Lender Concentration of External Debts and Sudden Stops

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Abstract

This paper studies how the lender structure of external debts affects international credit through a model with various lender sizes. While atomistic lenders take prices as given, large lenders internalize the pecuniary externality whereby selling collateral reduces the collateral price. Thus, concentrating debt among large lenders maintains the collateral price during downturns, leading borrowers to demand less precautionary savings and overborrow. I document that emerging countries borrow from fewer US banks, implying that emerging countries tend to overborrow. This mechanism complements the existing view of overborrowing due to borrowers' pecuniary externalities. Optimal lender concentration raises debt and improves borrower's welfare.

Keywords: Sudden stops; Pecuniary externality; Overborrowing; Lender structure.

JEL Codes: F34, F41.

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1 Introduction

It is often argued that the pecuniary externality driven by borrowers' decisions causes inefficiency and should be internalized. However, a pecuniary externality can also be internalized by lenders during collateral foreclosure when borrowers fail to repay debt. Specifically, lenders who own a large share of debt may be reluctant to foreclose on collateral entirely because they understand that selling foreclosed collateral injects asset supply and reduces the collateral price. Thus, a more concentrated lender structure leads to fewer foreclosures and a higher equilibrium collateral price (Favara and Giannetti, 2017). Since the open-economy literature has focused on pecuniary externalities that stem from borrowers' decisions, this paper aims to fill the gap by emphasizing the lender side of external debt.[1] Specifically, I ask how lender concentration affects overborrowing of external debt and how allowing lender countries to choose the lender structure optimally affects borrowers' welfare.

This paper begins by documenting two new empirical facts about lender concentration of external debt using the quarterly exposure of individual US banks to the external debts of other countries. First, the lender concentration of the external debt of emerging countries has been considerably higher than that of rich countries since the Global Financial Crisis (GFC). Second, the lender concentration of the external debt alleviates sudden stop events, characterized by abrupt drying up of capital inflows, in terms of the magnitude of the current account reversal. These empirical facts provide a possible explanation for overborrowing due to lender structure: emerging countries tend to overborrow more because a more concentrated lender structure alleviates the severity of crises, thus demanding less precautionary saving.

To analyze the effect of lender concentration on overborrowing, this paper incorporates two new features into a standard SOE-DSGE with a continuum of identical domestic borrowers constrained by an occasionally binding collateral constraint. First, as in practice, borrowers may consume collateral only when debts are repaid. Second, when borrowers do not repay, lenders optimally choose how much collateral to foreclose on. Under these two assumptions, the lender structure affects the borrowers' credit conditions by supplying

[1] A recent illustrative case highlighting the impact of foreclosure on collateral associated with external debt, as opposed to mortgage debt, is the foreclosure event that followed the defaults by Venezuela's state oil firm, PDVSA, in 2017 and 2019. PDVSA had used its shares in its U.S. subsidiary, CITGO, as collateral for a 1.5 billion USD (1.3% of Venezuela's GDP in 2016) external loan from the Russian company Rosneft in 2016. The U.S. court scheduled the auction of PDVSA's collateralized shares for October 2023. The Venezuelan government tried to halt the auction to prevent substantial decline in the collateral price. However, these efforts were dismissed by the court.

foreclosed collateral that controls the collateral price.

These assumptions contrast those in the literature concerning the open economy models with collateral constraints, which assume that agents can entirely consume all goods that serve as collateral before the debts are repaid. In these models, agents always borrow less than or equal to the borrowing capacity unaffected by foreclosure. Thus, the effects of lenders' decisions on foreclosing collateral are muted.[2] These effects are especially important for emerging countries because they tend to rely more on secured borrowing that involves collateral (Menkhoff et al., 2006).

There are two types of lenders: atomistic lenders who take the collateral price as given, and one large lender who internalizes the pecuniary externality of foreclosing on collateral. During foreclosure events, atomistic lenders sell all the seized collateral, whereas the large lender sells only a fraction of the seized collateral to maintain the collateral price. Thus, when the large lender owns a larger share of external debts (i.e., a more concentrated lender structure), the rate of foreclosure sales to total seized collateral (hereafter, the foreclosure rate) is lower. With less seized collateral sold by lenders, agents allocate more resources to noncollateralizable goods and the collateral price increases. Depending on the lender-specific expected repayments in foreclosure and no-foreclosure states, the two types of lenders then charge the endogenous interest rates.

To study how lender concentration affects overborrowing, measured as the gap between the borrowing decisions in the competitive equilibrium (CE) and the maximization problem of the social planner (SP), I demonstrate how lender concentration affects the two equilibria separately. First, I show that lender concentration increases the agent's borrowing in the CE, both in states with foreclosure and without foreclosure. In foreclosure states, the lender concentration increases agents' debt holdings by alleviating the price reduction, thereby raising borrowing capacity. This mechanism also raises agents' current debt decisions in no-foreclosure states because lender concentration maintains consumption and borrowing capacity in future foreclosure states, diminishing the precautionary motive.

In addition to the above mechanism, the SP's debt decisions can be affected by two additional channels. The normative perspective considered in this model is an SP facing the same collateral constraint and internalizing how current debt holding affects the endogenous

[2] Although Mendoza (2010) argues that a collateral haircut may be viewed as limited enforcement (soft default) when borrowers default, such enforcement is not endogenously determined by lenders.

collateral price and interest rate. In foreclosure states with a binding collateral constraint, lender concentration may alter the SP's debt decision by affecting the nominal tightness of the collateral constraint. The impact can be ambiguous since the lender concentration increases the collateral price while loosening the collateral constraint. Additionally, lender concentration can influence the SP's debt decision through the pecuniary externality associated with the interest rate, depending on how lender concentration affects the expected repayment from foreclosed collateral, which determines the interest rate set by the lenders. The effect of lender concentration on the expected repayment is also ambiguous because, while lender concentration increases the expected repayment by increasing the price of foreclosed collateral, it also decreases the expected repayment by lowering the foreclosure rate.

With the theoretical results in hand, I conduct a numerical analysis by calibrating the model to data from Argentina, a small open economy prone to sudden stops. Consistent with the literature, the numerical result shows that decentralized agents overborrow because of pecuniary externalities. With higher debt holdings, agents in the CE encounter foreclosure with a probability of 2%, during which the large lenders choose to sell a third of the seized collateral. However, foreclosure never occurs in the SP's allocation. The difference between the SP's problem and CE implies that allowing the large lender to internalize the pecuniary externality is insufficient to achieve the SP's allocation.

Then, I highlight the numerical importance of lenders in internalizing the pecuniary externality by separately quantifying the magnitude of the pecuniary externality internalized by lenders and borrowers. To this end, I compare the credit allocation in three equilibria. The first equilibrium is the SP's allocation, where both lenders and borrowers internalize the pecuniary externality. The second equilibrium is a decentralized equilibrium where only the large lender, not the borrowers, internalizes the pecuniary externality. The third equilibrium is a decentralized equilibrium in which the large lender forecloses on all the collateral, similar to the atomistic lenders. In this case, both borrowers and lenders fail to internalize the pecuniary externality. The result shows that the pecuniary externality internalized by lenders is two-thirds of the typical pecuniary externality internalized by borrowers.

Next, I numerically study the effect of lender concentration on debt allocation in the decentralized equilibria and the SP's problem. Consistent with the theoretical predictions, the decentralized agents' debt decision increases with lender concentration. However, the debt decision in the SP's problem is independent of changes in lender concentration, as foreclosure events never occur. Thus, measuring the gap between the two debt decisions, we observe that overborrowing is increasing in the lender concentration. This result aligns with the numerical evidence that debt capacity is considerably supported by lender concentration in foreclosure states, reducing decentralized agents' precautionary savings.

Finally, in light of the discussion since the COVID-19 pandemic on concentrating lender structure akin to the Brady Plan in the late 1980s to combat the increasing coordination problem among dispersed lenders, I consider the welfare implications of allowing lenders to optimally choose the lender structure. To gain higher repayment from the seized collateral, the lender countries would choose to further concentrate the existing lender concentration. Benefiting from a more concentrated lender structure, domestic agents consume and borrow more, thus encountering sudden stop events with a higher probability. However, owing to more frequent debt deleveraging in sudden stops, agents completely avoid foreclosure events. Compared with the baseline CE, allowing lender countries to choose the optimal concentration increases the borrower country's consumption-equivalent welfare by 1.53%, implying that managing lender structure benefits both sides of the international credit market.

Related Literature

This paper is related to a large and growing literature on the open economy models with pecuniary externalities that can be internalized by borrowers. Selected works include Coulibaly (2023), Benigno et al. (2023), Schmitt-Grohé and Uribe (2021), Chi et al. (forthcoming), Jeanne and Korinek (2019), Schmitt-Grohé and Uribe (2018), Bianchi and Mendoza (2018), Benigno et al. (2016), Benigno et al. (2013), Bianchi (2011), and Uribe (2006). This paper complements the literature by incorporating a large lender who also internalizes the pecuniary externality.

Several studies have focused on the relationship between lender concentration and external debt. Fernández and Ozler (1999) empirically find that lender concentration raises the secondary-market prices of external debt. They develop a model where lenders threaten countries with a costly penalty, which becomes more credible as large lenders obtain higher repayment because of the higher concentration. Thus, debt repayment and debt prices increase in concentration as more repayments are guaranteed. Using country-level data, Hardy (2019) documents that lender concentration of external debt among cross-country banking systems has been increasing in emerging economies since the GFC. Afonso et al. (2013) document that banks in the U.S. overnight interbank market tend to form concentrated lending relationships so that borrowers are insulated from a sharp increase in interest rates under adverse liquidity shocks. This paper contributes to the literature by emphasizing the mechanism of foreclosure decisions that affect debt holdings in downturns.

Finally, this paper relates to the vast literature on optimal creditor concentration. Bolton and Scharfstein (1996) analyze the optimal number of creditors by considering the tradeoff in inefficient renegotiation between deterring defaults and incurring costs. Bolton and Jeanne (2009) further study the coordination problem under a dispersed lender structure in the context of renegotiating sovereign defaults. More recently, Zhong (2021) derives the optimal lender concentration in a dynamic framework by considering the tradeoff between rollover risk due to coordination problems and the incentive for repayment. This paper differs from the literature by emphasizing a novel effect of the lender structure that affects efficiency via pecuniary externalities. Thus, policies such as collective action clauses intended to alleviate the coordination problem of debt restructuring may be insufficient to fully decentralize the impact of the lender structure.

The remainder of this paper is organized as follows. Section 2 presents the empirical patterns of lender structure among emerging and advanced countries and discusses their implications for overborrowing. Section 3 introduces the model and discusses the mechanism by which the lender structure affects overborrowing. Section 4 provides numerical analyses of the model and quantifies the effect of the lender structure. Section 5 studies the outcome for the borrowing countries when the lender countries optimally choose the lender structure. Finally, Section 6 concludes the paper.

2 Lender Structure in the Data

This section empirically demonstrates that the lender structure of emerging countries' external debts is more concentrated. Furthermore, lender concentration alleviates sudden stop events in terms of the magnitude of capital reversal. These results lead to a fundamental implication: Large lenders to emerging countries internalize the pecuniary externality and alleviate sudden stop events, entailing less precautionary savings and more overborrowing by emerging countries.

The data on lender concentration come from the Federal Financial Institutions Examination Council's (FFIEC) 009a form that collects the quarterly exposure of individual US banks to the external debts of other countries from 2003Q1 to 2022Q2. According to FFIEC

Table 1: Concentrations for lenders of external debts

Borrower	μ_{num}	p^{50}_{num}	σ_{num}	μ_{L1}	p^{50}_{L1}	σ_{L1}	μ_{L3}	p^{50}_{L3}	σ_{L3}
Emerging countries	3.59	4	1.39	0.69	0.69	0.16	0.95	0.97	0.06
Argentina	3.59	3	1.54	0.76	0.74	0.16	0.97	1.00	0.04
Brazil	9.18	9	2.30	0.69	0.69	0.16	0.95	0.97	0.04
Colombia	4.68	5	0.92	0.49	0.47	0.11	0.91	0.94	0.06
Ecuador	3.55	4	1.23	0.63	0.57	0.17	0.95	0.96	0.06
Guatemala	3.49	3	1.39	0.56	0.50	0.21	0.93	1.00	0.10
Israel	1.92	2	0.77	0.75	0.73	0.20	1.00	1.00	0.00
Mexico	8.78	9	1.96	0.75	0.80	0.21	0.93	0.97	0.08
Panama	3.15	3	0.97	0.69	0.71	0.14	0.98	1.00	0.04
Venezuela	6.46	7	1.48	0.38	0.34	0.09	0.79	0.78	0.08
Rich countries	11.83	11.5	1.98	0.38	0.28	0.16	0.74	0.69	0.12
Canada	16.99	15.5	5.86	0.32	0.23	0.17	0.63	0.58	0.16
France	12.15	12	1.78	0.35	0.28	0.16	0.73	0.69	0.12
Germany	12.91	13	1.68	0.32	0.28	0.11	0.71	0.66	0.13
Japan	11.50	11	4.42	0.41	0.27	0.24	0.75	0.68	0.16
Netherlands	7.90	8	2.17	0.63	0.63	0.17	0.93	0.94	0.06
Singapore	2.08	2	0.77	0.90	0.94	0.11	1.00	1.00	0.00
Switzerland	6.38	6	1.76	0.70	0.68	0.17	0.98	0.99	0.03
United Kingdom	22.31	22	4.01	0.31	0.25	0.15	0.61	0.58	0.12

Notes: This table lists the mean (μ), median (p^{50}), standard deviation (σ) of the quarterly data on the number of lenders (num), share of the top-1 lender ($L1$), and total share of the three largest lenders ($L3$). The moments of emerging and rich countries are the median across countries. The data are a balanced panel ranges from 2003Q1 to 2022Q2. Classification of emerging and rich countries follows Schmitt-Grohé and Uribe (2017). Figure A.3 in the Online Appendix visualizes the median external debts held by top holders. Source: FFIEC 009a.

(2019), the exposure to external debt is defined as the sum of the amount of cross-border claims outstanding after mandated adjustments for transfer, the amount of foreign office claims on local residents, and the amount of gross claims outstanding from derivative products after mandated adjustments for transfer of exposure. The types of cross-border claims include, but are not limited to, cash, deposit balances held at banks, securities, and loans. Exposure is measured as claims on the basis of the country of residence of the guarantor or collateral provided. This measure basis is useful because the pecuniary externality internalized by lenders stems from changes in the prices of the underlying collateral, not the price of external debt.

In each quarter, the data provide bank-level exposures in two parts. First, the exposures to any country that exceeds 1% of the reporting institution's total assets or 20% of its total capital, whichever is less, are fully revealed. Second, for exposures that exceed 0.75% but does not exceed 1% of the reporting institution's assets or are between 15% and 20% of its total capital, whichever is less, the data report a list of eligible countries and the total exposure to these countries. Since the exact exposure to a country cannot be identified in this case, I only use the second part of the data when only one country is on the list. The total number of banks included in each quarter ranges from 32 (2006Q4) to 51 (2020Q4), and the average number of banks across quarters is 43.5. There are 99 countries that borrow from banks, and 18 countries borrow every quarter.

The lender structure of the external debt of emerging counties is significantly more concentrated. Table 1 shows the empirical moments regarding the number of US lenders, the share of the largest lender, and the total share of the three largest lenders. The median number of US lenders is 3.59 for emerging countries but 11.83 for rich countries. The top lender to emerging and rich countries, on average, owns 69% and only 38% of the total external debt, respectively. The top three lenders own 95% and 74% of emerging and rich countries' external debt, respectively.[3] Figure A.4 in the Online Appendix further shows that the discrepancy between rich and emerging countries' lender concentration is more significant among countries that heavily rely on US lending. Moreover, to encompass loans originating from economies beyond the US, I supplement this analysis with evidence from DealScan data. Although DealScan data only include syndicated loans, the gap in lender concentration persists.[4]

This discrepancy in lender structure has existed since the GFC. Figure 1 shows that the sums of the top-3 lender concentration of emerging and rich countries were initially

[3] Among these countries, the share of external debt associated with US banks to the total cross-border loans ranges from 0.1% to 29.4%. US banks play a particular role in the external debt of Brazil, Canada, Mexico, France, Germany, and Japan, in which the share exceeds 10%. For example, the largest US bank that lends to Brazil covers 17.4% of the country's external debt, with Citigroup frequently being the top lender.

[4] Figure A.5 available in the Online Appendix uses DealScan data to demonstrate that top lenders holdings in emerging economies exceed those in rich economies by 20% to 25%. This discrepancy closely aligns with the measures derived from the FFIEC 009a data, where the gap between the top three lenders in the two categories of economies stands at 21%.

