Heterogeneous Sovereign Debt Crisis Costs*

Preliminary and Incomplete

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Abstract

Sovereign debt crisis costs vary across restructurings. We compile data on corporate borrowing from sovereigns' (governments') foreign creditor countries in 1977–2020. We find that prior to preemptive restructurings, corporates have higher external borrowing, and during preemptive restructurings, both corporate external borrowing and output decline modestly. We build sovereign debt model with endogenous sovereign' choice of preemptive and default/post-default restructurings, corporate external borrowing, and output. We quantitatively show that sovereign's preemptive restructuring choice moderately reduces the foreign creditor's net worth and corporate external borrowing, which in turn, results in a moderate output decline—"external financing channel". Data support theoretical predictions.

JEL Classification Codes: F34, F41, H63

Key words: Sovereign Debt Crisis; Corporate Debt; Output Cost; Sovereign Debt; Sovereign Default; Debt Restructuring; GDP growth;

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1 Introduction

Sovereign debt crisis costs vary across restructurings. We compile data on corporate borrowing from sovereigns' (governments') foreign creditor countries in 1977–2020. We find that prior to preemptive restructurings, corporates have higher external borrowing, and during preemptive restructurings, both corporate external borrowing and output decline modestly. We build sovereign debt model with endogenous sovereign' choice of preemptive and default/post-default restructurings, corporate external borrowing, and output. We quantitatively show that sovereign's preemptive restructuring choice moderately reduces the foreign creditor's net worth and corporate external borrowing, which in turn, results in a moderate output decline—"external financing channel". Data support theoretical predictions.

We demonstrate a new dataset on corporate (private sector) external borrowing in 1977–2021. It is a balanced panel for 71 countries that have experienced sovereign debt restructurings with private external creditors. We compile two data series; (i) corporate external borrowing from sovereigns' (governments') creditor chair countries and (ii) those from sovereigns' non-creditor chair countries—rest of the world—based on BIS bank cross-border position dataset which covers country-level creditor geographic locations. We classify between the sovereigns' creditor chair and non-creditor chair countries based on the nationality (and location) of appointed creditor chairs at sovereign debt restructurings—often the debtors' largest creditor or creditor who had chaired the previous debt renegotiations—in Asonuma and Joo (2020). We merge with our dataset with existing datasets on restructuring duration and GDP on 197 sovereign debt restructurings in Asonuma and Trebesch (2016).

Our novel dataset on corporate external borrowing from sovereigns' creditor countries shows five new stylized facts. First, corporates (private sector) borrow from sovereigns' creditor chair countries prior to, during, and after sovereign debt restructurings. Second, prior to sovereign debt restructurings, countries which experience a preemptive (default/post-default) restructuring have high (low) corporate external borrowing from sovereigns' creditor chair countries. Third, corporate borrowing from creditor chair countries declines sharply and recovers slowly in post-default restructurings. Fourth, corporate borrowing from creditor chair countries declines mildly in preemptive restructurings. Fifth, GDP declines severely in post-default restructurings, while mildly in preemptive restructurings.

These stylized facts unveil a new dimension of sovereign debt crisis, which the sovereign debt literature has not considered thoroughly. These stylized facts raise a new question: why corporate external borrowing dynamics differ between preemptive and post-default restructurings? By exploring this question, we consider a more important question in the sovereign debt literature: Why output dynamics (costs) differ between preemptive and post-default restructurings? The sovereign debt literature has not answered this question thoroughly. Only the empirical strand of the literature shows that output costs differ between two types of sovereign debt restructurings (Asonuma and Trebesch 2016; Asonuma et al. 2024).

Our paper is the first one to explain theoretically the heterogeneous sovereign debt crisis costs. To explore these two questions, we construct a theoretical model of sovereign debt

that embeds endogenous sovereign' choice of preemptive and default/post-default restructurings, corporate external borrowing, and output. We take a conventional model set-up of Eaton and Gersovitz (1981) as in the growing theoretical literature of sovereign debt. Our model follows closely two model frameworks in the literature: (i) endogenous output (production) by labor, two types of intermediate goods and productivity (Mendoza and Yue 2012); (ii) two types of debt restructurings with the foreign creditor (Asonuma and Trebesch 2016; Asonuma and Joo 2024).

We newly introduce endogenous corporate choice on repayment and default and external borrowing. Both the sovereign and the corporate access to the segmented international market and borrow from one representative risk averse foreign creditor—"common creditor". The sovereign makes the choice of repayment, a preemptive restructuring and a default/post-default restructuring, and borrowing. The corporate (final goods firm) makes the choice of repayment and default, and borrowing. Both the sovereign and corporate choice interacts through the risk averse foreign creditor's net worth and lending choice. In this aspect, we differentiate our model from (i) Mendoza and Yue (2012) with endogenous output with no corporate borrowing and (ii) Bocola (2016), Perez (2017) and Sosa-Padilla (2018) with endogenous output with corporate domestic borrowing from banks.

Our model provides two main novel predictions. First, our model shows predictions on how the sovereign's choice among repayment, a preemptive restructuring and a default/post-default restructuring changes respect to level of corporate debt. *After* realization of the current mean TFP, i.e., ex post, the sovereign opts a default/post-default restructuring when corporate debt is high. The final goods firm (corporate) is more willing to default and file for bankruptcy liquidation on high corporate debt, resulting in higher corporate yields. The sovereign sees higher costs of repayment on sovereign debt net of lower benefits of new debt issuance with higher sovereign bond yields which is driven by the risk averse foreign creditor's lower net worth. On the contrary, it finds broadly unchanged costs of a default/post-default restructuring on sovereign debt—longer periods of financial exclusion, larger output loss, and accumulation of arrears—net of benefits of a larger debt relief, except when the final goods firm defaults (i.e., corporate default).

Before realization of the current mean TFP shock, i.e., ex ante, the sovereign opts a preemptive restructuring when corporate debt is high. Given high likelihood of a default/post-default restructuring ex post (after realization of the current mean TFP), ex ante, the sovereign anticipates high expected and uncertain costs of a default/post-default restructuring ex post—longer periods of financial exclusion, larger output loss, and accumulations of arrears—net of benefits of a larger debt relief. On the contrary, the sovereign sees low certain costs of a preemptive restructuring—short periods of financial exclusion and smaller output loss—net of benefits of a smaller debt relief and no accumulations of arrears.

Second, our model shows predictions on heterogeneous corporate external borrowing and output dynamics under the sovereign's choice of repayment, a preemptive restructuring, and a default/post-default restructuring. *After* realization of the current mean TFP, under the

sovereign's default/post-default restructuring choice, the final firm repays corporate debt or defaults. When it repays (at moderate and low levels of corporate debt), it borrows less (lower corporate debt in the next period) due to higher corporate bond yields, imports less foreign intermediate goods, which in turn, results in a severe decline in output. While it maintains a full access and borrows from the foreign creditor, its corporate external borrowing severely reduces because the foreign creditor's net worth is severely reduced due to the sovereign's default and post-default restructuring choice and he charges higher corporate bond yields. When it defaults (high level of corporate debt), it does not import foreign intermediate goods and purchase more domestic intermediate goods, which, in turn, results in a more severe decline in output. Under the sovereign's repayment choice, the final goods firm repays corporate debt in full, borrows more (high corporate debt in the next period), and imports more foreign intermediate goods which in turn, results in stable and high output.

Before realization of the current mean TFP shock, under the sovereign's preemptive restructuring choice, the final goods firm repays corporate debt in full, borrows moderately (moderate corporate debt in the next period), and imports moderately foreign intermediate goods which, in turn, results in a mild decline in output. While it maintains a full access and borrows from the foreign creditor, it could borrow moderately (moderate corporate debt in the next period) because the foreign creditor's net worth is mildly reduced due to the sovereign's preemptive debt restructuring choice and he charges moderate corporate bond yields.

Data support our two key theoretical predictions: both the sovereign's choice among repayment, a preemptive restructuring and a default/post-default restructuring, and heterogeneous corporate external borrowing and output dynamics. We calibrate our model to two episodes: (i) Argentine default/post-default restructuring in 2001–05; and (ii) Uruguayan preemptive restructuring in 2003. Our quantitative analysis successfully replicates stylized facts: (i) corporate external borrowing from the foreign creditor around sovereign debt crises; (ii) higher corporate external borrowing prior to preemptive restructuring than that prior to a default/post-default restructuring; (iii) a sharp decline and a slow recovery in corporate external borrowing in a default/post-default restructuring; (iv) a mild decline in corporate external borrowing in a preemptive restructuring; (v) a sharp decline in GDP in a default/post-default restructuring vs. a milder decline in GDP in a preemptive restructuring.

Our model of endogenous output and corporate external borrowing differs from a model of endogenous output without corporate external borrowing (Mendoza and Yue 2012) in three important dimensions. First, our model of endogenous output and corporate external borrowing explains endogenous output declines (costs) due to corporate external borrowing—"external financing channel". On the contrary, the model of endogenous output without corporate external borrowing explains endogenous output declines due to a collapse of firms' working capital—"trade channel". Second, our model of endogenous output and corporate external borrowing generates different output dynamics between a default/post-default restructurings and a preemptive restructuring. This is because outcomes of a default/post-default restructuring and a preemptive restructuring have different impacts on the risk averse foreign creditor's net

worth, resulting in different declines in corporate external borrowing. On the contrary, the model of endogenous output without corporate external borrowing generates only output dynamics in a default/post-default restructuring because a collapse of working capital occurs only in default/post-default restructuring—the sovereign does not take a preemptive restructuring. Third, our model of endogenous output and corporate external borrowing accounts for the five facts, but the model of endogenous output without corporate external borrowing accounts for none of these facts.

Literature Review Our paper builds on a large body of both empirical and theoretical work on costs of sovereign defaults (e.g., Sturzenegger 2004; Tomz and Wright 2007; Borensztein and Panizza 2009; De Paoli et al. 2009; Reinhart and Rogoff 2009; Levy-Yeyati and Panizza 2011; Mendoza and Yue 2012; Sandleris 2014; Gennaioli et al. 2014, 2018; Asonuma and Trebesch 2016; Perez 2017; Sosa-Padilla 2018; Trebesch and Zabel 2017; Kuvshinov and Zimmermann 2019; Asonuma et al. 2024). In the theoretical strand of literature, Mendoza and Yue (2012) explain endogenous output costs of sovereign defaults on external debt through trade channel, i.e., a collapse of firms' working capital to finance imports of foreign intermediate goods. Sosa-Padilla (2018) and Perez (2017) show the output costs on domestically-held sovereign debt due to domestic financial channel, i.e., bank exposure to sovereign debt. We newly explain the output costs of sovereign defaults/restructurings on external debt due to "external financial channel" i.e., corporate external borrowing and provide supporting empirical evidence.

Our paper is related to Ağca and Celasun (2012), Corsetti et al. (2014), Arellano et al. (2016, 2024), Bocola (2016), De Ferra (2018), Bevilaqua et al. (2020), Kaas et al. (2020), Du and Schreger (2022), Wu (2022), and Moretti (2023) which all study sovereign borrowing and corporate borrowing. Bocola (2016) theoretically explain the linkage between sovereign default risk and corporate default risk through domestic bank intermediation. Arellano et al. (2016) and Kaas et al. (2020) explain the linkage between sovereign default risk and corporate default risk through the sovereign's interference in private debt markets and fiscal policy (i.e., corporate tax). Our new contribution to the literature are two-hold, such as explaining theoretically a new linkage between sovereign default and corporate default through risk averse foreign private creditor' lending choice, and showing empirically new stylized facts on corporate external borrowing during sovereign debt crises.

We also contribute to the growing literature on heterogeneity in sovereign debt crises.[1] Asonuma and Trebesch (2016) is the first to classify sovereign debt crises by those with missed payments—i.e., a "default/post-default restructuring"—, and those without missed payments—i.e., a "preemptive restructuring" in the data. They theoretically show explain the sovereign's optimal choice of both a preemptive restructuring and a default/post-default restructuring, and provide new stylized facts. *Within* sovereign defaults/post-default restructurings, Arellano et al. (2023) classify "partial default" and "full default" by amount of missed debt payments, and

[1]See Hatchondo et al. (2014), Gordon and Guerron-Quintana (2020), Mihalache (2020), Dvorkin et al. (2021), Asonuma et al. (2023, 2024).

provide a theory of partial default rationalizing the two types of defaults. Similarly, Trebesch and Zabel (2017) classify "hard defaults" and "soft defaults" by both debtor repayment and negotiation behavior and the size of haircuts and show different patterns of output dynamics. Our paper fills a gap in the literature by explaining theoretically different output dynamics between default/post-default restructurings and preemptive restructurings due to external financing channel, and show empirically different patterns of corporate external borrowing.

2 Datasets and Stylized Facts

2.1 New Dataset on Corporate External Borrowing

To shed light on the role of corporate external borrowing in sovereign debt crises, we construct a new dataset of corporate external borrowing from sovereigns' creditor chair countries in 1977–2021. It is a balanced panel for 71 countries that have experienced sovereign debt restructurings with private external creditors.

We use the Bank of International Settlement (BIS) bank cross-border position dataset which covers country-level creditor geographic locations. We combine with Asonuma and Joo (2020) dataset on the appointed creditor chairs (institutions and nationality)—often the sovereign debtors' largest creditor or creditor who had chaired the previous debt renegotiation—at 197 sovereign debt restructurings in 1975–2020. We compile the two data series; (i) corporate external borrowing from sovereigns' (governments') creditor chair countries and (ii) those from sovereigns' non-creditor chair countries—rest of the world. With the detailed information on the sovereigns' creditor chairs and their nationality (location), we can identify explicitly corporate external borrowing from the sovereigns' creditor chair countries, and separate that from the sovereigns' non-creditor chair countries.

Table 1: Corporate External Borrowing from Sovereigns' Creditor Chair Countries

A. Panel dataset in 1977–2021

	Total	Mean	Median	Std.Dev
Country coverage	71			
Country-creditor chair pairs (episodes)	116			
Flow (Percent of GDP)	5,054	0.8%	0.1%	3.8%
Stock (Percent of GDP)	5,014	12.3%	6.9%	16.1%
Stock (Percent of total liabilities)	5,350	28.0%	25.7%	23.5%

Panel A in Table 1 summarizes our corporate external borrowing from sovereigns' creditor chair countries. There are three key advantages compared to exiting datasets, such as IMF WEO. First and most prominently, it is the first comprehensive dataset on corporate external borrowing from the sovereigns' creditor chair countries. Our dataset provides differentiated

data series on corporate external borrowing from the sovereigns' creditor chair countries which is isolated with that from the sovereigns' non-creditor chair countries. Second, the two data series in our dataset cover long time series, i.e., 44 years of observations for each country-creditor chair pair. Third, our dataset provides wide country coverage of 71 countries that have experienced sovereign debt restructurings with private external creditors.

Our corporate external borrowing dataset covers both (i) 197 privately-held sovereign external debt restructurings and (ii) 325 non-debt crisis recessions in 1975–2020. Debt restructuring episodes are from Asonuma and Trebesch (2016) and non-debt crisis recession episodes are from Asonuma and Joo (2024).

