.

In contrast to the small open economy literature, the exogenous collateral value prevents the constraint from generating further inefficiencies, as in Bianchi (2011), to the one generated by the constraint itself. In other words, the exogenous collateral constraint, proposed in this paper, does not yield any pecuniary externality extensively studied in the literature. For the purpose of this paper, this simple form for the foreign borrowing constraint is convenient since it allows me to focus on the inefficiency caused by the interaction of limited liability and deposit insurance.

4.1. Binding foreign borrowing constraint

Here we solve the model assuming that the foreign collateral constraint binds.[41] As a result, in equilibrium at the margin banks demand domestic deposits and $D_0^F = \phi$.[42]

To clearly explain the distortions created by the interaction of limited liability and deposit insurance, we first show the case where banks have unlimited liability (ULL), which leads to the socially efficient allocation,[43] and then the case with limited liability (LL) and deposit insurance.

Unlimited liability: Bank future profits are the difference between loans payments, $R_1^L L_0$, and deposits payments, $R_0^B D_0 + R_0^F D_0^F$:

$$N_1 = R_1^L L_0 - R_0^B D_0 - R_0^F D_0^F. \tag{4}$$

If future profits are negative, i.e., $N_1 < 0$, bank transfers negative dividends to its owners (households); otherwise, it transfers positive dividends.[44] The representative bank optimally chooses the level of domestic deposits to maximize the expected present value of future profits, $V_0 = \mathbb{E}_0\{\beta N_1\}$, where β is the households' discount factor, subject to (2). The first order condition yields,

$$1 - \delta + \alpha \bar{Z} L_0^{1-\alpha} = R_0^B, \tag{5}$$

where $\bar{Z} = \mathbb{E}_0\{Z_1\}$. Not surprisingly, condition (5) requires that the return of loans (marginal product of capital) equals the marginal cost of loans, R_0^B. Clearly, the domestic interest rate directly affects the marginal cost of loans. As a result, a lower domestic rate increases banks' incentives to supply loans due to the diminishing marginal returns assumption.

Limited liability: While unlimited liability is very far from being a realistic assumption, it leads to the efficient allocation and hence works as our benchmark. When bank faces limited liability, bank's profits (dividends) cannot take negative values, i.e.,

$$N_1 = max\{0, R_1^L L_0 - R_0^F D_0^F - R_0^B D_0\}.$$

For a given L_0 there is going to be a R_1^{L*} such that bank profits are zero,

$$0 = R_1^{L*} L_0 - R_0^B D_0 - R_0^F D_0^F, \tag{6}$$

where in equilibrium,

$$R_1^{L*} = 1 - \delta + \alpha Z^* L_0^{\alpha-1}.$$

This means that if $Z_1 \geq Z^*$, the bank does not default; otherwise, the bank is not able to pay in full deposits and consequently it defaults.[45] It follows that the endogenous bank default probability yields,

$$p_0 = F(Z^*),$$

where Z^* is for convenience is rewritten as,

$$Z^* = \frac{(R_0^B - 1 + \delta)L_0 - R_0^B N_0 - (R_0^B - R_0^F)\phi}{\alpha L_0^{\alpha}}. \tag{7}$$

Since we are interested in the cases of positive default probability, we parametrize the model so that in equilibrium $Z^* > 0$ holds. From (7)

[39] It is assumed that banks can verify if investors are domestic or foreign.

[40] Kiyotaki and Moore (1997), Bianchi (2011) and Mendoza (2010) also introduce a borrowing constraint that aims to capture some financial friction between the domestic economy and foreign creditors. For instance, Bianchi (2011) states that these informational frictions can be associated with monitoring costs, limited enforcement, asymmetric information, and imperfections in the judicial system.

[41] This is, we assume ϕ is low enough. Specifically, the constraint is tight enough so that in equilibrium domestic deposits are positive. In other words, the marginal productivity of capital, when capital is $\phi + N_0$, is higher than the cost of domestic deposits.

[42] There exists $\bar{\phi}_d^{ULL}$ and $\bar{\phi}_d^{LL}$, defined in Appendix G, where $0 < \bar{\phi}_d^{ULL} < \bar{\phi}_d^{LL}$, such that if $\phi \leq \bar{\phi}_d^{ULL}$, the constraint binds and domestic deposits are positive under unlimited liability. If $\phi \leq \bar{\phi}_d^{LL}$, the constraint binds and domestic deposits are positive under limited liability. So I am assuming that $\phi \leq \bar{\phi}_d^{ULL}$. Hence, in equilibrium $D_0^F = \phi$ and $D_0 > 0$ under both ULL and LL. For completeness: Under unlimited liability: if $\bar{\phi}_d^{ULL} \leq \phi \leq \bar{\phi}_u^{ULL}$, $\{ K_0 = \phi + N_0, D_0^F = \phi, D_0 = 0 \}$, i.e., banks do not want to issue any additional unit of loans since its marginal cost, R_0^B, is larger than its marginal benefit (marginal productivity of capital); if $\bar{\phi}_u^{ULL} \leq \phi$, the solution is given by (5). Under limited liability: if $\bar{\phi}_d^{LL} \leq \phi \leq \bar{\phi}_u^{LL}$, $\{ K_0 = \phi + N_0, D_0^F = \phi, D_0 = 0 \}$, i.e., banks do not want to issue any additional unit of loans since its marginal cost, R_0^B, is larger than its marginal benefit (marginal productivity of capital); if $\bar{\phi}_u^{LL} \leq \phi$ the solution is given by (13).

