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Serial Sovereign Defaults and Debt Restructurings

by Tamon Asonuma

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Serial Sovereign Defaults and Debt Restructurings

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Abstract

Emerging countries that have defaulted on their debt repayment obligations in the past are more likely to default again in the future than are non-defaulters even with the same external debt-to-GDP ratio. These countries actually have repeated defaults or restructurings in short periods. This paper explains these stylized facts within a dynamic stochastic general equilibrium framework by explicitly modeling renegotiations between a defaulting country and its creditors. The quantitative analysis of the model reveals that the equilibrium probability of default for a given debt-to-GDP level is weakly increasing with the number of past defaults. The model also accords with an additional fact: lower recovery rates (high NPV haircuts) are associated with increases in spreads at renegotiation.

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I. INTRODUCTION

Emerging countries (EM) that have defaulted on their debt repayment obligations in the past are more likely to default again in the future than are non-defaulters with the same external debt-to-GDP ratio. These countries actually have repeated defaults or restructurings in short periods. This paper explains these stylized facts within a dynamic stochastic general equilibrium framework that explicitly models renegotiations between a defaulting country and its creditors. Specifically, the model extends the existing literature by allowing the defaulter and creditors to bargain not just over recovery rates, but also over the rate of return offered on newly-issued debt. Quantitative analysis of the model reveals that the equilibrium probability of default for a given debt-to-GDP level is weakly increasing with the number of past defaults, consistent with empirical observations. The equilibrium of the model also accords with an additional observed trend: a country for which default terms require less than a 100 percent recovery rate tend to pay a higher rate of return (relative to a risk-free rate) on debt that is issued subsequently than do defaulting countries that agree to a full recovery rate. These findings are robust to extensions that allow the renegotiation outcome to be modeled more flexibly.

The empirical section of the paper presents new stylized facts on serial sovereign defaults and debt restructurings. First, we contrast characteristics between EM defaulters, which have experienced at least one default or restructuring on external private debt over 1985–2010, and non-defaulters. Through cross-sectional analysis, we find that (i) past defaulters suffer higher borrowing costs both in terms of interest spreads and yield on newly issued bonds and (ii) are more likely to default again than non-defaulters. Next, we focus specifically on serial sovereign defaults and debt restructurings using Cruces and Trebesch (2013) data, which covers 179 sovereign defaults and debt restructurings on private external debt over 1978–2010. We newly confirm that (iii) EM serial defaulters have repeated 3.7 defaults and restructurings in 1978–2010, (iv) have reached next default or restructuring quickly than the previous ones, and that (v) lower recovery rates (higher haircuts) at renegotiation are associated with larger increases in yield spreads.

The theoretical part of the paper deals with endogenous debt renegotiation after default in a standard dynamic model of defaultable debt. The renegotiation process involves Nash bargaining between the defaulting debtor and creditors over both the recovery rate and increases in rates of return on new debt. Evidence suggests that the spread between the rate of return on new debt and the risk-free rate increases after default more for defaulters that pay less than a full recovery rate than for defaulters that agree to repay all of the defaulted debt (i.e., a 100 percent recovery rate). Thus, it appears that, at least implicitly, a country that defaults negotiates with its creditors both over recovery rates and over future rates of return. This reflects a trade-off for defaulting country: the defaulted debt can be repaid in the present at a high short-run cost in return for only a small or even negligible deterioration in long-term credit condition; or the short-run benefit of repaying the debt only partially will be offset by having to pay lenders a higher rate of return on future issuances. The trade-off for creditors is symmetric: if they are not appeased by a full recovery of funds in the short term, they can attempt to recoup their losses by demanding higher rates of return for holding the country's bonds in the future.

We seek to incorporate theoretically these trade-offs facing the debtor and creditors during renegotiations following defaults. In the model, the endogenously-determined terms of renegotiations following default present the observed pattern, i.e., lower recovery rates (higher haircuts) are associated with larger increases in yield spreads. An emerging country that defaults once therefore pays a penalty either through a large recovery rate in the short term or through higher borrowing costs in the long term. If it chooses to repay less than full recovery rates, it will face high borrowing costs, which leads to increased risks that the country will default again in the future. This mechanism drives the equilibrium serial default behavior in the model, and it is a plausible explanation of the pattern of repeat defaults observed in the data. Hence, the model is able to jointly explain both stylized facts of debt restructurings and repeat defaults.

We embed the debt renegotiation in a dynamic sovereign debt model with endogenous defaults where an emerging country is subject to exogenous income shocks. This part of the model builds on recent quantitative analysis of sovereign debt such as Aguiar and Gopinath (2006), Arellano (2008), and Tomz and Wright (2007), which is based on classical setup of Eaton and Gersovitz (1981). At the renegotiation, creditors and defaulting country bargain over increases in rate of return on new debt together with recovery rates. Outcomes of the renegotiation represent trade-offs of both defaulting country and creditors, as indicated above. Total spread between the rate of return on new debt and the risk-free rate, incorporates not only the probability of future default but also impacts on increases in rate of return on new debt agreed to buy both side at the past renegotiations.

Our paper is most closely related with Yue (2010), in which a dynamic model of defaultable debt is augmented with an endogenous treatment of debt renegotiation after default. Our model differs from her model in that we incorporate the effects of increases in rate of return on new debt. At the renegotiation, both parties bargain not only over recovery rates, but also over increases in rate of return on new debt. Therefore, its credit condition, i.e., borrowing cost of the country after re-entry to the market, depends on how much the country pays at the debt renegotiation. Increase in borrowing costs accompanied by repaying the debt only partially will lead to increase future default probability. In special cases where the country always repays in full the level of defaulted debt, increases in rate of return on new debt will be close to zero. As impacts of additional default premia are totally negligible, results will be quite similar to those in Yue (2010).

The rest of the paper is structured as follows: Section II reviews three strands of literature. Section III overviews new stylized facts on serial sovereign defaults and restructurings. We provide our theoretical model of sovereign debt and defaults in Section IV. We define recursive equilibrium of the model in Section V. Quantitative analysis of the theoretical model is discussed in Section VI. Model implications are indicated in Section VII. A short conclusion summarizes the discussion. The computation algorithm is provided in Appendix 1.

II. LITERATURE REVIEW

This paper is related to the literature of serial sovereign default such as Reinhart and others (2003), Reinhart and Rogoff (2005, 2009), Eichengreen and others (2003) and Catao and others (2009).[1] Reinhart and others (2003) and Reinhart and Rogoff (2005, 2009) advocate the role of past credit history in debt intolerance.[2] In contrast, Eichengreen and others (2003) show that countries with "original sin", inability to issue bonds in their domestic currencies, must pay an additional risk premium when they borrow, increasing their solvency risks since the financial market knows this inability is a source of financial fragility.[3] However, none provides economic models describing how weak credit history or "original sin" features are associated with serial defaults. Catao and others (2009) explain that vicious cycles in sovereigns' credit histories arise due to output persistence coupled with asymmetric information about output shocks. This paper improves these papers by explaining theoretically how outcomes of current debt renegotiation, such as additional spread premia, lead to higher probability of the next default in future.

The other strand of literature models the sovereign default and renegotiation as a game between a sovereign debtor and its creditors (e.g., Bulow and Rogoff 1989; Benjamin and Wright 2009; Kovrijnykh and Szentes 2007; Bi 2008; Bai and Zhang 2010; D'Erasmo 2010; Yue 2010; Pitchford and Wright 2012; Arellano and Bai 2014; Hatchondo and others 2014; and Asonuma and Trebesch 2016). Yue (2010) treats debt renegotiation process using a one-round Nash bargaining game. Moreover, Bai and Zhang (2012), Benjamin and Wright (2009) and Bi (2008) presume a multi-round bargaining to analyze delay in renegotiation. Furthermore, Pitchford and Wright (2012) regard multi-creditor renegotiation process as a series of bilateral bargaining games to explain delays in renegotiation. Similarly, Kovrijnykh and Szentes (2007) also study multi-creditor renegotiation and make the time of exclusion from the financial market endogenously and potentially long. Our paper differs from this literature in that we focus on the renegotiation game where the debtor and its creditors bargain not only over recovery rates, but also over the rate of return offered on the newly issued debt.[4]

Lastly, our empirical finding is linked to studies analyzing the impacts of past defaults on future borrowing costs (e.g., Ozler 1992 and 1993; Cantor and Packer 1996; Lidert and

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[1] See Sturzenegger and Zettlemeyer (2006, 2008), Finger and Mecagni (2007), Diaz-Cassou and others. (2008), Panizza and others. (2009), Das and others. (2012), Duggar (2013) for recent case studies of sovereign debt restructurings and Asonuma and others (2014) for Belize case of serial debt restructurings. See also survey by Tomz and Wright (2013).

[2] See also Reinhart and Rogoff (2009, 2011) for detailed discussions.

[3] Using both refined data on duration of restructurings and classification of preemptive and post-default restructurings, Asonuma and Trebesch (2016) find that 64 percent of preemptive debt restructurings succeeded in preventing an outright default within four years after their completion.

[4] We assume that debt renegotiation takes place only once for each default in Yue (2010) and Hatchondo and others (2014).

Morton 1989; Catao and others 2009; Cruces and Trebesch 2013; and Benczur and Ilut 2016). Ozler (1993) finds that past defaulters had to pay a premium on the interest rate for the sovereign debt issued in the 1970s.[5] Cantor and Packer (1996) also confirm that sovereign yields tend to rise as sovereign has a bad default history.[6] In the similar vein, Catao and others (2009) find the existence of history-dependent "default premium" and of significant effect of output persistence and Benczur and Ilut (2016) also confirm effect of past repayment problems on current spreads on bank loans to developing countries between 1973–1981. In the recent work, using enriched sovereign debt restructuring dataset, Cruces and Trebesch (2013) show that restructurings involve higher haircuts are associated with higher subsequent bond yields. What is distinctive in our paper relative to previous work is that we analyze the deterioration of long-term borrowing on bonds, i.e., increases in spreads at the time of renegotiations for recent debt renegotiations during 1986–2010 to explain tradeoffs of both creditors and the sovereign.

III. Five New Stylized Facts on Serial Sovereign Defaults and Debt Restructurings

A. Sovereign Debt Defaulters and Non-Defaulters - EMs

We start our empirical analysis from some features differentiated by country's history of defaults and restructurings, in particular interest spreads (yields of newly issued bonds) and default probability. Our analysis centers on emerging market (EM) countries defined by the IMF World Economic Outlook (WEO) and our EM sample consists of 83 countries. Throughout this section, we use private external debt defaults and restructurings dataset in Cruces and Trebesch (2013) which cover 179 episodes over 1978–2010.[7] Cruces and Trebesch (2013) focus on distressed debt exchanges, defined as restructurings of bonds and bank loans at less favorable terms than the original bonds and bank loans. They thereby follow the definition and data provided by Standard & Poor's (2006, 2011).