2.2 Empirical Findings: Five Stylized Facts

We merge our dataset on corporate external borrowing from creditor chair countries with existing datasets on restructuring duration and GDP on 197 sovereign debt restructurings in Asonuma and Trebesch (2016). We present five main stylized facts on corporate external borrowing and output dynamics around sovereign debt restructurings in 1975–2020.

- ***Stylized fact 1: Private sector borrows from sovereigns' creditor chair countries prior to, during, and after sovereign debt restructurings.***

Panel B in Table 1 shows two novelties of our dataset on sovereign external debt restructurings. First, both flow and stock series of corporate external borrowing from the sovereigns' creditor chair countries cover around 55 percent of restructuring episodes. Second, the two corporate external borrowing series cover three phases around restructuring episodes: pre-restructuring, restructuring and post-restructuring periods.

Table 1: Corporate External Borrowing from Sovereigns' Creditor Chair Countries

B. Sovereign Debt Restructurings in 1975–2020

	Observation	Mean	Observation	Mean	Observation	Mean
Restructuring Episodes			197			
Pre-Restructuring Duration			3.2			
	Pre-restructuring periods		**Restructuring periods**		**Post-restructuring periods**	
Flow (percent of GDP)[1/]	111	1.4	111	0.8	111	0.8
Stock (percent of GDP)[1/]	111	12.0	111	14.5	111	15.7
Stock (percent of total liabilities)[1/]	121	33.0	121	31.8	121	31.9

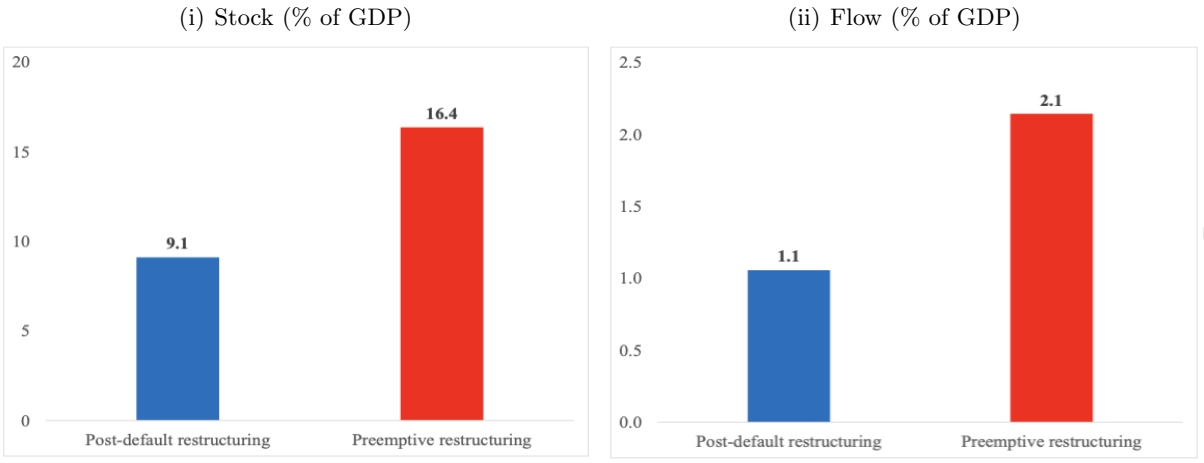
- ***Stylized fact 2: Countries which experience a preemptive (post-default) restructuring had high (low) corporate borrowing from sovereigns' creditor chair countries prior to debt crises.***

Corporate external borrowing from the sovereigns' creditor chair countries accounts for 0.8–1.4 percent of GDP in flow terms and 12–16 percent of GDP in stock terms on average

around sovereign debt restructurings. The corporate external borrowing from the sovereigns' creditor chair countries accounts for a third (i.e., 33%) of total corporate external borrowing. Despite that the sovereigns restructure sovereign debt held by private external creditors (mainly creditor chairs), the corporates (private sector) in the debtor countries continue external borrowing from the sovereigns' creditor chair countries.

Figure 1 shows average corporate external borrowing from the sovereigns' creditor chair countries prior to debt crises. Panels (i) and (ii) show average corporate external borrowing from the sovereigns' creditor chair countries in stock and flow terms, respectively and in both panels, that prior to post-default and preemptive restructurings are shown in blue and red bars, respectively. Prior to post-default restructurings (blue bar in panel (ii)), corporate external borrowing from the sovereigns' creditor chair countries in flow terms is low (1 percent of GDP). On the contrary, prior to preemptive restructurings, corporate external borrowing from the sovereigns' creditor chair countries is high (2 percent of GDP). It is also true in terms of stock (Panel (i)).

Figure 1: Corporate External Borrowing from Sovereigns' Creditor Chair Countries prior to Debt Crises



- ***Stylized fact 3: Corporate external borrowing from creditor chair countries declines sharply and recovers only gradually in post-default restructurings.***

- ***Stylized fact 4: Corporate external borrowing from creditor chair countries declines mildly in preemptive restructurings.***

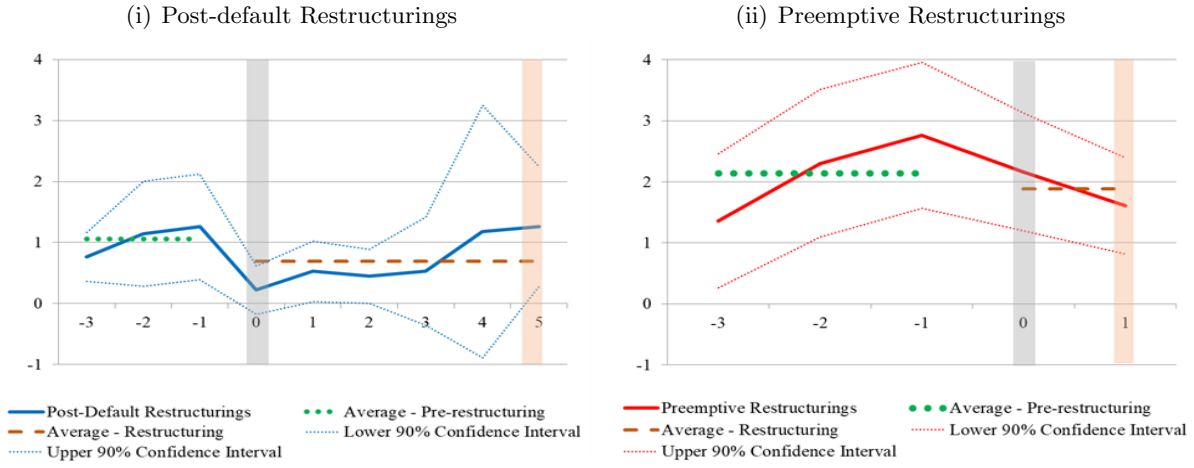
Figure 2 shows the dynamics of corporate external borrowing from the sovereigns' creditor chair countries around post-default and preemptive restructurings. In panels (i)–(ii), the start and end of the restructurings are marked by gray and orange vertical bars, respectively. Corporate external borrowing from the sovereigns' creditor chair countries is presented in percent of GDP (%). The blue and red solid lines represent the average for all post-default and preemptive

restructurings, respectively, for which corporate external borrowing series is available in our dataset. The green dotted and brown dash lines show the average corporate external borrowing during the pre-restructuring and restructuring periods.

In post-default restructurings (panel (i)), corporate external borrowing from the sovereigns' creditor chair countries declines severely at the onset of debt crises (year 0) and stays below the pre-crisis level in the subsequent years. Corporate external borrowing from the sovereigns' creditor chair countries recovers only gradually to reach above the pre-crisis level in year 4, leading to the debt settlement in year 5.

In preemptive restructurings (panel (ii)), corporate external borrowing from the sovereigns' creditor chair countries declines mildly at the onset of debt crisis (year 0). In year 1, when the sovereigns reach settlement, the corporate external borrowing from the sovereigns' creditor chair still continues a gradual declining trend.

Figure 2: Corporate External Borrowing from Sovereigns' Creditor Chair Countries (% of GDP)



- ***Stylized fact 5: GDP declines severely in post-default restructurings while mildly in preemptive restructurings.***

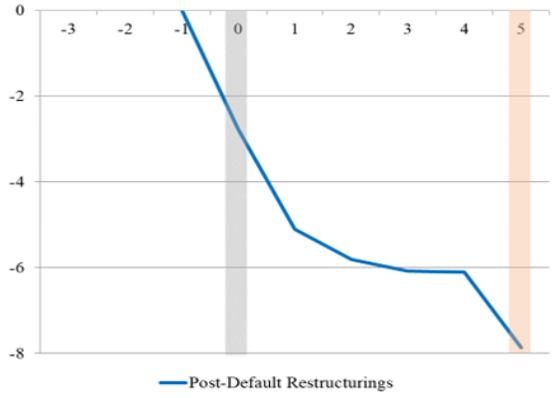
Figure 3 shows the GDP dynamics around post-default and preemptive restructurings. We follow the same presentation approach as in Figure 2 in terms of time horizon and timing of events, and measure the GDP dynamics in terms of cumulative change in GDP (%) from pre-restructuring year (year -1). In post-default restructurings (panel (i)), GDP declines severely at the onset of debt crises (year 0) and continues a declining trend until the end of restructurings. On average, GDP declines by 5% from the pre-restructuring trend in the first two years and by 8% during post-default restructurings (around 5 years).

In preemptive restructurings (panel (ii)), GDP declines moderately at the onset of debt crises (year 0) and the decline becomes negligible in the next year (year 1). On average, GDP declines by 2.5% from the pre-restructuring trend in the first two years. The output decline in preemptive

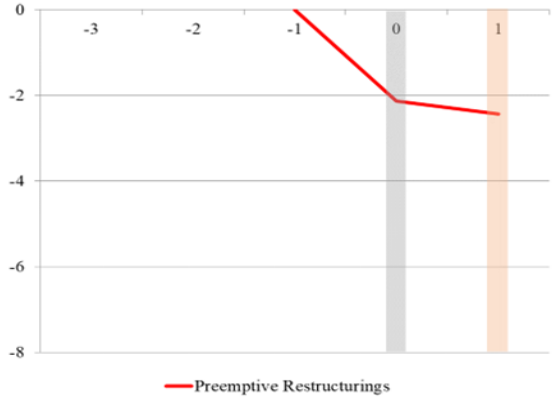
restructuring is much smaller and only over shorter horizon than that in post-default restructurings. Asonuma and Trebesch (2016) were the first to show post-default restructurings are associated with a larger GDP loss (in terms of GDP growth) than preemptive restructurings and Asonuma et al. (2024) measure GDP loss in a cumulative GDP decline from pre-restructuring year.

Figure 3: Cumulative change in GDP from Pre-restructuring Year (%)

(i) Post-default Restructurings



(ii) Preemptive Restructurings



3 Theoretical Model

3.1 Summary of Theoretical Findings

Our model provides two main novel predictions. First, our model shows predictions on how the sovereign's choice among repayment, a preemptive restructuring and a default/post-default restructuring changes respect to level of corporate debt. *After* realization of the current mean TFP, i.e., ex post, the sovereign opts a default/post-default restructuring when corporate debt is high. The final goods firm (corporate) is more willing to default and file for bankruptcy liquidation on high corporate debt, resulting in higher corporate yields. The sovereign sees higher costs of repayment on sovereign debt net of lower benefits of new debt issuance with higher sovereign bond yields due to the risk averse foreign creditor's lower net worth. On the contrary, it sees broadly unchanged costs of a default/post-default restructuring on sovereign debt debt—longer periods of financial exclusion, larger output loss, and accumulations of arrears—except when the final goods firm defaults (i.e., corporate default).

Before realization of the current mean TFP shock, i.e., ex ante, the sovereign opts a preemptive restructuring when corporate debt is high. Given high likelihood of a default/post-default restructuring ex post (after realization of the current mean TFP), ex ante, the sovereign anticipates high expected and uncertain costs of a default/post-default restructuring ex post—longer periods of financial exclusion, larger output loss, and accumulations of arrears—net of benefits

of a larger debt relief. On the contrary, the sovereign sees low certain costs of a preemptive restructuring—short periods of financial exclusion, smaller output loss—net of benefits of a smaller debt relief and no accumulations of arrears.

Second, our model shows predictions on heterogeneous corporate external borrowing and output dynamics under the sovereign's choice of repayment, a preemptive restructuring and a default/post-default restructuring. *After* realization of the current mean TFP, under the sovereign's default/post-default restructuring choice, the final firm repays corporate debt or defaults. If it repays, it borrows less (lower corporate debt in the next period) due to higher corporate bond yields, imports less foreign intermediate goods, which in turn, results in a severe decline in output. While it maintains a full access and borrows from the foreign creditor, it could only borrow less (low corporate debt in the next period) because the foreign creditor's net forth is severely reduced due to the sovereign's default and post-default restructuring choice and he charges higher corporate bond yields. If it defaults, it does not import foreign intermediate goods and purchases more domestic intermediate goods, which, in turn, results in a more severe decline in output.

Under the sovereign's repayment choice, the final goods firm repays corporate debt in full, borrows more (high corporate debt in the next period), and imports more foreign intermediate goods which in turn, results in stable and high output.

Before realization of the current mean TFP, i.e., ex ante, under the sovereign's preemptive restructuring choice, the final goods firm repays corporate debt in full, borrows moderately (moderate corporate debt in the next period), and imports moderately foreign intermediate goods which, in turn, results in a mild decline in output. While it maintains a full access and borrows from the foreign creditor, it could borrow moderately (moderate corporate debt in the next period) because the foreign creditor's net forth is mildly reduced due to the sovereign's preemptive debt restructuring choice and he charges moderate corporate bond yields.

3.2 Assumptions in the Model

In this model, there are a household, a final goods firm, an intermediate goods firm, a sovereign (government), and a representative foreign creditor. The economy is small relative to the rest of the world in that neither the sovereign's nor the firms' decisions affect the world risk-free interest rate (r^*). However, both the sovereign and the final goods firm access the segmented international capital market in that they can only borrow from the foreign creditor facing income fluctuation—his borrowing/lending decisions do not influence the world interest rate. Both the sovereign and foreign creditor are risk averse and maximize the household's utility function and his utility function, respectively:

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, L_t) \qquad E_0 \sum_{t=0}^{\infty} (\beta^*)^t v(c_t)$$

where $0 < \beta < 1$ and $0 < \beta^* < 1$ are discount factors of the household and foreign creditor, c_t and c_t^* are consumption of the two agents, L_t is the household's labor supply, $u(.,.)$ and $v(.)$

are one-period utility functions of the two agents, which are continuous, strictly increasing and strictly concave, and satisfy the Inada conditions. While the discount factor of foreign creditor reflects only time preference, the discount factor of the sovereign (household) reflects both time preference and probability that the sovereign (household) remains at office in the next period (i.e., impatience).

In each period, the sovereign is assigned with a sovereign credit record $h_t \in [0, 1, 2]$. The sovereign credit record is defined as (i) "good" $h_t = 0$, when it has full access to the international market, (ii) "intermediate" $h_t = 1$, when it has partial access during a preemptive restructuring, or (iii) "bad" $h_t = 2$ when it has no access during a post-default restructuring. The sovereign and the foreign creditor receive a productivity shock a_t and an endowment shock y_t^*, respectively. We denote a vector of two shock processes as $s_t = [a_t, y_t^*]$. It is stochastic, drawn from a compact set $S_t = [a_{min}, a_{max}] \times [y_{min}^*, y_{max}^*] \subset R_+^*$. $\mu(s_{t+1}|s_t)$ is a probability distribution of a vector of shocks s_{t+1} conditional on its previous realization s_t.