[43] Notice that since we are not removing the binding foreign borrowing limit, this efficient allocation corresponds to the (constrained) social planner.

[44] Negative dividends means that bank's owner needs to put their own money to pay in full the deposits.

[45] When bank defaults, loans payments $R_1^L L_0$ are complemented with government insurance $R_0^F D_0^F + R_0^B D_0 - R_1^L L_0$ such that all depositors are fully repaid.

it is easy to verify that ceteris paribus higher loans (or higher bank leverage) leads to higher bank default probability. Also, ceteris paribus the lower the foreign interest rate or the higher the foreign borrowing limit (or the higher the foreign debt participation), the smaller the bank default probability.

Under limited liability the expected present value of the future profits is,

$$V_0 = \mathbb{E}_0\{\beta\left(max\{0, R_1^L L_0 - R_0^B D_0 - R_0^F D_0^F\}\right)\}. \tag{8}$$

In this case bank cares only about the states of nature where its revenues are higher than all its obligations. Since bank deposit returns are risk-insensitive due to the deposit insurance, the bank cannot internalize the effects of its risk-taking decision through the required return of deposits, R_0^F and R_0^B.[46] The bank seeks to maximize (8) subject to (2). To understand the bank's incentives when there is limited liability and deposit insurance, we rewrite (8) as,

$$V_0 = \mathbb{E}_0\{\beta(R_1^L L_0 - R_0^B D_0 - R_0^F D_0^F)\} + \int_{1-\delta}^{R_1^{L*}} \beta(R_0^F D_0^F + R_0^B D_0 - R_1^L L_0) dF^{R^L}(R_1^L). \tag{9}$$

where F^{R^L} is the cumulative distribution function of R_1^L, which inherits the distributional properties of Z_1. The first term of (9) is the discounted expected final bank profits, given that the bank services its deposits under all circumstances. The second term appears due to the presence of limited liability and deposit insurance. From banks' perspective, this represents an advantage resulting from the fact that the individual bank does not fully service its debt under all circumstances, but only when it does not default. Each time the bank defaults, it can avoid paying back that part of the promised deposit repayment that exceeds its revenues, $R_0^F D_0^F + R_0^B D_0 - R_1^L L_0$, and this advantage (from the bank's perspective) contributes to the final equity to the extent of the probability that it happens, $f^{R^L}(R_1^L)$, for each $R_1^L < R_1^{L*}$. Hence, the first term of (9) delivers the same trade-off discussed in the unlimited liability case and the second term motivates the bank for a higher D_0, since it produces a positive marginal benefit, as is shown later. The first order condition for D_0 yields,

$$\beta(\bar{R}_1^L - R_0^B) + \int_{1-\delta}^{R_1^{L*}} \beta(R_0^B - R_1^L L_0) dF^{R^L}(R_1^L) + \beta(R_0^F D_0^F + R_0^B D_0 - R_1^{L*} L_0) f^{R^L}(R_1^{L*}) \frac{\partial R_1^{L*}}{\partial D_0} = 0.$$

By (6), $R_1^{L*} L_0 - R_0^B D_0 - R_0^F D_0^F = 0$, the optimality condition becomes,

$$\beta(\bar{R}_1^L - R_0^B) + \int_{1-\delta}^{R_1^{L*}} \beta(R_0^B - R_1^L) dF^{R^L}(R_1^L) = 0. \tag{10}$$

It collapses in,

$$\int_{R_1^{L*}}^{+\infty} \beta(R_1^L - R_0^B) dF^{R^L}(R_1^L) = 0, \tag{11}$$

and then, it holds that in equilibrium,

$$1 - \delta + \alpha \bar{Z}^+ L_0^{\alpha-1} = R_0^B, \tag{12}$$

where $\bar{Z}^+ = \mathbb{E}_0\{Z_1 | Z_1 > Z^*\}$. Then, domestic deposits' gross return is higher than the capital marginal productivity when the bank defaults, i.e., $R_0^B - (1-\delta) - \alpha Z_1 L_0^{\alpha-1} > 0$, $\forall\ Z_1 < Z^*$. Then, the second term in (10), is positive and hence an additional marginal benefit of issuing loans from bank perspective.