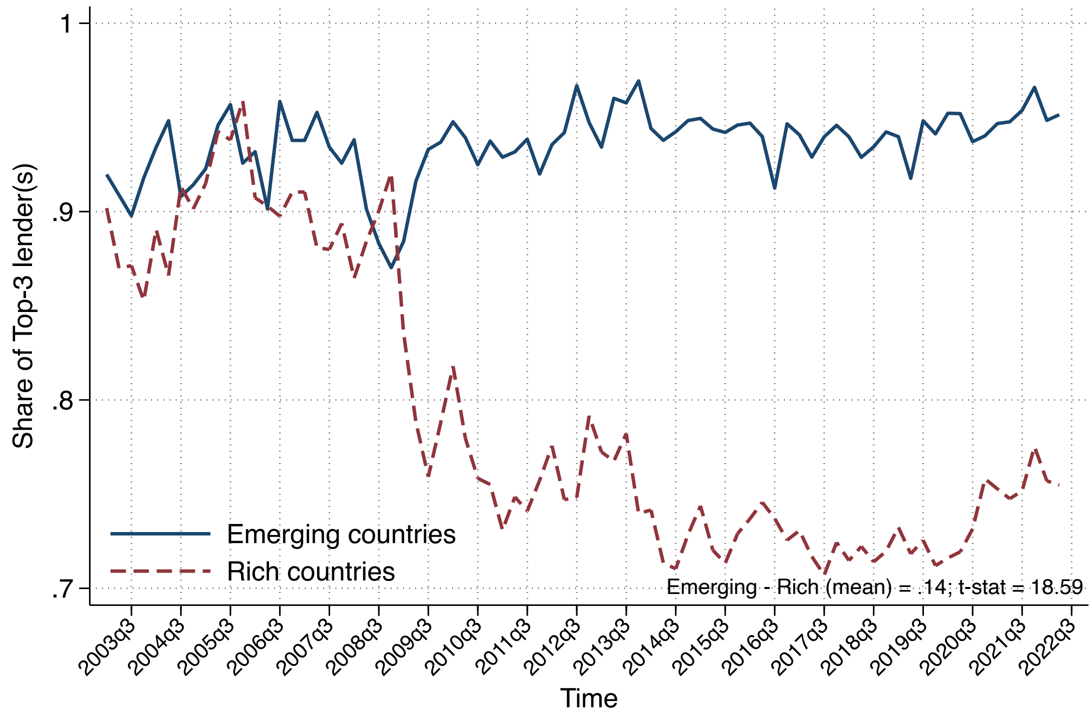

Figure 1: Top-3 lenders' shares of total external debt

Notes: t-stat is the t-statistics of the t tests on the equality of means of concentration in emerging and rich countries across the country panel. Source: FFIEC 009a and author's calculation.

similar before the GFC, but they become significantly different after the crisis as the lender structure of rich countries become concentrated. The average difference in the mean lender concentration is 0.14, and this difference is significant, with a t-statistic equal to 18.59. The correlation between the annual gross domestic product (GDP) and the top-1 lender's and top-3 lenders' shares are -0.198 and -0.197, respectively. Figure A.6 shows similar results obtained via alternative concentration measures, such as the total shares of top-1, top-2, and top-4 lenders, and the Herfindahl–Hirschman index (HHI), which considers the entire lender structure. One potential explanation for the post-crisis discrepancy in lender structures of rich and emerging countries is that many banks, not only large banks, increase holdings of rich countries' debt relative to emerging countries' debt to fulfill the tightening policy on the minimum capital adequacy ratio that limits banks' risk-weighted sum of assets, in which emerging countries' debt is typically assigned a higher risk factor. This paper does not focus on modeling the occurrence of this discrepancy but rather focuses on its implications for the relationship between lender concentration and overborrowing.

A major theoretical prediction in the next section is that lender concentration alleviates the severity of sudden stops when lenders initiate foreclosure. To empirically test this argument, I check whether current account reversal, which is a typical feature of sudden stop events, is less severe under a more concentrated lender structure by running the following difference-in-difference specification at a quarterly frequency:

$$ca_{i,t} = \alpha_0 + \alpha_1 SS_{i,t} + \alpha_2 Con_{i,t-1} + \alpha_3 SS_{i,t} \times Con_{i,t-1} + X_{i,t} + F_i + F_t + \epsilon_{i,t}, \qquad (1)$$

where $ca_{i,t}$ stands for country i's growth rate of the net current account in USD, $SS_{i,t}$ is a dummy for sudden stop events, and $Con_{i,t-1}$ represents the measures of past lender concentration used in Figure 1 and A.6, including the loan amount of the US top-1 lender and the top-3 lenders to the total US lending to country i, denoted as $L^{Top1}_{i,t-1}$ and $L^{Top3}_{i,t-1}$, as well as the Herfindahl–Hirschman index ($HHI_{i,t-1}$). Other control variables denoted by the vector $X_{i,t}$ include the growth rate of the current account in the last quarter to capture the lagged effect and the log of GDP ($gdp_{i,t}$) to control for country size. To isolate the potential mechanism that lender's motive to roll over debt may reduce current account reversal in sudden stop events, I consider another specification that adds to $X_{i,t}$ a triple interaction term ($Triple_{i,t} = SS_{i,t} \times Con_{i,t-1} \times Short_{i,t-1}$), where $Short_{i,t-1}$ is the standard proxy for rollover risk measured by the existing ratio of short term debt to total debt security (Kalemli-Ozcan et al., 2022). F_i and F_t represent the country and year-quarter fixed effects, respectively.

The sudden stop dummy is taken from the list of quarterly sudden stop events collected by Eichengreen and Gupta (2016), who set the start of a sudden stop event as the quarter in which capital flows by nonresidents drop below the mean of the past 20 quarters by more than one standard deviation and lasts for more than one quarter. Furthermore, capital flow in at least one quarter must be two standard deviations lower than the average. The end date of a sudden stop is defined as the period in which the capital flow rebounds to the mean of the last 20 quarters.

Table 2 shows that while sudden stop events raise the current account, its magnitude significantly decreases with lender concentration, as indicated by the negative and statistically significant α_3. This finding remains consistent when various concentration measures and definitions of sudden stop events are employed. During sudden stops, an additional percentage point of lender concentration mitigates the growth of the current account by a

Table 2: Lender concentration and changes in current account

Dependent: $ca_{i,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Con_{i,t-1}$ measure	$L^{Top1}_{i,t-1}$	$L^{Top1}_{i,t-1}$	$L^{Top1}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$HHI_{i,t-1}$	$HHI_{i,t-1}$	$HHI_{i,t-1}$
$SS_{i,t}$	1.475	2.157	2.447	15.51***	19.02**	18.78**	1.176	1.743	2.025
	(0.67)	(1.11)	(1.17)	(2.66)	(2.56)	(2.07)	(0.61)	(1.00)	(1.10)
$Con_{i,t-1}$	-0.024	-0.025	-0.027	-0.045	-0.041	-0.051	-0.016	-0.018	-0.019
	(-0.89)	(-0.94)	(-1.02)	(-0.84)	(-0.65)	(-0.77)	(-0.73)	(-0.79)	(-0.83)
$SS_{i,t} \times Con_{i,t-1}$	-0.067***	-0.081***	-0.095***	-0.195***	-0.235***	-0.233**	-0.065***	-0.079***	-0.093***
	(-2.66)	(-4.66)	(-2.71)	(-3.44)	(-3.47)	(-2.45)	(-2.95)	(-4.65)	(-2.75)
$ca_{i,t-1}$		-0.022***	-0.023***		-0.022***	-0.023***		-0.022***	-0.023***
		(-6.14)	(-5.42)		(-5.40)	(-4.63)		(-6.11)	(-5.57)
$gdp_{i,t}$		-2.991	-4.723		-2.631	-4.284		-3.144	-4.902
		(-0.41)	(-0.63)		(-0.35)	(-0.54)		(-0.43)	(-0.65)
$Triple_{i,t}$			0.089			-0.014			0.100
			(0.27)			(-0.03)			(0.30)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	3,045	2,875	2,722	3,045	2,875	2,722	3,045	2,875	2,722
R^2	0.041	0.045	0.047	0.041	0.045	0.047	0.041	0.045	0.047

Notes: Standard errors clustered at the country-year-quarter level. t statistics are in parentheses. *$p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$. Data sources: Eichengreen and Gupta (2016), FFIEC 009a, IMF International Financial Statistics, World Development Indicators, Joint External Debt Hub, and author's calculation.

range of 6.5 basis points to 23.5 basis points. Specifically, a one-standard deviation increase in $L^{Top3}_{i,t}$ (= 7.2%) results in a 1.7% reduction in the growth of the current account, constituting 8.9% of the overall increase in current account growth observed in column (6). The result is similar when the current-account-to-GDP ratio as the dependent variable is used in the specification (1).[5] Finally, the mechanism by which the lender concentration alleviates the current account reversal persists even when controlling for the lender's motive to roll over debt, as demonstrated by Columns (3), (6), and (9).

Figure 2 shows no pre-trend differences in α_3 across different specifications, thus validating the difference-in-difference approach. Moreover, lender concentration is observed to solely alleviate the current sudden stop by reducing the degree of sudden stop reversal, without leaving a persistent impact. This finding corresponds to the fact that countries tend to recover quickly from sudden stops (Calvo et al., 2006b). Finally, the impact attributed to

[5] Table A.1 in the Online Appendix shows the results of the changes in the current-account-to-GDP ratio. On average, a 1% increase in lender concentration measured by the sum of the top-3 lender shares alleviates the reversal of the current-account-to-GDP ratio during sudden stop events by 1.9% to 3%.

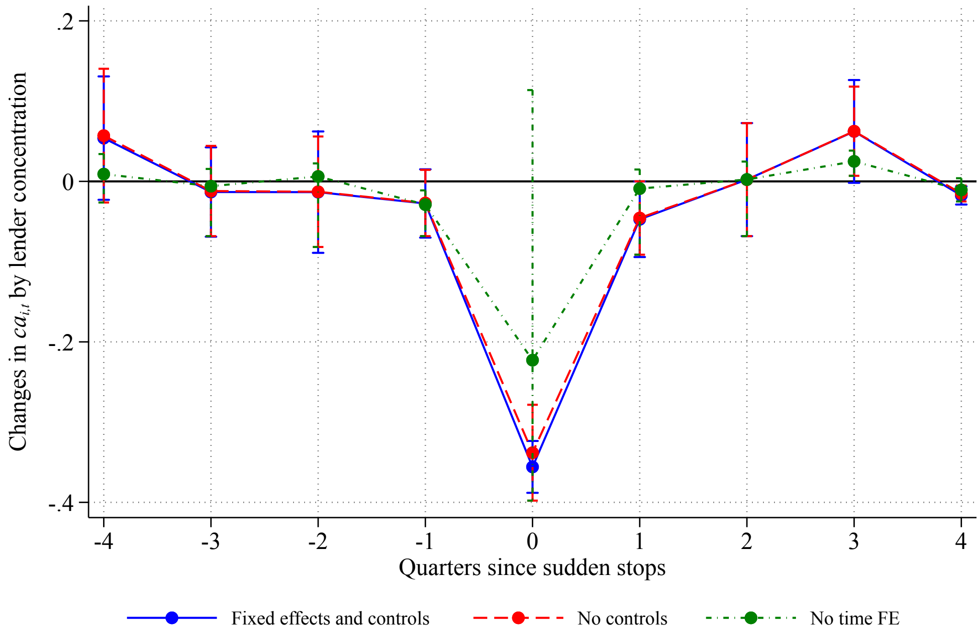

Figure 2: Dynamic effects of lender concentration on current account

Notes: This figure illustrates the dynamic effects of lender concentration on the current account within a one-year symmetric window, denoted as $\alpha_{3,s}$ for $s \in [-4, 4]$. Specifically, the solid line represents the baseline regression as follows: $ca_{i,t} = \alpha_0 + \alpha_1 L^{Top3}_{i,t} + \alpha_2 Con_{i,t} + \sum_{s=-4}^{4} \alpha_{3,s} L^{Top3}_{i,s} \times Con_{i,s} + X_{i,t} + F_i + F_t + \epsilon_{i,t}$. The dashed line corresponds to a model that excludes $X_{i,t}$, which is a vector of $gdp_{i,t}$ and $ca_{i,t}$. The dash-dotted line represents the model that excludes the time fixed effect F_t. The bars denote the 95% robust confidence intervals, computed with standard errors clustered at the country-year-quarter level.

lender concentration exhibits slight mean-reverting tendency in the third quarter following the sudden stops.

Does lender concentration empirically protect the collateral price in downturns? To answer this question, Table 3 replaces the current and past growth rates of the current account in USD (ca) in specification (1) with the current and past growth rate of the effective real rate (rer). In a standard open macroeconomic model, the value of the real exchange rate is negatively associated with the relative price of nontradable goods (Schmitt-Grohé and Uribe, 2017), which is served as collateral in the model assumed in Section 3. The positive coefficients on the flags for sudden stop events are consistent with standard real depreciation documented in the literature (Calvo et al., 2006a, 2003; Korinek and Mendoza, 2014), implying reduction in the relative price of collateralized nontradables. More importantly, lender concentration alleviates the price reduction, as shown by the negative coefficients of

Table 3: Lender concentration and changes in real effective exchange rates

Dependent: $rer_{i,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Con_{i,t-1}$ measure	$L^{Top1}_{i,t-1}$	$L^{Top1}_{i,t-1}$	$L^{Top1}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$HHI_{i,t-1}$	$HHI_{i,t-1}$	$HHI_{i,t-1}$
$SS_{i,t}$	0.0480***	0.0489***	0.069***	0.261**	0.254***	0.363**	0.030***	0.031***	0.049**
	(4.05)	(5.66)	(3.04)	(2.59)	(2.76)	(2.43)	(3.51)	(5.32)	(2.55)
$Con_{i,t-1}$	0.000	0.000	0.000	-0.000	-0.000	-0.000	0.000	0.000	0.000
	(1.29)	(0.97)	(0.64)	(-0.59)	(-1.22)	(-1.85)	(1.39)	(1.06)	(0.71)
$SS_{i,t} \times Con_{i,t-1}$	-0.001***	-0.001***	-0.001***	-0.003**	-0.003***	-0.004**	-0.001***	-0.001***	-0.001***
	(-6.21)	(-9.66)	(-5.93)	(-2.64)	(-2.79)	(-2.47)	(-6.13)	(-9.69)	(-4.85)
$rer_{i,t-1}$		0.161***	0.156***		0.163***	0.157***		0.161***	0.156***
		(3.01)	(2.79)		(3.08)	(2.88)		(3.01)	(2.77)
$gdp_{i,t}$		-0.005	-0.006		-0.005	-0.005		-0.004	-0.006
		(-0.91)	(-1.03)		(-0.96)	(-1.03)		(-0.84)	(-0.99)
$Triple_{i,t}$			-0.008			-0.004*			-0.010
			(-1.39)			(-1.72)			(-1.49)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	2,197	2,077	1,979	2,197	2,077	1,979	2,197	2,077	1,979
R^2	0.099	0.120	0.126	0.095	0.117	0.122	0.099	0.120	0.126

Notes: Standard errors clustered at the country-year-quarter level. t statistics are in parentheses. $^*p < 0.1$, ** $p < 0.05$, and *** $p < 0.01$. Data sources: Eichengreen and Gupta (2016), FFIEC 009a, IMF International Financial Statistics, World Development Indicators, Joint External Debt Hub, and author's calculation.

the interaction term. Finally, although rollover need measured by the short-term debt ratio indeed diminishes changes in the real exchange rate, the mechanism of lender concentration persists and is statistically significant, as shown by Columns (3), (6), and (9).

3 Model

With the empirical evidence in hand, I analyze how the lender structure affects the equilibrium. I extend the representative-agent SOE-DSGE model of Bianchi (2011) by incorporating the lender structure similar to Favara and Giannetti (2017). The model features a continuum of identical and infinitely lived households of measure unity and two types of risk-neutral foreign lenders: one large lender who provides an exogenous share η of the total loans and the atomistic lenders who lend out $1 - \eta$ in aggregate.

3.1 Domestic agents

Domestic agents receive tradable endowments y_t^T and two types of nontradable endowments: collateralizable goods y_t^N, such as plants and machinery, and noncollateralizable goods $\bar{y}_t^N$, such as electricity and water supply.[6] I assume that only y_t^N can serve as collateral and can never be consumed by agents directly unless the collateral is seized and sold by lenders in the domestic market at the same price as $\bar{y}_t^N$.[7] This assumption contrasts with the standard assumption in the literature that collateral can be traded and consumed. Since from the agents' perspective, the only function of y_t^N in period t is to serve as collateral, they will collateralize the entire amount of y_t^N to maximize borrowing capacity for consumption smoothing. Importantly, y_t^N can be consumed only in period $t+1$ once the loan d_{t+1} is repaid. This assumption is also emphasized by Donaldson et al. (2021), who study the inefficiency of asset allocation when assets are locked in as collateral. Throughout the theoretical analysis and numerical exercise under plausible parameterization, domestic agents are assumed to be borrowers with $d_{t+1} \geq 0$, for all t.

At the beginning of period t, agents receive tradable endowments y_t^T and repay initial borrowing d_t. If $y_t^T < d_t$, agents cannot fully repay debts, and lenders will waive d_t and make foreclosure decisions on selling an optimal share of the seized collateral y_{t-1}^N. Agents then receive $\{\bar{y}_t^N, y_t^N\}$ and pledge y_t^N as collateral. Next, the agents are allowed to consume the remaining collateral not foreclosed upon. As will be shown later, when agents default, lenders may not foreclose on all collateral y_{t-1}^N because selling foreclosed collateral increases the supply of nontradable goods and reduces the price. If no foreclosure occurs, the full amount of collateral y_{t-1}^N will be consumed by domestic agents in period t.

The agents' optimization problem is given by

$$\max E_0 \left[\sum_{t=0}^{\infty} \beta^t u\left(c_t\right) \right],$$

subject to the budget constraint

[6] As will become clear later, $\bar{y}_t^N$ is imposed to ensure well-defined nontradable prices in nonbinding states where no collateralized nontradable goods are sold. $\bar{y}_t^N$ also improves the calibration to match empirical foreclosure decisions.

[7] The intuition for this assumption is that only lenders can utilize collateralizable goods y_t^N to produce noncollateralizable goods $\bar{y}_t^N$ following a linear production function $\bar{y}^N = y^N$. For example, lenders may use collateralizable-nontradable plants and machinery to produce noncollateralizable electricity and water supply, which is nontradable and can be consumed by agents.

$$c_t^T + p_t c_t^N = y_t^T + p_t \bar{y}_t^N + \frac{d_{t+1}}{1+r_t} - d_t(1-I_t) - \delta I_t, \tag{2}$$

and an occasionally binding collateral constraint

$$\frac{d_{t+1}}{1+r_t} \leq \kappa p_t y_t^N, \tag{3}$$

where d_{t+1} is the debt chosen in period t. p_t is the relative price of nontradable goods and κ is the associated collateral margin, which indicates the borrowing capacity per dollar of collateral. In accordance with the literature, a binding constraint (3) with $d_{t+1} < d_t$ defines a sudden stop event. δ is the coefficient for the output loss of default that improves model calibration. The utility function is constant-relative-risk-aversion with σ being the parameter of risk aversion. c_t aggregates tradable consumption c_t^T and nontradable consumption c_t^N:

$$c_t = \left[a \left(c_t^T \right)^{1-1/\xi} + (1-a) \left(c_t^N \right)^{1-1/\xi} \right]^{1/(1-1/\xi)},$$

where $\xi > 0$ represents the elasticity of substitution between tradable and nontradable goods and $a \in (0,1)$ is the weight on tradable consumption. r_t is the borrowing rate endogenously affected by the debt level, as characterized later in the lender's problem. I_t is a binary variable for foreclosure:

$$I_t = \begin{cases} 0 & \text{if } y_t^T \geq d_t \\ 1 & \text{if } y_t^T < d_t \end{cases}, \tag{4}$$

where lenders foreclose on collateral against a domestic agent when the agent's tradable endowment is insufficient to repay the initial borrowing.