The information is symmetric and perfect for all agents. All agents make decisions at two different points in time, ex ante, i.e., before realization of the current shocks under its intermediate credit record, and ex post, i.e., after realization of the current shocks under its good and bad credit records.

The sovereign decides its choice of repayment and default (settlement and delay), external borrowing, and transfers to the household. The household receives both transfers from the sovereign and dividends from the two firms, and chooses labor supply and consumption. The final goods firm chooses demand for labor, domestic intermediate goods, and foreign intermediate goods, and external borrowing, and sells the final goods and pays dividends to the household. The intermediate goods firm chooses demand for labor, sells the domestic intermediate goods to the final goods firm, and pays dividends to the household.

Both sovereign and corporate bond markets are incomplete. Both the sovereign and the final goods firm can borrow and lend only via one-period, zero-coupon sovereign and corporate bonds.[2] b_{t+1} and f_{t+1} denote the amount of sovereign and corporate bonds to be repaid in the next period and their sets are defined as $B = [b_{min}, b_{max}] \subset R$ and $F = [f_{min}, f_{max}] \subset R$ with $b_{min} < 0 < b_{max}$ and $f_{min} < 0 < f_{max}$.[3] The foreign creditor can lend via both one-period, zero-coupon sovereign and corporate bonds. b_{t+1}^* and b_{t+1}^{*f} denote the amount of sovereign and corporate bonds which the foreign creditor receives payments in the next period and their sets are defined as $B^* = [b_{min}^*, b_{max}^*] \subset R$ and $F^* = [f_{min}^*, f_{max}^*] \subset R$. The prices of sovereign and

[2]Our model of debt restructuring with one-period bonds follows Yue (2010), Benjamin and Wright (2013), and Asonuma and Trebesch (2016). Relaxing the model to include long-duration bonds does not provide additional insights but increases technical difficulty to track the model. This is because old bonds are exchanged with new bonds with the same maturity and smaller outstanding (debt stock), that is, no change in maturity structure of bonds due to an exchange (Hatchondo, Martinez, and Padilla 2014). See Hatchondo and Martinez (2009), Arellano and Ramanarayanan (2012), Chatterjee and Eyigungor (2012), and Hatchondo, Leonardo, and Padilla (2016) for long-duration bond models without debt restructuring accounting for high debt-to-GDP ratio.

[3]The lower bound for the sovereign's bond holding at $b_{min} \geq y_{max}/r^*$, $f_{min} \geq y_{max}/r^*$ the highest debt that the sovereign and the corporate can repay, and the upper bound for the sovereign and corporate bonds b_{max} and f_{max} is the highest level of assets that the sovereign and corporate may accumulate.

corporate bonds are determined in equilibrium.

The foreign creditor always commits to repay his debt. The sovereign decides between taking or passing a preemptive restructuring before realization of the current shocks (ex ante) and between repayments and defaulting/taking a post-default restructuring after realization of the current shocks (ex post). When it opts a default/post-default restructuring, it is subject to full loss in market access, larger productivity loss, and accumulation of arrears. When it opts a preemptive restructuring (no default), it suffers partial loss in market access and smaller productivity loss, but no arrear accumulation. The assumptions of two different productivity losses follows empirical findings in the literature (e.g., Asonuma and Trebesch 2016, Asonuma et al. 2024) on a larger output decline in post-default restructurings than preemptive restructurings. The final goods firm repays their debt when its current profit is higher than or equal to zero, and defaults otherwise. When the final good firm defaults, it is subject to full loss in market access and accumulation of arrears.

The sovereign and foreign creditor negotiate a reduction of sovereign debt via multi-round bargaining either preemptively i.e., before realization of the current shocks or post-default i.e., after realization of the current shocks. These two types of debt restructurings have identical bargaining game and power. One of the two parties is randomly selected as a proposer. The proposer chooses among proposing recovery rates (haircuts), passing, and quitting the renegotiations in preemptive restructurings, and between proposing recovery rates (haircuts) and passing in post-default restructurings. The other party chooses among accepting, rejecting, and quitting the renegotiations in preemptive restructurings, and between accepting and rejecting in post-default restructurings. In both types of restructurings, when the proposer proposes recovery rates (haircuts) and the other party accepts ("settlement"), the sovereign repays recovered debt payments to the foreign creditor and resumes full access to the international market in the next period. When the proposer passes ("delay"), both parties continue the debt renegotiations in the next period. Only in preemptive restructurings, both parties quit the renegotiations ("quit"), both parties move to the sovereign choice of passing a preemptive restructuring before realization of the current shocks.

On corporate debt in arrears, bankruptcy liquidation is applied when the sovereign and the foreign creditor settle on sovereign debt in arrears. The final goods firm repays fixed recovered debt payments to the foreign creditor, i.e., liquidation value of the final goods firm.[4] A new representative final goods firm which replaces the old final goods firm gains an access to the international market in the next period.

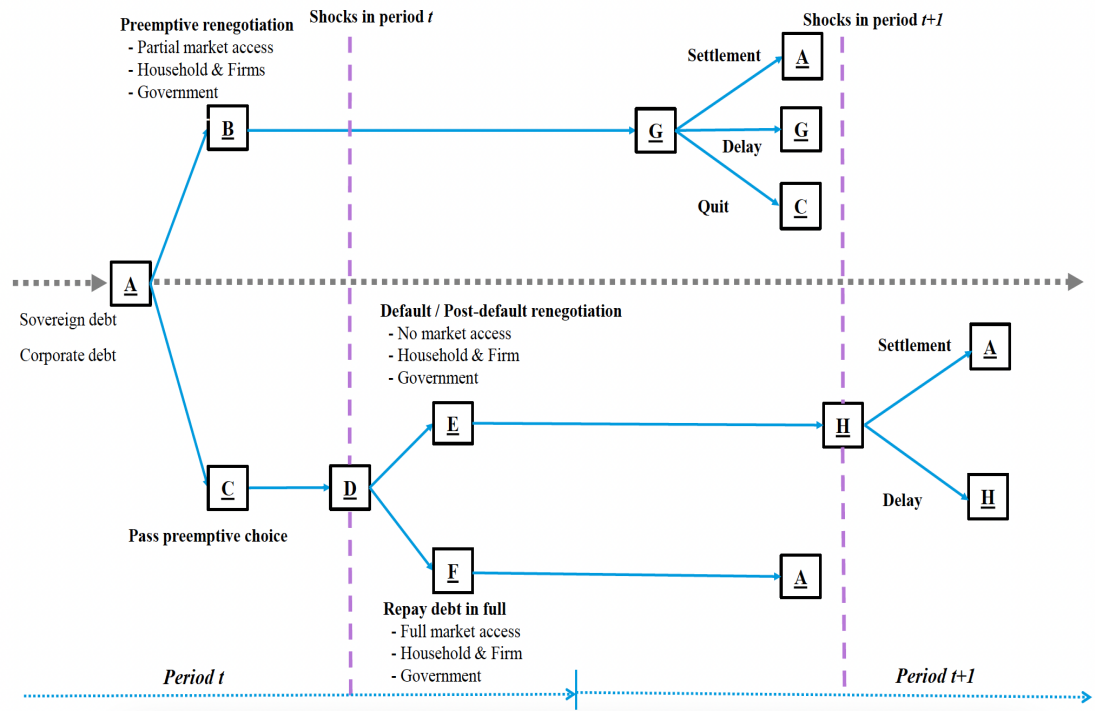
3.3 Timing of the Model

The timing of events and decisions in the model is reported in Figure 4.

1. The sovereign starts the current period (period t) with sovereign debt and corporate debt.

[4]When a corporate is liquidated, its assets are distributed to creditors in a specific order. The liquidation value of the corporate corresponds to recovered debt payments. See the literature on corporate defaults e.g., Gilson, John and Lang (1990).

Figure 4: Timing of Model



We are in node (A).

2. The sovereign chooses whether to take a preemptive restructuring or not.

   (a) In node (B) (preemptive restructuring node), if it opts a preemptive restructuring, we move to an upper branch of the tree. It has partial access to the international market and suffers smaller productivity loss. The household, the two firms and the foreign creditor make decision. We move to node (G) in the next period.

   (b) In node (C) (passing a preemptive restructuring node), if the sovereign passes a preemptive restructuring, we move to a lower branch of the tree.

3. Shocks in the current period (period t) materialize. In node (D), the sovereign chooses whether to repay debt in full or to default/take a post-default restructuring.

   (a) In node (E) (default/post-default restructuring node), if it defaults/takes a post-default restructuring, we move to a middle-upper branch of the tree. It fully loses access to the international market and suffers larger productivity loss. The household, the two firms and the foreign creditor make decision. We proceed to node (H) in the next period.

   (b) In node (F) (repayment node), the sovereign repays debt in full, we move to a lower branch of the tree. It maintains full access to the international market and chooses

external borrowing. The household, the two firms and the foreign creditor make decision. We proceed to node (A) in the next period.

4. The sovereign continues the next period (period $t+1$).

5. In node (G) (preemptive restructuring node), the sovereign and foreign creditor settle, delay or quit the preemptive renegotiations.

   (a) In the case of settlement, the sovereign regains full market access, and we move to node (A) in the next period.

   (b) In the case of delay, the sovereign's market access remains partial, and we move back to node (G) in the next period.

   (c) In the case of quit, the sovereign recovers market access without debt relief, and we move back to node (C).

6. Shocks in the next period (period $t+1$) materialize. In node (H) (post-default restructuring node), the sovereign and foreign creditor settle or delay the post-default renegotiations.

   (a) In the case of settlement, the sovereign regains full market access, and we move to node (A) in the next period.

   (b) In the case of delay, the sovereign has still no market access, and we move back to node (H) in the next period.

4 Recursive Equilibrium

4.1 Household's Problem

We define the recursive equilibrium of theoretical model in this section. The household maximizes his utility subject to its budget constraint defined below:

$$\max_{c_t, l_t} E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, L_t)$$

$$s.t. \quad c_t = w_t L_t + \pi_t^f + \pi_t^m + T_t \tag{1}$$

The household chooses consumption c_t and labor supply L_t and receives wage income $w_t L_t$ and profits π_t^f,π_t^m from the final and intermediate goods firms, and transfers from the sovereign T_t. He does not borrow directly from abroad, but the sovereign borrows and provides transfers internalizing the household's utility.[5]

[5]Though the household lacks access to the international capital market as in conventional sovereign debt models, his utility can still be improved through three methods: (i) consumption through transfers from the sovereign, (ii) consumption through profits from the two firms, and (iii) labor supply.

The optimality condition of the household is shown as follows:

$$\frac{u_l(c_t, L_t)}{u_c(c_t, L_t)} = w_t \tag{2}$$

4.2 Firms' Problem

Final goods firm

We define the final goods firm's problem when it repays its corporate debt. Appendix C.2 define the case when the final goods firm defaults (corporate default). The final goods firm's production function is Cobb-Douglas and defined as follows:

$$y_t = a_t(M(m_t^d, m_t^f))^{\alpha_M}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k} \tag{3}$$

The final goods firm uses labor L_t^f, aggregate intermediate goods $M(m_t^d, m_t^f)$ and fixed private capital stock $\bar{k}$ for production, given a productivity shock a_t, with $0 < \alpha_k, \alpha_L, \alpha_M < 1$ and $\alpha_k + \alpha_L + \alpha_M = 1$. The fixed private capital stock assumption follows closely Mendoza and Yue (2012) and Azzimonti (2015).

Aggregate intermediate goods are composed of domestic intermediate goods m_t^d and foreign intermediate goods m_t^f in a standard constant elasticity of substitution (CES) Armington aggregator form defined as:

$$M(m_t^d, m_t^f) = [\omega(m_t^d)^\mu + (1-\omega)(m_t^f)^\mu)]^{\frac{1}{\mu}} \tag{4}$$

where the Armington elasticity of substitution between domestic intermediate goods and foreign intermediate goods is defined as $\eta = \frac{1}{\mu - 1}$ where $\mu < 1$. Armington weight of domestic intermediate goods is $0 \leq \omega < 1$. Relative price of foreign intermediate goods respect to price of final goods p_t^* and relative price of domestic intermediate goods respect to price of final goods p_t^m are endogenous determined in equilibrium.

The final goods firm maximizes a sum of discounted profits by choosing labor demand, demands for domestic and foreign intermediate goods, corporate bonds and makes decision of repayment and default. The final goods firm repays their corporate debt in the current period when its sum of expected discounted profits is higher or equal to zero. Otherwise, it defaults. Its value function is written as follows as in Gourio (2013):

$$W(b_t, f_t, h_t, s_t) = max[W^R(b_t, f_t, h_t, s_t), W^D(b_t, f_t, h_t, s_t)] \tag{5}$$

$W^R(b_t, f_t, 0, s_t)$ is the value of repayment of corporate bonds:

$$W^R(b_t, f_t, h_t, s_t) = \max_{m_t^d, m_t^f, L_t^f, f_{t+1}} \left\{ \begin{array}{c} a_t(M(m_t^d, m_t^f))^{\alpha_M}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k} - w_t L_t^f - p_t^m m_t^d - p_t^* m_t^f \\ +f_t - q^f(b_{t+1}, f_{t+1}, h_t, s_t) f_{t+1} \end{array} \right\}$$
$$+ \beta \int_S \frac{\Lambda_{t+1}}{\Lambda_t} W(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1}) d(s_{t+1}|s_t) \tag{6}$$

where $\Lambda_t = u_c(c_t, L_t)$ is the household's marginal utility respect to consumption. Therefore, $\beta \frac{\Lambda_{t+1}}{\Lambda_t}$ is the household's stochastic discount factor. The final goods firm has two resources, domestic sales and external borrowing (corporate bonds).

Corporate bonds in our model differ from working capital constraint in Mendoza and Yue (2012) in two aspects: first, corporate bonds in our model finance both domestic and external expense, while working capital constraint only finances external expense; second, the choice of payment and default on corporate bonds is endogenous, while working capital is assumed to link with sovereign's choice of repayment and default on sovereign bonds.

$W^D(b_t, f_t, 0, s_t)$ is the value of defaulting of corporate bonds.

$$W^D(b_t, f_t, h_t, s_t) = \max_{m_t^d, L_t^f} \left\{ a_t(M'(m_t^d))^{\alpha_M}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k} - w_t L_t^f - p_t^m m_t^d \right\}$$
$$+ \beta \int_S \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ \begin{array}{l} (1 - \mathbf{1}_{POST_SETTLE}) W^D(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1}) \\ +\mathbf{1}_{POST_SETTLE} W^{D,PD}(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1}) \end{array} \right\} d(s_{t+1}|s_t) \tag{7}$$

where $\mathbf{1}_{POST_SETTLE}$ is an index function of settlement at sovereign post-default restructuring defined in Section 4.5. $M'(m_t^d)$ is aggregate intermediate goods comprised of only domestic intermediate goods and $W^{D,PD}(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1})$ is the value of defaulting of corporate bonds and bankruptcy liquidation both defined in equations (3a) and (58) in Appendix C.2.1.