A comparison between the optimality conditions (5) and (10) shows that the bank's choices are distorted. The first term of (10) in the unlimited liability case gives zero, which yields the optimal decision of domestic debt. However, when there is limited liability and deposit insurance, this decision is no longer socially optimal. This is because increasing the domestic deposits has an additional advantage (additional positive marginal benefit) represented by the second term of (10) due to the fact that banks do not have to fully pay deposits if they default.

Equivalently, from Eqs. (5) and (12), the interaction of bank limited liability and deposit insurance yields that the expected return of bank loans from banks' perspective becomes conditional to non-default. This makes that banks overestimate the marginal benefit of loans (i.e., $\bar{Z}^+ > \bar{Z}$). In other words, since banks do not absorb negative losses and required returns of deposits are risk-insensitive, banks take excessive risk that leads to an inefficiently high level of capital and bank loans.

Notice that from Eq. (12) ceteris paribus the bank default probability increases bank incentives to take risk or to issue excessive loans. The impact on bank risk-taking and on credit through the bank default probability is called the *excessive bank risk-taking channel*.

Our inefficiency measure or excess bank risk-taking measure, which involves credit volume, is the relative difference in loans under LL and under ULL, i.e., $L_0^{LL}/L_0^{ULL} - 1$. We refer to this as relative excess loans.

Implications of the foreign monetary policy and foreign borrowing limit: According to (12) the foreign interest rate has no direct effect on the marginal cost of loans since at the margin the last source of funding is domestic deposits; while it might affect credit only indirectly through its effect on bank default probability, Eq. (7). A higher foreign interest rate leads to higher excess bank risk-taking, or to higher excess bank loans. This is because the higher foreign rate increases banks' obligations and hence bank default probability. This in turn increases the marginal return of loans conditional to non-default. In other words, the overestimation of marginal benefits of loans from banks' perspective is increased. With this, banks are going to have more incentives to issue more excessive credit. In addition, the size of the impact of the foreign rate on bank default probability depends on the foreign deposit participation. This leads to the following proposition.

Proposition 1. *In an open economy with a binding foreign borrowing constraint*[47]*:*

1. *A lower (higher) foreign rate decrease (increases) bank default probability and excessive bank risk-taking, and thus relative excess loans.*
2. *A higher foreign deposit participation increases the impact of the foreign interest rate on bank default probability and hence on excessive bank risk-taking.*

Proposition 1.1 is aligned with the empirical findings in Section 3.3, where if the foreign borrowing limit binds (financially closed economy), the foreign policy rate increases bank risk-taking. In addition, Proposition 1.2 is also in line with the empirical findings in Section 3.3, where capital to RWA ratio is used as the bank risk-taking measure (see Table 3). Consequently, according to our model, *the excessive risk-taking channel* drives these empirical results.

Similarly, regarding the foreign borrowing limit, we can state the following proposition:

[46] In other words, a higher loan level, which increases bank default probability, is not going to increase the deposit returns and hence it does not reduce the bank's profits when the bank does not default. In the absence of deposit insurance, deposit returns are risk-sensitive and hence V_0 looks like as in the case of unlimited liability. As a result, the optimality condition under limited liability and in the absence of deposit insurance is going to be the same, as under unlimited liability, i.e., in this two-period framework the limited liability by itself does not create any inefficiency in this two-period model. Appendix H shows that the bank maximization problem under limited liability and non-deposit insurance is equivalent to the maximization problem under unlimited liability in this two-period model.

[47] The proof is in Appendix C.

Proposition 2. *A higher (lower) foreign borrowing limit reduces (increases) bank default probability since banks are more (less) able to substitute expensive domestic deposits for cheap foreign deposits. This in turn increases banks' incentives to take excessive risk and thus relative excess loans.*[48]

This proposition is also aligned with our empirical results in Section 3.2, where if the limit binds (financially closed economy), the foreign debt participation reduces bank risk-taking. Again, the explanation of the empirical finding according to our theoretical model is the presence of an *the excessive risk-taking channel*.

The magnitude of the effects of the foreign borrowing limit depends essentially on the difference between the domestic and the foreign risk-free interest rates. It is expected that a higher spread generates greater savings from substituting domestic deposits for foreign deposits and hence the stronger the reduction of bank's obligations. This yields a stronger reduction in excess bank risk-taking.

Implications of the domestic monetary policy: Under unlimited liability, a higher domestic interest rate clearly reduces bank loans. This is because a higher domestic rate directly increases the marginal cost of loans, as suggested in (5).