Following definition of defaults and restructurings in Cruces and Trebesch (2013), we define sovereign debt defaulters and non-defaulters as follows:

- ***Sovereign debt defaulters***: sovereigns which have experienced at least one default or restructuring since 1985 (1990) – 36 (34) EMs.
- ***Non-defaulters****:* sovereigns which have experienced neither a default nor a restructuring since 1985 (1990) – 47 (49) EMs.

[5]In a similar context, Ozler (1992) empirically shows that borrower's repeated experience in the market contributes significantly to the variation of spreads.

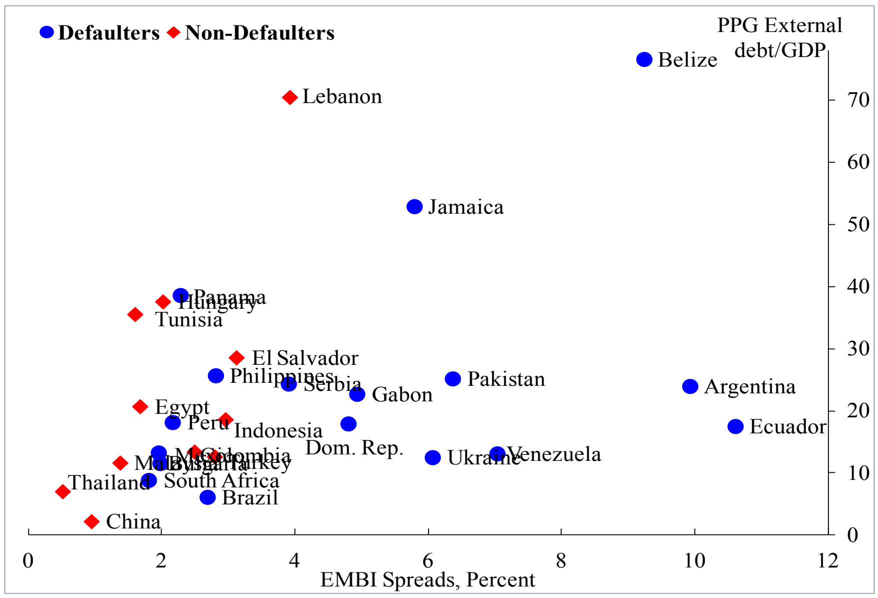
[6] n contrast, Lindert and Morton (1989) focusing on borrowing experience in late 1970s, find no evidence that defaulters were punished by creditors through higher interest rates on new loans.

[7]Reinhart and Rogoff (2009) document external and domestic private debt defaults and restructurings over 1800-2010 and Sturzenegger and Zettelmeyer (2006) report selected external private debt defaults and restructurings over 1820-2004. On official external debt restructurings, see Paris Club's web-site and Das and others (2012).

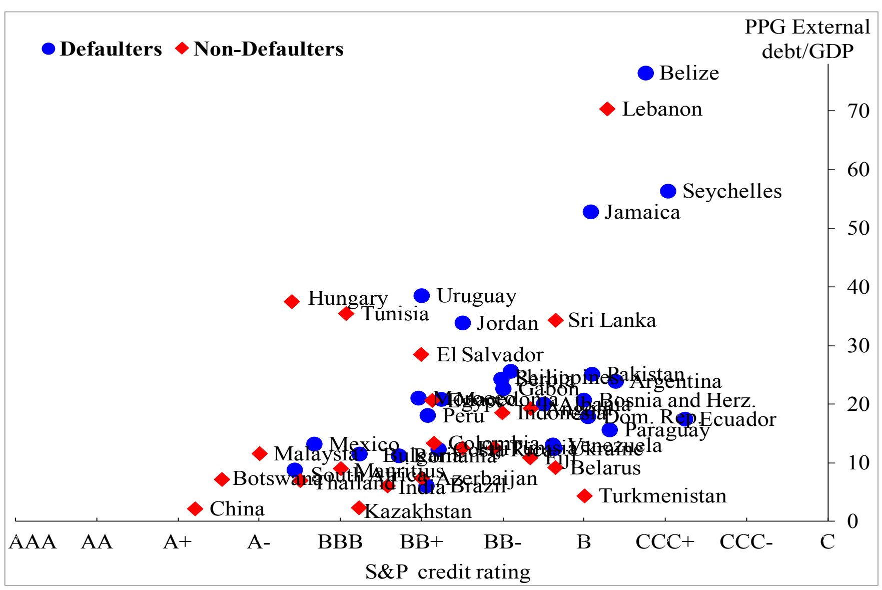
We set two ranges of time intervals for defaults and restructurings: (i) from 1985 (over 25 years), (ii) from 1990 (over 20 years). Our choice of two periods follow two rationales: they cover enough restructuring episodes (more than 130 and 80 cases respectively) and time intervals are consistent with finite investors' memory, i.e., sovereigns' credit history recovers over 25 (20) years. Among 83 EMs, there are 36 sovereign debt defaulters and 47 non-defaulters.

Figure 1. PPG External Debt/GDP, EMBIG Spreads, Credit Ratings, Average 2005–11

(A) EMBIG Spreads



(B) Credit Ratings



Sources: Bloomberg, Cruces and Trebesch (2013), IMF WEO, Moody's, Standard and Poor, WB International Debt Statistics

Figure 1 reports average Emerging Market Bond Index Global (EMBIG) spreads and credit ratings relative to public and publically guaranteed (PPG) external debt in 2005–2011. Panel A shows that past defaulters suffer higher borrowing costs at the external markets, proxied by EMBIG spreads, than non-defaulters given PPG external-to-GDP ratio. From Panel B, it is obvious that past defaulters have lower credit ratings (average of Moody's and Standard and Poor ratings) reflecting higher default probability, given PPG external debt ratio.[8]

More robust evidence appears in Table 1 which reports cross-section regression results on borrowing costs and default probability using EM sample comprised of both defaulters and non-defaulters. For borrowing costs, proxied by EMBIG spreads, our benchmark specification follows closely Eichengreen and Mody (1998) and Ardagna and others (2007). The baseline regression result (1st column) suggests that past defaulters suffer higher borrowing costs by 2.4 percentage points. If sovereigns have higher debt (PPG external debt-to-GDP ratio) and experience larger exchange rate depreciation, they have higher EMBIG spreads. This result is robust even if we include CPI inflation rates as one of controls (2nd column) and the shorter interval for past defaults starting from 1990 (3rd column). Moreover, Appendix II demonstrates that defaulters' yields on newly issued bonds in general are higher than non-defaulters.

On default probability, we use both average credit ratings of Moody's and Standard and Poor and Credit Default Swap (CDS) spreads as proxies. Our baseline specification is in line with Kohlscheen (2009) and Dreher and Walter (2010). From our benchmark regression using credit ratings (4th column), past defaulters are more likely to default, estimated by 1.5 notches lower in credit ratings. Their default probability is higher if sovereigns accumulate higher debt (PPG external debt-to-GDP), have higher CPI inflation rates and hold lower reserves (reserves-to-GDP ratio). This is also the case with specification with the shorter interval for past defaults starting from 1990 (5th column). Regression results using CDS spreads complement our baseline results despite the limited sample of CDS spreads. Past defaulters suffer higher CDS spreads than non-defaulters by 1 percentage point (6th column). The main results remain robust with the shorter interval for past defaults starting from 1990 (7th column).

- ***Stylized fact 1: Past defaulters suffer higher borrowing costs than non-defaulters.*** EMBIG spreads for past defaulters are higher than those for non-defaulters by 2-2.4 percentage points.

- ***Stylized fact 2: Past defaulters are more likely to default again.*** Default probability for past defaulters are higher than those for non-defaulters, measured by lower credit ratings and higher CDS spreads.

[8] Despite limited sample of EMs with liquid market, Credit Default Swap spreads of past defaulters are much higher than those of non-defaulters, implicitly measuring sovereigns' future default risk.

Table 1. Regression Results on Borrowing Costs and Default Probability[1/]

	Borrowing costs			Default probability			
Explanatory variable	**EMBIG Spreads (%)**			**Credit Ratings, ave Moody's and S&P[2/]**		**Credit Default Swap Spreads (%)**	
Constant	-	-	-	12.09*** (1.18)	11.99*** (1.18)	-0.85 (0.91)	-0.70 (0.90)
Past Default Dummy (since 1985)	2.39*** (0.81)	2.06** (0.89)	-	-1.50** (0.68)	-	1.03* (0.52)	-
Past Default Dummy (since 1990)	-	-	2.39*** (0.81)	-	-1.49** (0.68)	-	0.97* (0.53)
PPG External Debt/GDP ave, 2004-10 (%)	0.070*** (0.022)	0.072*** (0.022)	0.070*** (0.022)	-0.094*** (0.019)	-0.093*** (0.019)	0.057*** (0.018)	0.055*** (0.018)
GDP growth rate, ave. 2005-11 (%)	0.24 (0.15)	0.15 (0.18)	0.24 (0.15)	-0.034 (0.117)	-0.027 (0.117)	-0.018 (0.119)	-0.031 (0.120)
CPI inflation rate, ave. 2005-11	-	0.14 (0.14)	-	-0.19** (0.071)	-0.19** (0.071)	0.35*** (0.063)	0.35*** (0.064)
Exchange rate depreciation, ave. 2005-11[3/]	0.20* (0.11)	0.059* (0.18)	0.20* (0.11)	-	-	-	-
Capital account openness, ave. 2005-11[4/]	-0.23 (0.30)	-0.28 (0.33)	-0.23 (0.30)	0.12 (0.23)	0.084 (0.23)	-0.32 (0.19)	-0.28 (0.19)
Reserves / GDP ave. 2005-11 (%)	-0.029 (0.031)	-0.039 (0.033)	-0.029 (0.031)	0.063*** (0.023)	0.063*** (0.023)	-	-
Sample countries	27	27	27	46	46	27	27
Adj-R^2	0.80	0.80	0.80	0.51	0.51	0.66	0.65
Root MSE	2.12	2.12	2.12	2.08	2.08	1.30	1.32

Sources: Bloomberg, Chinn and Ito (2006), Cruces and Trebesch (2013), Haver Analytics Data, IMF WEO, Moody's, Standard and Poor, WB International Debt Statistics and author's calculation
Note: Standard errors are in parentheses. ***, **, * show significance at 1, 5, and 10 percent levels respectively.
[1/] All regression results are based on least square estimations.
[2/] Credit ratings of Moody's and Standard and Poor are converted to numerical values using a linear scale from 0 to 20 with SD and Ca ratings corresponding to values of zero and 1 respectively, and AAA ratings being assigned a value of 20 as in Sy (2002). We take an average of ratings of Moody's and Standard Poor on foreign-currency debt.
[3/] Change in end of period annual exchange rate from the previous level.
[4/] Capital account openness index from Chinn and Ito (2006) ranges from -1.86 and 2.44 corresponding to the lowest and highest degree of capital openness respectively.