The optimality condition of the final goods firm is shown as follows

$$\alpha_L a_t(M(m_t^d, m_t^f))^{\alpha_M}(L_t^f)^{\alpha_L - 1}(\bar{k})^{\alpha_k} = w_t \tag{8}$$

$$\alpha_M a_t(M(m_t^d, m_t^f))^{\alpha_M - 1}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k}\omega(m_t^d)^{\mu - 1} = p_t^m \tag{9}$$

$$\alpha_M a_t(M(m_t^d, m_t^f))^{\alpha_M - 1}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k}(1 - \omega)(m_t^f)^{\mu - 1} = p_t^* \tag{10}$$

$$q^f(b_{t+1}, f_{t+1}, h_t, s_t) = \int_S \beta \frac{u_c(c_{t+1}, L_{t+1})}{u_c(c_t, L_t)} \mathbf{1}_{Non_Cor_Def} d\mu(s_{t+1}|s_t) \tag{11}$$

The final goods firm's corporate default choice is characterized by corporate default set $D^f(b_t, b_t^f, h_t) \subset S$. It is a set of vectors of current shocks s_t at which when its sum of expected discounted profits is lower than the value of defaulting.

$$D^f(b_t, f_t, h_t) = \{s_t \in S : W^R(b_t, f_t, h_t, s_t) < W^D(b_t, f_t, h_t, s_t)\} \tag{12}$$

Intermediate goods firm

The representative intermediate goods firm uses labor L_t^m for production, given constant productivity A. His production function is defined as:

$$m_t^d = A(L_t^m)^\gamma \tag{13}$$

The intermediate goods firm maximizes his current profit by choosing labor demand:

$$\max_{L_t^m} \pi_t^m(b_t, f_t, h_t, s_t) = p_t^m A(L_t^m)^\gamma - w_t L_t^m \tag{14}$$

The optimality condition of the intermediate goods firm is shown as follows:

$$\gamma A(L_t^m)^{\gamma-1} = \frac{w_t}{p_t^m} \tag{15}$$

Market Clearing Conditions for Domestic Factor Inputs

Market clearing conditions for labor and domestic intermediate goods are follows:

$$L_t^f + L_t^m = L_t \tag{16}$$

$$A(L_t^m)^\gamma = m_t^d \tag{17}$$

4.3 Sovereign's (Government's) Problem

Sovereign's good credit record (full market access)

The sovereign maximizes expected lifetime utility. Prior to realization of the current shocks, the sovereign chooses whether to take a preemptive restructuring or pass it. Its ex ante value function is defined as follows:

$$V^{EXANTE}(b_t, f_t, 0, s_{t-1}) = \max[V^{PRE}(b_t, f_t, 0, s_{t-1}), V^{NON_PRE}(b_t, f_t, 0, s_{t-1})] \tag{18}$$

$V^{PRE}(b_t, f_t, 0, s_{t-1})$ is the ex ante value of a preemptive restructuring:

$$V^{PRE}(b_t, f_t, 0, s_{t-1}) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, f_{t+1}} \int_S [u(c_t, L_t) + \beta V(b_t, f_{t+1}, 1, s_t)] d\mu(s_t|s_{t-1}) \tag{19}$$

$$s.t. \quad (5) - (11),\ (15) - (17)\ and$$

$$T_t = 0 \tag{20}$$

where equation (20) is the budget constraint for the sovereign which it has no resources to allocate to transfers T_t.

$V^{NON_PRE}(b_t, f_t, 0, s_{t-1})$ is the sovereign's ex ante value of passing a preemptive restructuring, based on its ex post value:

$$V^{NON_PRE}(b_t, f_t, 0, s_{t-1}) = \int_S V(b_t, f_t, 0, s_t) d\mu(s_t|s_{t-1}) \tag{21}$$

The sovereign's preemptive restructuring choice can be characterized by preemptive restructuring set $PRE(b_t, f_t, 0) \subset S$. It is a set of vectors of shocks S_t at which the value of preemptive restructuring provides higher than or equal to the value of passing a preemptive restructuring:

$$PRE(b_t, f_t, h_t) = \{s_{t-1} \in A : V^{PRE}(b_t, f_t, 0, s_{t-1}) \geq V^{NON_PRE}(b_t, f_t, 0, s_{t-1})\} \tag{22}$$

After realization of the current shocks, the sovereign chooses whether to repay the debt or to default and its ex post function is defined as follows:

$$V(b_t, f_t, 0, s_t) = max[V^R(b_t, f_t, 0, s_t), V^D(b_t, f_t, 0, s_t)] \tag{23}$$

$V^R(b_t, f_t, 0, s_t)$ is its ex post value of repayment:

$$V^R(b_t, f_t, 0, s_t) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, b_{t+1}, f_{t+1}} u(c_t, L_t) + \beta V^{EXANTE}(b_{t+1}, f_{t+1}, 0, s_t) \tag{24}$$

$$s.t. \quad (5) - (11),\ (15) - (17)\ and$$

$$T_t + q(b_{t+1}, f_{t+1}, 0, s_t) b_{t+1} = b_t \tag{20a}$$

where equation (20a) is a budget constraint for the sovereign when it repays debt b_t, and issues new debt $q(.)b_{t+1}$, to allocate resources to transfers T_t.

$V^D(b_t, f_t, 0, s_t)$ is its ex post value of default/post-default restructuring:

$$V^D(b_t, f_t, 0, s_t) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, f_{t+1}} u(c_t, L_t) \quad + \beta \int_S V((1 + r^*) b_t, f_{t+1}, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{25}$$

$$s.t. \quad (5) - (11),\ (15) - (17),\ and\ (20)$$

The sovereign's default/post-default restructuring choice is defined by default/post-default restructuring set $D(b_t, f_t, 0) \subset S$. It is a set of vectors of shocks s_t at which the value of default/post-default restructuring is higher than or equal to the value of repayment:

$$D(b_t, f_t, 0) = \{s_t \in S : V^D(b_t, f_t, 0, s_t) > V^R(b_t, f_t, 0, s_t)\} \tag{26}$$

Sovereign's intermediate and bad credit records (partial and no market access)

Value functions for intermediate and bad credit records ($h_t = 1, 2$) are expected payoffs for preemptive and post-default debt renegotiations for the sovereign:

$$V(b_t, f_t, 1, s_{t-1}) = \Psi(b_t, f_t, 1, s_{t-1}) \tag{27}$$

$$V(b_t, f_t, 2, s_t) = \Gamma(b_t, f_t, 2, s_t) \tag{28}$$

4.4 Foreign Creditors' Problem

Sovereign's good credit record (full market access)

The representative foreign creditor is also risk-averse and maximizes expected lifetime utility. Prior to realization of the current shocks, the foreign creditor's ex ante value which depends on the sovereign's preemptive and non-preemptive choice is defined as follows:

$$V^{*,EXANTER}(b_t, f_t, 0, s_{t-1}) = \mathbf{1}_{PRE} V^{*,PRE}(b_t, f_t, 0, s_{t-1}) + (1 - \mathbf{1}_{PRE}) V^{*,NON_PRE}(b_t, f_t, 0, s_{t-1}) \tag{29}$$

$V^{*,PRE}(b_t, f_t, 0, s_{t-1})$ is the ex ante value when the sovereign opts a preemptive restructuring:

$$V^{*,PRE}(b_t, f_t, 0, s_{t-1}) = \max_{c_t^*, f_{t+1}^*} \int_S \Big[\upsilon(c_t^*) + \beta^* V^*(b_t, f_{t+1}, 1, s_t) \Big] d\mu(s_t | s_{t-1}) \tag{30}$$

$$c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q^f(b_{t+1}, f_{t+1}, 0, s_{t-1}) f_{t+1}^* = y_t^* + \bar{\omega} y_{t-1}^* + f_t^* \tag{31}$$

where equation (31) is a budget constraint for the foreign creditor. He receives income y_t^*, repayments on risk-free assets and corporate bonds, $\bar{\omega} y_{t-1}^*$ and f_t^* invested in the previous period, and allocates to current consumption, exports of intermediate goods (to the final goods firm), risk-free assets (i.e., sovereign bonds issued in advanced economies) and corporate bonds in the next period. The foreign creditor invests fixed portion of the current income to risk-free assets.

$V^{*,NON_PRE}(b_t, f_t, 0, s_{t-1})$ is the ex ante value when the sovereign opts passing a preemptive

restructuring:

$$V^{*,NON_PRE}(b_t, f_t, 0, s_{t-1}) = \int_S V^*(b_t, f_t, 0, s_t) d\mu(s_t|s_{t-1}) \tag{32}$$

After realization of the current shocks, the foreign creditor's ex post value which depends on the sovereign's repayment and default choice is defined as follows:

$$V^*(b_t, f_t, 0, s_t) = \mathbf{1}_{NON_DEF} V^{*R}(b_t, f_t, 0, s_t) + (1 - \mathbf{1}_{NON_DEF}) V^{*D}(b_t, f_t, 0, s_t) \tag{33}$$

$V^{*,R}(b_t, f_t, 0, s_t)$ is the ex post value when the sovereign repays:

$$V^{*,R}(b_t, f_t, 0, s_t) = \max_{c_t^*, b_{t+1}^*, f_{t+1}^*} \upsilon(c_t^*) + \beta^* V^{*,EXANTE}(b_{t+1}, f_{t+1}, 0, s_t) \tag{34}$$

$$c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q(b_{t+1}, f_{t+1}, 0, s_t) b_{t+1}^* + q^f(b_{t+1}, f_{t+1}, 0, s_t) f_{t+1}^* = y_t^* + \bar{\omega} y_{t-1}^* + b_t^* + f_t^* \tag{31a}$$

where the foreign creditor receives repayments on risk-free assets, sovereign and corporate bonds invested in the previous period, and allocates to current consumption, exports of intermediate goods (to the final goods firm), risk-free assets, sovereign and corporate bonds in the next period.

$V^{*D}(b_t, f_t, 0, s_t)$ is its ex post value when the sovereign defaults:

$$V^{*D}(b_t, f_t, 0, s_t) = \max_{c_t^*, f_{t+1}^*} \upsilon(c_t^*) + \beta^* \int_S V^*((1 + r^*) b_t, f_{t+1}, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{35}$$

$$s.t.\ (31)$$

Sovereign's intermediate and bad credit records (partial and no market access)

The foreign creditor's value functions for intermediate and bad credit records ($h_t = 1, 2$) are expected payoffs for preemptive and post-default debt renegotiations for the foreign creditor:

$$V^*(b_t, f_t, 1, s_{t-1}) = \Psi^*(b_t, f_t, 1, s_{t-1}) \tag{27a}$$

$$V^*(b_t, f_t, 2, s_t) = \Gamma^*(b_t, f_t, 2, s_t) \tag{28a}$$

Sovereign and corporate bond prices

We obtain both sovereign and corporate bond prices given the sovereign's choice of a preemptive debt restructuring, a default and repayment, the firm' choice of default and expected recovery rates:

$$q(b_{t+1}, f_{t+1}, 0, s_t) = \int_S \beta^* \frac{v'(c^*_{t+1})}{v'(c^*_t)} \Big[\mathbf{1}_{PRE} \delta(b_{t+1}, f_{t+1}, 1, s_t) + (1 - \mathbf{1}_{PRE}) \Big(\mathbf{1}_{NON_DEF} + (1 - \mathbf{1}_{NON_DEF}) \gamma(b_{t+1}, f_{t+1}, 2, s_{t+1}) \Big) \Big] d\mu(s_{t+1}|s_t) \tag{36}$$

$$q^f(b_{t+1}, f_{t+1}, 0, s_t) = \int_S \beta^* \frac{v'(c^*_{t+1})}{v'(c^*_t)} \left[\begin{array}{c} \mathbf{1}_{NON_COR_DEF} + \\ (1 - \mathbf{1}_{NON_COR_DEF}) \gamma^f(b_{t+1}, f_{t+1}, 2, s_{t+1}) \end{array} \right] d\mu(s_{t+1}|s_t) \tag{37}$$

where $\delta(b_{t+1}, f_{t+1}, 1, s_t)$ and $\gamma(b_{t+1}, f_{t+1}, 2, s_{t+1})$ are expected recovery rates for preemptive and post-default restructurings at time t+1 conditional on the sovereign choice of preemptive and default/post-default restructuring. $\gamma^f(b_{t+1}, f_{t+1}, 2, s_{t+1})$ is expected recovery rate on corporate bonds for default and liquidation.

4.5 Sovereign Debt Renegotiations

Two types of sovereign debt renegotiations (preemptive and post-default) are symmetric in bargaining game and power. Both renegotiations take the form of a two-player stochastic bargaining game with complete information as in Merlo and Wilson (1995).[6] It is a multi-round stochastic bargaining game in that both the vector of shock processes and the identity of the proposer are stochastic. For simplicity, each player has a constant probability of being selected as the proposer in each round of the renegotiations. That is, the identity of the proposer is independent of the vector of shock processes. Let ϕ denote the probability that the borrower, B, can propose and $1 - \phi$ is the probability that the lender, L, can propose. The probability which one of the players is selected as the proposer is a parsimonious way to reflect the bargaining power obtained through one's ability to enjoy the first-mover advantage.

Two types of debt renegotiations differ in three aspects: (i) timing, (ii) strategies and (iii) outside options for two parties. Preemptive renegotiations take place before realization of the current shocks, while post-default renegotiations after realization of the current shocks. Quitting the renegotiations is included in strategies for both parties under preemptive renegotiations, while not under post-default renegotiations. Outside options under the preemptive restructuring are ex ante values of passing a preemptive restructuring—also correspond to values of quitting the renegotiations—for both the sovereign and the foreign creditor. Those under the the post-default are the value of permanent autarky for the sovereign and the value with no recovered debt payments for the foreign creditor.

In every round, the proposer may either propose recovery rates (haircuts), pass or quit the renegotiations. If he proposes, then the other party chooses to accept, reject the proposal or quit the renegotiations. When the proposer proposes the offer with recovery rates (haircuts) and

[6]While there are alternative modeling approaches of bargaining game, all equilibrium outcomes remain identical. For simplicity and tractability, we follow the conventional model set-up in Merlo and Wilson (1995).

the other party accepts ("settlement"), the sovereign repays the recovered debt payments and resumes full access to the international market in the next period. When the proposer passes ("delay"), both parties repeat the bargaining game in the next period. When both parties quit the renegotiations ("quit"), both parties move back to the sovereign's choice of passing a preemptive restructuring.

We define some basic concepts of the game. A stochastic bargaining game is denoted by $(C, \beta, 1/(1+r^*))$, where for each vector of shocks $s \in S$, $C(s)$ is the set of feasible utility vectors that may be agreed upon in that state. β and $1/(1+r^*)$ are the discount factors for B and L, respectively.[7] A payoff function is an element $\Delta(s) \in C(s)$, where $\Delta_i(s)$ is the utility to player i for $i = B, L$.