Under limited liability, according to (12), there is also a direct impact of the domestic interest rate on the effective marginal cost of loans. The novelty, under limited liability, is the impact of R_0^B and the general equilibrium effects of credit on bank default probability. On the one hand, for a given loan level a lower domestic rate reduces bank obligations and hence bank default probability; while on the other hand, the higher credit (caused by the direct impact of domestic rate on marginal cost of loans) produces the opposite effects on bank default probability. As a result, the effect of domestic rate on excessive bank risk-taking seems ambiguous. For realistic calibrations in Section 5, we find that a higher domestic rate increases bank loans, raises bank default probability and hence excessive bank risk-taking.[49]

Results suggest that the general equilibrium effect of bank loans on bank default probability dominates and hence a higher domestic interest diminishes excessive bank risk-taking. In other words, due to the *excessive bank risk-taking channel* credit increases faster under limited liability than under unlimited liability after a domestic interest rate cut. We can summarize the results in,

Proposition 3. *Under a realistic calibration, in an open economy with a binding foreign borrowing constraint*[50]*:*

- *After an (a) expansionary (contractionary) domestic monetary policy, bank default probability increases (decreases), which in turn increases (reduces) bank risk-taking incentives to take excessive risk and hence to supply excessive loans.*
- *The higher the domestic debt participation, the stronger the impact of the domestic rate on bank profits. As a result, the weaker the negative impact of the domestic rate on bank default probability and hence on excess bank risk-taking.*

Implications of bank net worth: It is worth mentioning the implications of bank net worth on bank credit and bank risk-taking. Ceteris paribus, a lower capitalization (N_0) leads to higher bank profits, which in turn reduces bank default probability and bank incentives to take excessive risk. This in turn reduces bank credit. In other words, ceteris paribus a lower capitalization leads to a higher bank leverage and to a lower capacity to absorb losses and hence the higher the bank default probability.[51]

[48] The proof is in Appendix D.

[49] In general, it is difficult to solve for the signs of the partial derivatives on capital and excess bank risk-taking, so we look for numerical solutions.

[50] Appendix E discusses the issues to analytically prove this proposition.

[51] The proof is presented in Appendix F.

4.2. Non-Binding foreign borrowing constraint

For illustrative purposes, in this subsection we assume that the foreign collateral constraint is not binding.[52] Since by assumptions $R_0^B > R_0^F$ and assuming that banks cannot lend to domestic depositors,[53] $D_0 = 0$ and then bank loans are funded only by bank initial equity and foreign deposits.

Under limited liability bank future profits become $N_1 = max\{0, R_1^L L_0 - R_0^F D_0^F\}$. Bank's goal is to maximize the expected present value of future profits, $V_0 = \mathbb{E}_0\{\beta N_1\}$. The first order condition yields,

$$1 - \delta + \alpha \bar{Z}^+ L_0^{1-\alpha} = R_0^F \tag{13}$$

where,

$$Z^* = \frac{R_0^F D_0^F - (1-\delta)L_0}{\alpha L_0^{\alpha}},$$

where $L_0 = D_0^F + N_0$.[54] In contrast to the binding foreign borrowing constraint, Eq. (5), in this case the marginal cost of funding is the foreign interest rate. As a result, movements of the foreign rate directly affect the marginal cost of funding.

As in the case of the domestic interest rate when the foreign borrowing limit binds, the foreign interest rate not only affects bank default probability but also directly affects the marginal cost of loans. In other words, the foreign rate affects, directly and indirectly, the marginal cost of funding and capital level in a similar way as the domestic interest rate does in a closed economy. As a result, we can state that,

Proposition 4. *Under a realistic calibration in an open economy with a non-binding foreign borrowing constraint*[55]*:*

- *An (a) expansionary (contractionary) foreign monetary policy, bank default probability increases (decreases), which in turn (increases) reduces bank risk-taking incentives to take excessive bank risk-taking and hence to supply excessive loans.*
- *The higher the foreign debt participation, the stronger the impact of the foreign rate on bank profits. As a result, the smaller the negative impact of the foreign rate on bank default probability and hence on excess bank risk-taking.*

From this subsection and the previous one, our model suggests that the driver of any positive relationship between the cost of foreign deposits and excess bank risk-taking and any negative relationship between the foreign borrowing limit (or access to foreign borrowing) and excess bank risk-taking, is the presence of a binding foreign borrowing limit. Quantitatively, these relationships depend, respectively, on the foreign borrowing limit and on the spread between the domestic and the foreign interest rates. In fact, banks' higher foreign debt participation and higher spreads are expected to be observed mainly in capital inflows, which are very common in emerging economies (see, e.g., Calvo and Leiderman, 1996; Ahmed and Zlate, 2014; Avdjiev et al., 2017).[56]

In line with our empirical results in Section 3.2, we find that when the foreign borrowing limit does not bind (measured in the empirical model, with the financial openness), foreign debt participation is positively associated with bank risk-taking.