While foreclosure events may trigger sudden stop events by depressing the collateral price, the model distinguishes the two types of events because they are fundamentally different: Sudden stops are episodes in which agents can repay initial debt but are constrained to issue *new debt* based on their current borrowing capacity, while foreclosure events occur when agents fail to repay *initial debt*.[8] This critical difference is also highlighted by Sánchez et al.

[8]Figure A.7 in the Online Appendix compares the sudden stops and foreclosures using simulated dynamics in a calibrated model. Both events tend to be triggered by negative endowment shocks. However, the initial debt level in foreclosures is significantly higher than that in sudden stops, whereas the current debt level declines more significantly in sudden stops.

(2018), who argue the importance of distinguishing the role of sudden stops in affecting debt maturity in a default model. Furthermore, modeling foreclosure based on initial debt d_t instead of current debt d_{t+1} like sudden stops alleviates the concern of multiple equilibria and provides a clean way to identify the effect of lender concentration. If foreclosure is also modeled as a consequence of a binding collateral constraint determined by d_{t+1}, multiple equilibria may be driven not only by self-fulfilling sudden stops, as emphasized in Schmitt-Grohé and Uribe (2021), but also self-fulfilling foreclosure and their combinations.

Agents' consumption depends on the foreclosure decisions of lenders. When foreclosure occurs, lenders will foreclose on collateral and sell it to domestic agents at the market price p_t. Thus, consumption is given by

$$c_t^N = \zeta_t^* y_{t-1}^N I_t + y_{t-1}^N (1 - I_t) + \bar{y}_t^N, \tag{5}$$

$$c_t^T = y_t^T + \frac{d_{t+1}}{1 + r_t} - d_t(1 - I_t) - p_t \left(c_t^N - \bar{y}_t^N\right) - \delta I_t, \tag{6}$$

where $\zeta_t^* = \eta \zeta_t^{L*} + (1 - \eta)\, \zeta_t^{A*}$ is the weighted sum of the lenders' foreclosure rates and $\{\zeta_t^{L*}, \zeta_t^{A*}\} \in [0, 1]$ represent the optimal foreclosure rate of nontradable collateral chosen by the large lender and atomistic lenders, respectively. For example, $\zeta_t^{L*} = 40\%$ means that the large lender forecloses on 40% of the underlying collateral when borrowers fail to repay debt. Equation (5) states that nontradable consumption equals the amount of seized collateral sold in period $t - 1$ when there is foreclosure, or the entire collateral when there is no foreclosure, plus the noncollateralizable nontradable endowment in period t. Equation (6) states that agents must allocate resources for tradable consumption to purchasing the collateralized nontradable goods.

The optimality conditions of the CE are given by

$$\lambda_t = \frac{\partial u(c_t)}{\partial c_t^T} \qquad (c_t^T), \tag{7}$$

$$p_t = \left(\frac{1 - a}{a}\right) \left(\frac{c_t^T}{c_t^N}\right)^{1/\xi} \qquad (c_t^N), \tag{8}$$

$$\lambda_t = -\beta(1 + r_t) U'(d_{t+1}) + \mu_t \qquad (d_{t+1}), \tag{9}$$

and the complementary slackness conditions,

$$\mu_t \left[\kappa p_t y_t^N - d_{t+1}\right] \geq 0, \tag{10}$$

$$\mu_t \geq 0, \tag{11}$$

where

$$U(d_{t+1}) = \int_{\underline{y}^T}^{d_{t+1}} u\left[c_{t+1}^F(y_{t+1}^T)\right] f(y_{t+1}^T|y_t)dy_{t+1}^T + \int_{d_{t+1}}^{\bar{y}^T} u\left[c_{t+1}^{NF}(d_{t+1};y_{t+1}^T)\right] f(y_{t+1}^T|y_t)dy_{t+1}^T$$

is the expected utility of consumption that aggregates the expected utility in the foreclosure and no-foreclosure states where F stands for foreclosure states in which $y_t^T < d_t$ and NF stands for no-foreclosure states in which $y_t^T \geq d_t$. $c_{t+1}^s = c(c_{t+1}^{T,s}, c_{t+1}^{N,s})$ is the consumption in future state $s \in \{F, NF\}$. λ_t and μ_t are the nonnegative multipliers of equations (2) and (3), respectively. $f(y_{t+1}^T|y_t)$ is the conditional probability of tradable endowment bounded within $[\underline{y}^T, \bar{y}^T]$. Equations (7) and (8) are the first-order conditions with respect to tradable and nontradable consumption. Equation (9) equates the marginal benefit that increases agents' current utility with the marginal cost that decreases agents' future utility and tightens the future collateral constraint.

Agents internalize that changing d_{t+1} changes the probability of facing future foreclosure and expected consumption. To see this, note that $U'(d_{t+1})$ measures the expected marginal utility (MU) of tradable consumption with respect to d_{t+1} and can be decomposed into the following two parts:

$$U'(d_{t+1}) = 1 - \left[\underbrace{u\left[c_{t+1}^F(d_{t+1})\right] - u\left[c_{t+1}^{NF}(d_{t+1};d_{t+1})\right]}_{\text{(a): Change in MU}}\right] + \underbrace{\mathscr{U}_1(d_{t+1},\bar{y}^T) - \mathscr{U}_2(d_{t+1},d_{t+1})}_{\text{(b): Expected MU with no foreclosure}}, \tag{12}$$

in which $\mathscr{U}(d_{t+1}, y_{t+1}^T) = \int u\left[c_{t+1}^{NF}(d_{t+1};y_{t+1}^T)\right] f(y_{t+1}^T|y_t)dy_{t+1}^T + \epsilon$ and $\mathscr{U}_1(d_{t+1}, y_{t+1})$ is the MU of tradable consumption with respect to d_{t+1} in no-foreclosure states. Component (a) is the precautionary saving captured by the marginal difference in consumption when agents with a given d_{t+1} move from a no-foreclosure state to a foreclosure state. As (a) decreases, the benefit of lowering d_{t+1} increases, implying higher precautionary saving. Component (b) measures the expected MU when no foreclosure occurs. (b) is uncorrelated with η because concentration only matters in states with foreclosure.

How concentration η affects the debt decision depends on how tradable, nontradable, and total consumption under foreclosure, $c_{t+1}^{T,F}$, $c_{t+1}^{N,F}$, and c_{t+1}^{F}, are affected. Specifically, using equation (12) we have that $\partial U'(d_{t+1})/\partial\eta = f(d_{t+1}|y_t)(\partial u[c_{t+1}^F(d_{t+1})]/\partial\eta)$ in which c_{t+1}^F aggregates $c_{t+1}^{N,F}$ and $c_{t+1}^{T,F}$. While $c_{t+1}^{N,F} = \zeta_{t+1}^* y_t^N + \bar{y}_{t+1}^N$ decreases with η because, as will be shown later, ζ_{t+1}^* is decreasing in lender concentration, the sign of $\partial c_{t+1}^{T,F}/\partial\eta$ is ambiguous. A lower $c_{t+1}^{N,F}$ means that agents have more resources for tradable consumption $c_{t+1}^{T,F}$. However, $c_{t+1}^{T,F}$ may decrease when nontradable goods become expensive. If $c_{t+1}^{T,F}$ increases with η and this effect dominates the decrease in $c_{t+1}^{N,F}$, then η increases c_{t+1}^F, and thus $\partial U'(d_{t+1})/\partial\eta > 0$. In this case, the decentralized debt level is increasing in η as it boosts agents' consumption in foreclosure events, reducing their incentives to borrow less to avoid foreclosure. As will be shown later in Figure 4, the calibrated result belongs to this case.

3.2 Foreign lenders

This subsection derives the foreclosure decisions of the two types of risk-neutral lenders, atomistic lenders and the large lender, when borrowers cannot repay their debt ($d_t > y_t^T$). I then characterize the interest rates that the two types of lenders charge based on the expected debt repayments that the lenders receive. The only difference between the two types of lenders is that atomistic lenders take the collateral price as given, while the large lender internalizes that her own foreclosure decision directly affects the supply of nontradable goods, influencing the following collateral price:

$$p_t \triangleq \begin{cases} p_t^{NF} = \left(\frac{1-a}{a}\right)\left(\frac{c_t^{T,NF}}{\bar{y}_t^N + y_{t-1}^N}\right)^{1/\xi} & \text{if } y_t^T \geq d_t \\ p_t^F = \left(\frac{1-a}{a}\right)\left(\frac{c_t^{T,F}}{\bar{y}_t^N + \zeta_t^* y_{t-1}^N}\right)^{1/\xi} & \text{if } y_t^T < d_t \end{cases}, \tag{13}$$

where p_t^{NF} and p_t^F are the nontradable price in states without foreclosure and with foreclosure, respectively.

The weighted sum of foreclosure rates ζ_t^* lowers p_t^F by increasing nontradable consumption and reducing tradable consumption. However, from equation (6) foreclosure may also raise the price when a significantly large initial debt d_t is foregone. When ζ_t^* approaches zero, nonzero $\bar{y}_t^N$ ensures a well-defined p_t^F. Now, we are prepared to analyze the foreclosure decisions of lenders.

3.2.1 Atomistic lenders

Taking p_t as given, the atomistic lenders seize and sell collateral to maximize the payoff:

$$\max_{\zeta_t^A} \zeta_t^A p_t y_{t-1}^N,$$

where the optimal foreclosure rate ζ_t^{A*} is always 1, meaning that atomistic lenders foreclose on all collateral.

3.2.2 The large lender

Considering the price function (13), the large lender chooses the foreclosure rate ζ_t^L to maximize the following payoff taking as given domestic agents' decisions $\{c_t^T, d_{t+1}\}$ and the foreclosure decision of atomistic lenders $\zeta_t^{A*} = 1$:

$$\max_{\zeta_t^L} \zeta_t^L \left(\frac{1-a}{a}\right) \left(\frac{c_t^T}{\bar{y}_t^N + [\eta_t \zeta_t^L + (1-\eta_t)]\, y_{t-1}^N}\right)^{1/\xi} y_{t-1}^N. \tag{14}$$

The foreclosure rate ζ_t^L affects the payoff in two opposite ways. Although it increases the payoff by directly raising the sold share, it also reduces the payoff because it lowers the nontradable price when the lender sells seized nontradable goods to domestic agents.[9] The resulting optimal foreclosure rate is then given by

$$\zeta_t^{L*} = \frac{\frac{\bar{y}_t^N}{y_{t-1}^N} + (1-\eta)}{\eta} \left(\frac{\xi}{1-\xi}\right), \tag{15}$$

When $\xi < 1$, as is standard in the literature, ζ_t^{L*} is decreasing in η because lender concentration strengthens the price decline that results from foreclosures. When the size of the large lender is sufficiently large (i.e., η is sufficiently large), the optimal foreclosure rate of the large lender will be less than one, so that $\zeta_t^{L*} < \zeta_t^{A*} = 1$ and $\zeta_t^{*'}(\eta) < 0$. In this case, a more concentrated lender structure helps maintain the collateral price and borrowing capacity in foreclosure events. Note that ζ_t^{L*} is decreasing in $y_{t-1}^N/\bar{y}_t^N$, which indicates the

[9] The maximization problem here considers a Nash equilibrium in which foreign lenders take the domestic borrowers' decisions $\{c_t^T, d_{t+1}\}$ as given, just as domestic borrowers take the lenders' decisions on foreclosure rates $\{\zeta_t^{L*}, \zeta_t^{A*}\}$ as given. It can be shown that relaxing the problem by allowing the large lender to additionally internalize how p_t^F is affected by ζ_t^L via c_t^T would yield the same optimal foreclosure rate as the initial maximization problem (14), taking as given d_{t+1}.

share of the supply of the nontradable good controlled by the foreclosure decision relative to the exogenous nontradable supply.[10] Moreover, ζ_t^{L*} is increasing in ξ because the price of nontradables declines by less as nontradable consumption increases. Equivalently, plugging (15) into $\zeta_t^* = \eta\zeta_t^{L*} + (1-\eta)$, we observe that lender concentration $\eta = 1-(1-\xi)\zeta_t^* + \xi\bar{y}_t^N/y_{t-1}^N$ decreases ζ_t^* when $\xi < 1$. This result is summarized by the following lemma.[11]

Lemma 1. *(Foreclosure decisions) Atomistic lenders foreclose on all their collateral. The large lender's foreclosure rate and the weighted-sum of foreclosure rates decrease with lender concentration η when $\xi < 1$.*

3.2.3 Interest rates and default risk

We now move on to how risk-neutral lenders set their interest rates. Depending on lender-specific future repayments in foreclosure and no-foreclosure states, the interest rates r_t^l charged by lender l for $l \in \{A, L\}$, denoting the atomistic and large lenders, are determined so that

$$(1+r^*) = \left(1+r_t^l\right)\left[\int_{\underline{y}^T}^{d_{t+1}} \frac{\zeta_{t+1}^{l*}\left(\bar{y}_{t+1}^N, y_t^N\right) p_{t+1}^F\left(y_{t+1}\right) y_t^N}{d_{t+1}} f(y_{t+1}^T|y_t)dy_{t+1}^T + \int_{d_{t+1}}^{\bar{y}^T} 1 f(y_{t+1}^T|y_t)dy_{t+1}^T\right], \tag{16}$$

indicating that the expected return per dollar of external debt in the previous period should be equivalent to the exogenous world interest rate r^*. Under the parameterization where the largest lender does not fully sell the collateral so that $\zeta_t^{L*} \leq 1 = \zeta_t^{A*}$, equation (16) indicates that the largest lender charges a higher interest rate ($r_t^L > r_t^A$) due to lower expected repayments from selling collateral.

Given the lender concentration measure η, the discounted debt that the domestic agents borrowed can be written as

[10] The foreclosure decision highlights another key role of distinguishing collateralizable and noncollateralizable nontradables y_t^N and $\bar{y}_t^N$, which determine a time-varying foreclosure decision. Without imposing $\bar{y}_t^N$, the foreclosure rate will be fixed at $\left(\left(1-\eta\right)/\eta\right)\left(\xi/\left(1-\xi\right)\right)$, which exceeds one under conservative value of ξ taken from the literature and η estimated from the data, as shown by the parameterization in Table 4.

[11] The negative relationship between lender concentration and the foreclosure rate can also be observed in a more general model with multiple large lenders. Suppose that every lender i accounts for η^i of the total loans and forecloses on collateral according to (15) where $\zeta_t^{i*} = \left(\frac{\xi}{1-\xi}\right)\frac{1}{\eta^i}\left(\frac{\bar{y}_t^N}{y_{t-1}^N} + \left(1-\eta^i\right)\right)$. We then have that $\zeta_t^* \propto -\sqrt{HHI + 2\prod_{i\neq j}\eta^i\eta^j}$, in which $HHI \triangleq \sum_{i=1}^N (\eta^i)^2$. Thus, a more concentrated structure (higher HHI) leads to a lower foreclosure rate ζ_t^*.

$$\frac{d_{t+1}}{1+r_t} = \eta \frac{d_{t+1}}{1+r_t^L} + (1-\eta) \frac{d_{t+1}}{1+r_t^A}, \tag{17}$$

where the interest rate of total external debt can be written as the weighted sum of lender-specific interest rates so that $1/(1+r_t) = \eta / \left(1+r_t^L\right) + (1-\eta) / \left(1+r_t^A\right)$. From equations (16) and (17), we observe that interest rates equal the world interest rate, that is $r_t = r_t^A = r_t^L = r^*$, if the default probability, $f(y_{t+1}^T | y_{t+1}^T < d_{t+1}, y_t)$, is zero. This special case is identical to standard open macroeconomic models with a collateral constraint but do not model defaults.

In cases with a positive default probability, the interest rate and the risk premium are affected by the borrowing level. To see this, it is useful to rewrite equations (16) and (17) as

$$\frac{1}{1+r_t\left(d_{t+1}, y_t\right)} = \frac{1}{1+r^*} \left[\left(1 - F_{y_{t+1}^T | y_t}\left(d_{t+1}\right)\right) + \int_{\underline{y}^T}^{d_{t+1}} \frac{\zeta_{t+1}^* p_{t+1}^F y_t^N}{d_{t+1}} f(y_{t+1}^T | y_t) dy_{t+1}^T \right],$$

where $F_{y_{t+1}^T | y_t}\left(d_{t+1}\right)$ denotes the cumulative density function of the tradable endowment shock y_{t+1}^T conditional on existing endowments $y_t = [y_t^T, \bar{y}_t^N, y_t^N]$, evaluated at d_{t+1}. By taking the partial derivative of $\left(1+r_t\left(d_{t+1}, y_t\right)\right)^{-1}$ with respect to d_{t+1}, we have that

$$\frac{\partial \left(1+r_t\left(d_{t+1}\right)\right)^{-1}}{\partial d_{t+1}} = \frac{1}{1+r^*} \left[\left(\frac{\zeta_{t+1}^* p_{t+1}^F y_t^N}{d_{t+1}} - 1 \right) f(d_{t+1} | y_t) - \int_{\underline{y}^T}^{d_{t+1}} \frac{\zeta_{t+1}^* p_{t+1}^F y_t^N}{d_{t+1}^2} f(y_{t+1}^T | y_t) dy_{t+1}^T \right], \tag{18}$$

as $\partial p_{t+1}^F / \partial d_{t+1} = 0$ because d_{t+1} is foregone in the foreclosure states.