As in Merlo and Wilson (1995), we focus on a game with stationary strategies, that is, the players' actions depend only on the current state $(b_t, f_t, h_t, s_t/s_{t-1})$ where $h_t = 1, 2$ and the current offer. We denote the proposer i's and the counterpart j's equilibrium strategies as follows: for $h_t = 1, 2$ (a) $\theta_i(b_t, f_t, h_t, s_t/s_{t-1}) = 1$ (propose) when the proposer i proposes and $\theta_j(b_t, f_t, h_t, s_t/s_{t-1}) = 1$ (accept) when the counterpart j accepts the offer, (b) $\theta_i(b_t, f_t, h_t, s_t/s_{t-1}) = 0$ (pass) when the proposer i passes and $\theta_j(b_t, f_t, h_t, s_t/s_{t-1}) = 0$ (reject) when the counterpart j rejects the offer. Furthermore, for a preemptive restructuring $(h_t = 1)$, (c) $\theta_i(b_t, f_t, h_t, s_t/s_{t-1}) = -1$ (quit) when the proposer i quits the renegotiations, and $\theta_j(b_t, f_t, h_t, s_t/s_{t-1}) = -1$ (quit) when the other party j also quits the renegotiations.

A stationary subgame perfect (SP) equilibrium is defined as the players' equilibrium stationary strategies θ and θ^*, and the payoff functions, Ψ and Ψ^*, Γ and Γ^*, associated with these strategies for player B and L. The expected payoff at preemptive and post-default debt renegotiations for the borrower B and lender L in period t, are shown as:

$$\begin{aligned}\Gamma(b_t, f_t, 2, s_t) &= \phi\Gamma^B(b_t, f_t, 2, s_t) + (1-\phi)\Gamma^L(b_t, f_t, 2, s_t)\\ \Gamma^*(b_t, f_t, 2, s_t) &= \phi\Gamma^{*B}(b_t, f_t, 2, s_t) + (1-\phi)\Gamma^{*L}(b_t, f_t, 2, s_t)\end{aligned} \tag{38}$$

$$\begin{aligned}\Psi(b_t, f_t, 1, s_{t-1}) &= \phi\Psi^B(b_t, f_t, 1, s_{t-1}) + (1-\phi)\Psi^L(b_t, f_t, 1, s_{t-1})\\ \Psi^*(b_t, f_t, 1, s_{t-1}) &= \phi\Psi^{*B}(b_t, f_t, 1, s_{t-1}) + (1-\phi)\Psi^{*L}(b_t, f_t, 1, s_{t-1})\end{aligned} \tag{38a}$$

where the superscript denotes the identity of the proposer: $\Gamma^B(\Gamma^{*B})$ represents the borrower's (lender's) payoff when the borrower proposes, and $\Gamma^L(\Gamma^{*L})$ refers to the borrower's (lender's) payoff when the lender proposes. We explain the case when the borrower B proposes below. We explain the case when the lender L proposes in the Appendix C.1.

[7] Merlo and Wilson (1995) assume that the players have the same discount factor. But they also explain that "there is no real restriction implied by the assumption that players discount utility at a common constant rate. So long as the discounted size of the "cake" converges uniformly to 0. $\cdots$ player-dependent discount factors can always be represented by a different "cake" process with a common fixed discount factor". So in our model, we assume that the borrower and the lender have different discount factors.

Post-default debt renegotiations

We denote the offered recovery rates as γ_t^B, the borrower's values of proposing and passing as V^{PRO} and V^{PASS}, and the foreign creditor's values of accepting and rejecting as V^{*ACT} and V^{*REJ}, respectively. When the borrower B proposes and the lender accepts the offer, the sovereign repays reduced debt arrears $-\gamma_t^B b_t$ and regains access to the international capital market in the next period with outstanding debt, i.e., net issuance at settlement as in Benjamin and Wright (2013).

$$V^{PRO}(b_t, f_t, 2, s_t) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, b_{t+1}, f_{t+1}} u(c_t, L_t) + \beta V^{EXANTE}(b_{t+1}, f_{t+1}, 0, s_t) \tag{39}$$

$$s.t. \quad (5)-(11),\ (15)-(17) \text{ and}$$

$$T_t + q(b_t, f_t, 2, s_t) b_{t+1} = \gamma_t^B b_t \tag{20b}$$

$$V^{*ACT}(b_t, f_t, 2, s_t) = \max_{c_t^*, b_{t+1}^*, f_{t+1}^*} v(c_t^*) + \beta^* V^{*,EXANTE}(b_{t+1}, f_{t+1}, 0, s_t) \tag{40}$$

$$s.t. \ \ c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q(b_{t+1}, f_{t+1}, 0, s_t) b_{t+1}^* + q^f(b_{t+1}, f_{t+1}, 0, s_t) f_{t+1}^* = y_t^* + \bar{\omega} y_{t-1}^* - \gamma_t^B b_t + f_t^* \tag{31b}$$

When the borrower B passes, both parties proceed to the next period with accumulated arrears.

$$V^{PASS}(b_t, f_t, 2, s_t) = \max_{c_t, m_t^d, m_t^*, L_t^f, L_t^m, L_t, f_{t+1}} u(c_t, L_t) + \beta \int_S V((1+r^*) b_t, f_{t+1}, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{41}$$

$$s.t. \quad (5)\text{–}(11),\ (15)\text{–}(17),\ and\ (20)$$

$$V^{*REJ}(b_t, f_t, 2, s_t) = \max_{c_t^*, f_{t+1}^*} v(c_t^*) + \beta^* \int_S V^*((1+r^*) b_t, f_{t+1}, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{42}$$

$$s.t.\ (31)$$

In equilibrium, the agreed recovery rates γ_t^{B*} satisfy the following:[8]

$$\gamma_t^{B*} = argmax V^{PRO}(b_t, f_t, 2, s_t)$$

[8]Off-equilibrium paths are eliminated in equilibrium.

$$s.t. \quad V^{PRO}(b_t, f_t, 2, s_t) \geq V^{PASS}(b_t, f_t, 2, s_t)$$
$$V^{*ACT}(b_t, f_t, 2, s_t) \geq V^{*REJ}(b_t, f_t, 2, s_t) \tag{43}$$

If both parties reach an agreement, two parties' payoffs are as follows:

$$\Gamma^B(b_t, f_t, 2, s_t) = V^{PRO}(b_t, f_t, 2, s_t)$$
$$\Gamma^{B*}(b_t, f_t, 2, s_t) = V^{*ACT}(b_t, f_t, 2, s_t) \tag{44}$$

Otherwise,

$$\Gamma^B(b_t, f_t, 2, s_t) = V^{PASS}(b_t, f_t, 2, s_t)$$
$$\Gamma^{B*}(b_t, f_t, 2, s_t) = V^{*REJ}(b_t, f_t, 2, s_t) \tag{44a}$$

The renegotiation settlement can be characterized by settlement set $R^B(b_t, f_t, 2) \subset S$. It is a set of vectors of the current shocks s_t which both parties agree on settlement:

$$R^B(b_t, f_t, 2) = \left\{ \begin{array}{r} s_t \in S : V^{PRO}(b_t, f_t, 2, s_t) \geq V^{PASS}(b_t, f_t, 2, s_t) \\ V^{*ACT}(b_t, f_t, 2, s_t) \geq V^{*REJ}(b_t, f_t, 2, s_t) \end{array} \right\} \tag{45}$$

Preemptive debt renegotiations

We denote the offered recovery rates as δ_t^B, the borrower's values of proposing, passing and quitting as V^{PRO}, V^{PASS}, V^{QUIT}, and the foreign creditor' values of accepting, rejecting and quitting as V^{*ACT}, V^{*REJ}, V^{*QUIT}, respectively. When the borrower B proposes and the lender accepts the offer, the sovereign repays reduced debt arrears $-\delta_t^B b_t$ and regains full access to the international capital market in the next period with outstanding debt.

$$V^{PRO}(b_t, f_t, 1, s_{t-1}) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, b_{t+1}, f_{t+1}} \int_S [u(c_t, L_t) + \beta V^{EXANTE}(b_{t+1}, f_{t+1}, 0, s_t)] d\mu(s_t|s_{t-1}) \tag{46}$$

$$s.t. \quad (5)\text{–}(11),\ (15)\text{–}(17)\ and$$

$$T_t + q(b_t, f_t, 1, s_t) b_{t+1} = \delta_t^B b_t \tag{20c}$$

$$V^{*ACT}(b_t, f_t, 1, s_{t-1}) = \max_{c_t^*, b_{t+1}^*, f_{t+1}^*} \int_S [\upsilon(c_t^*) + \beta^* V^{*,EXANTE}(b_{t+1}, f_{t+1}, 0, s_t)] d\mu(s_t|s_{t-1}) \tag{47}$$

$$s.t.\ \ c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q(b_{t+1}, f_{t+1}, 0, s_t) b_{t+1}^* + q^f(b_{t+1}, f_{t+1}, 0, s_t) f_{t+1}^* = y_t^* + \bar{\omega} y_{t-1}^* - \delta_t^B b_t + f_t^* \tag{31c}$$

When the borrower B passes, both parties proceed to the next period with the same level of outstanding debt:

$$V^{PASS}(b_t, f_t, 1, s_{t-1}) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, f_{t+1}} \int_S [u(c_t, L_t) + \beta V(b_t, f_{t+1}, 1, s_t)] d\mu(s_t | s_{t-1}) \tag{48}$$

$$s.t.\ \ (5)\text{–}(11),\ (15)\text{–}(17)\ and\ (20)$$

$$V^{*REJ}(b_t, f_t, 1, s_{t-1}) = \max_{c_t^*, f_{t+1}^*} \int_S [\upsilon(c_t^*) + \beta^* V^*(b_t, f_{t+1}, 1, s_t)] d\mu(s_t | s_{t-1}) \tag{49}$$

$$s.t.\ (31)$$

When the borrower B quits the renegotiations, the sovereign proceeds to its choice between repayment and default without any debt treatment and the foreign creditor receives expected return on sovereign bonds:

$$V^{QUIT}(b_t, f_t, 1, s_{t-1}) = \int_S V(b_t, f_t, 0, s_t) d\mu(s_{t+1} | s_t) \tag{50}$$

$$V^{*QUIT}(b_t, f_t, 1, s_{t-1}) = \int_S V^*(b_t, f_t, 0, s_t) d\mu(s_{t+1} | s_t) \tag{51}$$

In equilibrium, the agreed recovery rates δ_t^{B*} satisfy the following:[9]

$$\begin{aligned} \delta_t^{B*} &= argmax V^{PRO}(b_t, f_t, 1, s_{t-1}) \\ s.t.\quad V^{PRO}(b_t, f_t, 1, s_{t-1}) &\geq V^{PASS}(b_t, f_t, 1, s_{t-1}) \\ V^{PRO}(b_t, f_t, 1, s_{t-1}) &\geq V^{QUIT}(b_t, f_t, 1, s_{t-1}) \\ V^{*ACT}(b_t, f_t, 1, s_{t-1}) &\geq V^{*REJ}(b_t, f_t, 1, s_{t-1}) \\ V^{*ACT} b_t, f_t, 1, s_{t-1}) &\geq V^{*QUIT}(b_t, f_t, 1, s_{t-1}) \end{aligned} \tag{52}$$

If both parties reach an agreement, two parties' payoffs are as follows:

$$\Psi^B(b_t, f_t, 1, s_{t-1}) = V^{PRO}(b_t, f_t, 1, s_{t-1})$$

[9]Off-equilibrium paths are eliminated in equilibrium.

$$\Psi^{B*}(b_t, f_t, 1, s_{t-1}) = V^{*ACT}(b_t, f_t, 1, s_{t-1}) \tag{53}$$

Otherwise,

$$\Psi^{B}(b_t, f_t, 1, s_{t-1}) = V^{PASS}(b_t, f_t, 1, s_{t-1})$$
$$\Psi^{B*}(b_t, f_t, 1, s_{t-1}) = V^{*REJ}(b_t, f_t, 1, s_{t-1}) \tag{53a}$$

or

$$\Psi^{B}(b_t, f_t, 1, s_{t-1}) = V^{QUIT}(b_t, f_t, 1, s_{t-1})$$
$$\Psi^{B*}(b_t, f_t, 1, s_{t-1}) = V^{*QUIT}(b_t, f_t, 1, s_{t-1}) \tag{53b}$$

The renegotiation settlement can be characterized by settlement set $R^B(b_t, f_t, 1) \subset S$. It is a set of vectors of the previous shocks s_{t-1} which both parties agree on settlement:

$$R^B(b_t, f_t, 1) = \left\{ \begin{array}{c} s_{t-1} \in S : V^{PRO}(b_t, f_t, 1, s_{t-1}) \geq V^{PASS}(b_t, f_t, 1, s_{t-1}) \\ V^{PRO}(b_t, f_t, 1, s_{t-1}) \geq V^{QUIT}(b_t, f_t, 1, s_{t-1}) \\ V^{*ACT}(b_t, f_t, 1, s_{t-1}) \geq V^{*REJ}(b_t, f_t, 1, s_{t-1}) \\ V^{*ACT} b_t, f_t, 1, s_{t-1}) \geq V^{*QUIT}(b_t, f_t, 1, s_{t-1}) \end{array} \right\} \tag{45a}$$

4.6 Market Clearing Conditions

Market clearing conditions for the final goods (including foreign intermediate goods) are as follows:

$$c_t + c_t^* + m_t^{f*} = y_t + y_t^*$$

Market clearing conditions for sovereign bonds and corporate bonds are as follows:

$$b_t + b_t^* = 0$$
$$f_t + f_t^* = 0 \tag{54}$$

4.7 Equilibrium

A recursive equilibrium is defined as a set of functions for (a) the sovereign's ex ante and ex post value functions, transfers, sovereign debt, sets of preemptive restructuring and default/post-default restructuring; (b) the foreign creditor's consumption, asset positions for sovereign and corporate bonds, (c) the final goods firm's value function, corporate debt, labor demand, demand for domestic and foreign intermediate goods; (d) the intermediate goods firm's labor demand; (e) the household's consumption and labor supply, (f) the sovereign's and the foreign creditor' decision functions, payoffs, recovery rates, settlement sets (all depending on who is the proposer), (g) prices for sovereign bonds, corporate bonds, domestic and foreign intermediate goods, and wage such that

[1]. the sovereign's ex ante and ex post value functions, transfers, sovereign debt, sets of preemptive restructuring and default/post-default restructuring satisfy its optimization problem

(18)–(28);

[2]. the foreign creditor's consumption, asset positions for sovereign and corporate bonds satisfy his optimization problem (29)–(37);

[3]. the final goods firm's value function, corporate debt, labor demand, demand for domestic and foreign intermediate goods, a set of corporate default satisfy its optimization problem (3)–(12);

[4]. the intermediate goods firm's labor demand satisfies its optimization problems (13)–(15);

[5]. the household's consumption and labor supply satisfy his optimization problem (1)–(2);

[6]. both parties' decisions, payoffs and recovery rates solve the multi-round preemptive and post-default debt renegotiation problems (38)–(53).

[7]. market clearing conditions for final goods, sovereign and corporate bonds, labor and domestic intermediate goods (16)–(17) and (54)–(55) are satisfied.