B. Serial Sovereign Defaults and Debt Restructurings

Next we focus specifically on serial sovereign defaults and restructurings and provide three new stylized facts. Panel (A) in Table 2 shows that serial defaulters account 61 percent of sovereigns that have experienced at least one default or restructuring in 1978–2010. These serial defaulters have repeated 3.7 defaults or restructurings on average over the time period.

Narrowing our focus to EM sovereigns, EM serial defaulters account 58 percent of total serial defaulters and have experienced 4.1 defaults or restructurings in average as reported in Panel (B) in Table 2. In addition, periods between restructurings are 3.2 years in average.

Panel (C) in Table 3 shows that it takes less time to default or restructure debt again as serial defaulters repeat more defaults or restructurings. After sovereigns experience their first defaults, it takes 13.1 quarters to reach the second defaults or restructurings. However, since the second defaults, it takes even less time (12.0 quarters) to reach the third defaults or restructurings on average. The same pattern applies to periods to the fourth default or restructuring (11.8 quarters). This evidence suggests that serial defaulters repeat next defaults or restructurings more quickly than the previous ones.

Table 2. Serial Sovereign Defaults and Debt Restructurings in 1978–2010

(A) Serial Defaulters and "One-time" Defaulters

	Num. of countries	Num. of defaults /restructurings in 1978–2010
Serial Defaulters	**41**	**3.7**
EM serial defaulters	24	4.1
Countries with a single default/restructuring	26	1.0

(B) EM Serial Defaulters

Country	Number of restructurings	Period between restructurings – Average (years)	Country	Number of restructurings	Period between restructurings – Average (years)
Algeria	2	4.3	Panama	3	5.3
Argentina	4	6.6	Peru	3	8.6
Brazil	6	2.2	Philippines	4	2.2
Chile	5	1.8	Poland	8	1.8
Costa Rica	3	3.3	Romania	3	1.9
Dom. Rep.	4	6.6	Russia	4	0.9
Ecuador	6	5.1	S. Africa	3	3.3
Gabon	2	6.4	Turkey	4	0.9
Jamaica	7	2.0	Ukraine	4	0.5
Mexico	6	1.3	Uruguay	5	5.0
Morocco	3	2.3	Venezuela	3	2.4
Pakistan	2	0.4	Yugoslavia	4	1.7
Average	**4.1**	**3.2**			

(C) Time between Restructurings (Quarters)

	from 1st to 2nd	from 2nd to 3rd	from 3rd to 4th
Serial Defaulters	**13.2**	**12.0**	**11.8**
Number of countries	41	28	19

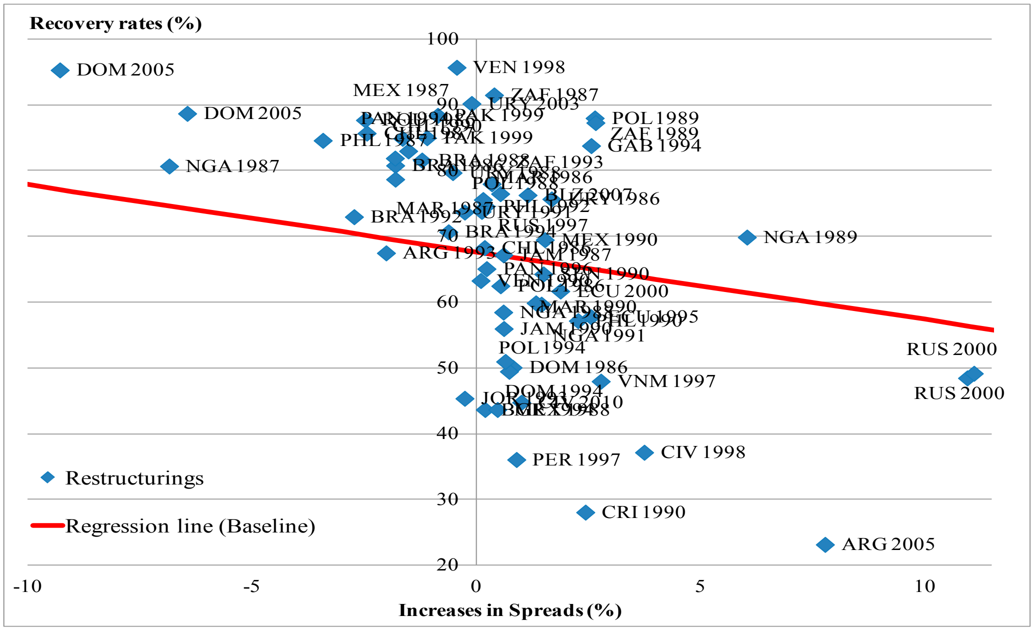
Source: Cruces and Trebesch (2013).

- ***Stylized fact 3: Serial defaulters, accounting 61 percent of past defaulters have repeated 3.7 defaults or restructurings in 1978–2010.***

- ***Stylized fact 4: Serial defaulters repeat next defaults or restructurings more quickly than the previous ones as they experience more defaults or restructurings.***

Figure 2 displays net present value (NPV) recovery rates and increases in spreads for 66 sovereign debt restructuring episodes during 1986–2010.[9]

Figure 2. Recovery Rates and Increases in Spreads for Recent Debt Restructurings



Sources: Cruces and Trebesch (2013), Datastream, and author's calculation.

We define "increases in spreads" as the difference in spreads between the time of completion of the restructurings and one year before the completion.[10] As most of EMBIG spreads are available from 1999, we extrapolate spread series by each country using London Inter-Bank Offered Rate (LIBOR) and International Country Risk Guide (ICRG) rating as explained in Appendix III. The fitted line is obtained by regressing recovery rates on increases in spreads controlling for GDP deviation from the trend and external debt-to-GDP ratio (1st column in Table 3). This negative relationship is robust even controlling for political risk and global factors and omitting some outlier episodes shown in the 2nd, 3rd, and 4th columns respectively.[11] These results reflect that lower recovery rates (larger haircuts) at the renegotiation are associated with larger increases in yield spreads between the rates of return

[9]Sturzenegger and Zettelmeyer (2006, 2008) define net present value (NPV) recovery rates as the market value of the new instruments, plus any cash payment received, relative to the NPV of the remaining contractual payments on the old instruments (inclusive of any principal or interest arrears). They attempt to compare the value of the new instruments to the value of the old debt in a situation in which the sovereign would not have defaulted. Cruces and Trebesch (2013) follow the same definition and computation of recovery rates (haircuts) as in Sturzenegger and Zettelmeyer (2006, 2008) and expand coverage to 179 debt restructuring cases.

[10]According to J.P. Morgan (1999), a new issue that meets the EMBI Global's admission requirements is added to the index on the first month end business date after its issuance, provided its issue date falls before the 15th of the month. A new issue whose issue date falls on or after the 15th of the month is added to the index on the last business day of the next month. Thus, the EMBI Global spreads reflect spreads on newly issued bonds.

[11]When we define "increase in spreads" for 2-year window, such as the difference between one year before and after the renegotiation, we still obtain the negative relationship with a flatter slope but with less significance.

on new debt and the risk-free rate. This presents a trade-off for defaulting countries; if the countries recover a larger fraction of debt during renegotiations, long-term borrowing costs will be smaller. At the same time, we can interpret it as a trade-off of creditors. If the creditors receive payments for only a small fraction of defaulted debt, they can recoup their losses by demanding higher rates of return for the newly issued bonds.

Table 3. Regression Results on Recovery Rates[1/]

Explanatory variable: **Recovery rates (%)**	(1) Baseline	(2) Political risks	(3) Increase in spreads below 10%	(4) Global factors
Constant	79.11*** (5.16)	113.77*** (19.21)	76.89*** (5.20)	91.94*** (27.30)
Increase in spreads (%)	-1.02*** (0.32)	-1.03*** (0.32)	-2.96*** (0.79)	-0.98*** (0.32)
GDP Deviation from trend (%)[2/]	-0.46 (0.53)	-0.67 (0.53)	0.066 (0.53)	-0.80 (0.55)
External Debt/GDP ratio (%)	-0.17** (0.067)	-0.21*** (0.068)	-0.14* (0.068)	-0.20*** (0.069)
Political risk[3/]	-	-0.57* (0.31)	-	-0.41 (0.34)
LIBOR (%)[4/]	-	-	-	2.14 (1.82)
GDP deviation from trend – Advance Economy (%)[2/]	-	-	-	-2.29 (2.66)
Sample	60	59	56	59
Adj-R^2	0.20	0.24	0.30	0.23
Root MSE	18.33	18.01	17.10	18.11

Sources: Cruces and Trebesch (2013), Datastream, PRC Group International Country Risk Guide (ICRG), IMF WEO, and author's calculation.
Note: Standard errors are in parentheses. ***, **, * show significance at 1, 5, and 10 percent levels respectively.
[1/] All regression results are based on least square estimations.
[2/] GDP deviation from the trend is a percentage deviation from the trend obtained by applying the Hodrick-Prescott (H-P) filter.
[3/] Political risk index is country composite index from ICRG is based on 100 points with zero and 100 corresponding to highest and lowest risks respectively.
[4/] London Interbank Offered Rate (LIBOR) is yearly average of monthly 1-year yields.

- ***Stylized fact 5: Lower NPV recovery rates (higher haircuts) at renegotiation are associated with larger increases in yield spreads.***

IV. Model Environment

The basic structure of the model follows previous work that extends the model of sovereign default by Eaton and Gersovitz (1981) and applies its quantitative analysis. Among these studies, the closest reference to our paper is Yue (2010). The distinctive feature in our model with respect to her model is that we introduce effects of increases in rate of return on new debt after the re-entry to the market. Since both recovery rates and increases in rate of return on new debt are determined endogenously, how much the country pays at the renegotiation will affect its credit condition in the future, i.e., borrowing costs of the country after re-entry to the market, which will have an impact on default probability.[12]

A. General Points

The model analyzes sovereign default and negotiation in a dynamic stochastic general equilibrium framework. We consider a risk-averse country that cannot affect the world risk-free interest rate. The country's preference is given by following utility function:

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

where $0 < \beta < 1$ is a discount factor, c_t denotes consumption in period t and $u(.)$ is its one-period utility function, which is continuous, strictly increasing and strictly concave and satisfies the Inada conditions. A discount factor reflects both pure time preference and the probability that the current sovereignty will survive into next period.