A crucial observation from (18) is that the interest rate r_t increases with d_{t+1} when $(\zeta_{t+1}^* p_{t+1}^F y_t^N)/d_{t+1} < 1$. The intuition is as follows. Increasing d_{t+1} will increase the probability of foreclosure, increasing the likelihood that agents earns sold collateral per dollar of discounted bond, $(\zeta_{t+1}^* p_{t+1}^F y_t^N)/d_{t+1}$, in the foreclosure state and reducing the likelihood of entering a no-foreclosure state and earning one unit per discounted bound. If the realization in the foreclosure state is smaller than that in the no-foreclosure state, that is, $(\zeta_{t+1}^* p_{t+1}^F y_t^N)/d_{t+1} < 1$, lenders earn less expected repayment and thus charge a higher interest rate r_t and a positive risk premium $r_t - r^* > 0$ from equation (16). Lemma 2 summarizes this result.

Lemma 2. *(Debt-dependent interest rate) If* $(\zeta_{t+1}^* p_{t+1}^F y_t^N)/d_{t+1} < 1$*, then* $\partial r_t / \partial d_{t+1} > 0$.

For states that satisfy Lemma 2, we have that $p_t \in \{p_t^F, p_t^{NF}\}$ is an increasing function of d_{t+1}, as summarized by Lemma 3. Furthermore, in states where r_t is a concave function of d_{t+1}, p_t is a convex function of d_{t+1} under empirically plausible $\xi \in (0,1)$.

Lemma 3. *(Convex collateral price) If $\partial r_t/\partial d_{t+1} > 0$, then (i) $\partial p_t/\partial d_{t+1} > 0$, and (ii) $\partial^2 p_t/\partial d_{t+1}^2 > 0$ if $\xi \in (0,1)$ and $\partial^2 r_t/\partial d_{t+1}^2 < 0$, for $p_t \in \{p_t^F, p_t^{NF}\}$.*

Proof: See Appendix 7.1.

The convexity of the collateral price matters for the uniqueness of the equilibrium, as emphasized in Schmitt-Grohé and Uribe (2021). Online Appendix a.1 studies the conditions for the presence of multiple equilibria and shows that the calibrated model is not subject to multiple equilibria and the associated equilibrium selection criterion.

3.3 Competitive equilibrium

The timing of the competitive equilibrium can be summarized as follows:

1. Period t begins. Agents receive y_t^T to repay the initial debt d_t.
2. If $y_t^T < d_t$, agents cannot fully repay their loans. In this case, proceed to Step 3. If $y_t^T \geq d_t$, proceed to Step 4.
3. Lenders initiate foreclosure by seizing collateral and waiving d_t. Proceed to Step 5.
4. Agents fully repay d_t. Proceed to Step 5.
5. Agents receive $\{\bar{y}_t^N, y_t^N\}$ and pledge y_t^N as collateral.
6. Lenders sell a total share ζ_t^* of y_{t-1}^N if there was a foreclosure, otherwise agents consume all the collateral. c_t^N is pinned down by available collateral and $\bar{y}_t^N$. Agents choose d_{t+1} and c_t^T, taking as given the equilibrium prices p_t and $r_t\left(r_t^A, r_t^L\right)$. In foreclosure states, $p_t = p_t^F$, $c_t^T = y_t^T + \frac{d_{t+1}}{1+r_t} - p_t^F \zeta_t^* y_{t-1}^N - \delta$, and $d_{t+1} \leq \kappa p_t^F y_t^N$. Otherwise, $p_t = p_t^{NF}$, $c_t^T = y_t^T + \frac{d_{t+1}}{1+r_t} - d_t - p_t^{NF} y_{t-1}^N$, and $d_{t+1} \leq \kappa p_t^{NF} y_t^N$.
7. Period $t+1$ begins. Agents receive y_{t+1}^T to repay the initial debt d_{t+1}.

The competitive equilibrium is defined as follows:

Definition 1. (Competitive equilibrium) A competitive equilibrium is a set of processes c_t^T, p_t, d_{t+1}, r_t, and λ_t satisfying equations (2)-(11), (15)-(17) for $t \geq 0$, given exogenous processes y_t^N, $\bar{y}_t^N$, y_t^T, I_t and the initial condition $d_{-1} > 0$.

A sudden stop is then defined as follows:

Definition 2. (Sudden-stop equilibrium) A sudden-stop equilibrium is a set of the processes c_t^T, p_t, d_{t+1}, r_t, and λ_t satisfying equations (2)-(6) for $t \geq 0$, $d_1 < d_0$, where equation (3) is binding.

We are now ready to analyze the social planner's allocation.

3.4 Social planner's allocation

While the decentralized agents above take the prices as given and fail to internalize the effect of individual debt decisions on the prices, the SP internalizes the externalities. This subsection studies an SP who directly chooses debt subject to the collateral constraint but allows the goods market to clear in a competitive way. Let y_{-1}^N represent the collateralizable nontradable endowment from the previous period. Under the assumption that $\gamma = 0$, the constrained-efficient allocation is characterized by the following recursive problem:

$$V(b, y) = \max_{d', c^T} u(c(c^T, c^N)) + \beta E_{y'|y} V(b', y'),$$

subject to

$$c^T = y^T + \frac{d'}{1+r} - d(1-I) - \left(\frac{1-a}{a}\right)\left(\frac{c^T}{c^N}\right)^{1/\xi}\left(c^N - \bar{y}^N\right) - \delta I, \tag{19}$$

$$c^N = \zeta^* y_{-1}^N I + y_{-1}^N (1-I) + \bar{y}^N,$$

$$\frac{d'}{1+r} \leq \kappa \left(\frac{1-a}{a}\right)\left(\frac{c^T}{c^N}\right)^{1/\xi} y^N. \tag{20}$$

The optimization problem is characterized by the price function (13), the interest rate function (16), the first-order conditions in sequential form:

$$\lambda_t^{SP} = \frac{\partial u(c_t)}{\partial c_t^T} + \mu_t^{SP} \frac{\partial(\kappa p_t y_t^N)}{\partial c_t^T}, \tag{21}$$

$$\lambda_t^{SP} = \beta(1+r_t)\left[-U'(d_{t+1}) - \frac{\kappa \partial E(\mu_{t+1}^{SP} p_{t+1} y_{t+1}^N)}{\partial d_{t+1}} - \frac{\partial (1+r_t)^{-1}}{\partial d_{t+1}} d_{t+1}\right] + \mu_t^{SP}, \tag{22}$$

and the following complementary slackness conditions:

$$\mu_t^{SP}\left[\kappa p_t y_t^N - d_{t+1}\right] \geq 0,$$
$$\mu_t^{SP} \geq 0,$$

where μ^{SP} and λ^{SP} indicate the shadow values of equations (19) and (20).

The fundamental difference between the first-order conditions of the CE and the SP's solution is driven by the fact that the SP internalizes two externalities when choosing d_{t+1}: changes in the collateral value and the interest rate. The first externality arises only when the future collateral constraint binds with a positive probability, and the second externality only arises when a foreclosure event occurs with a positive probability, as highlighted in Subsection 3.2.3. From equations (21) and (22), the Euler equation for consumption when the current collateral constraint is not binding ($\mu_t^{SP} = 0$) is

$$\frac{\partial u\left(c_t\right)}{\partial c_t^T} = \beta\left(1+r_t\right)\left[-U'(d_{t+1}) - \frac{\kappa \partial E(\mu_{t+1}^{SP} p_{t+1} y_{t+1}^N)}{\partial d_{t+1}} - \frac{\partial\left(1+r_t\right)^{-1}}{\partial d_{t+1}} d_{t+1}\right], \tag{23}$$

which equates the marginal cost with the marginal benefit of lowering a unit of debt. The first term in brackets is the future marginal utility, the second term is the benefit of loosening the future collateral constraint, and the third term is the benefit of reducing the borrowing cost. Comparing equation (23) with the agents' Euler equation characterized by equations (7) and (9), we observe that the SP has two additional marginal benefits of lowering d_{t+1}, $-\kappa \partial E(\mu_{t+1}^{SP} p_{t+1} y_{t+1}^N)/\partial d_{t+1}$ and $-d_{t+1}\partial\left(1+r_t\right)^{-1}/\partial d_{t+1}$. Agents tend to overborrow (underborrow) when the sum of the two additional marginal benefits is positive (negative).

Thus, how η affects the difference between the debt holdings in the SP's problem and the CE depends not only on how η affects the expected marginal utility with respect to d_{t+1}, as previously discussed in Subsection 3.1, but also how η affects the two externality terms if foreclosure occurs with a positive probability in the SP's problem. However, if the foreclosure occurs with a zero probability in the SP's problem, η will not change the debt decision in the SP's problem, and thus η can only affect the overborrowing via the debt decision in the CE. Section 4 shows that the calibrated model belongs to this case. Below I analyze the two externality terms and briefly discuss how they can be affected by η.

As emphasized by Lemma 2, the sign of the pecuniary externality associated with the interest rate, $-d_{t+1}\partial\left(1+r_t\right)^{-1}/\partial d_{t+1}$, tends to be positive as current debt exceeds the expected collateral value. In this case, domestic agents pay a higher risk premium as lenders expect to receive fewer repayments in foreclosure states than in no-foreclosure states. To understand how this externality is influenced by lender concentration, we take the partial derivative of equation (16) with respect to η:

$$\frac{\partial\left(1+r_t\right)^{-1}}{\partial d_{t+1}\partial\eta}=\frac{1}{1+r^*}\left(\frac{1}{d_{t+1}}\right)\left[g(d_{t+1},y_t^N,y_t^T)-\frac{1}{d_{t+1}}\int_{\underline{y}^T}^{d_{t+1}}g(y_{t+1}^T,y_t^N,y_t^T)dy_{t+1}^T\right], \quad (24)$$

where $g(x,y_t^N,y_t^T)\triangleq f(x|y_t^T)\partial(\zeta_{t+1}^*p_{t+1}^F y_t^N)/\partial\eta$ measures the extent to which lender concentration increases the expected repayments from foreclosed collateral. The sign of equation (24) is ambiguous, primarily because the sign of $\partial(\zeta_{t+1}^*p_{t+1}^F y_t^N)/\partial\eta$ is ambiguous. This ambiguity is due to η reducing ζ_{t+1}^* but increasing p_{t+1}^F by lowering the supply of nontradables. Furthermore, even if the sign of $\partial(\zeta_{t+1}^*p_{t+1}^F y_t^N)/\partial\eta$ is determined, the two terms within the bracket of equation (24) influence $\partial\left(1+r_t\right)^{-1}/\left(\partial d_{t+1}\partial\eta\right)$ in opposite directions. Suppose that $\partial(\zeta_{t+1}^*p_{t+1}^F y_t^N)/\partial\eta<0$ for all states. The first component in the bracket is thus positive, indicating that η reduces expected repayments from foreclosed collaterals, incentivizing lenders to charge a higher interest rate. However, the second component in the bracket is negative. The intuition here is that although increasing the lender's initial investment d_{t+1} reduces the rate of return per invested dollar in future foreclosure states as repayments are independent of d_{t+1}, η mitigates this reduction in the rate of return, thereby incentivizing lenders to charge a lower interest rate.

Another crucial component that determines overborrowing is the pecuniary externality associated with the collateral price, $-\kappa\partial E(\mu_{t+1}^{SP}p_{t+1}y_{t+1}^N)/\partial d_{t+1}$. Since endogenous variables in the no-foreclosure states are affected by $y_t=\left[\bar{y}_t^N,y_t^T\right]$ and d_t, and those in the foreclosure states are only affected by y_t, I denote the endogenous variable x in post-foreclosure and no-foreclosure states with a binding collateral constraint in $t+1$ by $x_{t+1}^{SP,F*}(y_{t+1}^T)$ and $x_{t+1}^{SP,NF*}(d_{t+1};y_{t+1}^T)$, respectively. The exogenous variable $\bar{y}_t^N$ is ignored because it does not determine foreclosure. It follows that the pecuniary externality associated with the collateral price is given by

$$-\frac{\partial E(\mu_{t+1}^{SP}p_{t+1})}{\partial d_{t+1}}=-f(d_{t+1}|y_t^T)\left[\mu_{t+1}^{SP,F*}(d_{t+1})p_{t+1}^{F*}(d_{t+1})-\mu_{t+1}^{SP,NF*}(d_{t+1};d_{t+1})p_{t+1}^{NF*}(d_{t+1};d_{t+1})\right]-\tilde{\mathscr{M}}_1, \quad (25)$$

scaled by the collateral value κy^N, where

$$\mathscr{M}(d_{t+1}; y^T_{t+1}) = \int p^{NF}_{t+1}(d_{t+1}; y^T_{t+1})\mu^{SP,NF}_{t+1}(d_{t+1}; y^T_{t+1}) f(y^T_{t+1}|y^T_t) dy^T_{t+1}$$

is the expected nominal shadow value of the collateral constraint in no-foreclosure states, and $\tilde{\mathscr{M}}_1 \triangleq \mathscr{M}_1(d_{t+1}; \bar{y}^T_{t+1}) - \mathscr{M}_1(d_{t+1}; d_{t+1})$ measures the expected marginal change in the nominal shadow value with respect to debt in no-foreclosure states. The first component on the right-hand side of equation (25) measures the changes in the priced shadow value when the economy moves from a no-foreclosure state with a binding collateral constraint to a post-foreclosure state with a binding collateral constraint under a given d_{t+1}. If this gap is negative, it means that the post-foreclosure binding state yields a lower marginal benefit of loosening the collateral constraint when d_{t+1} is decreased. In this case, overborrowing is greater than that in the model without foreclosure because the SP now reduces debt not only for the marginal benefit of loosening the collateral constraint but also to avoid future foreclosure that reduces this marginal benefit.

Lender concentration affects the pecuniary externality associated with the collateral price via two opposite effects. Since η only matters in foreclosure states, it affects overborrowing only via $\mu^{SP,F*}_{t+1} p^{F*}_{t+1}$ so that the partial derivative of overborrowing with respect to η is given by

$$-\kappa y^N \frac{\partial E(\mu^{SP}_{t+1} p_{t+1})}{\partial d_{t+1} \partial \eta} = -\kappa y^N f(d_{t+1}|y^T_t) \left[p^{F*}_{t+1} \frac{\partial \mu^{SP,F*}_{t+1}}{\partial \eta} + \mu^{SP,F*}_{t+1} \frac{\partial p^{F*}_{t+1}}{\partial \eta} \right]. \tag{26}$$

The two opposite effects refer to $p^{F*}_{t+1}(\partial \mu^{SP,F*}_{t+1}/\partial \eta)$ and $\mu^{SP,F*}_{t+1}(\partial p^{F*}_{t+1}/\partial \eta)$, which tend to have opposite signs. When η increases p^{F*}_{t+1}, the shadow value $\mu^{SP,F*}_{t+1}$ that measures the tightness of the collateral constraint decreases. When the effect of a negative $p^{F*}_{t+1}(\partial \mu^{SP,F*}_{t+1}/\partial \eta)$ dominates a positive $\mu^{SP,F*}_{t+1}(\partial p^{F*}_{t+1}/\partial \eta)$, η alleviates post-foreclosure sudden stops by lowering the nominal shadow value of the collateral constraint, $\mu^{SP,F*}_{t+1} p^{F*}_{t+1}$, leading to more overborrowing.

4 Quantitative Analysis

Following Bianchi (2011) and Chi et al. (forthcoming), I assume that the exogenous endowment vector $y_t = \left[y^T_t, \bar{y}^N_t\right]'$ follows an AR(1) process, $logy_t = \alpha logy_{t-1} + \epsilon_t$, where $\epsilon_t = \left[\epsilon^T_t \; \epsilon^N_t\right]'$ follows a bivariate normal distribution featuring zero mean and a variance-covariance matrix $V = [0.0022, 0.0016; 0.0016, 0.0017]$. The estimated AR(1) coefficient

Table 4: Calibration

Parameter	Value	Description
σ	2.00	Parameter of risk aversion
β	0.91	Subjective discount factor
r^*	0.04	World interest rate
κ	0.972	Collateral margin of nontradable goods
η	0.74	Median top-1 concentration of emerging countries
δ	0.32	Coefficient of output loss
ξ	0.55	Elasticity of substitution between c^T and c^N
a	0.0015	Weights on tradables in CES aggregator
y^N	6.90	Collateralizable non-tradable endowment
Discretization of State Space		
n_{y^T}	13	Number of equally-spaced grid points for lny^T
$n_{\bar{y}^N}$	13	Number of equally-spaced grid points for $ln\bar{y}^N$
n_d	800	Number of equally-spaced grid points for d_t
$[ln\underline{y}^T, ln\overline{y}^T]$	$[-0.1093, 0.1093]$	Range for logarithm of tradable endowment
$[ln\underline{\bar{y}}^N, ln\overline{\bar{y}}^N]$	$[-0.1328, 0.1328]$	Range for logarithm of nontradable endowment
$[\underline{d}, \overline{d}]$	$[0, 1.1]$	Debt range
Model	Data	Calibration target
0.102	0.108	Average debt-to-output ratio
0.051	0.055	Sudden stop probability
0.021	0.026	Foreclosure probability
0.746	0.747	Average foreclosure rate in defaults

Notes: The average debt-to-output ratio is the time average for the period of 1970 to 2022 from the External Wealth of Nations database collected by Lane and Milesi-Ferretti (2018). The sudden stop probability is from Bianchi (2011). The foreclosure probability is from Schmitt-Grohé and Uribe (2017). The average foreclosure rate is the share of mortgages that are ever foreclosed on between 2007 and 2010 calculated by Favara and Giannetti (2017).

$\alpha = [0.9010, 0.4950; -0.4530, 0.2250]$. The transition probability matrix of the endowment vector is estimated via the approach in Schmitt-Grohé and Uribe (2014). Following Bianchi (2011), I set $\sigma = 2$, $\beta = 0.91$, and $r^* = 0.04$.