In addition, according to our model the fact that the likelihood that the foreign borrowing constraint does not bind (or the higher the

[52] Note that there exist $\bar{\phi}_u^{ULL}$ and $\bar{\phi}_u^{LL}$, defined in Appendix G, where $0 < \bar{\phi}_u^{ULL} < \bar{\phi}_u^{LL}$ such that if $\bar{\phi}_u^{ULL} < \phi$, the foreign borrowing constraint does not bind under unlimited liability; otherwise, it does. If $\bar{\phi}_u^{LL} < \phi$ the foreign collateral constraint does not bind under limited liability; otherwise, it does.

[53] We also assume that the bank cannot be a net lender to domestic depositors, i.e., $0 \leq D_0$. This could be because it is difficult to monitor domestic depositors directly and they prefer to invest in firms or projects where financial information is more public. The previous condition ensures that for high values

Table 5
Parameters.

Description	Parameter	Value	
Risk-free foreign interest rate	R_0^F	1.01	Kydland and Prescott (1982) and Prescott (1986)
Capital's share in output	α	0.33	Standard value
Capital depreciation rate	δ	0.20	
Parameters set to match the data			*Targeted to match*
Discount of domestic HHs	β	0.984	Annualized spread, $R_0^B - R_0^F$, of 2.5%
Foreign borrowing collateral	ϕ	0.528	Foreign debt ratio of 33%
Initial level of bank's equity	N_0	0.353	Bank leverage ratio of 5.5
Std. Dev. of $\ln(Z_1)$	σ_z	0.724	Annualized bank default probability of 3.5%

Table 6
Average real and financial indicators across countries by regions and income groups.

	Obs	All	HI	UMI	LMI	LI	LAC	MENA	SSA	ECA	EAP	NA	SA
Financially open countries: $KA \leq 0.60$													
Period: 2001–2017													
Leverage	988	6.73	7.08	6.16	6.19	4.89	6.56	6.31	5.75	6.97	7.16	7.21	–
BankCred-GDP (%)	1104	68.5	92.7	32.4	26.2	9.3	36.1	55.4	28.7	88.3	110.3	74.9	–
ForDebt part (%)	447	47.2	47.6	45.4	–	–	33.1	37.6	32.4	56.1	34.0	34.9	–
Real spread (%)	789	2.40	2.32	2.95	1.85	–	2.53	1.70	2.79	2.55	2.02	1.31	–
Period: 1995–2017													
Prob. Banking crisis* (%)	1516	9.17	9.97	9.09	7.43	1.92	7.96	0.47	5.97	14.80	4.22	10.87	0.00
Capital depreciation rate (%)	1516	4.10	4.01	4.04	4.74	3.82	4.13	4.78	4.37	3.85	4.02	3.74	4.68
Financially closed countries: $KA > 0.60$													
Period: 2001–2017													
Leverage	891	6.05	5.80	5.85	6.66	5.36	6.29	6.90	6.05	5.47	5.92	–	7.42
BankCred-GDP (%)	1906	33.9	58.5	44.1	28.2	11.0	46.3	38.6	16.2	42.4	48.5	–	33.0
ForDebt part (%)	197	47.3	57.7	38.8	91.6	–	43.5	95.6	36.5	59.7	34.6	–	–
Real spread (%)	779	2.71	2.38	2.08	2.23	5.00	2.55	0.26	4.11	2.74	1.95	–	0.53
Period: 1995–2017													
Prob. Banking crisis (%)	3383	3.07	2.29	2.85	3.80	3.41	2.07	0.37	3.20	5.42	3.29	0.00	0.00
Capital depreciation rate (%)	2555	4.43	4.20	4.61	4.63	4.05	4.10	4.34	4.55	3.70	5.48	6.74	4.96

Table shows the average of some indicators at the country-year level. KA: Overall index of capital controls on both inflows and outflows from Fernández et al. (2016): It goes from 0 to 1. 0: no restrictions, and 1: restrictions on all types of international transactions. This data is available for the 1995–2017 period. Leverage: Bank risk-weighted assets to capital. ForDebt Part (%): International private debt securities to domestic and international private debt securities. Real spread: average-period domestic policy rate – domestic inflation – average-period shadow policy rate for the U.S. economy + USA inflation. Shadow policy is taken from Wu and Xia (2016). Prob. Banking Crisis: Annual probability of being in a Banking Crisis. We build these using the Systemic Banking Crisis Database of Laeven and Valencia (2020). The full database covers the 1970–2017 period for 214 countries. An indicator at country-year level takes value of 0 if there is not a banking crisis and 1 if there is a banking crisis. The banking crisis probability for each country is then built by taking the average to this indicator across time. However, we focus on the 1995–2017, due to availability of KA information. *If we assume that in this period the country-year observations that do not have KA information have a KA ≤ 0.60, then bank default probability is 4.6% smaller on average. Capital depreciation rate is the average depreciation rate of capital stock of the Penn World Table 10.0 from Feenstra et al. (2015). It contains information for 183 countries between 1950 and 2019. Obs.: Number of country-year level observations. HI: High income. UMI: Upper middle income. LMI: Lower middle income. LI: Low income. LAC: Latin America & Caribbean. MENA: Middle East & North Africa. SSA: Sub-Saharan Africa. ECA: Europe & Central Asia. EAP: East Asia & Pacific. NA: North America. SA: South Asia. Source: IMF, World Bank. Outliers: We do not include leverage ratios higher than 25, credit to GDP ratios higher than 800%, and real spreads lower than −70%.