All the information on the country's asset, credit history, and income realization is perfect and symmetric and only future income process remains uncertain.[13] In each period, the country starts with its credit history h_t, which satisfies $h_t \in H$ where $H = [0,1,2, \dots, h_{max}]$. The credit history expresses number of debt renegotiations the country has experienced in the past.[14] The reason we assume multi-state credit history rather than binary credit history as in Yue (2010) is to analyze how the outcomes of past debt renegotiations associated with defaults affect the probability of next default. Moreover, we assume that the credit history reverts with exogenous probability χ conditional on that the country chooses to pay the spread returns after defaults.[15] This is consistent with what we observe in the data (Cruces and Trebesch 2013).

[12] On the contrary, Yue (2010) has not taken into account impacts of increases in rate of return on new debt. In her model, both parties negotiate over only recovery rate after default. The reason why effects of increases in rate of return on new debt are missing in her model is that the country's credit condition will always return to the same level irrelevant to recovery rate which is determined at the renegotiation.

[13] Alfaro and Kanczuk (2005), Hatchondo and others (2009), and D'Erasmo (2010) develop a model of sovereign debt with heterogeneous governments where governments alternate over time and there is private information. Focusing on consumer credits, Chatterjee, Corbae and Rio Rull (2008) consider an environment with heterogeneous borrowers and private information. These papers have merits of incorporating reputation effects, but have not taken into account persistent impacts of past events.

[14] The model simply distinguishes $h_t = 0$ and $h_t > 0$ as the non-default history and defaulting history, not as the non-exclusion and exclusion periods. After default and renegotiation, the country will be excluded from the market for short periods.

[15] Our assumption on finite periods of creditor memory is aligned to one in consumer default literature for instance Chatterjee and others (2007).

The country receives an exogenous income shock y_t. Income shock (y_t) is stochastic, drawn from a compact set $Y = [y_{min}, \dots, y_{max}] \subset \mathbb{R}_+$. $\mu(y_{t+1}|y_t)$ is the probability distribution of a shock y_{t+1} conditional on previous realization y_t.

There is an infinite number of investors who are risk-neutral and behave competitively in the international capital market. They keep track credit history and additional spread premia agreed to by both sides at the previous debt renegotiation. We also assume that they can borrow or lend as much as needed at a constant risk-free interest rate (r) in the market. Since they are symmetric and similarly ranked, we can interpret them as "a representative investor" lending money to the country. The country borrows the money from the same representative investor through bond exchanges even after it defaults.[16] As investors are able to collude at the debt renegotiation, "a representative investor" has bargaining power at the renegotiation in order to impose higher spreads on future bonds, though the bargaining power is still low compared to that of the country.[17,18,19] Moreover, we assume that all the investors behave in the same manner: they all lend to the country every time the country issues bonds, and there is no sub-group of investors who behave differently from the majority of investors such as they still lend to the country even if the country defaults and refuses to negotiate with the majority of investors.[20]

The international capital market is incomplete. The country and foreign investors can borrow and lend only via one-period zero-coupon bonds where b_{t+1} denotes the amount of bonds to be repaid next period. When the country purchases bonds, $b_{t+1} > 0$, and when it issues new

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[16]The country negotiates with the creditors who hold its debt and the creditors receive the recovered debt as in current model. Thus, it is true that the country borrows again from the same creditors. Our assumption of borrowing from the same creditors is aligned with London Club restructurings on bank loans in 1980s and 1990s; Rieffel (2003) documents that sovereign debtors commonly and repeatedly negotiated with the same creditors selected as a Bank Advisory Committee (BAC). For bond issuance, while in the reality, there exist the secondary markets of bonds where the creditors can sell and purchase the exchanged bonds, the current model abstracts this feature.

[17]In typical debt restructurings, bondholders organize a committee, which conducts research on the sovereign and consolidates creditors' view to facilitate the discussion. All creditors vote on the restructuring plan proposed by the sovereign. If a critical mass of the creditor approve, the proposal is passed and finalized. Otherwise, the government has to revise the proposal until it passes. In order to smooth the renegotiation, the committee plays an important role to reflect the creditors' view on the sovereign's proposal. Thus, it is identical to say that a committee has bargaining power, but it is relatively low as the committee has a difficulty to consolidate views across investors. Rieffel (2003) provides a detailed description of sovereign debt renegotiation.

[18] In some recent sovereign debt restructurings, creditors become risk-averse during the negotiation. Asonuma and Joo (2014) relax the assumption of risk-neutral creditors and explore how risk-averse creditors' behavior influences both process and outcomes of renegotiation (delay in negotiation and haircuts).

[19] Bi and others (2011) show theoretically that collective action problems, although a possibility, are not inevitable even in the absence of minimum participation thresholds and exit consents.

[20]It is true that the current model abstracts from both entry of new creditors and existence of secondary markets. The rationale for this is to keep the model tractable to deliver our main implications. Thus, if there has not been a default in the past, creditors behave competitively, making zero profits. When the sovereign defaults, they collude and ask the sovereign for higher spreads in future.

bonds, $b_{t+1} < 0$. The set of amount of bonds is $B = [b_{min}, \ldots\ldots, b_{max}] \subset \mathbb{R}$ where $b_{min} \leq 0 \leq b_{max}$. The upper bound is the highest level of assets that the country can accumulate and the lower bound is the highest level of debt that the country can hold. We assume $q(b_{t+1}, h_t, y_t)$ is the price of a bond with asset position (b_{t+1}), credit history (h_t), and income level (y_t). The bond price will be determined in equilibrium.
We assume that foreign investors always commit to repay their debt. However, the country is free to decide whether to repay its debt or to default. If the country chooses to repay its debt, it will preserve access to the international capital market next period.

If the country chooses not to pay its debt, it is subject to both exclusion from the international capital market and direct output cost.[21, 22] When a default occurs, the country and foreign investors negotiate a reduction of unpaid debt via Nash bargaining. At the renegotiation, both recovery rates and additional spread premia on the newly issued bonds are agreed to by both parties.[23, 24] The country regains access to the market after financial exclusion for short periods, but the country's credit history records the current debt renegotiation.

In order to avoid permanent exclusion from the international capital market, the country has an incentive to negotiate over recovery rates (haircut rates) and additional default premia. From foreign investors' point of view, they want to maximize the payment from recovered debt and spread returns on newly issued bonds after default, so they are also willing to negotiate over the reduction of unpaid debt.

[21]There are several estimates for output loss at the time of default. Sturzeneger (2004) estimates output loss as around 2 percent of GDP. Asonuma and Trebesch (2016) also confirm that sovereign debt crisis are associated with 2 percent lower annual growth in the first two crisis years and that preemptive restructurings suffer significantly lower output costs than post-default cases. On the contrary, De Paoli and others (2006) suggest that the output loss in the wake of sovereign default appears to be very large—around 7 percent a year on the median measure—as well as long lasting.

[22]Mendoza and Yue (2012) explain that output cost associated with sovereign default is efficiency loss of production through two channels: inefficient production using domestic inputs which are imperfect substitutable with imported inputs, and labor reallocation away from final goods production.

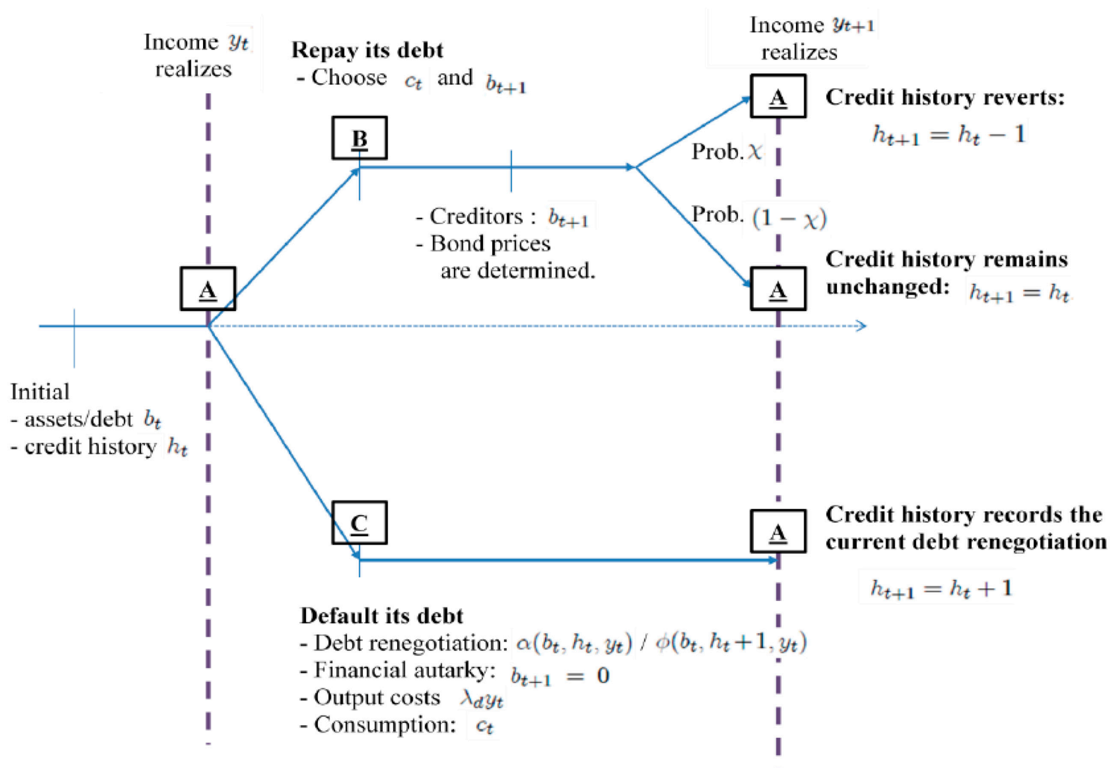
[23]After the bond exchanges are announced, the creditors at the market price the yields and spreads of exchanged bonds depending on recovered level of bonds. At each round of debt renegotiations, both parties take into account the possible impact of spreads depending on proposed recovery rates. Thus, it is identical to say that both recovery rates and increases in spreads are determined by both parties at the renegotiation.

[24]Negotiation in our model follows a one-round Nash bargaining game as in Yue (2010). Benjamin and Wright (2009), Bi (2008), D'Erasmo (2010) and Asonuma and Joo (2014) consider multi-round negotiation to replicate longer financial exclusion.

B. Timing of the Model

Figure 3 summarizes the timing of decisions within each period.

Figure 3. Timing of the Model



1. The sovereign starts current period with initial assets/debt b_t, and credit history h_t. We are in node (A).

2. An income shock y_t realizes. The sovereign decides whether to pay its debt or to default after observing its income.

3. (i) In node (B) (payment node), if payment is chosen, we move to the upper branch of a tree. The sovereign chooses its consumption (c_t) and level of assets/debt in next period (b_{t+1}). Default risk is determined and creditors also choose b_{t+1}. The price of bonds is determined in the market. With exogenous probability χ, we return to node (A) with upgraded credit history next period ($h_{t+1} = h_t - 1$). Otherwise, we move back to node (A) with unchanged credit history next period ($h_{t+1} = h_t$).