The baseline model assumes that $\eta = 0.74$, which is the median concentration of the largest US lender of Argentina's external debt across quarters. Owing to data limitations, κ is estimated from NY Fed Tri-Party/GCF Repo data, which collects assorted asset haircuts in

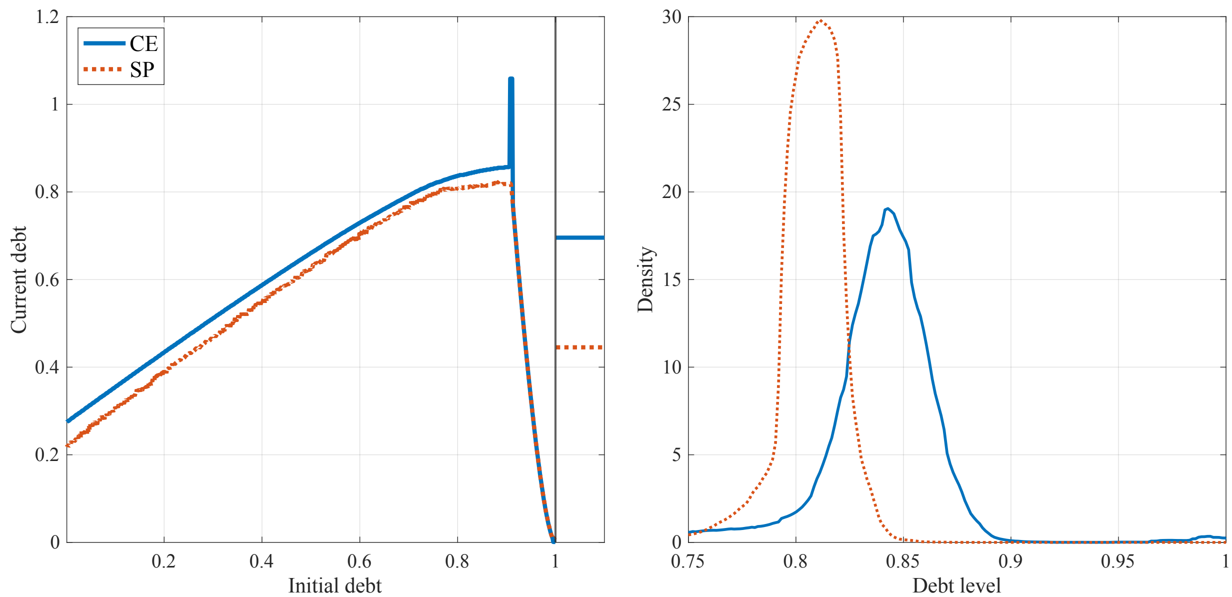

Figure 3: Policy functions and unconditional distributions of debt

Notes: The left panel plots the policy function under the medium grids of exogenous y_t^T and $\bar{y}_t^N$. The vertical solid line represents $y^T = 1$. Following Schmitt-Grohé and Uribe (2021), densities in the right panel are smoothed by averaging the densities of grid points d_{i-20} to d_i for $i = 21, ..., 800$. The models are simulated for one million periods where the first decile of periods are dropped.

the US triparty repo market.[12] The data are monthly from September 2010 to July 2011. The remaining coefficients δ, ξ, a, and y^N are calibrated to the following four empirical moments : (1) Argentina's debt-to-output ratio, (2) the probability of sudden stop in Argentina, (3) the probability of default in Argentina, and (4) the average foreclosure rate.[13] Table 4 lists the parameter values and calibration. With the calibrated model in hand, I analyze overborrowing by comparing debt decisions and allocations in the CE and the SP's problem.

The left panel of Figure 3 shows the policy function of debt. Consistent with the literature, the policy function of debt is nonmonotonic. It increases with the initial debt when the future collateral constraint never binds. Then, the slope of the policy function decreases when the future collateral constraint binds with a positive probability, as borrowers reduce debt to avoid future sudden stops. Another feature of the policy function is that the convex-

[12] κ is estimated by the volume-weighted time-average of margins of a set of liquid and illiquid assets, including all the assets with Investment Grade, ABS Non Investment Grade, Agency CMOs, Agency Debentures & Strips, Agency MBS, CDOs, Equities, International Securities, Money Market, Municipality Debt, US Treasuries Strips, US Treasuries excluding Strips.

[13] Given the absence of available data regarding foreclosing on secured external debt, the model is calibrated to match the average share of mortgage debts foreclosed on by US financial institutions. This alternative approach assumes that US financial institutions internalize the price change when foreclosing on secured external debt in the same way as they do with mortgages.

ity of the collateral price may lead to a hike in current debt when the initial debt approaches the foreclosure threshold, represented by the solid vertical line. In these states, the price function is sufficiently convex that the collateral constraint binds at two different levels of current debt. The agents in the CE then choose the binding equilibrium with the higher current debt. A sudden jump in the policy function is also found by Schmitt-Grohé and Uribe (2021).

Unlike the literature suggesting that initial debt reduces current wealth and borrowing capacity in binding states, this model's policy function remains flat as initial debt rises toward foreclosure states. This result is obtained because any initial debt obligation, regardless of its level, will be waived. With initial debt being waived, the collateral constraint may not be binding in these states, leading the social planner to borrow less than agents who borrow to smooth consumption subject to the output loss. However, in states where sudden stops and foreclosure events jointly occur, the two horizontal debt decisions in the CE and the SP's problem coincide. The right panel of Figure 3 shows that the model features overborrowing as the debt distribution in the CE is to the right of that in the SP's problem.

Table 5 shows the simulated results of competitive equilibria and the SP's problem. We begin by comparing the SP's allocation (SP) and CE. Comparable to the numerical findings in the literature, overborrowing is 0.0086 ($= 0.8157 - 0.8071$) in terms of mean debt. Defining overborrowing by median debt or the mean or median debt-to-output ratio yields similar results. Consistent with the literature, the crisis is less severe in SP as debt decreases by 4.7% ($= 1 - 0.7694/0.8075$) in sudden stops from the level in normal times, whereas the magnitude is 36.5% ($= 1 - 0.5281/0.8320$) in CE. This result is obtained because the initial debt is lower in the SP's allocation when the collateral constraint binds. The crisis is also less severe in SP when measuring the severity of a crisis by the reduction in the mean collateral price. By borrowing less debt, the SP reduces the sudden stop probability to less than 1% and never encounters foreclosure, leading to higher consumption than that in CE. The difference between SP and CE implies that allowing the large lender to internalize the pecuniary externality is insufficient to achieve the SP's allocation.

A fundamental question is then whether the pecuniary externality internalized by lenders is quantitatively important compared with that internalized by borrowers. To this end, I consider a CE, denoted as CE^f, in which the large lender does not internalize changes in the collateral price and chooses to foreclose on all collateral ($\zeta_t^{L*} = 1$), similar to the atomistic

Table 5: Simulated results of the equilibrium solutions

	SP	CE	CE^f	CE^{oe}
Mean debt	0.8071	0.8157	0.8092	0.8176
Mean debt in sudden stops	0.7694	0.5281	0.5021	0.6200
Mean debt in normal times	0.8075	0.8320	0.8236	0.8342
Median debt	0.8084	0.8387	0.8387	0.8400
Mean debt-to-output ratio	0.1005	0.1016	0.1008	0.1018
Median debt-to-output ratio	0.1010	0.1045	0.1043	0.1046
Mean price	0.1302	0.1328	0.1316	0.1302
Mean price in sudden stops	0.1103	0.0756	0.0715	0.0889
Mean price in normal times	0.1304	0.1359	0.1343	0.1336
Mean consumption	7.2868	7.2512	7.2846	7.2834
Sudden stop probability	0.0098	0.0514	0.0419	0.0773
Foreclosure probability	0.0000	0.0206	0.0259	0.0000
Mean η_t among foreclosure	NaN	0.7400	0.7400	NaN
Mean ζ_t^{L*} among foreclosure	NaN	0.6571	1	NaN
Mean ζ_t^* among foreclosure	NaN	0.7463	1	NaN

Notes: SP stands for the allocation of the SP's solution. CE stands for the allocation of the baseline CE; CE^f denotes the CE with full foreclosure ($\zeta_t^{*L} = \zeta_t^{*A} = 1$); CE^{oe} denotes the CE under optimal lender concentration η_t set by the lender country, as characterized in section 5. In SP, CE, and CE^f, the lender concentration η_t is fixed at 0.74. Except for $\{\eta_t, \zeta_t^{L*}, \zeta_t^*\}$, all the other parameters of CE^f and CE^{oe} follow Table 4. The debt-to-output ratio is defined as $d_{t+1}/(y_t^T + p_t y_t^N)$. Binding probability is the probability that (3) binds. The values of mean η_t, ζ_t^{L*}, and ζ_t^* among foreclosure is NaN if the foreclosure probability is zero. Simulated moments are calculated from the last 1 million periods of a simulation of 1.1 million periods.

lenders. Unlike CE, in which the large lender internalizes the pecuniary externality by only selling 65.71% of the seized collateral, both lenders and borrowers in CE^f fail to internalize the pecuniary externality.

With a more concentrated lender structure that protects the price in foreclosure, agents in CE tend to borrow more, leading to a higher sudden stop probability. With higher initial debt, a binding collateral constraint can be triggered by less volatile endowment shocks than those that triggered a binding collateral constraint in CE^f, leading to mean debt and mean price in sudden stops in CE being slightly higher than those in CE^f. However, CE^f features a slightly higher foreclosure probability, as fewer sudden stops force agents to reduce debt holding.

The relative size of the pecuniary externality internalized by lenders to the pecuniary externality internalized by borrowers is significant. To see this, I compare CE and CE^f with SP, in which both the large lender and borrowers internalize the pecuniary externality. Allowing the large lender to internalize the pecuniary externality widens overborrowing from 0.0021 (= 0.8092 − 0.8071) to 0.0086 in terms of mean debt as sudden stops in CE are less severe than those in CE^f, thus requiring less precautionary savings by agents. Thus, the pecuniary externality internalized by lenders is −0.0059 (= 0.0021 − 0.0086), whose absolute value is two-thirds that of the pecuniary externality internalized by borrowers, which is simply the overborrowing in CE equal to 0.0086.

4.1 The effect of lender concentration on overborrowing

One of the primary goals of this paper is to understand how lender concentration affects overborrowing. Panel (a) in Figure 4 shows that overborrowing increases with η as the mean debt in CE increases with η. As noted in Section 3, this implies that the expected marginal utility with respect to debt, $U'(d_{t+1})$, in equation (9) increases with η. As shown by panel (d), this relationship is essentially driven by debt capacity in potential foreclosure events, in which η reduces nontradable supply and increases borrowing capacity. In foreclosure states, debt holding increases by 1.3% for a one percent increase in lender concentration. In contrast, debt in the SP's problem is independent of changes in η because foreclosure events never occur within the selected range of η, as shown by panels (b) and (c).[14] Panel (c) shows that the mean debt level slightly decreases with η because of more frequent sudden stops in CE in which agents are forced to deleverage, while the social planner consistently borrow less in no-foreclosure states because of the pecuniary externality. The patterns of debt holdings across different states in CE are consistent with panels (e) and (f), where η raises mean debt and results in a higher sudden stop probability. However, more frequent debt deleveraging in sudden stops reduces the foreclosure probability.

[14] η does not change debt decisions in the SP's problem because the additional pecuniary externalities associated with the collateral price and interest premium characterized in equations (24) and (26) do not change across η as $g(x, y_t^N, y_t^T) = 0$. This result is obtained because $f(d_{t+1}|y_t^T) = 0$ when $d_{t+1} > y_{t+1}^T$ and $\partial(\zeta_{t+1}^* p_{t+1}^F y_t^N)/\partial\eta = 0$ when $d_{t+1} \leq y_{t+1}^T$ by construction.

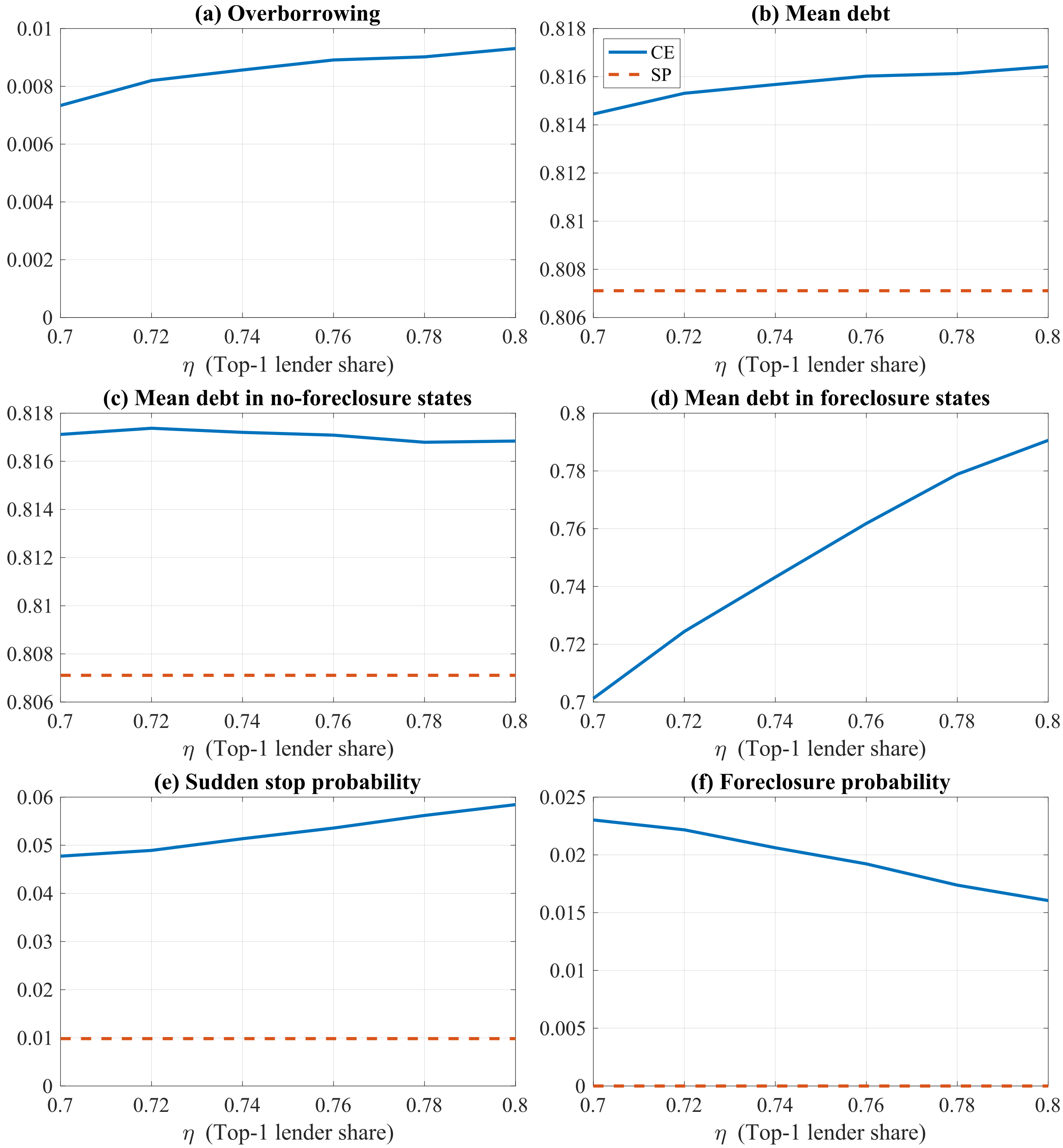

Figure 4: Overborrowing and lender concentration

Notes: This figure plots the simulated mean of counterfactuals under different η values. Other parameters follow the values in Table 4. The models are simulated for 1.1 million periods where the first 0.1 million periods are dropped.

5 Optimal Lender Concentration

Since lender concentration affects the returns of each lender, the lender countries have an incentive to maximize returns by optimally choosing the concentration. An example of this type of policy is the Brady plan in the 1980s where the US bought back sovereign bonds of emerging countries via US Treasury bonds, thus concentrating the lender structure to solve the coordination problem among lenders. Such a policy exercise has been recently emphasized by the World Bank (2022) due to the growing accumulation of external debt during the COVID-19 pandemic. While lender concentration raises the collateral price in bad times due to limited foreclosure, it may also incentivize domestic borrowers to borrow more, leading to a higher probability of foreclosure and a binding collateral constraint. Thus, determining whether allowing the lender country to optimally set lender concentration benefits or harms the domestic borrowers requires numerical analysis. This section provides the results of this exercise.

The numerical exercise is particularly crucial because the optimal lender structure presents a potential tradeoff. While a concentrated lender structure can safeguard collateral prices during adverse economic conditions, it can also magnify the pecuniary externality that constrains funding opportunities during collateral sales. This latter mechanism implies a risk of concentrating lending toward a single borrower, aligning with the risk management guidelines published by federal banking agencies (FDIC, 2006). These agencies, including the Federal Deposit Insurance Corporation, the Board of Governors of the Federal Reserve System, and the Office of the Comptroller of the Currency, expect banks with a higher concentration of commercial real estate holdings to adopt more stringent risk management practices.