financial openness) diminishes the positive impact of the foreign policy rate on bank risk-taking, is driven by the existence of the *excessive risk-taking channel*.

5. Quantitative analysis

5.1. Parameters values

We parametrize the open economy model with limited liability and deposit insurance with a binding foreign borrowing limit. The foreign risk-free gross interest rate, R_0^F, is calibrated following the suggestion of Kydland and Prescott (1982) and Prescott (1986) for the annual real interest rate in the US, i.e., we set $R_0^F = 1.04^{1/4}$. The capital's share in output is set to 0.33, which is a standard value in the literature. We set our quarterly capital depreciation rate to 20%, which is higher than the literature,[57] to avoid an explosive response of credit, but later we perform a robustness analysis.[58] Table 6 reports the average of real and financial indicators for (financially open and closed) countries grouped by income level and geographic location. We use those values as references. We consider the overall index of capital controls on both inflows and outflows (KA) of Fernández et al. (2016) to define

of ϕ, the bank cannot exhaust all their foreign debt capacity and hence cannot make profits by borrowing from abroad and lending to domestic depositors.

[54] As when the foreign borrowing limit binds the level of capital and bank loans is going to be inefficiently high when banks face limited liability since under unlimited liability bank loans are solved in $1 - \delta + \alpha \bar{Z} L_0^{1-\alpha} = R_0^F$.

[55] The proof follows the same spirit and hence proof issues of *Proposition* 3.

[56] Calvo and Leiderman (1996) highlights that one cause for capital inflows is the sustained decline in the world interest rate. Ahmed and Zlate (2014) state that interest rate differentials are a determinant of private capital flows to emerging economies. Avdjiev et al. (2017) find that the bank's external borrowing is procyclical.

[57] From Penn World Table version 10.0 of Feenstra et al. (2015) we find an average annual capital depreciation rate of 4.10% for countries that we define as financially open in Table 6.

[58] As reported in Appendix I the smaller the depreciation rate the stronger the response of credit after domestic interest rate movement. Later, we provide an explanation for this. In order to ensure a positive default probability, in the worst state of nature bank revenues must be smaller than bank obligations, i.e., $\delta > 1 - R_0^B + (R^B - R_0^F)(1/(1/For\_share - 1))(1/(Lev)) + R_0^B(1/Lev)$, where For_share = foreign debt to total bank debt ratio and Lev = bank loans to bank net worth ratio. This yields a lower bound for δ. Indeed, the lower bound for our annualized δ results higher than the observed in the data.

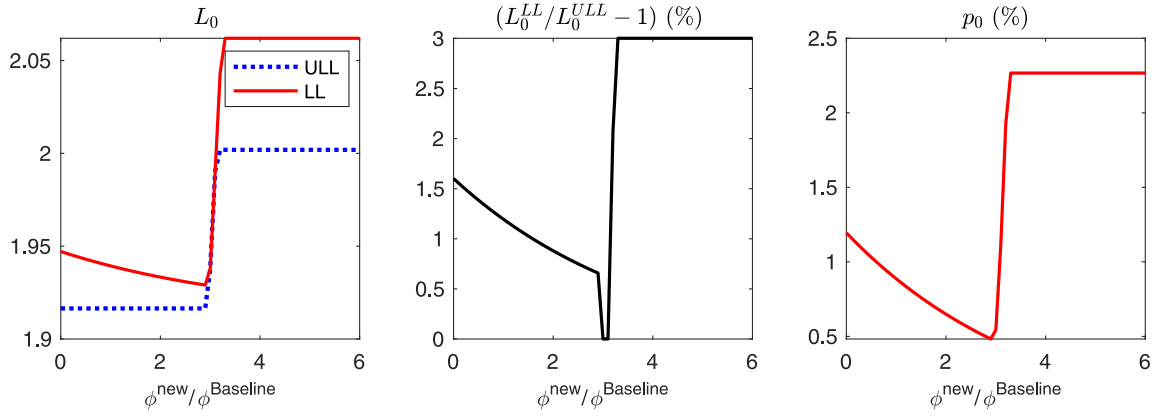

Fig. 1. Non-binding and binding foreign borrowing limit. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