4. (ii) In node (C) (default node), if default is chosen, we move on to the lower branch of a tree. The sovereign and foreign investors negotiate a debt reduction. Both recovery rates $\alpha(b_t, h_t, y_t)$ and additional spread premia $\phi(b_t, h_t + 1, y_t)$ are agreed to by both sides. After negotiation, the sovereign pays recovered debt $\alpha(b_t, h_t, y_t)b_t$ and suffers output costs $\lambda_d y_t$. The sovereign cannot raise funds in the international capital market this period ($b_{t+1} = 0$), but will regain access to the market next period. Consumption is determined with remaining income. The sovereign's credit history records the current

debt renegotiation ($h_{t+1} = h_t + 1$). We move back to node (A) with deteriorated credit history.

5. An income shock y_{t+1} realizes.

V. RECURSIVE EQUILIBRIUM

A. Sovereign Country's Problem

In this section, we define the stationary recursive equilibrium of the model. The country's problem is to maximize its expected lifetime utility. The country makes its default decision and determines its assets for next period (b_{t+1}), given its current asset position (b_t), credit history (h_t), and income shock (y_t). Let $V(b_t, h_t, y_t)$ be the value function of the country that starts the current period.

Given with the bond market price $q(b_{t+1}, h_t, y_t)$, debt recovery rates $\alpha(b_t, h_t, y_t)$, and additional spread premia $\phi(b_t, h_t, y_t)$, the country solves its optimization problem. We assume both the debt recovery rates and additional spread premia determined at current debt negotiation depend on these state variables.

For simplicity, we consider the problem with $h_t = 0$, indicating that the country has never experienced debt renegotiation in the past. Later, we consider the problem with general cases $h_t \geq 1$.

For $b_t \geq 0$ ($h_t = 0$), the country has savings. The country receives payments from foreign investors and determines its next-period asset position b_{t+1} and its consumption c_t to maximize utility, given the price of bond $q(b_{t+1}, 0, y_t)$. Thus the value function is

$$V(b_t, 0, y_t) = \max_{c_t, b_{t+1}} u(c_t) + \beta \int_Y V(b_{t+1}, 0, y_{t+1}) d\mu(y_{t+1}, y_t)$$
$$\text{s.t. } c_t + q(b_{t+1}, 0, y_t) b_{t+1} = y_t + b_t \tag{1}$$

For $b_t < 0$ ($h_t = 0$), the country has debt. If the country decides to pay its debt, it chooses its next-period asset position b_{t+1} and consumption c_t. On the contrary, if the country chooses to default, it suffers financial autarky for this period and its credit history deteriorates to $h_{t+1} = 1$ next period. Due to agreement in debt renegotiation, the country must pay $-\alpha(b_t, 0, y_t) b_t$ in current period, and it regains access to the international capital market next period with history $h_{t+1} = 1$. With deteriorated credit history ($h_{t+1} = 1$), when the country issues new bonds, it must pay interests on newly issued bonds equal to the sum of the risk-free rate (r) and the spread premia agreed at the last renegotiation ($\phi(b_{t+1}, 1, y_{t+1})$). Thus, the price of bonds after default $q(b_{t+2}, 1, y_{t+1})$ incorporates the spread premia.

Given the option to default, $V(b_t, 0, y_t)$ satisfies

$$V(b_t, 0, y_t) = \max\left[V^R(b_t, 0, y_t), V^D\big(b_t, 0, y_t; \alpha(b_t, 0, y_t), \phi(b_t, 1, y_t)\big)\right] \qquad (2)$$

where $V^R(b_t, 0, y_t)$ is the value associated with paying debt:

$$V^R(b_t, 0, y_t) = \max_{c_t, b_{t+1}} u(c_t) + \beta \int_Y V(b_{t+1}, 0, y_{t+1}) d\mu(y_{t+1}, y_t)$$
$$\text{s.t. } c_t + q(b_{t+1}, 0, y_t) b_{t+1} = y_t + b_t \qquad (3)$$

and $V^D\big(b_t, 0, y_t; \alpha(b_t, 0, y_t), \phi(b_t, 1, y_t)\big)$ is the value associated with default given with debt recovery schedule $\alpha(b_t, 0, y_t)$, and additional spread premia $\phi(b_t, 1, y_t)$ which will be determined at renegotiation after current default:

$$V^D\big(b_t, 0, y_t;\ \alpha\,(b_t, 0, y_t), \phi(b_t, 1, y_t)\big)$$
$$= u\big((1 - \lambda_d) y_t + \alpha\,(b_t, 0, y_t) b_t\big) + \beta \int_Y V(0, 1, y_{t+1}) d\,\mu\,(y_{t+1}, y_t) \quad (4)$$

where $V(0, 1, y_{t+1})$ is value function next period with credit history $h_{t+1} = 1$ defined below in general cases with $h_t \geq 1$ and $-\alpha(b_t, 0, y_t) b_t$ is the amount of defaulted debt which the country repays at the debt negotiation and $\lambda_d y_t$ denotes output costs which the country suffers due to current default.

Next we consider the problem with $h_t \geq 1$ expressing that the country has experienced the debt renegotiation at least once in the past. For $b_t \geq 0$ ($h_t \geq 1$), the country has savings. The country receives payments from foreign investors and determines its next-period asset position (b_t) and its consumption (c_t) to maximize utility. Thus the value function is

$$V(b_t, h_t, y_t) = \max_{c_t, b_{t+1}} u(c_t) + \beta \int_Y V(b_{t+1}, h_t, y_{t+1}) d\mu(y_{t+1}, y_t)$$
$$\text{s.t. } c_t + q(b_{t+1}, h_t, y_t) b_{t+1} = y_t + b_t \qquad (5)$$

Note that credit history remains unchanged in next period $h_{t+1} = h_t$.

For $b_t < 0$ ($h_t \geq 1$), the country has debt. The country can borrow from the foreign investors, but the country needs to pay not only the risk-free interest rate (r), but also the additional spread premia $\phi(b_t, h_t, y_t)$ which was agreed to by both the country and foreign investors at the time of previous debt renegotiations. Thus, the price of bonds $q(b_{t+1}, h_t, y_t)$ is different from the one with history $h_t = 0$, defined as $q(b_{t+1}, 0, y_t)$, as it incorporates the effects of additional default premia associated with deteriorated credit history. As in the case of history $h_t = 0$, the country chooses either to pay the debt or to default. The values are as before:

$$V(b_t, h_t, y_t) = \max\left[V^R(b_t, h_t, y_t), V^D\left(b_t, h_t, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\right)\right] \quad (6)$$

where $V^R(b_t, h_t, y_t)$ is the value associated with paying debt with history $h_t \geq 1$:

$$V^R(b_t, h_t, y_t) = \max_{c_t, b_{t+1}} u(c_t) + \beta \begin{bmatrix} (1-\chi)\int_Y V(b_{t+1}, h_t, y_{t+1}) d\mu(y_{t+1}, y_t) \\ +\chi \int_Y V(b_{t+1}, h_t - 1, y_{t+1}) d\mu(y_{t+1}, y_t) \end{bmatrix}$$

$$\text{s.t. } c_t + q(b_{t+1}, h_t, y_t) b_{t+1} = y_t + b_t \quad (7)$$

Note that with exogenous probability χ, the country's credit history next period will revert due to limited memory of the investors as $h_{t+1} = h_t - 1$. Otherwise, it remains constant as $h_{t+1} = h_t$.

$V^D\left(b_t, h_t, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\right)$ is the value associated with default given with debt recovery schedule $\alpha(b_t, h_t, y_t)$, and additional spread premia agreed after current default $\phi(b_t, h_t + 1, y_t)$ which are defined:

$$\begin{aligned} &V^D\left(b_t, h_t, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\right) \\ &= u\left((1-\lambda_d) y_t + \alpha(b_t, h_t, y_t) b_t\right) + \beta \int_Y V(0, h_t + 1, y_{t+1}) d\mu(y_{t+1}, y_t) \end{aligned} \quad (8)$$

where $V(0, h_t + 1, y_{t+1})$ is the value function next period with credit history $h_{t+1} = h_t + 1$ and $-\alpha(b_t, h_t, y_t) b_t$ is amount of defaulted debt which the country recovers after negotiation.

Every time (at period t) the country defaults, its credit history records the current debt renegotiation $h_{t+1} = h_t + 1$. Thus, the credit condition i.e., borrowing costs of the country after re-entry to the market depends on how much the country pays during the renegotiation. When the country issues new bonds after it defaults, it must pay returns based on the risk-free rate and the sum of additional spread premia, which are determined at the previous debt renegotiations.

The country's default policy can be characterized by default set $D(b_t, h_t) \subset Y$, defined as the set of income shock y's for which default is optimal given the debt position b_t, and credit history h_t.

$$D(b_t, h_t) = \{y_t \in Y: V^R(b_t, h_t, y_t) < V^D\big(b_t, h_t, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\big)\} \tag{9}$$

Furthermore, we define an indicator of non-defaulting given initial asset position ($b_t < 0$), credit history (h_t), and income level (y_t) as follows;

$$I(b_t, h_t, y_t) = \begin{cases} 1 & \text{if} \quad y_t \in D(b_t, h_t) \\ 0 & \text{if} \quad y_t \notin D(b_t, h_t) \end{cases}$$

Finally, based on the policy function of asset position derived above ($b_{t+1}(b_t, h_t, y_t)$) and non-defaulting indicator $I(b_t, h_t, y_t)$, we define discounted value of expected amount of debt which will be paid to investors next period as:

$$P(b_t, h_t, y_t) = \frac{1}{1+r} \int_Y I(b_{t+1}(b_t, h_t, y_t), h_t, y_{t+1}) b_{t+1}(b_t, h_t, y_t) d\mu(y_{t+1}, y_t) \tag{10}$$

Note that we use the discount factor for foreign investors ($\frac{1}{1+r}$), not the discount factor for the country (β).

B. Debt Renegotiation Problem

The debt renegotiation takes a form of generalized Nash bargaining game. Not only the recovery rate, but also additional spread premia are agreed to by both parties. This is because foreign investors will obtain interest returns every time the country issues new bonds after current default as long as the country does not default again. From the country's perspective, it has to pay interests on bonds every time it issues new bonds after renegotiation, unless it chooses to remain in the financial autarky permanently.