I consider a planner of the foreign lender country who maximizes lenders' profit, taking as given the foreclosure decisions of atomistic lenders, $\zeta_t^{A*} = 1$, and the large lenders given by equation (15). The foreign planner's maximization problem is given by

$$\max_{\eta_t} \zeta_t^*(\eta) p_t^F(\eta_t) y_{t-1}^N + \pi_{t+1} d_{t+1} + (1 - \pi_{t+1}) \zeta_{t+1}^* p_{t+1}^F y_t^N,$$

where $\pi_{t+1} = Pr\left(d_{t+1} \leq y_{t+1}^T\right)$ is the probability that the borrowers fully repay the debt, and the first component of the objective is the foreclosure value. The second and third components are the expected repayments in future foreclosure and no-foreclosure states, respectively. Similar to the maximization problem considered in Subsection 3.4, in which the domestic planner chooses the debt while taking the lender's foreclosure decisions and lender concentration as given, I assume that the foreign planner also takes the borrower's debt decision d_{t+1} as given. While the third term $(1-\pi_{t+1})\,\zeta^*_{t+1}(\eta_{t+1})p^F_{t+1}y^N_t$ is affected by η_{t+1}, I focus on the optimal lender concentration without commitment as one can show that the plan under commitment is time-inconsistent. The above maximization problem can then be simplified to maximizing $\zeta^*_t(\eta_t)p^F_t(\eta_t)y^N_{t-1}$ by choosing η_t, which yields the following first-order condition:

$$\frac{d\zeta^*_t}{d\eta_t}p^F_t + \frac{\partial p^F_t}{\partial \eta_t}\zeta^*_t = 0, \tag{27}$$

under which the optimal foreclosure rate under the optimal concentration η^*_t is characterized by $\zeta^*_t(\eta^*_t) = -p^F_t(d\zeta^*_t/d\eta_t)/(\partial p^F_t/\partial \eta_t)$. Since we assume $\xi < 1$, $d\zeta^*_t/d\eta_t = -(1-\xi)^{-1} < 0$ as shown by Lemma 1. In this case, a tradeoff exists because while lender concentration decreases profits by incentivizing the large lender to foreclose on less collateral, it also increases profits by increasing the collateral price under foreclosure, as shown by the first and second components in equation (27). Online Appendix a.2 shows that $\zeta^*_t(\eta^*_t)$ is positive and given by $\eta^* = 1$, which satisfies the second-order condition of the foreign planner's maximization problem. This result implies that the lender country's planner has an incentive to increase lender concentration that significantly exceeds the empirical lender concentration of 0.74.

How does the optimal concentration set by the foreign planner affect the CE? The final column in Table 5 shows the simulated results of the CE under the optimal lender concentration, denoted as CE^{oe}. Several unique observations emerge. First, agent's borrowing is highest in the CE with optimal lender concentration. This result is obtained because a higher lender concentration in CE^{oe} makes future binding states less severe by boosting the collateral price and borrowing capacity. However, higher borrowing results in more frequent sudden stops that force agents to reduce debt, which in turn leads to zero foreclosure probability. Second, with higher borrowing in CE^{oe}, a binding collateral constraint can be triggered under less volatile shocks than those in CE, leading to on average less severe sudden stops in CE^{oe} measured by changes in mean debt or the mean collateral price.[15] Finally, compared

[15]However, under large endowment shocks that trigger binding collateral constraints in CE and CE^{oe}, the impulse responses in both models are almost identical, as foreclosure occurs with extremely low probability. This finding is illustrated in Figure A.8 in the Online Appendix, which examines the event study under the SP's allocation, CE, and CE^{oe}. Consistent with the literature, the SP's allocation exhibits less volatile sudden stops compared to the competitive equilibria.

with CE, agents in CE^{oe} can borrow, on average, 0.2% (= (0.8176 − 0.8157)/0.8157) more, increasing agents' mean consumption by 0.4% (= (7.2834−7.2512)/7.2512) and consumption-equivalent welfare by 1.53%.[16] This comparison implies that lender structure regulation by foreign policy makers can improve the welfare of borrower countries.

6 Conclusion

This paper studies the effect of lender concentration on countries' external debt via the pecuniary externality internalized by large lenders. This mechanism is motivated by the empirical fact that the external debt of emerging countries tends to have a more concentrated lender structure, which alleviates the severity of sudden stops.

With the empirical facts in hand, this paper develops a model that incorporates the influence of lender concentration via lenders' foreclosure decisions, with which lenders affect the collateral price via nontradable supply. The theoretical results show that how lender concentration affects overborrowing depends on how it affects the expected marginal utility with respect to debt, and the pecuniary externalities associated with the collateral price and interest rate. Lender concentration can increase overborrowing when it increases consumption in foreclosure states as agents raises tradable consumption by consuming less nontradable good supplied by less foreclosed collateral. Agents then dare to borrow more ex-ante as the reduction in consumption utility in foreclosure states decreases with lender concentration.

Quantitative analysis shows that decentralized agents overborrow. Comparing equilibria in which borrowers and lenders internalize or do not internalize the pecuniary externality, I show that the pecuniary externality internalized by lenders is two-thirds that of a typical pecuniary externality internalized by borrowers, highlighting the quantitative importance of lenders' decisions. Furthermore, overborrowing increases with lender concentration, and this result is driven by the debt decision in the competitive equilibrium, as foreclosure is completely prevented in the social planner problem. Lender concentration significantly alleviates the foreclosure events and increases borrowing, leading to a higher sudden stop probability. Finally, I show that lender countries have an incentive to concentrate their lender structure to increase their payoff, allowing borrower countries to borrow and consume more.

[16] The consumption-equivalent welfare gain ($gain$) is given by $(1 + gain)^{(1-\sigma)}\bar{u}_{ce} = \bar{u}_{ce}^{oe}$, where $\bar{u}_{ce}$ and $\bar{u}_{ce}^{oe}$ are the simulated mean utility under the baseline CE and that under optimal lender concentration, respectively.

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7 Appendix

7.1 Proof of Lemma 3

The derivative of p_t^F with respect to d_{t+1} under foreclosure is given by

$$\frac{\partial p_t^s}{\partial d_{t+1}} = \frac{p_t^s}{\xi c_t^{T,s}} \left(\frac{1}{1+r_t} - d_{t+1} \frac{1}{(1+r_t)^2} \frac{\partial r_t}{\partial d_{t+1}} - \left((1-I_t) + I_t \zeta_t^*\right) y_{t-1}^N \frac{\partial p_t^s}{\partial d_{t+1}} \right)$$

where $s \in \{NF, F\}$. Thus, $\partial p_t^s / \partial d_{t+1} > 0$ for $s \in \{NF, F\}$ when $\partial r_t / \partial d_{t+1} < 0$. Denote $\hat{\zeta}_t = ((1-I_t) + I_t \zeta_t^*)$, we have that

$$\frac{\partial^2 p_t^s}{\partial d_{t+1}^2} = \left(\frac{1}{\xi} - 1\right) \frac{p_t^s}{\xi} \left(\frac{1}{1+r_t} - d_{t+1} \frac{1}{(1+r_t)^2} \frac{\partial r_t}{\partial d_{t+1}} - \hat{\zeta}_t y_{t-1}^N \frac{\partial p_t^s}{\partial d_{t+1}}\right)^2 \left(\frac{1}{c_t^{T,s}}\right)^2 +$$
$$\frac{p_t^s}{\xi} \frac{1}{c_t^{T,s}} \left(-\frac{2}{(1+r_t)^2} \frac{\partial r_t}{\partial d_{t+1}} - \left[\left(-2 \frac{d_{t+1}}{(1+r_t)^3} \frac{\partial r_t}{\partial d_{t+1}}\right) \frac{\partial r_t}{\partial d_{t+1}} + \frac{d_{t+1}}{(1+r_t)^2} \frac{\partial^2 r_t}{\partial d_{t+1}^2}\right] - \hat{\zeta}_t y_{t-1}^N \frac{\partial^2 p_t^s}{\partial d_{t+1}^2}\right),$$

where $\partial^2 p_t^s / \partial d_{t+1}^2 > 0$ if $\xi \in (0, 1)$ and $\partial^2 r_t / \partial d_{t+1}^2 < 0$.

A Online Appendix (Not For Publication) to

Lender Concentration of External Debts and Sudden Stops

Chun-Che Chi

a.1 The Issue of Multiple Competitive Equilibria

This section studies potential multiple equilibria, which may call for equilibrium selection criteria. To illustrate this issue, I follow Schmitt-Grohé and Uribe (2021) by assuming that the model starts from an initial steady-state equilibrium with no-foreclosure and deterministic endowment where $y_t^T = y^T$, $\bar{y}_t^N = \bar{y}^N$, $y_t^N = y^N$, and $r_t = r^*$ for all t. To visualize the initial equilibrium, the downward-sloping line in Figure A.1 plots the collateral value $\kappa \left(\frac{1-a}{a}\right)\left(\frac{y^T - \frac{r^*}{1+r^*}d_{t+1}}{\bar{y}^N + y^N}\right)^{1/\xi}$ multiplied by $(1+r_t)$ in which $d_{t+1} = d_t$. It follows that for d_{t+1} that belongs to an initial steady-state equilibrium, it must be that $d_{t+1} = d_t \in \left[0, \tilde{d}\right]$, where $\tilde{d}$ is given by

$$\tilde{d} = \kappa \left(\frac{1-a}{a}\right)\left(\frac{y^T - \frac{r^*}{1+r^*}\tilde{d}}{\bar{y}^N + y^N}\right)^{1/\xi}. \tag{a.1}$$

Consider an equation that multiplies both sides of the collateral constraint (3) by $(1+r_t)$. Then, the 45-degree solid line plots the left-hand side and the dash-dotted curve plots the right-hand side of this equation where d_{t+1} is not necessarily equal to d_t. Any equilibrium above the 45-degree line satisfies the collateral constraint. Under a given initial debt d_t, point A is a steady-state equilibrium, where the collateral values (dash-dotted curve) intersect with the set of steady state equilibria (downward-sloping line) so that $d_{t+1} = d_t$. The issue of multiple equilibria arises because there are also multiple equilibria with a binding collateral constraint (3) (hereafter, binding equilibrium) in addition to the steady-state equilibrium A. In a no-foreclosure state, points B and C are two equilibria in which equation (3) is binding.

The issue of multiple equilibria with a binding collateral constraint in no-foreclosure states can be theoretically characterized. Denote $S(d_{t+1}) = \partial p_t^{NF}(d_{t+1})\kappa y_t^N / \partial d_{t+1}$ as the slope of the collateral value with respect to d_{t+1} and $\hat{d}$ as the debt level that satisfies $S(\hat{d}) = 1$. Under a convex price p_t as characterized in Lemma 3, the criterion to determine the number of binding solutions is summarized by the following lemma:

Lemma 4. *(Uniqueness of the no-foreclosure binding equilibrium) If $y_t^T = d_t$, there exists a unique binding equilibrium. If $y_t^T > d_t$ and $\xi \in (0,1)$,*

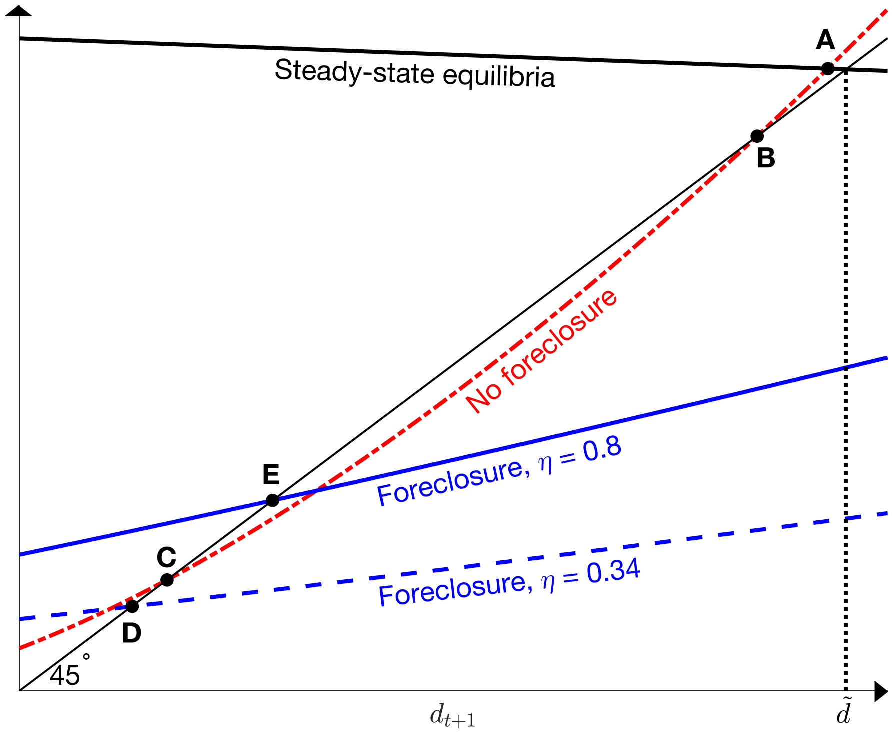

Figure A.1: Multiple equilibria and lender concentration

(i) there exist two binding equilibria when $p_t^{NF}(\hat{d})\kappa y_t^N < \hat{d}$,

(ii) there exists one binding equilibrium when $p_t^{NF}(\hat{d})\kappa y_t^N = \hat{d}$, *and*

(iii) there exists no binding equilibrium when $p_t^{NF}(\hat{d})\kappa y_t^N > \hat{d}$.

Proof: See Online Appendix a.3.

Thus, when the collateral constraint binds in no-foreclosure states, the parameterization that guarantees a unique binding equilibrium is a knife-edge case. The selection criterion is especially important when the two binding equilibria in case (i) have different relationships between lender concentration and borrowing. For example, if the lowest possible y_t^T lies within the corresponding debt levels of points B and C, then the criterion that favors point C is not subject to foreclosure, and thus borrowing is independent of lender concentration.

However, in foreclosure states, the binding equilibrium is unique within a much wider set of parameterizations with a sufficiently large foreclosure rate $\zeta_t^* > \underline{\zeta}_t$. The reason is that d_{t+1} increases the collateral price by less under a higher foreclosure rate because nontradable consumption crowds out tradable consumption. Thus, the slope of p_t^F with respect to d_{t+1} is flat enough that this curve intersects with the 45-degree line only once. For example, the bold solid and dashed lines in Figure A.1 represent the collateral values times the gross interest rate in foreclosure states with maximum and minimum empirical median holdings of the top-1 lender across emerging countries, respectively, as documented in Table 1. In the two extreme cases, the corresponding collateral value when the large lender owns 34% (80%) of total loans is associated with a unique binding equilibrium at point D (E). Lemma 5 summarizes this result. Under the parameters calibrated in Section 4 or used in Figure A.1, all pairs of states satisfy condition (a.5), which guarantees the uniqueness of the post-foreclosure binding equilibrium.

Lemma 5. *(Uniqueness of the post-foreclosure binding equilibrium) There exists a unique post-foreclosure binding equilibrium when* $\zeta_t^* > \underline{\zeta}_t$.

Proof: See Online Appendix a.3.

With the presence of multiple equilibria, the relationship between lender concentration and overborrowing can be affected by the selection criterion of the decentralized equilibrium. Consider an empirically relevant scenario where $\eta = 0.8$. Under criterion (C), which chooses point C over A and B in Figure A.1, the debt level in the binding equilibrium is unaffected by η because debt is too low to trigger foreclosure, as denoted by point E. In this case, the magnitude of overborrowing will be fully driven by the response of the SP's allocation to changes in η. However, when foreclosure does not occur in the SP's problem, the SP's allocation is unaffected by η, as in the baseline parameterization in Section 4.

To check whether the calibrated model is subject to the issue of multiple equilibria and requires an equilibrium selection criterion, I compare the policy functions and the simulated distribution under optimistic and pessimistic equilibria. I denote the optimistic equilibrium selection criterion by criterion (A), under which decentralized agents select a d_{t+1} that satisfies equations (2)-(11) and the collateral constraint is not binding for every state $(y_t^T, \bar{y}_t^N, d_t)$. If no such d_{t+1} exists, agents choose the binding equilibrium with the higher d_{t+1} if there are multiple binding equilibria. I denote the pessimistic equilibrium selection criterion by criterion (C), under which decentralized agents choose the binding equilibrium with the lowest d_{t+1} such as point C in Figure A.1. Under criterion (C), agents choose only the nonbinding equilibrium when there is no binding equilibrium.