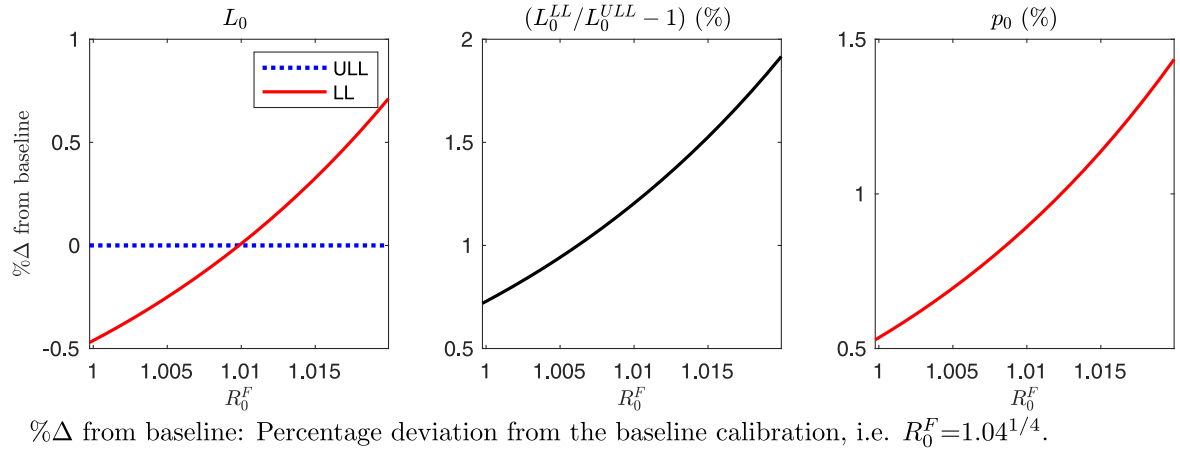

Fig. 2. Foreign monetary policy and binding foreign constraint.

an economy as financial open (KA ≤ 0.60) or closed (KA > 0.60).[59] The domestic households' discount factor, β, is set to 0.984, which is a relatively standard value in the literature, in order to obtain an annualized real interest rate differential, $R_0^B - R_0^F$, of 2.5%, which is close to the average of upper middle-income countries and higher than in other countries group that we consider as financially open. It is assumed that $\mu_z = -0.5\sigma_z^2$ so the unconditional mean of the productivity is zero. Thus, σ_z will only affect the volatility of the productivity and will help us to calibrate the size of the bank default probability.

The other three parameters, { ϕ, N_0, σ_z }, are set to make the following three variables of the model consistent with average data for financially open economies during the 2001–2017 period, reported in Table 6: bank leverage ratio (L_0/N_0), foreign debt participation ratio ($D_0^F/(D_0 + D_0^F)$), and bank default probability (p_0).

Bank initial net worth, N_0, is calibrated to obtain a bank leverage equal to 5.5. This is clearly higher than the average for financially open economies, but most importantly this is consistent with its trend according to figure 7 in Appendix J. Bank leverage has slowly declined since the 2008 global financial crisis. This results in $N_0 = 0.353$. The foreign borrowing limit, ϕ, is set to obtain a foreign debt participation of 33%. This is similar to the average of the regions except for countries in the ECA. It results in $\phi = 0.528$. Finally, σ_z is set to have an annual bank default probability of 3.5% (or a quarterly bank default probability of 0.89%).[60] This is a conservative value with respect to the bank crisis probability built from the database of Laeven and Valencia (2020) and reported in Table 6. In particular, in terms of income level, this is only higher than for low-income countries. This results in $\sigma_z = 0.724$. Calibration is summarized in Table 5. It gives us a credit to GDP ratio of 38.9%, which is smaller than in the data, and bank loans being 1.19% inefficiently high.

5.2. Numerical results

Fig. 1 shows the equilibriums when the foreign borrowing limit takes values from 0 to 5 times its baseline value in order to observe when foreign borrowing constraint binds and when it does not. Under limited liability and deposit insurance (red solid line) bank loans are inefficiently higher whatever the binding status is.[61] We can also observe that when the foreign borrowing constraint does not bind, the bank default probability and the relative excess loans are higher than when the constraint binds. This is because when the borrowing constraint does not bind, the marginal cost of loans is R_0^F rather than R_0^B and hence smaller. According to Fig. 1 when foreign borrowing limit binds, greater access to the international credit market reduces excess bank risk-taking and hence excessive loans. As the economy is

[59] This is a *de jure* measure. The index goes from 0, representing no restrictions, to 1, representing restrictions on all types of international transactions. The higher the KA, the stricter the capital controls.