After debt renegotiation, the country pays a fraction $\alpha(b_t, h_t, y_t)$ of defaulted debt. The value of the country after the renegotiation is defined above;

$$\begin{aligned} &V^D\big(b_t, h_t, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\big) \\ &\qquad = u\big((1-\lambda_d)y_t + \alpha(b_t, h_t, y_t) b_t\big) + \beta \int_Y V(0, h_t + 1, y_{t+1}) d\mu(y_{t+1}, y_t) \end{aligned}$$

Needless to say, this value takes into account the impact of both debt reduction to $-\alpha(b_t, h_t, y_t)b_t$, and additional spread premia $\phi(b_t, h_t + 1, y_t)$ which will be agreed to by both sides at current debt negotiation.

Foreign investors obtain the present value of the reduced debt $\alpha(b_t, h_t, y_t)$ and interests on newly issued bonds after debt negotiation. The present value of expected payment of bonds which investors receive in the future after the country's re-entry to the market, can be defined in the following recursive form:

$$R(b_t, h_t, y_t) = P(b_t, h_t, y_t) + \frac{1}{1+r}\int_Y R(b_{t+1}, h_t, y_{t+1})d\mu(y_{t+1}, y_t)$$
$$\text{s.t. } b_{t+1} = b^*_{t+1}(b_t, h_t, y_t) \tag{11}$$

where $P(b_t, h_t, y_t)$ is the discounted value of expected amount of bonds which are returned in next period defined in equation (10) and $b^*_{t+1}(b_t, h_t, y_t)$ is policy function of the country if it chooses not to default ($h_{t+1} = h_t$).

We assume that debt negotiation takes place only once for each default event. The threat point of the bargaining game is that the country stays in financial auturky permanently and foreign investors get nothing. The country suffers output cost $\lambda_d y_t$. The expected value of autarky for the country, $V^{AUT}(\, y_t)$ is given by following expression;

$$V^{AUT}(\, y_t) = u\big((1-\lambda_d)y_t\big) + \beta\int_Y V^{AUT}(y_{t+1})d\mu(y_{t+1}, y_t) \tag{12}$$

We consider one-round bargaining since one-round bargaining keeps the model tractable as there is no need to consider multiple rounds of bargaining or the debt arrears based on different reduction schedules.[25]

For any debt recovery rate a_t and additional spread premia sp_t, we denote the country's surplus in Nash bargaining by $\Delta^B(a_t, sp_t;\ b_t, h_t\,, y_t)$, which is the difference between the value of accepting a proposal of debt recovery rate a_t and additional spread premia sp_t, and the value of rejecting it, given the country's debt level (b_t), credit history (h_t), and income level (y_t).

$$\Delta^B(a_t, sp_t;\ b_t, h_t\,, y_t) = V^D\big(b_t, h_t\,, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\big) - V^{AUT}(\, y_t) \tag{13}$$

[25]Bi (2008) and Benjamin and Wright (2009) analyze multi-round bargaining to consider delay in renegotiation. Based on the assumption that the lenders have an option to "pass" proposing to the debtor, Bi (2008) argues that both parties can be better off by waiting and dividing a larger "cake" as it takes time for the economy to recover. In a similar approach, Benjamin and Wright (2009) assume that the debtor and the representative creditor randomly alternate in their ability to propose a bargaining outcome with changes in the probability of making future proposals serving to capture changes in bargaining power. They find that both parties find it optimal to postpone renegotiation until future default risk is low since the debtor's ability to share the future surplus created by a debt renegotiation is limited by future default risk.

The surplus to the country comes from two sources. First, the country will be able to issue bonds again from the following period, though its credit history deteriorates. Second, the country will no longer suffer output costs after negotiation.

In constrast, the surplus to investors is the present value of the sum of recovered debt and interest returns on newly issued bonds after renegotiation:

$$\Delta^{L}(a_t, sp_t;\ b_t, h_t, y_t) = -a_t b_t - R(b_t, h_t, y_t) \tag{14}$$

where interest returns are evaluated with expected payment incorporating the future default choices of the country as in equation (11).

We assume that the country has a bargaining power θ and foreign investors have a bargaining power $1-\theta$. The bargaining power θ summarizes the institutional arrangement of debt negotiation. To ensure that the bargaining problem is well defined, we define the bargaining power set $\Theta \subset [0,1]$ such that for $\theta \in \Theta$, the negotiation surplus has an unique optimum for any debt ($b_t < 0$), credit history (h_t), income level (y_t).

Given the country's debt ($b_t < 0$), credit history (h_t), and income level (y_t), optimal recovery rates $\alpha(b_t, h_t, y_t)$ and additional spread premia $\phi(b_t, h_t+1, y_t)$ solve the following bargaining problem:

$$\begin{Bmatrix} \alpha(b_t, h_t, y_t) \\ \phi(b_t, h_t+1, y_t) \end{Bmatrix} = \operatorname{argmax}_{a_t, sp_t} \left[\left(\Delta^{B}(a_t, sp_t;\ b_t, h_t, y_t)\right)^{\theta} \left(\Delta^{L}(a_t, sp_t;\ b_t, h_t, y_t)\right)^{1-\theta} \right]$$
$$\text{s.t. } \Delta^{B}(a_t, sp_t;\ b_t, h_t, y_t) \geq 0$$
$$\text{s.t. } \Delta^{L}(a_t, sp_t;\ b_t, h_t, y_t) \geq 0 \tag{15}$$

Note that $\phi(b_t, h_t+1, y_t)$ is a function specifying state-variant contracts depending on future streams of b_t and h_t.[26] Since the set of both debt recovery schedule and additional spread premia that maximize total negotiation surplus conditional on the country's debt, credit history and income level, negotiation outcome provides better insurance to the country in the case of default.

C. Foreign Investors' Problem

For the cases with $h_t \geq 1$, our derived bond price incorporates the effects of additional spread premia agreed at previous debt renegotiations, which are the new elements in our model. First, we consider foreign investors' problem given the country's credit history $h_t = 0$.

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[26]As the credit history keeps track of timing of default and debt renegotiation and reverts with exogenous probability, the spread premia are pinned down by both current level of debt (b_t) and income (y_t) together with credit history. Thus, value functions of sovereign do not need to include the spread premia as an additional state variable.

With the country's credit history $h_t = 0$, taking the bond price function as given, foreign investors choose the amount of assets (b_{t+1}) that maximizes their expected profit $\pi(b_{t+1}, 0, y_t)$, given by

$$\pi(b_{t+1}, 0, y_t) = \left\{ \begin{array}{ll} q(b_{t+1}, 0, y_t)b_{t+1} - \frac{1}{1+r} b_{t+1} & \text{if } b_{t+1} \geq 0 \\ \frac{1 - p(b_{t+1}, 0, y_t) + p(b_{t+1}, 0, y_t)\gamma(b_{t+1}, 0, y_t)}{1+r}(-b_{t+1}) - q(b_{t+1}, 0, y_t)(-b_{t+1}) & \text{otherwise} \end{array} \right\} \quad (16)$$

where $p(b_{t+1}, 0, y_t)$ and $\gamma(b_{t+1}, 0, y_t)$ are the expected default probability and expected recovery rates respectively for country with debt ($b_{t+1} \leq 0$), credit history ($h_t = 0$), income level (y_t), and r is risk-free rate.

Since we assume that the market for new sovereign bonds is completely competitive, foreign investors' expected profit is zero in equilibrium. Using the zero expected profit condition, we get

$$q(b_{t+1}, 0, y_t) = \left\{ \begin{array}{ll} \frac{1}{1+r} & \text{if } b_{t+1} \geq 0 \\ \frac{1-p(b_{t+1},0,y_t)+p(b_{t+1},0,y_t)\gamma(b_{t+1},0,y_t)}{1+r} & \text{otherwise} \end{array} \right\} \quad (17)$$

When the country buys bonds from foreign investors $b_{t+1} \geq 0$, the sovereign bond price is equal to the price of risk-free bond, $\frac{1}{1+r}$. When the country issues bonds to foreign investors $b_{t+1} \leq 0$, there is default risk, and the bond is priced to compensate foreign investors for this. Since $0 \leq p(b_{t+1}, 0, y_t) \leq 1$ and $0 \leq \gamma(b_{t+1}, 0, y_t) \leq 1$, the bond price $q(b_{t+1}, 0, y_t)$ lies in $\left[0, \frac{1}{1+r}\right]$.

Next, we consider foreign investors' problem for general cases with the country's history $h_t \geq 1$. Note that the borrowing costs of the country is denoted by $1 + r + \phi(b_t, h_t, y_t)$ which include the additional spread premia agreed at the previous debt renegotiations. Given the borrowing costs, together with the bond price $q(b_{t+1}, h_t, y_t)$, foreign investors maximize their expected profit $\gamma(b_{t+1}, h_t, y_t)$, given by

$$\pi(b_{t+1}, h_t, y_t) = \left\{ \begin{array}{ll} q(b_{t+1}, h_t, y_t)b_{t+1} - \frac{1}{1+r} b_{t+1} & \text{if } b_{t+1} \geq 0 \\ \frac{1 - p(b_{t+1}, h_t, y_t) + p(b_{t+1}, h_t, y_t)\gamma(b_{t+1}, h_t, y_t)}{1 + r + \phi(b_t, h_t, y_t)}(-b_{t+1}) - q(b_{t+1}, h_t, y_t)(-b_{t+1}) & \text{otherwise} \end{array} \right\} \quad (18)$$

where $p(b_{t+1}, h_t, y_t)$ and $\gamma(b_{t+1}, h_t, y_t)$ are as above. Using the zero profit condition, we obtain

$$q(b_{t+1}, h_t, y_t) = \left\{ \begin{array}{ll} \dfrac{1}{1+r} & \text{if } b_{t+1} \geq 0 \\ \dfrac{1 - p(b_{t+1}, h_t, y_t) + p(b_{t+1}, h_t, y_t)\gamma(b_{t+1}, h_t, y_t)}{1 + r + \phi(b_t, h_t, y_t)} & \text{otherwise} \end{array} \right\} \quad (19)$$

When the country issues bonds to foreign investors, the bond price $q(b_{t+1}, h_t, y_t)$ lies in $\left[0, \frac{1}{1+r+\phi(b_t,h_t,y_t)}\right]$ since $0 \leq p(b_{t+1}, h_t, y_t) \leq 1$ and $0 \leq \gamma(b_{t+1}, h_t, y_t) \leq 1$. Thus, the bond price incorporates the additional default premia $\phi(b_t, h_t, y_t)$ due to the previous debt renegotiations; the price of bonds decreases as additional spread premia increase.

Moreover, for any credit history (h_t), interest rate on sovereign bonds is defined as follows; $r^S(b_{t+1}, h_t, y_t) = \frac{1}{q(b_{t+1},h_t,y_t)} - 1$. It is bounded below by the risk-free rate (r). We define the country's total spreads which is a difference between country's interest rate and the risk-free rate:

$$s(b_{t+1}, h_t, y_t) = \frac{1}{q(b_{t+1}, h_t, y_t)} - (1 + r) \quad (20)$$

D. Recursive Equilibrium

We define a stationary recursive equilibrium of the model.