With the parameter values in Table 4, Figure A.2 shows that the policy functions and the simulated results for borrowing are almost identical between criteria (A) and (C) across the selected range of η.

a.2 Optimal Lender Concentration

Suppose that the foreign lender country optimally and discretely sets its lender concentration. From equation (27), the optimal η is given by

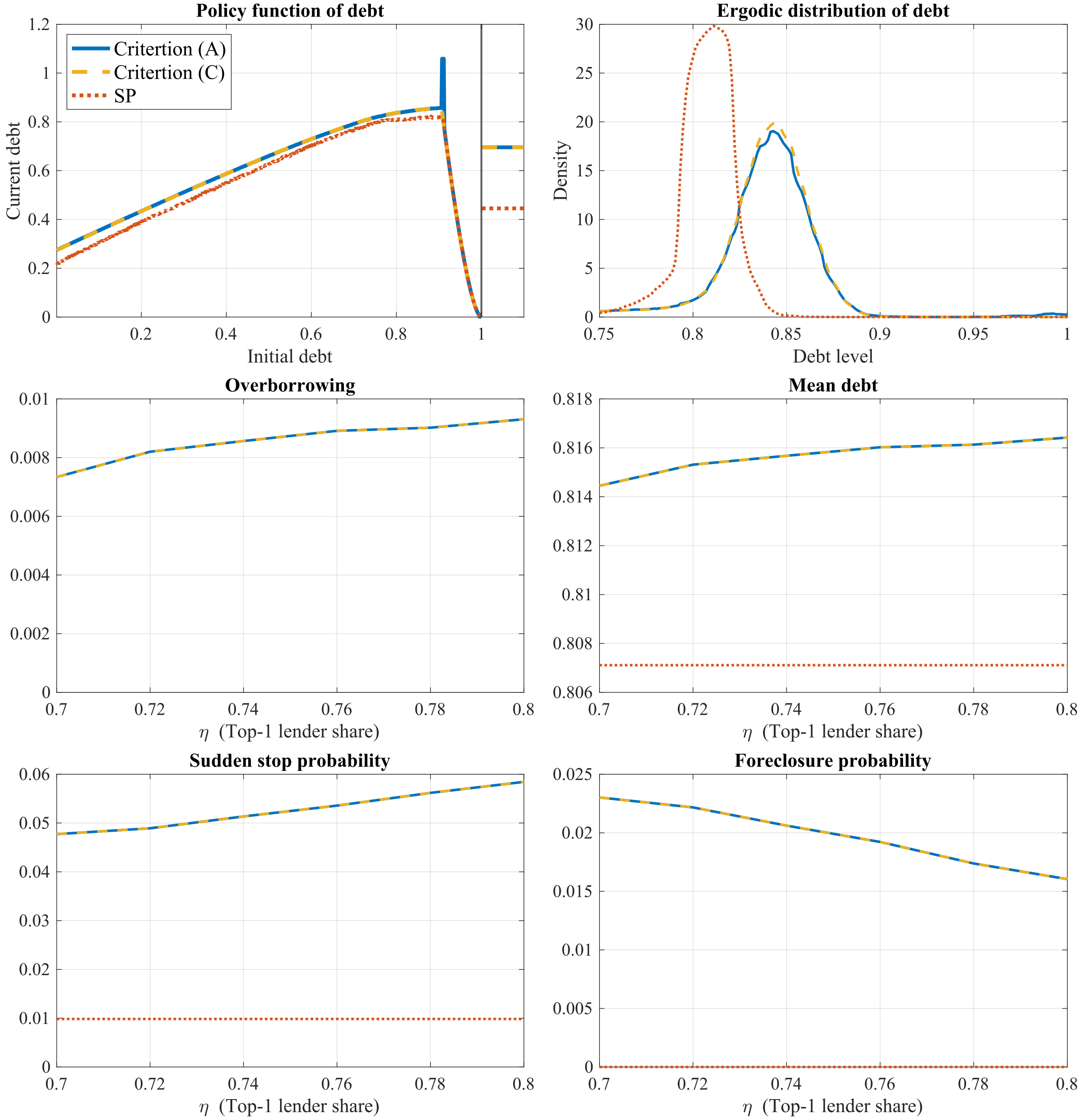

Figure A.2: Policy functions and unconditional distributions of debt

Notes: The upper left panel plots the policy function under the medium grids of exogenous y_t^T and $\bar{y}_t^N$. The vertical solid line represents $y^T = 1$. Densities in the upper right panel are smoothed by averaging the densities of grid points d_{i-20} to d_i for $i = 21, ..., 800$. The models are simulated for one million periods where the first decile of periods are dropped. The bottom four figures plot the simulated mean of counterfactuals under different η values. Other parameters follow the values in Table 4.

$$\zeta_t^* = -p_t^F \frac{d\zeta_t^*}{d\eta_t}\left(\frac{\partial p_t^F}{\partial \eta_t}\right)^{-1},$$

where $d\zeta_t^*/d\eta_t = -(1-\xi)^{-1} < 0$ as shown by Lemma 1, and

$$\frac{\partial p_t^F}{\partial \eta_t} = \frac{p_t^F}{\xi}\frac{c_t^{T,NF}\left(d_{t+1}\left(\frac{1}{1+r_t^L}-\frac{1}{1+r_t^A}\right)-\frac{\partial p_t^F}{\partial \eta_t}\zeta_t^* y_{t-1}^N\right)+\frac{y_{t-1}^N}{1-\xi}\left[p_t^F \bar{y}_t^N + \left(y_t^T + \frac{d_{t+1}}{1+r} - \delta\right)\right]}{c_t^{T,F} c_t^{T,NF}}.$$

Since $r_t^L \geq r_t^A$ as shown in equation (16), the sign of $\partial p_t^F/\partial \zeta_t^*$ is ambiguous. Increasing the concentration η creates a tradeoff because although η increases the nontradable price by reducing the nontradable supply, it also increases the weight sum of interest rates r_t as debt becomes more concentrated on the largest lender, making debt more expensive and thus reducing tradable consumption and the nontradable price. Under the parameterization that consecutive foreclosure states occur with a zero probability so that $r_t^L = r_t^A$, we have that

$$\frac{\partial p_t^F}{\partial \eta} = \frac{p_t^F}{\xi}\frac{1}{1-\xi}\frac{y_{t-1}^N\left[p_t^F \bar{y}_t^N + \left(y_t^T + \frac{d_{t+1}}{1+r} - \delta\right)\right]}{c_t^{T,F} c_t^{T,NF}}\left(1 + \frac{p_t^F}{\xi}\frac{\zeta_t^* y_{t-1}^N}{c_t^{T,F}}\right)^{-1} > 0$$

and $\partial p_t^F/\partial \zeta_t^* < 0$. The optimal foreclosure rate is then given by

$$\zeta_t^* = \frac{\left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N\right)\left[(1-\xi)\, p_t^F \zeta_t^* y_{t-1}^N + \xi\left(y_t^T + \frac{d_{t+1}}{1+r} - \delta\right)\right]}{y_{t-1}^N\left(y_t^T + \frac{d_{t+1}}{1+r} + p_t^F \bar{y}_t^N - \delta\right)}, \tag{a.2}$$

which can be rearranged as the following function

$$0 = \left[(1-\xi)\,\zeta_t^* - \frac{\bar{y}_t^N}{y_{t-1}^N}\xi\right]\left[p_t^F y_{t-1}^N \zeta_t^* - \left(y_t^T + \frac{d_{t+1}}{1+r} - \delta\right)\right],$$

indicating two solutions $\zeta_t^* = \left\{\frac{\bar{y}_t^N}{y_{t-1}^N}\frac{\xi}{1-\xi}, \frac{\left(y_t^T + \frac{d_{t+1}}{1+r} - \delta\right)}{p_t^F y_{t-1}^N}\right\}$. However, the solution $\zeta_t^* = \frac{\left(y_t^T + \frac{d_{t+1}}{1+r} - \delta\right)}{p_t^F y_{t-1}^N}$ violates the nonnegativity condition of tradable consumption $c_t^{T,F} = y_t^T + \frac{d_{t+1}}{1+r_t} - p_t \zeta_t^* y_{t-1}^N - \delta$. Thus, the lender country will choose $\zeta_t^* = \frac{\bar{y}_t^N}{y_{t-1}^N}\frac{\xi}{1-\xi}$, implying that $\eta_t^* = 1$ under the optimal foreclosure decision $\zeta_t^* = \left(\frac{\bar{y}_t^N}{y_{t-1}^N} + (1-\eta_t^*)\right)\left(\frac{\xi}{1-\xi}\right) + (1-\eta_t^*)$ derived in subsection 3.2.

Next, we check whether the second-order condition holds for the solution $\eta_t^* = 1$. Note that the first order condition can also be written as $\frac{d\zeta_t^*}{d\eta_t}p_t^F + \frac{\partial p_t^F}{\partial \eta_t}\zeta_t^* = 0$. The second-order condition is thus given by

$$\frac{\partial^2 p_t^F}{\partial \zeta_t^{*2}}\zeta_t^* + 2\frac{\partial p_t^F}{\partial \zeta_t^*} < 0, \tag{a.3}$$

where $\partial p_t^F / \partial \zeta_t^* < 0$. Let $\omega = \left(y_t^T + \frac{d_{t+1}}{1+r} - \delta \right)$. The second derivative with respect to ζ_t^* is given by

$$\frac{\partial^2 p_t^F}{\partial \zeta_t^{*2}} = - \frac{\left[\left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N \right) \left((1-\xi) \zeta_t^* y_{t-1}^N + \frac{\xi}{p_t^F} \omega \right) y_{t-1}^N \bar{y}_t^N \frac{\partial p_t^F}{\partial \zeta_t^*} \right]}{\left[\left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N \right) \left((1-\xi) \zeta_t^* y_{t-1}^N + \frac{\xi}{p_t^F} \omega \right) \right]^2}$$
$$- \frac{-y_{t-1}^N \left[p_t^F \bar{y}_t^N + \omega \right] \left[y_{t-1}^N \left((1-\xi) \zeta_t^* y_{t-1}^N + \frac{\xi}{p_t^F} \omega \right) + \left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N \right) \left((1-\xi) y_{t-1}^N - \xi \omega \left(p_t^F \right)^{-2} \frac{\partial p_t^F}{\partial \zeta_t^*} \right) \right]}{\left[\left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N \right) \left((1-\xi) \zeta_t^* y_{t-1}^N + \frac{\xi}{p_t^F} \omega \right) \right]^2}$$

The second derivative evaluated at $\zeta_t^* = \frac{\bar{y}_t^N}{y_{t-1}^N} \frac{\xi}{1-\xi}$ can be expressed as

$$\frac{\partial^2 p_t^F}{\partial \zeta_t^{*2}} = - \frac{y_{t-1}^N}{\bar{y}_t^N} \frac{1-\xi}{\xi} \left[\frac{\partial p_t^F}{\partial \zeta_t^*} - y_{t-1}^N p_t^F \left(\frac{1}{\left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N \right)} + \frac{1-\xi}{\left((1-\xi) \zeta_t^* y_{t-1}^N + \frac{\xi}{p_t^F} \omega \right)} \right) \right]. \quad \text{(a.4)}$$

Plugging equation (a.4) into (a.3), the second-order condition can be written as

$$\frac{\partial p_t^F}{\partial \zeta_t^*} + y_{t-1}^N p_t^F \left(\frac{1}{\left(\bar{y}_t^N + \zeta_t^* y_{t-1}^N \right)} + \frac{1-\xi}{\left((1-\xi) \zeta_t^* y_{t-1}^N + \frac{\xi}{p_t^F} \omega \right)} \right) < 0,$$

which can be guaranteed by

$$\left(\xi - 1 + \frac{1}{1 + \frac{\omega}{p_t^F \bar{y}_t^N}} \right) < 0,$$

which always holds under positive $c_t^{T,F}$ and p_t^F.

a.3 Proofs of Lemmas

Proof of Lemma 4

If $y_t^T = d_t$, then $S(0) = 0$ and the collateral value equals 0. Since p_t^{NF} is increasing and convex in d_{t+1}, there exists only one intersection other than the point where $c_t^T = 0$ and $d_{t+1} = 0$. If $y_t^T > d_t$, then $S(0) > 0$ and $p_t^{NF}(0) \kappa y_t^N > 0$. Thus, there exists only one equilibrium when $p_t^{NF}(d_{t+1}) \kappa y_t^N$ is tangent to the 45-degree line, implying that $p_t^{NF}(\hat{d}) \kappa y_t^N = \hat{d}$. If $p_t^{NF}(\hat{d}) \kappa y_t^N < \hat{d}$, the slope is flat enough that two equilibria exist. If $p_t^{NF}(\hat{d}) \kappa y_t^N > \hat{d}$, the slope is too steep for the curve to cross the 45-degree line.

Proof of Lemma 5

Denote by $\bar{d}$ the natural debt limit. Since $p_t > 0$ with c_t^T and $c_t^N > 0$ and that p_t is increasing and convex in d_{t+1}, the following condition guarantees the uniqueness of a binding solution in states of foreclosure when $d_t < \bar{d}$:

$$\kappa p_t^F(\bar{d}) y_t^N < \frac{\bar{d}}{1 + r_t(\bar{d})}, \tag{a.5}$$

Note that $\kappa p_t^F(\bar{d}) y_t^N$ is given by

$$\kappa y_t^N \left(\frac{1-a}{a}\right) \left(\frac{y_t^T + \frac{\bar{d}}{1+r_t(\bar{d})} - p_t^F(\bar{d})\zeta_t^* y_{t-1}^N - \delta}{\bar{y}_t^N + \zeta_t^* y_{t-1}^N}\right)^{1/\xi} < \kappa y_t^N \left(\frac{1-a}{a}\right) \left(\frac{y_t^T + \frac{\bar{d}}{1+r_t(\bar{d})}}{\bar{y}_t^N + \zeta_t^* y_{t-1}^N}\right)^{1/\xi}.$$

Thus, a sufficient condition for $\kappa p_t^F(\bar{d}) y_t^N < \bar{d}/\left(1 + r_t(\bar{d})\right)$ in states of foreclosure where $y_t^T < d_t$ is

$$\zeta_t^* > \frac{1}{y_{t-1}^N} \left[\left(y_t^T + \frac{\bar{d}}{1 + r_t(\bar{d})} \right) \left(\frac{\frac{1-a}{a} \kappa y_t^N}{\bar{d}/\left(1 + r_t(\bar{d})\right)} \right)^{\xi} - \bar{y}_t^N \right] \triangleq \underline{\zeta}_t.$$

a.4 Figures and Tables

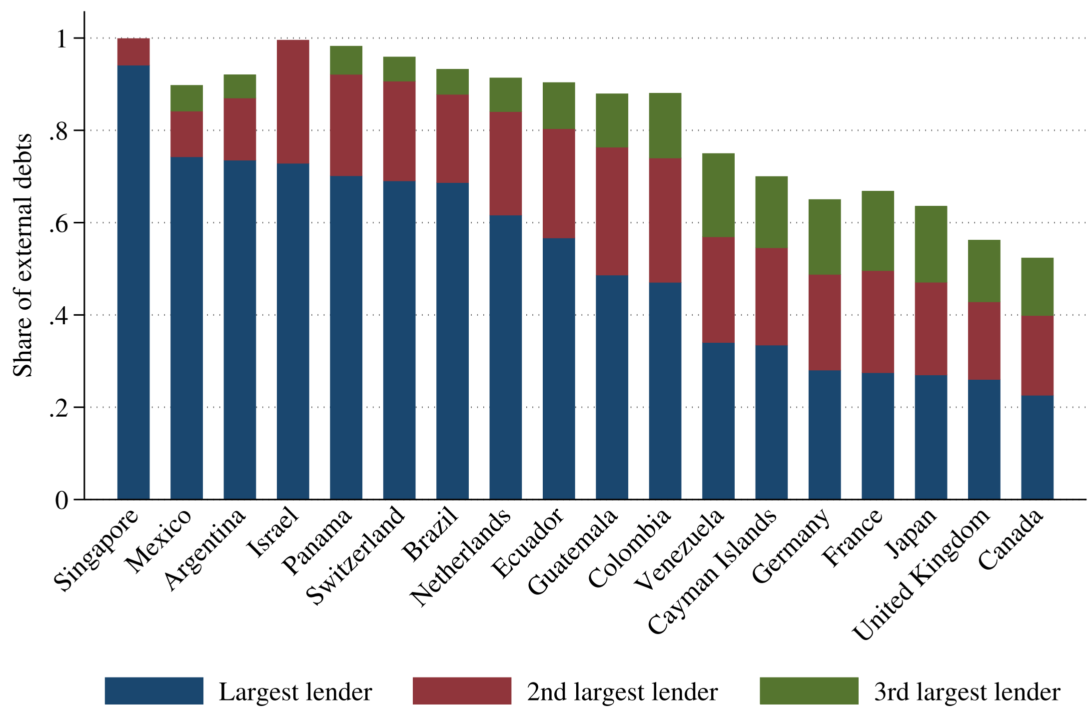

Figure A.3: Median external debts held by top holders

Notes: This figure displays the median external debts held by the top three lenders. Countries are arranged in order of the proportion of external debts held by the top-1 lender. Source: FFIEC 009a.

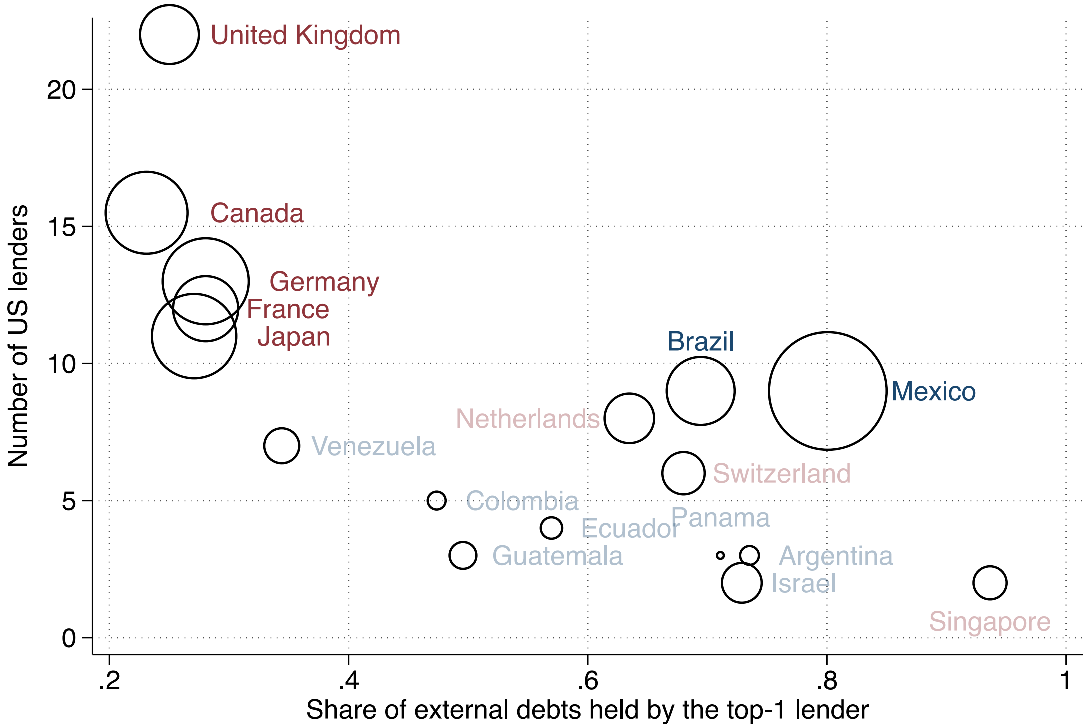

Figure A.4: Lender concentrations of rich and emerging countries' external debt

Notes: Size of circles are proportional to the ratio of countries' external debt held by US lenders to countries' total external debt. Total external debt is taken from Joint External Debt Hub. Countries with a US lending share lower than 10% are labeled by transparent names. Source: FFIEC 009a, Joint External Debt Hub, and author's calculation.