In equilibrium, default probability and settlement probability are defined by the sovereign's default/post-default restructuring set and settlement sets for two types of sovereign debt restructurings:

$$p^D(b_{t+1}, f_{t+1}, 0, s_t) = \int_{D(b_{t+1}, f_{t+1}, 0)} d\mu(s_{t+1}|s_t),$$

$$p^{POST}(b_{t+1}, f_{t+1}, 2, s_t) = \phi \int_{R^B(b_{t+1}, f_{t+1}, 2)} d\mu(s_{t+1}|s_t) + (1-\phi) \int_{R^L(b_{t+1}, f_{t+1}, 2)} d\mu(s_{t+1}|s_t),$$

$$p^{PRE}(b_{t+1}, f_{t+1}, 1, s_t) = \phi \int_{R^B(b_{t+1}, f_{t+1}, 1)} d\mu(s_{t+1}|s_t) + (1-\phi) \int_{R^L(b_{t+1}, f_{t+1}, 1)} d\mu(s_{t+1}|s_t) \quad (55)$$

Expected recovery rates conditional on the sovereign's preemptive and default/post-default restructuring choice and those conditional on the final goods firm's default choice are shown as:

$$\delta(b_{t+1}, f_{t+1}, 1, s_t) = \int_S \begin{bmatrix} \phi \mathbb{1}_{s_{t+1} \in R^B(b_{t+1}, f_{t+2}, 1)} \delta^{B*}(b_{t+1}, f_{t+2}, 1, s_{t+1}) \\ +(1-\phi) \mathbb{1}_{s_{t+1} \in R^L(b_{t+1}, f_{t+2}, 1)} \delta^{L*}(b_{t+1}, f_{t+2}, 1, s_{t+1}) \\ + \begin{pmatrix} \phi \mathbb{1}_{s_{t+1} \notin R^B(b_{t+1}, f_{t+2}, 1)} \\ +(1-\phi) \mathbb{1}_{s_{t+1} \notin R^L(b_{t+1}, f_{t+2}, 1)} \end{pmatrix} \delta(b_{t+1}, f_{t+2}, 1, s_{t+1}) \end{bmatrix} d\mu(s_{t+1}|s_t)$$

$$\gamma(b_{t+1}, f_{t+1}, 2, s_{t+1}) = \int_S \begin{bmatrix} \phi \mathbb{1}_{s_{t+2} \in R^B(b_{t+2}, f_{t+2}, 2)} \gamma^{B*}((1+r^*)b_{t+1}, f_{t+2}, 2, s_{t+2}) \\ +(1-\phi) \mathbb{1}_{s_{t+2} \in R^L(b_{t+2}, f_{t+2}, 2)} \gamma^{L*}((1+r^*)b_{t+1}, f_{t+2}, 2, s_{t+2}) \\ + \begin{pmatrix} \phi \mathbb{1}_{s_{t+2} \notin R^B(b_{t+2}, f_{t+2}, 2)} \\ +(1-\phi) \mathbb{1}_{s_{t+2} \notin R^L(b_{t+2}, f_{t+2}, 2)} \end{pmatrix} \gamma((1+r^*)b_{t+1}, f_{t+2}, 2, s_{t+2}) \end{bmatrix} d\mu(s_{t+2}|s_{t+1})$$

$$\gamma^f(b_{t+1}, f_{t+1}, 2, s_{t+1}) = \int_S \left[\begin{array}{c} \phi \mathbb{1}_{s_{t+2} \in R^B(b_{t+2}, f_{t+2}, 1)} \\ +(1-\phi)\mathbb{1}_{s_{t+2} \in R^L(b_{t+2}, f_{t+2}, 1)} \bar{\gamma}^f \\ + \left(\begin{array}{c} \phi \mathbb{1}_{s_{t+2} \notin R^B(b_{t+2}, f_{t+2}, 1)} \\ +(1-\phi)\mathbb{1}_{s_{t+2} \notin R^L(b_{t+2}, f_{t+2}, 1)} \end{array} \right) \gamma^f((1+r^*)b_{t+2}, f_{t+2}, 1, s_{t+2}) \end{array} \right] d\mu(s_{t+2}|s_{t+1}) \tag{56}$$

The difference between the country's interest rate and the risk-free rate is the sovereign's total spread, defined as

$$sp(b_{t+1}, f_{t+1}, 0, s_t) = \frac{1}{q(b_{t+1}, f_{t+1}, 0, s_t)} - (1+r^*)$$

$$sp^f(b_{t+1}, f_{t+1}, 0, s_t) = \frac{1}{q^f(b_{t+1}, f_{t+1}, 0, s_t)} - (1+r^*)$$

4.8 Implication:

5 Quantitative Analysis

5.1 Parameters and Functional Forms

Parameter	Value	Source
Int. goods share in gross output of final goods	$\alpha_m = 0.43$	Argentina's national accounts
Capital share in gross output of final goods	$\alpha_k = 0.17$	Standard capital share in GDP (0.3)
Labor share in gross output of final goods	$\alpha_L = 0.4$	Standard labor share in GDP (0.7)
Labor share in GDP of int. goods	$\gamma = 0.7$	Standard labor share in GDP (0.7)
Coefficient of relative risk aversion	$\sigma = 2$	Standard RBC value
Risk-free interest rate	$r^* = 0.01$	Standard RBC value
Bargaining power	$\theta = 0.975$	Asonuma and Joo (2020) -Argentina 2001-05
Curvature parameter of labor supply	$\omega = 1.455$	Frisch wage elasticity (2.2)
Armington weight of domestic inputs	$\lambda = 0.62$	Regression estimate
Armington curvature parameter	$\mu = 0.65$	Regression estimate
Dixit-Stiglitz curvature parameter	$\nu = 0.59$	Gopinath and Neiman (2010)
Share of risk-free assets	$\bar{\omega} = 0.95$	Estimated
Autocorrelation of TFP shocks	$\rho_\epsilon = 0.95$	Estimated
Standard deviation of TFP innovations	$\sigma_\epsilon = 0.017$	Estimated
Intermediate goods TFP coefficient	$A = 0.31$	Estimated
Subjective discount factor	$\beta = 0.88$	Estimated
TFP semi-elasticity of exogenous capital flows	$\xi = -0.67$	Estimated

5.2 Numerical Results on Equilibrium Characteristics

We explore the sovereign's equilibrium choice of repayment, a preemptive restructuring, and a default/post-default restructuring for Uruguay in Figure 6—that for Argentina in Figure E1 in Appendix E. We measure both sovereign debt and corporate debt as sovereign debt/mean GDP ratio and corporate debt/mean GDP ratio. In Part A, we keep corporate debt/GDP ratio at the mean level and show the sovereign's equilibrium choice in the presentation of TFP (horizontal axis) and sovereign debt/GDP ratio (vertical axis). We replicate main findings in Yue (2010) and Asonuma and Trebesch (2016). Panel A-ii shows the sovereign's equilibrium choice between repayment and a default/post-default restructuring given the current TFP (horizontal axis) ex post, i.e., after realization of current shocks (TFP). The sovereign opts a default/post-default restructuring when sovereign debt is high and the current TFP is low (the red region), while it opts repayment when sovereign debt is low and the current TFP is high (the green region) (Yue 2010). When sovereign debt is high, costs of repayment on higher sovereign debt despite of benefits of new debt issuance outweighs costs of a default/post-default restructuring—longer periods of financial exclusion, larger output loss, and accumulations of arrears—despite benefits of a larger reduction in debt repayment. Therefore, the sovereign opts a defaulting/post-default restructuring.

Panel A-i shows the sovereign's choice between a preemptive restructuring and passing a preemptive restructuring given the lagged TFP (x-axis) ex ante, i.e., before realization of current shocks (TFP). The sovereign opts a preemptive restructuring when sovereign debt is high and the lagged TFP is low (the blue region), while it opts passing a preemptive restructuring when

sovereign debt is low and the lagged TFP is high (the green region). Given high sovereign debt, the sovereign is more likely to default and take a post-default restructuring ex post, i.e., after realization of the current TFP. Expected costs of a default/post-default restructuring—longer periods of financial exclusion, larger output loss, and accumulations of arrears—despite benefits of a larger reduction in debt repayments outweighs certain costs of a preemptive restructuring—short periods of financial exclusion, smaller output loss—despite benefits of a smaller reduction in debt payments and no accumulations of arrears (Asonuma and Trebesch 2016). Therefore, the sovereign opts passing a preemptive restructuring.

Panel A-iii merges both the ex ante choice and ex post equilibrium choice, and shows the equilibrium choice among repayment, a post-default restructuring, and a default/post-default restructuring given the current TFP (horizontal axis) and the lagged TFP fixed at the mean level. Before realization of the current TFP, given the mean lagged TFP, when sovereign debt is high, it opts a preemptive restructuring (the blue region). Otherwise (when sovereign debt is low), it opts passing a preemptive restructuring. After realization of the current TFP, when the current TFP is low, the sovereign opts a default/post-default restructuring (the red region). Otherwise (when the current TFP is high), the sovereign opts repayment (the green region).

Second in part B, we keep both the lagged and current TFP at the mean level and show the sovereign's equilibrium choice in the presentation of corporate debt/GDP ratio (horizontal axis) and sovereign debt/GDP ratio (vertical axis). We show our new findings on how the sovereign's equilibrium choice of repayment, a preemptive restructuring, and a default/post-default restructuring on sovereign debt changes respect to the level of corporate debt. Panel B-ii shows the sovereign's equilibrium choice between repayment and a default/post-default restructuring given the corporate debt/GDP ratio (horizontal axis) ex post, i.e., after realization of *current shocks (TFP)*. The sovereign opts a default/post-default restructuring on sovereign debt when corporate debt is high (the red region), while it opts repayment on sovereign debt when corporate debt is low (the green region). When corporate debt is high, the final goods firm is more likely to default and file for bankruptcy liquidation on corporate debt. Costs of repayment on sovereign debt despite of lower benefits of new debt issuance with higher sovereign bond yields outweighs costs of a default/post-default restructuring on sovereign debt—longer periods of financial exclusion, larger output loss, and accumulations of arrears—with additional costs associated with corporate default (i.e., a lack of foreign intermediate goods) despite benefits of a larger reduction in sovereign debt repayment. Therefore, the sovereign opts a defaulting/post-default restructuring.

Panel B-i shows the sovereign's equilibrium choice between a preemptive restructuring and passing a preemptive restructuring given corporate debt/GDP ratio (x-axis) ex ante, i.e., before realization of the current shocks (i.e., mean TFP). The sovereign opts a preemptive restructuring when corporate debt is high (the blue region), while it opts passing a preemptive restructuring when corporate debt is low (the green region). When corporate debt is high, after realization of the current mean TFP, the final goods firm is more likely to default and file for bankruptcy liquidation, and the sovereign is also more likely to default and take a post-default restruc-

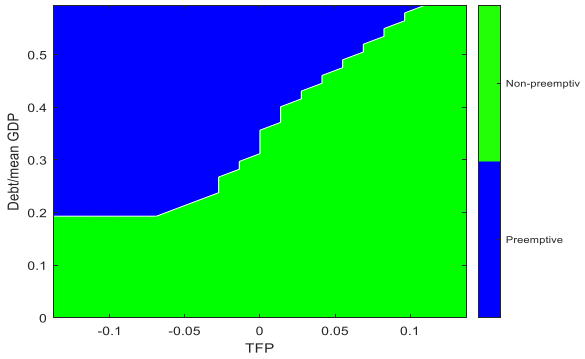
turing. Before realization of the current TFP, the sovereign anticipates high expected and uncertain costs of the sovereign's default/post-default restructuring ex post, i.e., after realization of mean TFP—longer periods of financial exclusion, larger output loss, and accumulations of arrears—combined additional costs associated with corporate default (i.e., a lack of foreign intermediate goods) despite benefits of a larger reduction in sovereign debt repayments. In contrast, the sovereign sees low certain costs of a preemptive restructuring—short periods of financial exclusion, smaller output loss—despite benefits of a smaller reduction in debt payments and no accumulations of arrears. Therefore, the sovereign opts a preemptive restructuring to avoid a default/post-default restructuring.

Panel B-iii merges both the ex ante choice and ex post equilibrium choice, and shows the equilibrium choice among repayment, a post-default restructuring, and a default/post-default restructuring ono sovereign debt given corporate debt (horizontal axis) and both the lagged and current TFP fixed at the mean level. Before realization of the current TFP, when corporate debt is high, it opts a preemptive restructuring (the blue region). Otherwise (when corporate debt is low), it opts passing a preemptive restructuring. After realization of the current mean TFP, when sovereign debt is high, the sovereign opts a default/post-default restructuring (the red region). Otherwise (when sovereign debt), the sovereign opts repayment (the green region).

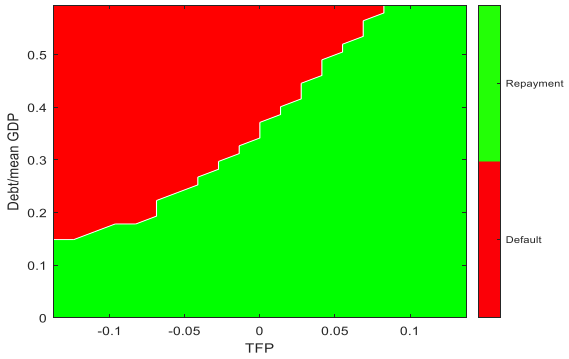
Figure 5: Sovereign's Equilibrium Choice (Uruguay)

Part A: Corporate debt at the Mean Level

(i) Ex Ante Choice of Preemptive Restructuring



(ii) Ex Post Choice for Default/Post-default Restructuring



(iii) Choice for Repayment, Preemptive Restructuring, and Default/Post-Default Restructuring

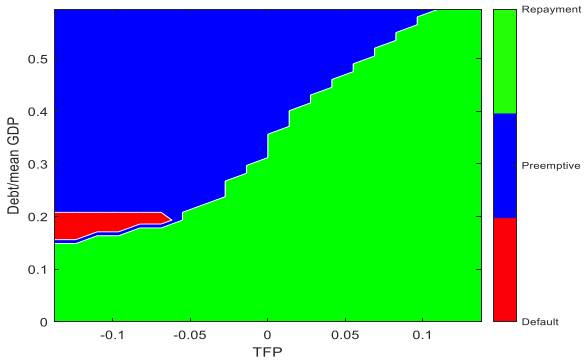
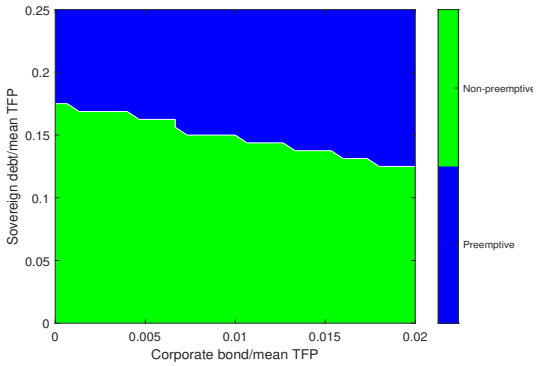


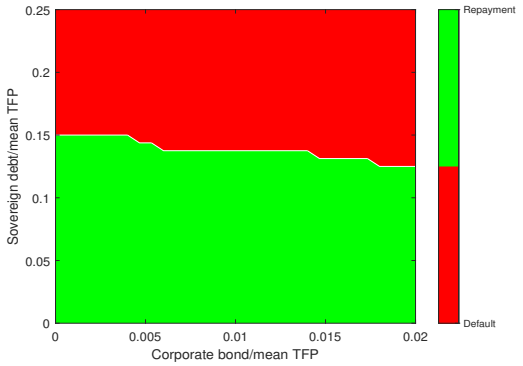
Figure 5: Sovereign's Equilibrium Choice (Uruguay) (cont.)