Definition: **A recursive equilibrium** is a set of functions for, (a) the country's value function $V^*(b_t, h_t, y_t)$ (together with $V^{R*}(b_t, h_t, y_t)$ and $V^{D*}\big(b_t, h_t, y_t; \alpha(b_t, h_t, y_t), \phi(b_t, h_t + 1, y_t)\big)$, asset position $b^*_{t+1}(b_t, h_t, y_t)$, consumption $c^*_t(b_t, h_t, y_t)$, default set $D^*(b_t, h_t)$, and discounted expected payment $P^*(b_t, h_t, y_t)$, (b) recovery rates $\alpha^*(b_t, h_t, y_t)$ and additional spread premia $\phi^*(b_t, h_t + 1, y_t)$, (c) bond price function $q^*(b_{t+1}, h_t, y_t)$,and total spreads $s^*(b_{t+1}, h_t, y_t)$ such that

[1]. Given the bond price function, recovery rate and additional spread premia, the country's value function, asset position, consumption, default set, and discounted expected payment satisfy the country's optimization problem (1)-(10).

[2]. Given the bond price function, the country's value function and discounted expected payment, recovery rate and additional spread premia solve debt renegotiation problem (15).

[3]. Given recovery rates and additional spread premia, the bond price fucntion and the total spreads satisfy optimal conditions of foreign investors' problem (17) and (19).

In equilibrium, default probabilityp$^*(b_{t+1}, h_t, y_t)$ is defined by using the country's default decision:

$$p^*(b_{t+1}, h_t, y_t) \; = \int\limits_{D^*(b_t,h_t)} d\mu(y_{t+1}, y_t) \tag{21}$$

The expected recovery rate $\gamma^*(b_{t+1}, h_t, y_t)$ in equilibrium is given by

$$\gamma^*(b_{t+1}, h_t, y_t) \; = \frac{\int_{D^*(b_t,h_t)} \alpha^*(b_t, h_t, y_t) d\mu(y_{t+1}, y_t)}{\int_{D^*(b_t,h_t)} d\mu(y_{t+1}, y_t)}$$

$$= \frac{\int_{D^*(b_t,h_t)} \alpha^*(b_t, h_t, y_t) d\mu(y_{t+1}, y_t)}{p^*(b_{t+1}, h_t, y_t)} \tag{22}$$

The numerator is expected proportion of the debt which the country will repays at renegotiation, and the denominator is default probability.

VI. Quantitative Analysis

This section provides quantitative analysis of the model. We set parameters and functional forms of the model and discuss equilibrium properties of the model. Simulation results based on equilibrium distribution of the model are presented in Section VI.C. We explore the decomposition of spreads in Section VI.D. Finally, we summarize main implications of quantitative analysis.

A. Parameters and Functional Forms

We use most of the parameters and functional forms specified in Yue (2010). There are three new elements in our model: (1) the maximum level of additional spread premia, (2) the maximum level of credit history, and (3) probability of upgrading in credit history. The rationale of the upper limits of both additional spread premia and credit history is to satisfy the stationarity of the model; if we do not set the upper limits, the country will face high borrowing costs and repeat defaults in short periods leading to higher spreads, and investors will not be able to receive spread payments. Reflecting the fact that the record of defaults remains on the country's credit history for only a finite number of years rather than infinite periods, we assume the probability of upgrading in credit history.

We define each period as a quarter. The following constant relative risk-aversion (CRRA) utility function is used:

$$u(c_t) = \frac{c_t^{1-\sigma} - 1}{1 - \sigma} \tag{23}$$

where σ expresses degree of risk aversion. We set σ equal to 2, which is a common value used in real business cycle studies. Following Arellano (2008), the risk-free rate is equal to

1.7 percent. The baseline output loss parameter λ_d is set to 2 percent based on Strurzeneger's (2004) estimate.

We follow the same stochastic process for output used in Yue (2010). She models the output growth rate as AR(1) process to capture the stochastic trend in GDP of Argentina as:

$$\log(g_t) = (1 - \rho_g)\log(1 + \mu_g) + \rho_g \log(g_{t-1}) + \epsilon_t^g$$

where growth rate is $g_t = \frac{y_t}{y_{t-1}}$, growth shock is $\epsilon_t^g \sim^{i.i.d} N(0, \sigma_g^2)$, and $\log(1 + \mu_g)$ is expected log gross growth rate of the country's endowment. We set $\mu_g = 0.0042$, $\sigma_g^2 = 0.0253$, and $\rho_g = 0.41$, and approximate this stochastic process as a discrete Markov chain of 21 equally spaced grids by using the quadrature method in Tauchen (1986).

Since a realization of the growth shock permanently affects endowment and the model economy is nonstationary, we detrend the model by dividing by the lagged endowment level y_{t-1}. The detrended counterpart of the any variable x_t is thus $\hat{x}_t = \frac{x_t}{x_{t-1}}$. The equilibrium value function, bond price function, recovery rate and interest spreads are evaluated based on the detrended variables.

Concerning time discount factor β and baseline country's bargaining power θ, we set $\beta = 0.75$ and $\theta = 0.72$, to obtain its average default frequency 2.65 percent annually or 0.66 percent quarterly and recovery rate 31.3 percent. We target default probability 2.7 percent annually and the average recovery rate 33 percent for the 2005 international debt restructuring estimated by Sturzenegger and Zettelmeyer (2006, 2008). For interest spreads, we set the maximum level of additional spread premia (ϕ_{max}) corresponding to the evidence in Figure 2 that the increase in spreads is less than 0.01 (100 basis points). Lastly, taking into account 3 defaults of Argentina in the period from 1901–2002 indicated in Reinhart, Rogoff, and Savastano (2003), we specify the maximum level of credit history (h_{max}) as 3. The probability of upgrading χ, which governs the average length of time that a recent default remains on the country's credit history is set to 0.025, reflecting that investors' memory lasts for 10 years.[27] This is also consistent with spreads dynamics in Argentina: an average of interest spreads for 2002Q1–2011Q4 is higher than one for pre-default period. Table 4 summarizes the model parameters. Our computation algorithm is shown in Appendix I.

[27]Chatterjee and others (2007) assume that creditors' memory lasts for 10 years in the case of consumer defaults.

Table 4. Model Parameters

Parameter	Value	Source
Risk aversion	$\sigma = 2$	RBC literature
Risk-free interest rate	$r = 0.017$	Arellano (2008)
Baseline output loss in default	$\lambda_d = 0.02$	Sturzenegger (2002)
Average endowment growth	$\mu_g = 0.0042$	Yue (2010)
Std. of endowment growth shock	$\sigma_g^2 = 0.0253$	Yue (2010)
Endowment growth AR(1) coefficient	$\rho_g = 0.41$	Yue (2010)
Discount factor	$\beta = 0.75$	Computed
Baseline bargaining power	$\theta = 0.72$	Computed
Max. level of additional spread premia	$\phi_{max} = 0.01$	Computed
Max. level of credit history	$h_{max} = 3$	Computed
Probability of upgrading in credit history	$\chi = 0.025$	Computed and Chatterjee and others (2007)

B. Numerical Results on Equilibrium Properties

In this subsection, we discuss the equilibrium properties of the model. Figure 4 shows the relationship between the increase in interest spreads and recover rates unconditional on income states.[28] To be consistent with Section III, we define the increase in spreads as the difference between spreads with defaults and those with non-defaults. We calculate spreads after default based on both expected recovery rates for next default and agreed additional spread premia, and spreads with non-defaults are measured with expected recovery rates for the current default. It is clear that there is a negative relationship between recovery rates and the increase in interest spreads. If the increase in spreads is high, recovery rate is low (haircut is high) and vice versa. One interpretation is that if the country repays a large fraction of its debt at the renegotiations, long-term borrowing costs will be small. In the case of Yue (2010), the slope of the contract curve is vertical as shown in Figure A2 in Appendix IV. A driving force which makes our results different from Yue (2010) is additional spread premia agreed to by both parties at the debt restructurings.

[28]Figure A1 in Appendix IV displays the relationship between the increase in interest spreads and recovery rates conditional on income states.

Figure 4. Relationship Between the Increase in Interest Spreads and Recovery Rates