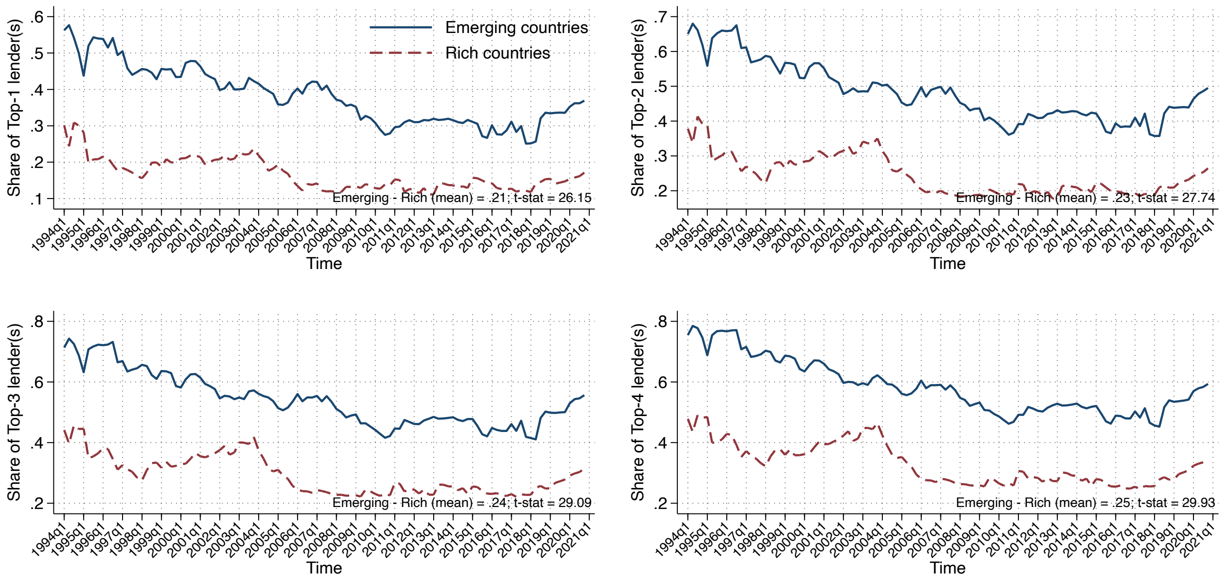

Figure A.5: Lender concentration in DealScan

Notes: The solid (dashed) lines represent lender concentration for emerging (rich) economies' external debt. t-stat is the t-statistics measures the significance of the difference in concentration means between emerging and rich economies. Borrower's location is merged from Compustat following Chava and Roberts (2008). The panel includes 29 emerging and 21 rich economies. Emerging economies include Argentina, Bulgaria, Bahrain, Brazil, Chile, Colombia, Cyprus, Egypt, Spain, Greece, Hungary, Israel, Jordan, South Korea, Morocco, Mexico, Malta, Malaysia, New Zealand, Panama, Peru, Portugal, Taiwan, Thailand, Trinidad and Tobago, Tunisia, Turkey, Venezuela, and South Africa. Rich economies include Australia, Austria, Belgium, Canada, Switzerland, Germany, Denmark, Finland, France, United Kingdom, Hong Kong, Ireland, Iceland, Italy, Japan, Luxembourg, Netherlands, Norway, Singapore, Sweden, and United States. Source: DealScan and author's calculation.

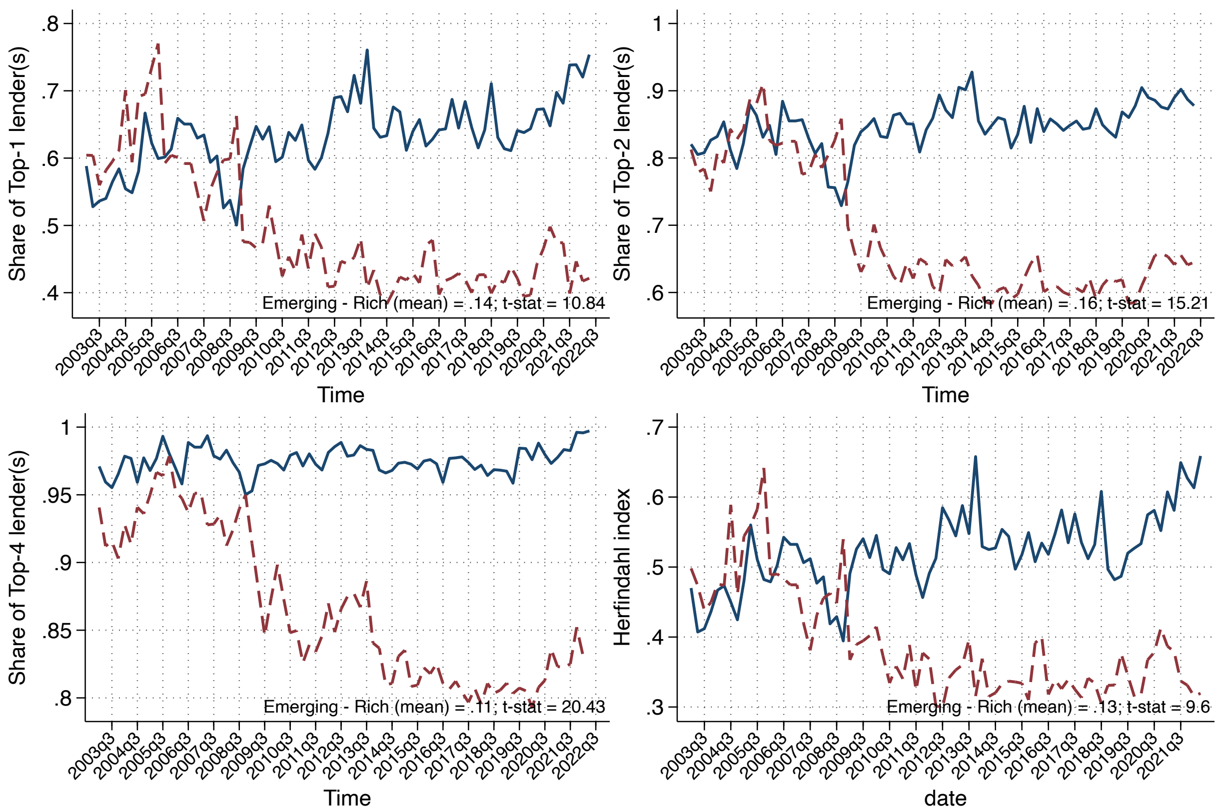

Figure A.6: Alternative lender concentration measures

Notes: The solid (dashed) lines indicate lender concentration of emerging (rich) countries' external debt. t-stat is the t-statistics of the t tests on the equality of means of concentration in emerging and rich countries across the country panel. Source: FFIEC 009a and author's calculation.

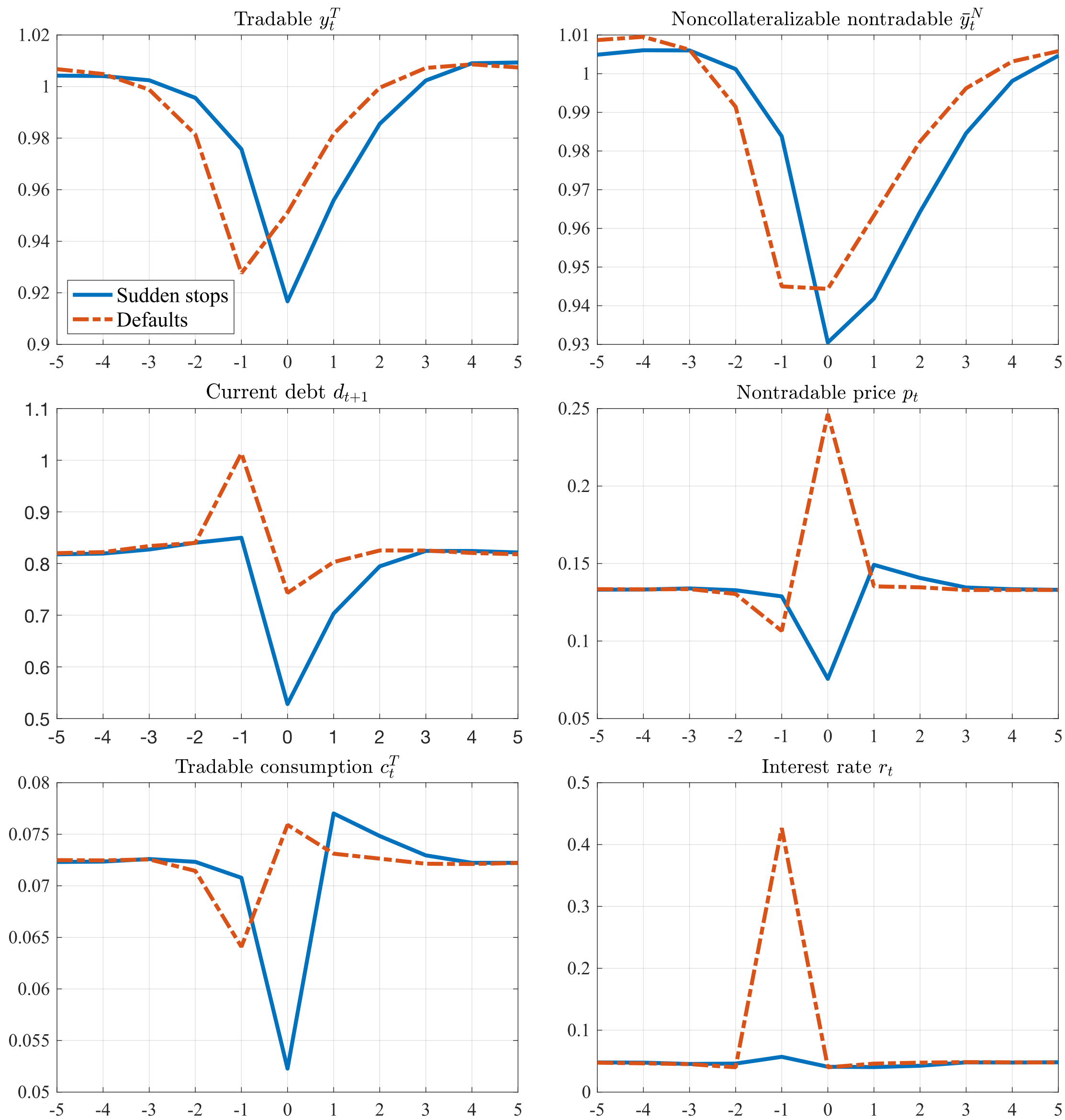

Figure A.7: Sudden stops and foreclosure events

Notes: This figure plots the average dynamics throughout the simulated sudden stops and foreclosure events. To compare the two dynamics, this figure excludes events classified as both sudden stops and foreclosure. Sudden stops are typically triggered by endowment shocks at period 0. Foreclosure events defined by initial debt not repaid by borrowers are typically triggered by endowment shocks at period -1. Both events feature a credit boom at period -1 and a subsequent reduction in credit at period 0. In line with the literature, the nontradable price declined in sudden stops, but it increased in foreclosure events, leading to the opposite movement in tradable consumption at period 0. Note that the price may decrease under other parameterizations with significant output loss δ and low lender concentration η. Finally, the interest rate hikes throughout the foreclosure events when the default probability rises at period -1, as shown in Schmitt-Grohé and Uribe (2017). The increase in the interest rate in foreclosure events is comparable to the sovereign CDS spread of Argentina, as documented by Damodaran (2024).[1] In contrast, the interest rate only increases by 1.7 percent before the sudden stops, justifying the assumption of a fixed interest rate in the related literature.

[1]The data on sovereign CDS spread is available at https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ctryprem.html.

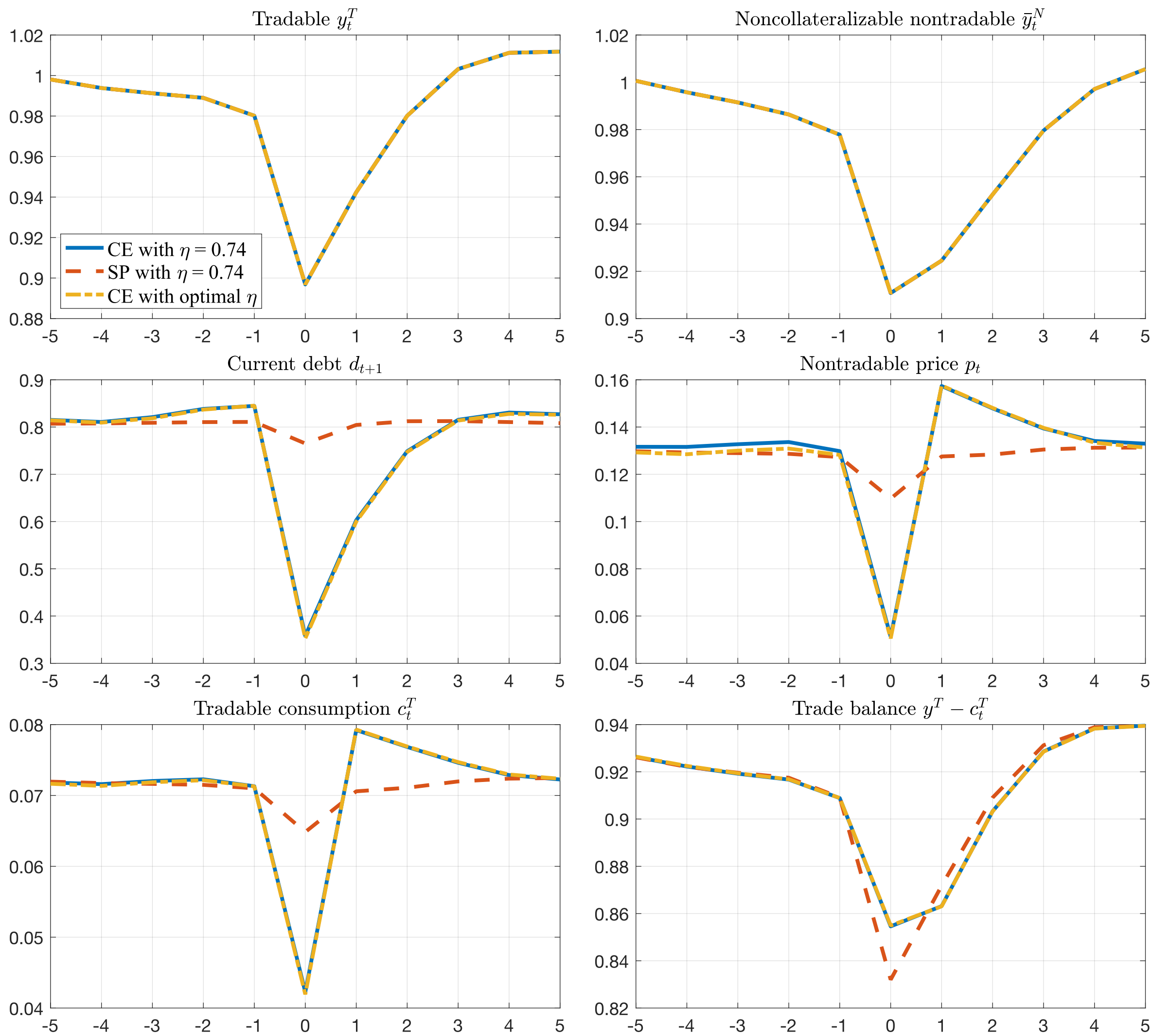

Figure A.8: Sudden stop episodes

Notes: This figure plots the average dynamics throughout the simulated sudden stops under the same endowment shocks on y_t^T and $\bar{y}_t^N$. Sudden stops occur at period 0 and are typically triggered by boom-bust endowment shocks. The bottom two panels plot the lender concentration and the implied foreclosure rate if foreclosure occurs.

Table A.1: Lender concentration and changes in the current-account-to-GDP ratio

Dependent: $CA_{i,t}/GDP_{i,t}$	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$Con_{i,t-1}$ measure	$L^{Top1}_{i,t-1}$	$L^{Top1}_{i,t-1}$	$L^{Top1}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$L^{Top3}_{i,t-1}$	$HHI_{i,t-1}$	$HHI_{i,t-1}$	$HHI_{i,t-1}$
$SS_{i,t}$	0.758**	0.411	0.657**	2.877**	1.744**	2.028***	0.705**	0.341	0.572**
	(2.27)	(1.68)	(2.92)	(2.84)	(2.47)	(3.34)	(2.18)	(1.49)	(2.79)
$Con_{i,t-1}$	0.002	0.002	0.002	0.000	0.001	0.001	0.001	0.002	0.002
	(0.87)	(1.57)	(1.72)	(0.04)	(0.21)	(0.40)	(0.70)	(1.35)	(1.51)
$SS_{i,t} \times Con_{i,t-1}$	-0.014**	-0.007	-0.016***	-0.0304**	-0.019**	-0.023***	-0.0151*	-0.007	-0.017***
	(-2.20)	(-1.65)	(-3.36)	(-2.85)	(-2.44)	(-3.64)	(-2.09)	(-1.45)	(-3.19)
$CA_{i,t-1}/GDP_{i,t-1}$		0.414***	0.418***		0.416***	0.421***		0.415***	0.419***
		(6.46)	(6.66)		(6.51)	(6.66)		(6.47)	(6.65)
$gdp_{i,t}$		-0.364	-0.515		-0.273	-0.429		-0.340	-0.490
		(-1.09)	(-1.57)		(-0.77)	(-1.22)		(-1.00)	(-1.48)
$Triple_{i,t}$			0.086**			0.037**			0.096**
			(2.65)			(2.90)			(2.47)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	1,232	1,232	1,200	1,232	1,232	1,200	1,232	1,232	1,200
R^2	0.824	0.855	0.858	0.823	0.855	0.858	0.824	0.855	0.858

Notes: This table uses a balanced panel during 78 quarters for the list of countries in Table 1 except for Venezuela due to lack of complete data on GDP, current account, and the effective real exchange rate after 2015Q1. Standard errors clustered at the country-year-quarter level. t statistics are in parentheses. $*p < 0.1$, $**\ p < 0.05$, and $***\ p < 0.01$. Data sources: Eichengreen and Gupta (2016), FFIEC 009a, IMF International Financial Statistics, World Development Indicators, Joint External Debt Hub, and author's calculation.