[60] The quarterly bank default probability p_0 of the model is found in the following equation $3.5\% = p_0\left[1 + (1-p_0) + (1-p_0)^2 + (1-p_0)^3\right]$.

[61] Only when $\bar{\phi}_d^{LL} \leq \phi \leq \bar{\phi}_u^{ULL}$ bank loans under both LL and ULL are identical and equal to $\phi + N_0$.

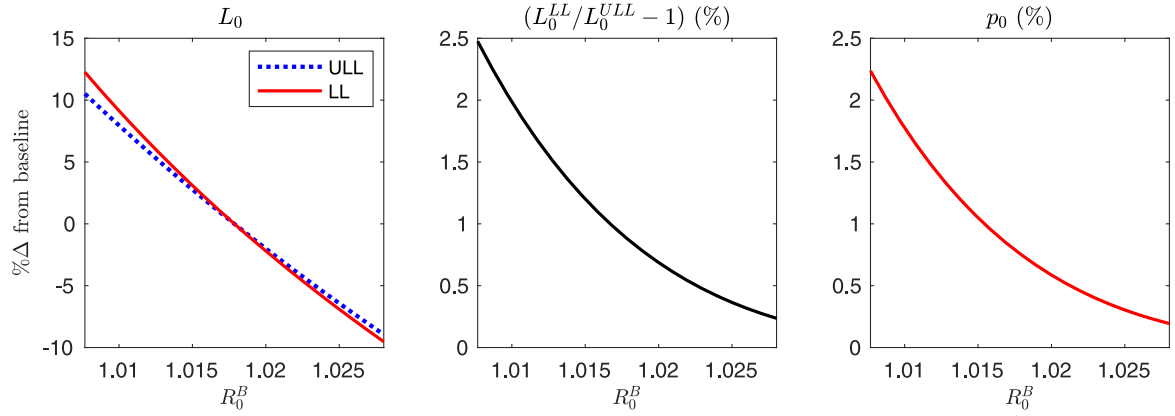

Fig. 3. Domestic monetary policy and binding foreign constraint.

more open, at some point, the foreign constraint is no longer binding and thus the foreign borrowing limit does not affect bank risk-taking decisions. Quantitatively, a 100% increase in the foreign borrowing limit decreases bank loans by 0.31%, reduces (quarterly) bank default probability by 24 bps, and diminishes relative excess loans by 22 bps.

The effects of the foreign interest rate in an economy with a binding foreign borrowing constraint are reported in Fig. 2. Under unlimited liability, foreign interest rate does not affect bank risk-taking and loans decisions; while under limited liability a lower foreign rate decreases bank incentives to take excess risk and hence reduces relative excess loans. Quantitatively, under limited liability a 100 bps (annualized) reduction in the foreign rate reduces bank loans by 0.13%, decreases (quarterly) bank default probability by 11 bps and reduces relative excess loans by 14 bps.

Fig. 3 shows the results for the domestic rate movements. The lower domestic rate increases bank credit, which in turn drives the increase in bank default probability and in bank incentives to take excessive risk. Quantitatively, a 100 bps (annualized) reduction in the domestic interest rate increases bank loans by 2.36%, raises (quarterly) bank default probability by 43 bps and increases relative excess loans by 57 bps.

Finally, according to Appendix I our results are qualitatively speaking robust to different values of capital depreciation rate, target bank leverage and target bank default probability.

6. Conclusions

This paper studies empirically the impact of foreign shocks on bank risk-taking in emerging economies. We do so in a country panel model over the 2001–2017 period. Using different measures from the literature for bank risk-taking, financial openness and foreign debt participation, we find if anything that the lower the financial openness in an economy, the higher the likelihood that foreign debt participation reduces bank risk-taking and that foreign interest rate increases bank risk-taking. Interestingly, we find some evidence that the domestic policy rate might have a positive effect on bank risk-taking. And when assessing the implications of domestic debt participation on the effect of the domestic policy rate on bank risk-taking, results are not robust. Interestingly, we find evidence that after a contractionary monetary policy, countries that are more financially constrained are more willing to take more risk.

To rationalize our empirical results we develop a two-period partially open economy model with domestic and foreign investors, and domestic banks subject to a binding foreign borrowing limit. The interaction of bank limited liability and deposit insurance leads to excessive bank risk-taking, which involves the volume of credit. The novel result, aligned with our empirical findings, but in contrast to what is commonly suggested in the theoretical literature, is that under a realistic calibration a lower foreign interest rate reduces excessive bank risk-taking. Similarly, the model suggests that a higher foreign borrowing limit reduces excessive bank risk-taking. However, as our empirical results suggest, when the foreign borrowing limit does not bind, the lower foreign rate increases bank risk-taking.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jfs.2023.101136.

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