Part B: Lagged and Current TFP at the Mean Level

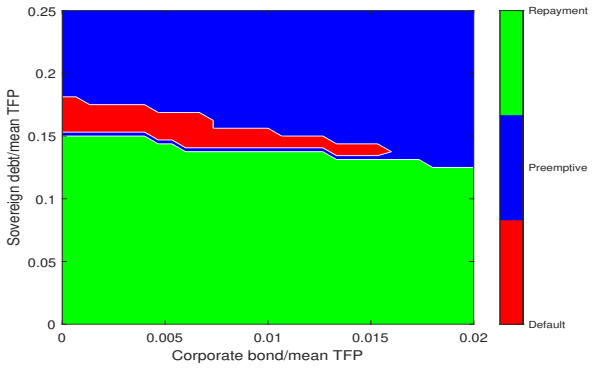
(i) Ex Ante Choice of Preemptive Restructuring



(ii) Ex Post Choice for Default/Post-default Restructuring



(iii) Choice for Repayment, Preemptive Restructuring, and Default/Post-Default Restructuring



We explore the final goods firm's (corporate) external borrowing choice for Uruguay in Figure 6—that for Argentina in Figure E2 in Appendix E. We follow the same presentation as in Panel B in Figure 6: corporate debt/GDP ratio (horizontal axis) and sovereign debt/GDP ratio (vertical axis). Panel ii reports corporate borrowing choice under sovereign default/post-default restructuring choice ex post, i.e., after realization of the current shocks (TFP). After the mean current TFP realizes, the final goods firm borrows less (has low corporate debt in the next period) when corporate debt is low (light green and green regions). When corporate debt is low in the current period, the final goods firm repays corporate debt payments in full, borrows less (has low corporate debt in the next period), and imports less foreign intermediate goods which results in a severe decline in output. While it maintains a full access and borrows from the foreign creditors, it could only borrow less (low debt) because the foreign creditor's net forth is severely reduced due to the sovereign's default and post-default restructuring choice. Its corporate borrowing under the sovereign's default and post-default restructuring is lower than that under the sovereign's preemptive restructuring choice or repayment choice.

On the contrary, when corporate debt in the current period is high, the final goods firm defaults (has corporate debt in arrears in the next period) (the blue region). With high corporate debt in the current period, the final goods firm opts defaulting, does not import foreign intermediate goods and purchase more domestic intermediate goods, which resulted in an even more severe decline in output (Mendoza and Yue 2012).

Panel i shows the corporate borrowing choice under the sovereign's preemptive restructuring choice ex ante, i.e., before realization of the current shocks (TFP). Given the mean TFP in previous period, the final goods firm borrows moderately (has moderate corporate debt in the next period) (the yellow and orange region). It repays corporate debt payments in full, borrows moderately (has moderate corporate debt in the next period), and imports moderately foreign intermediate goods which results in a mild decline in production. While it maintains a full access and borrows from the foreign creditors, it could borrow moderately (moderate corporate debt) because the foreign creditor's net forth is mildly reduced due to the sovereign's preemptive debt restructuring choice. Its corporate borrowing under the sovereign's preemptive restructuring is lower than that under the sovereign's repayment choice but higher than that under the sovereign's default/post-default restructuring choice.

Panel iii shows the corporate borrowing choice under the sovereign's repayment choice ex post, after realization of the current shocks (TFP). After the mean current TFP realizes, the final goods firm borrows more (has more corporate debt in the next period) (the light yellow region). It repays corporate debt payments in full, borrows more (has high corporate debt in the next period), and imports more foreign intermediate goods which results in constant output. Its corporate borrowing under the sovereign's repayment is higher than that under the sovereign's preemptive restructuring choice or default/post-default restructuring choice.

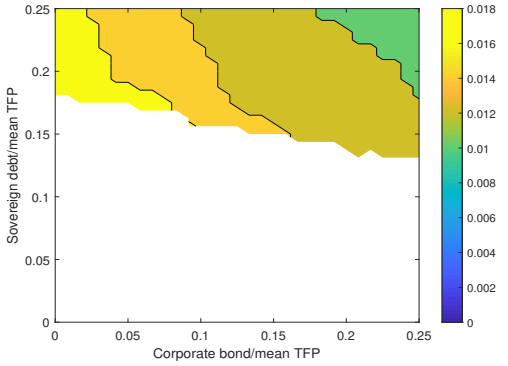
What is novel in our paper is that corporate borrowing and defaulting choice depends on the sovereign's repayment, a preemptive restructuring and a default/post-default restructuring choice. This is because the sovereign's choice of repayment, a preemptive restructuring and

a default/post-default restructuring choice significantly influence the net worth of risk averse foreign creditor. Based on the net worth calculated after receiving full repayments on sovereign debt or anticipating when and how much the sovereign recovered on sovereign debt, the foreign creditor decides the amount of corporate debt provided to the final goods firm. This corporate borrowing corresponds to "external financing channel".

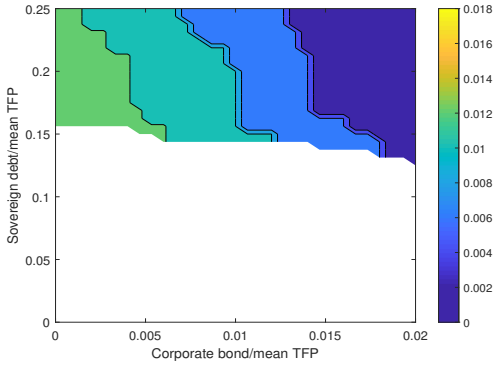
Furthermore, our "external financing channel" generates three types of sovereign and corporate debt crisis: (i) both a default and post-default restructuring on sovereign debt and a default on corporate debt; (ii) only a default/post-default restructuring on sovereign debt (no default on corporate debt); (iii) only a preemptive restructuring on sovereign debt (no default on corporate debt). This is different from Mendoza and Yue (2012) which generates only one type of sovereign and corporate debt crisis; (i) both a default and post-default restructuring on sovereign debt and a default on corporate debt.

Figure 6: Corporate External Borrowing Choice (Uruguay)

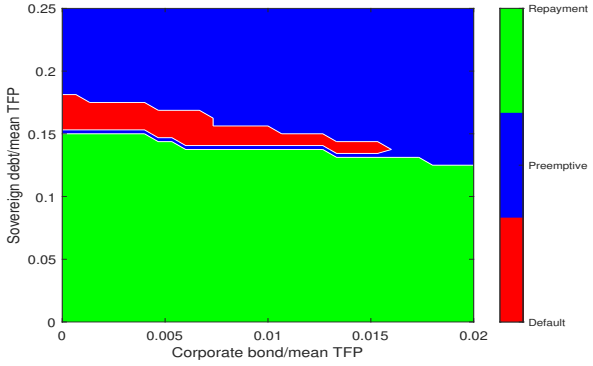
(i) Under Sovereign's Preemptive Restructuring Choice (ex ante)



(ii) Under Sovereign's Default/Post-default Restructuring Choice (ex post)



(iii) Under Sovereign's Repayment Choice (ex post)



5.3 Simulation Exercise

We show our simulation results and explore how our model successfully explains (i) Argentine default and post-default restructuring in 2001–05 and (ii) Uruguayan preemptive restructuring in 2003. Following the convention in the literature on quantitative analysis of sovereign debt, we apply 1000 rounds of simulation and for each round, we withdraw 40 observations in pre-restructuring periods and observations in restructuring periods. For Argentina, the post-default restructuring episode corresponds 1993Q1–2001Q4 (pre-restructuring period) and 2002Q1–2005Q2 (restructuring period). For Uruguay, the preemptive restructuring episode corresponds 1993Q–2002Q4 (pre-restructuring period) and 2003Q1–Q2 (restructuring period).

Simulated Dynamics. Figures 8 contrasts our model simulation results and data on dynamics of corporate external borrowing and output. Panels (i)–(ii) in Figure 8 follow the same presentation format as in Figures 2–3.

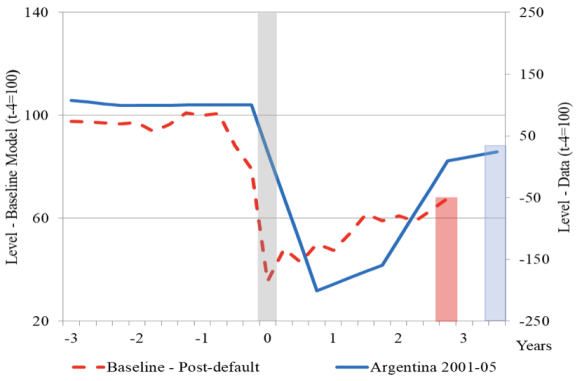
First, panel (i) in Figure 8 shows that in a post-default restructuring (part a), our model generates a sharp decline in corporate external borrowing at the start of default/post-default restructurings and gradual recovery of corporate external borrowing to a pre-restructuring level (part a). On the contrary, in a preemptive restructuring (part b), our model generates a gradual decline of corporate external borrowing prior to the start of restructurings and a quick recovery in corporate external borrowing before the end of restructuring. Both patterns of corporate external borrowing dynamics are the same with the data in Figure 2.

Second, panel (ii) in Figure 8 shows that in our model, output declines sharply at the start of a post-default restructuring and recovers gradually to reach a pre-restructuring level before the end of post-default restructurings (part a). On the contrary, output declines gradually prior to the start of preemptive restructuring and recovers quickly before the end of preemptive debt restructurings. Both output dynamics are consistent with the data reported in Figure 3.

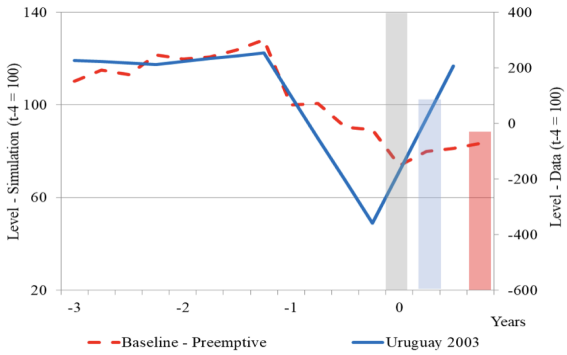
Figure 7: Simulated Results on Argentina and Uruguay

(i) Corporate External Borrowing

(a) Post-default Restructuring – Argentina

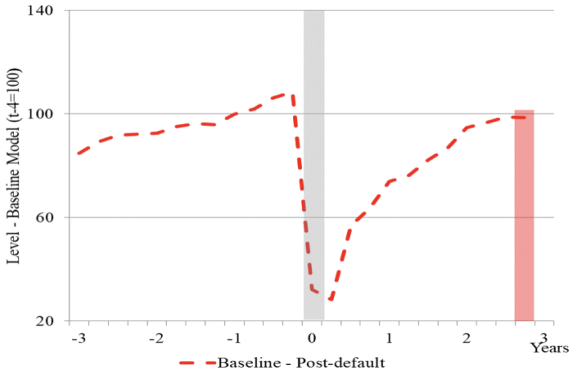


(b) Preemptive Restructuring – Uruguay

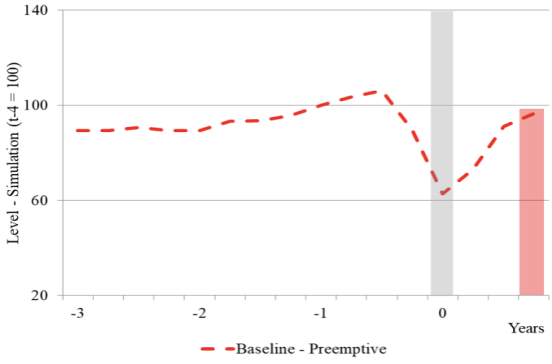


(ii) Output

(a) Post-default Restructuring – Argentina



(b) Preemptive Restructuring – Uruguay



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Appendix A Further Theoretical Model

A.1 Debt Renegotiations – When Lender Proposes

Post-default debt renegotiations

We denote the offered recovery rates as γ_t^L, the lender's values of proposing and passing as V^{*PRO} and V^{*PASS}, and the sovereign's values of accepting and rejecting as V^{ACT} and V^{REJ}, respectively. When the lender L proposes and the borrower B accepts the offer, the sovereign repays reduced debt arrears $-\gamma_t^L b_t$ and regains access to the international capital market in the next period with outstanding debt.

$$V^{*PRO}(b_t, f_t, 2, s_t) = \max_{c_t^*, b_{t+1}^*, f_{t+1}^*} \upsilon(c_t^*) + \beta^* V^{*,EXANTE}(b_{t+1}, f_{t+1}, 0, s_t) \tag{40a}$$

$$s.t.\ \ c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q(b_{t+1}, f_{t+1}^*, 0, s_t) b_{t+1}^* + q^f(b_{t+1}, f_{t+1}^*, 0, s_t) f_{t+1}^* = y_t^* - \bar{\omega} y_{t-1}^* - \gamma_t^L b_t + f_t^* * \tag{31c}$$

$$V^{ACT}(b_t, f_t, 2, s_t) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, b_{t+1}, f_{t+1}} u(c_t, L_t) + \beta V^{EXANTE}(b_{t+1}, f_{t+1}, 0, s_t) \tag{39a}$$

$$s.t. \quad (5)\text{–}(11),\ (15)\text{–}(17)\ and$$

$$T_t + q(b_t, f_t, 2, s_t) b_{t+1} = \alpha_t^L b_t \tag{20d}$$

When the borrower L passes, both parties proceed to the next period with accumulated arrears.

$$V^{*PASS}(b_t, f_t, 2, s_t) = \frac{1}{1+r^*} \int_S \Gamma^*((1+r^*) b_{t+1}, f_{t+1}, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{42a}$$

$$V^{REJ}(b_t, f_t, 2, s_t) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, b_{t+1}, f_{t+1}} u(c_t, L_t) + \beta \int_S V((1+r^*) b_t, f_{t+1}, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{41a}$$

$$s.t. \quad (5)\text{–}(11),\ (15)\text{–}(17)\ and\ (20)$$

In equilibrium, the agreed recovery rates γ_t^{L*} satisfy the following:[10]

[10] Off-equilibrium paths are eliminated in equilibrium.

$$\gamma_t^{L*} = argmax V^{*PRO}(b_t, f_t, 2, s_t)$$
$$s.t. \quad V^{*PRO}(b_t, f_t, 2, s_t) \geq V^{*PASS}(b_t, f_t, 2, s_t)$$
$$V^{ACT}(b_t, f_t, 2, s_t) \geq V^{REJ}(b_t, f_t, 2, s_t) \tag{43a}$$

If both parties reach an agreement, two parties' payoffs are as follows:

$$\Gamma^B(b_t, f_t, 2, s_t) = V^{ACT}(b_t, f_t, 2, s_t)$$
$$\Gamma^{B*}(b_t, f_t, 2, s_t) = V^{*PRO}(b_t, f_t, 2, s_t) \tag{44b}$$

Otherwise,

$$\Gamma^B(b_t, f_t, 2, s_t) = V^{REJ}(b_t, f_t, 2, s_t)$$
$$\Gamma^{B*}(b_t, f_t, 2, s_t) = V^{*PASS}(b_t, f_t, 2, s_t) \tag{44c}$$

The renegotiation settlement can be characterized by settlement set $R^L(b_t, f_t, 2, s_t) \subset S$. It is a set of current shocks s_t which both parties agree on settlements:

$$R^L(b_t, f_t, 2) = \left\{ \begin{array}{c} s_t \in S : V^{*PRO}(b_t, f_t, 2, s_t) \geq V^{*PASS}(b_t, f_t, 2, s_t) \\ V^{ACT}(b_t, f_t, 2, s_t) \geq V^{REJ}(b_t, f_t, 2, s_t) \end{array} \right\} \tag{45b}$$

Preemptive debt renegotiations

We denote the offered recovery rates as δ_t^L, the lender's values of proposing, passing and quitting as V^{*PRO}, V^{*PASS}, V^{*QUIT}, and the borrower's values of accepting, rejecting and quitting as V^{ACT}, V^{REJ}, V^{QUIT}, respectively. When the lender L proposes and the offer is accepted, the sovereign repays reduced debt arrears $-\delta_t^L b_t$ and regains full access to the international capital market in the next period with outstanding debt.

$$V^{*PRO}(b_t, f_t, 1, s_{t-1}) = \max_{c_t^*, b_{t+1}^*, f_{t+1}^*} \int_S [\upsilon(c_t^*) + \beta^* V^{*,EXANTE}(b_{t+1}, f_{t+1}, 0, s_t)] d\mu(s_t|s_{t-1}) \tag{47a}$$

$$s.t. \;\; c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q(b_{t+1}, f_{t+1}, 0, s_t) b_{t+1}^* + q^f(b_{t+1}, f_{t+1}, 0, s_t) f_{t+1}^* = y_t^* + \bar{\omega} y_{t-1}^* - \delta_t^L b_t + f_t^* \tag{31d}$$

$$V^{ACT}(b_t, f_t, 1, s_{t-1}) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, b_{t+1}, f_{t+1}} \int_S [u(c_t, L_t) + \beta V^{EXANTE}(b_{t+1}, f_{t+1}, 0, s_t)] d\mu(s_t|s_{t-1}) \tag{46a}$$

$$s.t. \quad (5)\text{–}(11), \; (15)\text{–}(17) \; and$$

$$T_t + q(b_{t+1}, f_{t+1}, 1, s_{t-1})b_{t+1} = \delta_t^L b_t \tag{20e}$$

When the lender L passes, both parties proceed to the next period with the same level of outstanding debt:

$$V^{*PASS}(b_t, f_t, 1, s_{t-1}) = \max_{c_t^*, f_{t+1}^*} \int_S [\upsilon(c_t^*) + \beta^* V^*(b_t, f_{t+1}, 1, s_t)] d\mu(s_t|s_{t-1}) \tag{49a}$$

$$s.t.\ (31)$$

$$V^{REJ}(b_t, f_t, 1, s_{t-1}) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t, f_{t+1}} \int_S [u(c_t, L_t) + \beta V((1+r^*)b_t, f_{t+1}, 1, s_t)] d\mu(s_t|s_{t-1}) \tag{48a}$$

$$s.t.\ \ (5)\text{–}(11),\ (15)\text{–}(17)\ and\ (20)$$

When the lender L quits the renegotiations, the sovereign proceeds to its choice between repayment and default without any debt treatment and the foreign creditor receives expected return on sovereign bonds as shown in equations (50)–(51).

In equilibrium, the agreed recovery rates δ_t^{L*} satisfy the following:[11]

$$\begin{aligned} \delta_t^{L*} &= argmax V^{*PRO}(b_t, f_t, 1, s_{t-1}) \\ s.t.\quad V^{*PRO}(b_t, f_t, 1, s_{t-1}) &\geq V^{*PASS}(b_t, f_t, 1, s_{t-1}) \\ V^{*PRO}(b_t, f_t, 1, s_{t-1}) &\geq V^{*QUIT}(b_t, f_t, 1, s_{t-1}) \\ V^{ACT}(b_t, f_t, 1, s_{t-1}) &\geq V^{REJ}(b_t, f_t, 1, s_{t-1}) \\ V^{ACT}(b_t, f_t, 1, s_{t-1}) &\geq V^{QUIT}(b_t, f_t, 1, s_{t-1}) \end{aligned} \tag{52a}$$

If both parties reach an agreement, two parties' payoffs are as follows:

$$\begin{aligned} \Psi^L(b_t, f_t, 1, s_{t-1}) &= V^{ACT}(b_t, f_t, 1, s_{t-1}) \\ \Psi^{L*}(b_t, f_t, 1, s_{t-1}) &= V^{*PRO}(b_t, f_t, 1, s_{t-1}) \end{aligned} \tag{53c}$$

Otherwise,

$$\begin{aligned} \Psi^L(b_t, f_t, 1, s_{t-1}) &= V^{REJ}(b_t, f_t, 1, s_{t-1}) \\ \Psi^{L*}(b_t, f_t, 1, s_{t-1}) &= V^{*PASS}(b_t, f_t, 1, s_{t-1}) \end{aligned} \tag{53d}$$

or

$$\Psi^L(b_t, f_t, 1, s_{t-1}) = V^{QUIT}(b_t, f_t, 1, s_{t-1})$$

[11] Off-equilibrium paths are eliminated in equilibrium.

$$\Psi^{L*}(b_t, f_t, 1, s_{t-1}) = V^{*QUIT}(b_t, f_t, 1, s_{t-1}) \tag{53e}$$

The renegotiation settlement can be characterized by settlement set $R^{PRE,L}(b_t, f_t, 1) \subset S$. It is a set of shocks in the previous period s_{t-1} which both parties agree on settlement:

$$R^{PRE,L}(b_t, f_t, 1) = \left\{ \begin{array}{c} s_{t-1} \in S : V^{*PRO}(b_t, f_t, 1, s_{t-1}) \geq V^{*PASS}(b_t, f_t, 1, s_{t-1}) \\ V^{*PRO}(b_t, f_t, 1, s_{t-1}) \geq V^{*QUIT}(b_t, f_t, 1, s_{t-1}) \\ V^{ACT}(b_t, f_t, 1, s_{t-1}) \geq V^{REJ}(b_t, f_t, 1, s_{t-1}) \\ V^{ACT}(b_t, f_t, 1, s_{t-1}) \geq V^{QUIT}(b_t, f_t, 1, s_{t-1}) \end{array} \right\} \tag{45e}$$

A.2 Under Both Sovereign Default and Corporate Default

A.2.1 Under Both Sovereign Default and Corporate Default

Final goods firm

When the final goods firm defaults (and the sovereign defaults), the final goods firm's production function is Cobb-Douglas and defined as follows:

$$y_t = a_t(M'(m_t^d))^{\alpha_M}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k} \tag{3a}$$

The final goods firm uses labor L_t^f, domestic intermediate goods $M'(m_t^d)$ and fixed private capital stock $\bar{k}$ for production, given a productivity shock a_t, with $0 < \alpha_k, \alpha_L, \alpha_M < 1$ and $\alpha_k + \alpha_L + \alpha_M = 1$. Domestic intermediate goods is defined as:

$$M'(m_t^d) = [\omega(m_t^d)^{\mu}]^{\frac{1}{\mu}} = \omega^{\frac{1}{\mu}} m_t^d \tag{4a}$$

The final goods firm maximizes a sum of discounted profits under corporate default by choosing only labor demand and demands for domestic intermediate goods. Its value of being corporate default is written as follows as

$$\begin{aligned} W^D(b_t, f_t, h_t, s_t) = & \max_{m_t^d, L_t^f} \left\{ a_t(M'(m_t^d))^{\alpha_M}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k} - w_t L_t^f - p_t^m m_t^d \right\} \\ & + \beta \int_S \frac{\Lambda_{t+1}}{\Lambda_t} \left\{ \begin{array}{l} (1 - \mathbf{1}_{POST_SETTLE}) W^D(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1}) \\ +\mathbf{1}_{POST_SETTLE} W^{D,PD}(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1}) \end{array} \right\} d(s_{t+1}|s_t) \end{aligned} \tag{7}$$

Under corporate default, the final goods firm does not have access to the international market, i.e., no external borrowing and no import of foreign intermediate goods.

The optimality conditions of the final goods firm are as follows:

$$\alpha_L a_t(M'(m_t^d))^{\alpha_M}(L_t^f)^{\alpha_L - 1}(\bar{k})^{\alpha_k} = w_t \tag{8a}$$

$$\alpha_M a_t(M'(m_t^d))^{\alpha_M - 1}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k}\omega(m_t^d)^{\mu - 1} = p_t^m \tag{9a}$$

When the final goods firm has corporate debt in arrears and the sovereign and the foreign creditor settle on post-default renegotiations on sovereign debt, bankruptcy liquidation is applied. The final goods firm maximizes only current profit by choosing labor demand, demands for domestic intermediate goods, repays the recovered corporate debt payments to the foreign creditor and dividends to the household, and exits:

$$W^{D,PD}(b_{t+1}, f_{t+1}, h_{t+1}, s_{t+1}) = \max_{m_t^d, L_t^f} \{a_t(M'(m_t^d))^{\alpha_M}(L_t^f)^{\alpha_L}(\bar{k})^{\alpha_k} - w_t L_t^f - p_t^m m_t^d + \bar{\gamma}^f f_t\} \tag{57}$$

where $\bar{\gamma}^f f_t$ is the liquidation value of the final goods firm. The optimality conditions are the same with equations (8a)–(9a). Note that a new final goods firm replaces the old final goods firm in the next period.

A.2.2 Sovereign's (Government's) Problem

Sovereign's good credit record (full market access)

$V^{D,CD}(b_t, f_t, 0, s_t)$ is its ex post value of default/post-default restructuring (when the final goods firm also defaults):

$$V^{D,CD}(b_t, f_t, 0, s_t) = \max_{c_t, m_t^d, L_t^f, L_t^m, L_t} u(c_t, L_t) \quad + \beta \int_S V((1+r^*)b_t, (1+r^*)f_t, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{25a}$$

$$s.t. \quad (7),\ (8a)-(9a),\ (13)-(15)\ and\ (20)$$

A.2.3 Foreign Creditor's Problem

Sovereign's good credit record (full market access)

$$V^{*,D,CD}(b_t, f_t, 0, s_t) = \max_{c_t^*} \upsilon(c_t^*) + \beta^* \int_S V^*((1+r^*)b_t, (1+r^*)f_t, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{35a}$$

$$c_t^* + q^R(\bar{\omega} y_t^*) = y_t^* + \bar{\omega} y_{t-1}^* \tag{31b}$$

A.2.4 Sovereign Debt Renegotiations: Preemptive and Post-default

Post-default debt renegotiations

We denote the offered recovery rates as $\gamma_t^{B,CD}$, the borrower's values of proposing and passing as $V^{PRO,CD}$ and $V^{PASS,CD}$, and the foreign creditor' values of accepting and rejecting as $V^{*ACT,CD}$ and $V^{*REJ,CD}$, respectively. When the borrower B proposes and the offer is accepted, the sovereign repays reduced debt arrears $-\gamma_t^{B,CD} b_t$ and regains access to the international capital market in the next period with outstanding debt.

$$V^{PRO,CD}(b_t, f_t, 2, s_t) = \max_{c_t, m_t^d, L_t^f, L_t^m, L_t, b_{t+1}} u(c_t, L_t) + \beta V^{EXANTE}(b_{t+1}, 0, 0, s_t) \tag{39a}$$

$$s.t. \quad (7),\ (8a) - (9a),\ (13) - (15) \text{ and}$$

$$T_t + q(b_{t+1}, f_{t+1}, 2, s_t) b_{t+1} = \gamma_t^{B,CD} b_t \tag{20d}$$

$$V^{*ACT,CD}(b_t, f_t, 2, s_t) = \max_{c_t^*, b_{t+1}^*} \upsilon(c_t^*) + \beta^* V^{*,EXANTE}(b_{t+1}, 0, 0, s_t) \tag{38}$$

$$s.t. \ \ c_t^* + m_t^{f*} + q^R(\bar{\omega} y_t^*) + q(b_{t+1}, f_{t+1}, 0, s_t) b_{t+1} = y_t^* + \bar{\omega} y_{t-1}^* - \gamma_t^{B,CD} b_t - \bar{\gamma}^f f_t \tag{29b}$$

When the borrower B passes, both parties proceed to the next period with accumulated arrears on sovereign and corporate debt:

$$V^{PASS,CD}(b_t, f_t, 2, s_t) = \max_{c_t, m_t^d, m_t^f, L_t^f, L_t^m, L_t} u(c_t, L_t) + \beta \int_S V((1+r^*)b_t, (1+r^*)f_t, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{41a}$$

$$s.t. \quad (7),\ (8a) - (9a),\ (13)\text{–}(15),\ and\ (20)$$

$$V^{*REJ,CD}(b_t, f_t, 2, s_t) = \max_{c_t^*} \upsilon(c_t^*) + \beta^* \int_S V^*((1+r^*)b_t, (1+r^*)f_t, 2, s_{t+1}) d\mu(s_{t+1}|s_t) \tag{42a}$$

$$s.t.\ (31)$$

In equilibrium, the agreed recovery rates $\gamma_t^{B*,CD}$ satisfy the following:[12]

$$\gamma_t^{B*,CD} = argmax V^{PRO,CD}(b_t, f_t, 2, s_t)$$

$$s.t. \quad V^{PRO,CD}(b_t, f_t, 2, s_t) \geq V^{PASS,CD}(b_t, f_t, 2, s_t)$$

$$V^{*ACT,CD}(b_t, f_t, 2, s_t) \geq V^{*REJ,CD}(b_t, f_t, 2, s_t) \tag{43a}$$

[12]Off-equilibrium paths are eliminated in equilibrium.

If both parties reach an agreement, two parties' payoffs are as follows:

$$\Gamma^{B}(b_t, f_t, 2, s_t) = V^{PRO,CD}(b_t, f_t, 2, s_t)$$
$$\Gamma^{B*}(b_t, f_t, 2, s_t) = V^{*ACT,CD}(b_t, f_t, 2, s_t) \tag{44c}$$

Otherwise,

$$\Gamma^{B}(b_t, f_t, 2, s_t) = V^{PASS,CD}(b_t, f_t, 2, s_t)$$
$$\Gamma^{B*}(b_t, f_t, 2, s_t) = V^{*REJ,CD}(b_t, f_t, 2, s_t) \tag{44e}$$

A.2.5 Market Clearing Conditions

A market clearing condition for goods in the case of sovereign default and corporate default is as follows:

$$c_t = y_t, \quad c_t^* = y_t^* \tag{54a}$$