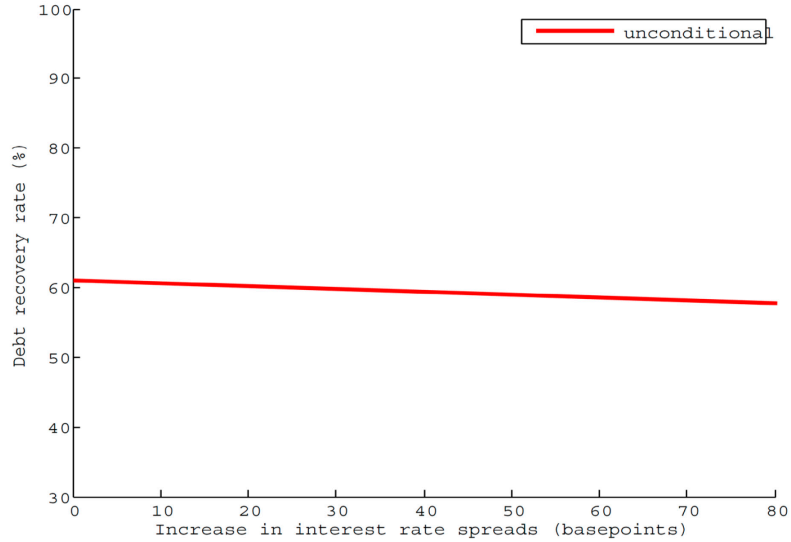


Figure 5. Default Probability under Baseline Case

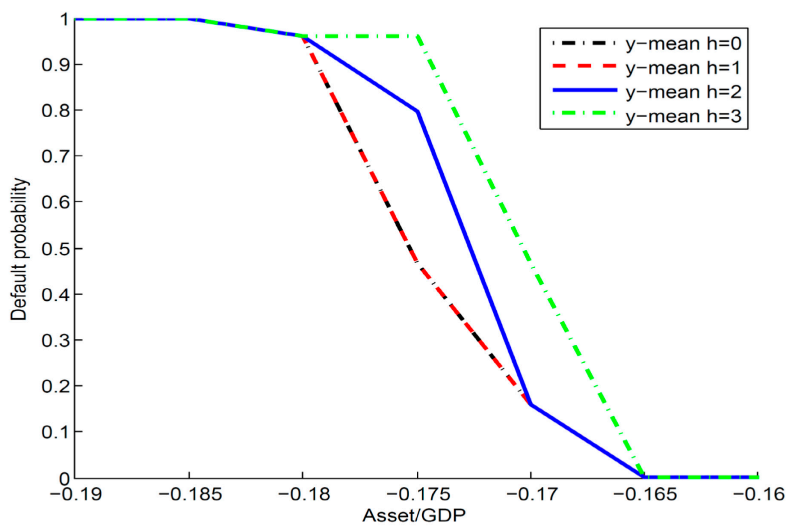
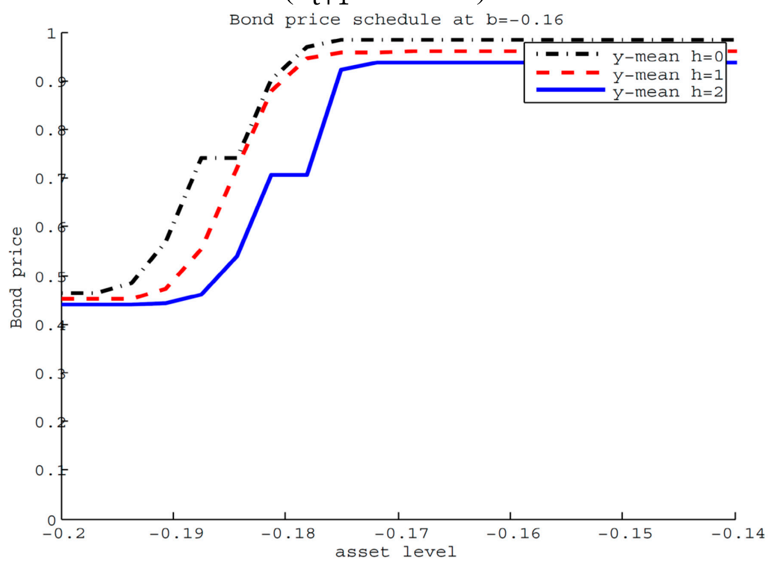


Figure 5 illustrates the baseline default probability at the mean income level. It is apparent that the default probability is weakly increasing with the credit history. At the higher level of credit history ($h_t = 3$), additional increase in spreads on the newly issued bonds, which is determined at the previous debt renegotiation, leads to higher borrowing costs for the country compared with non-default credit history $h_t = 0$. The country facing higher borrowing costs is more likely to default given the debt-to-GDP ratio.

Figure 6 shows that the bond price is also weakly decreasing with respect to the credit history. This is driven by the additional spread premia agreed to by both parties at the past debt renegotiations: as explained in detail in Section VI.D., these additional spread premia reduce the bond price both directly and indirectly through default probability as explained above.

Figure 6. Bond Price Schedule under Baseline Case

$(b_{t+1} = -0.16)$



C. Simulation Results

We conduct 1000 rounds of simulations with 2000 periods per round and then extract 80 observations before and 25 observations after each default event in stationary distribution to compute statistics.[29] Bond spreads are from the J.P. Morgan's Emerging Markets Bond Index Global (EMBIG) for Argentina for 1997Q1–2001Q4 and 2005Q3–2011Q3. Output data are seasonally adjusted from the the Ministry of Economy and Production in Argentina (MECON) for 1980Q1–2001Q4 and 2005Q3–2011Q3. Consumption and trade balance data are also seasonally adjusted from the MECON for 1993Q1–2001Q4 and 2005Q3–2011Q3. The trade balance is calculated as ratio to nominal GDP. Argetina's external debt data are from the IMF World Economic Outlook (WEO) for 1980–2001 and 2005–11. We compute two measures of the sovereign's indebtness: the first measure is the average external debt/GDP ratio. We also compute the ratio of the country's debt service (including short-term debt) to its GDP for Argentina. One advantage of our model compared with Yue (2010) or Aguiar and Gopinath (2006) is that we obtain the statistics for post-default periods.

As obvious from Table 5, the model matches the business cycle statistics in data. For pre-default periods, our model replicates volatile consumption and trade balance-to-GDP volatility, both of which are prominent features of emerging market business cycle models. In addition, it also generates the negative correlation between trade balance and output. However, a novelty of our model comes from the better match of statistics with data in

[29]We choose 80 observations prior to and 25 observations after a default event to compute the sample in the data for Argentina from 1980Q1 to 2001Q4 (pre-default periods) and from 2005Q3 to 2011Q3 (post-default periods). See also Arellano (2008) and Yue (2010) for this treatment of simulation.

post-default periods, particilarly on consumption volatility and correlation of trade balance and output.

Table 5. Business Cycle Statistics for Argentina

	Data	Model	Yue (2010)	A. and G. (2006)
Before Default				
Consumption Std./Output Std.	1.03	1.24	1.04	1.05
Trade Balance/Output Std Dev.(%)	1.23	3.71	2.81	0.95
Corr. (Trade Balance/GDP, Output)	-0.83	-0.005	-0.16	-0.19
After Default				
Consumption Std./Output Std.	1.00	1.31		
Trade Balance/Output Std Dev.(%)	1.03	4.20		
Corr. (Trade Balance/GDP, Output)	-0.74	-0.02		

Sources: Aguiar and Gopinath (2006), author's calculation, Datastream, IMF WEO, MECON, Yue (2010).

We move on to non-business cycle statistics of the model and data reported in Table 6. First of all, in pre-default periods, the model replicates a moderate level of debt relative to data statistics. In the data, the total debt service-to-GDP ratio and short-term debt-to-GDP ratio are 12.7 percent and 10.2 percent. Our model generates the average debt-to-GDP ratio of 9.5 percent. In addition, the model also shows the relation among bond spreads, debt-to-GDP ratio and output as in the data. Bonds spreads are possitively correlated with debt-to-GDP, but negatively correlated with output. This is because default probability is high and recovery rates are low in low income states resulting in high spreads. The average bond spreads is 3.1 percent in our simulations, lower than 7.4 percent reported in the data, but higher than in Yue (2010). The volatility of bond spreads is 1.9 percent in our simulation, close to the data (2.9 percent). The debt recovery rates are negatively correlated with default probability.

More importantly, what makes our model more distinctive is that the model accounts the regularities in the post-default periods. The average debt-to-GDP ratio is 12.3 percent, close to the short-term debt-to-GDP ratio of 13.2 percent. It is clear that the model explains one prominent feature of average debt-to-GDP ratio in both pre-default and post-default periods: the average debt-to-GDP ratio is higher in post-default period (12.3 percent) than in pre-default period (9.5 percent). What drives this is the increase in borrowing costs which forces the sovereign to accumulate higher debt. Furthermore, our model provides the better match of the relation among bond spreads, debt-to-GDP ratio and output in post-default periods than in pre-default periods. Even in the same low income states, the sovereign tends to accumulate higher debt in post-default periods leading to higher spreads than in pre-default periods. This is also justified by the average bond spreads in post-default periods (3.9 percent) higher than one in pre-default periods (3.1 percent). It also shows an obvious improvement of the average spreads compared with Yue (2010). In constast, the volatility of bond spreads in post-default periods is only marginally higher than one in the pre-default periods.

Table 6. Model Statistics for Argentina

	Data	Model	Yue (2010)	A. and G. (2006)
Target Statistics				
Default Probability	2.7	2.65	2.67	0.92
Average Recovery Rate (%)	33	31.3	27.31	0
Non-Target Statistics				
Before Default[1/]				
Average Debt/GDP ratio[3/]	12.7 / 10.2	9.5	10.1	5.95
Corr. (Spreads, Output)	-0.86	-0.19	-0.11	-0.29
Average Bond Spreads. (%)	7.4	3.1	1.86	3.58
Bond Spreads Std Dev. (%)	2.9	1.9	1.58	6.36
Corr. (Debt/GDP, Spreads)[3/]	0.43	0.72	-	-
Debt Renegotiation[2/]				
Corr. (Default Prob., Recovery Rates)	-	-0.31	-0.26	
Corr. (Defaulted Debt, Recovery Rates)	0.33	0.31	0.31	
Average Exclusion (years)	3.5	0.25	0.25	2.5
After Default[2/]				
Average Debt/GDP ratio[3/]	43.0 / 13.2	12.3	-	-
Corr. (Spreads, Output)	-0.43	-0.32	-	-
Average Bond Spreads. (%)	6.7	3.9	-	-
Bond Spreads Std Dev. (%)	4.1	2.0	-	-
Corr. (Debt/GDP, Spreads)[3/]	0.72	0.90	-	-
Span Between Defaults (Years)		14.25	-	-

Sources: Aguiar and Gopinath (2006), author's calculation, Datastream, IMF WEO, MECON, and Yue (2010).
[1/] Data statistics before default correspond to sample of 1980Q1–2001Q1 (Output), 1990Q1–2001Q4 (trade balance and consumption), and 1997Q1–2001Q4 (spreads).
[2/] Data statistics during and after debt renegotiation correspond to samples of 2002Q1–2005Q2 and of 2005Q3–2011Q3 respectively.
[3/] Two meatures are the average total debt service (interest and amortication paid) and the average short-term debt outstanding at year end. We use the second measure (short-term debt outstanding) to calculate correlations.

Furthermore, we calculate the average time spans between defaults based on 2000 rounds of simulations by extracting the initial 200 periods of total 2000 periods per round. Table 7 reports that the average spans between defaults are weakly decreasing with respect to the number of past debt renegotiations. This pattern is robust to extensions related with the upper limits of credit history. Our model successfully replicats the observed stylized fact 3 and 4 in Section III.

Table 7. Average Time Spans between Defaults (quarters)

Data: group average (EM countries) in 1824-2001						64	Def. Prob.	2.7
	1st def.	2nd def.	3rd. def.	4th. def	5th def.	6th def.		
$\mathbf{h_{max} = 3}$	**57**	**19**	**8**	**-**	**-**	**-**		**2.65**
$h_{max} = 4$	57	30	8	8	-	-		2.99
$h_{max} = 5$	59	27	16	14	8	-		3.67
$h_{max} = 6$	59	27	22	16	14	8		4.47

Source: author's calculation.

D. Decomposition of Interest Spreads

In this subsection, we explain how additional spread premia agreed at past debt renegotiations lead to an increase in spreads, which distinguishes this paper from previous work. Based on equation (19) and (20), we can rewrite interest spreads for credit history $h_t \geq 1$ as follows.

$$s(b_{t+1}, h_t, y_t) = \begin{cases} 0 & \text{if } b_{t+1} \geq 0 \\ \frac{1+r+\phi(b_t,h_t,y_t)}{1-p(b_{t+1},h_t,y_t)+p(b_{t+1},h_t,y_t)\gamma(b_{t+1},h_t,y_t)} - (1+r) & \text{otherwise} \end{cases}$$

Given risk-free rate (r), total spreads can be decomposed into two factors:

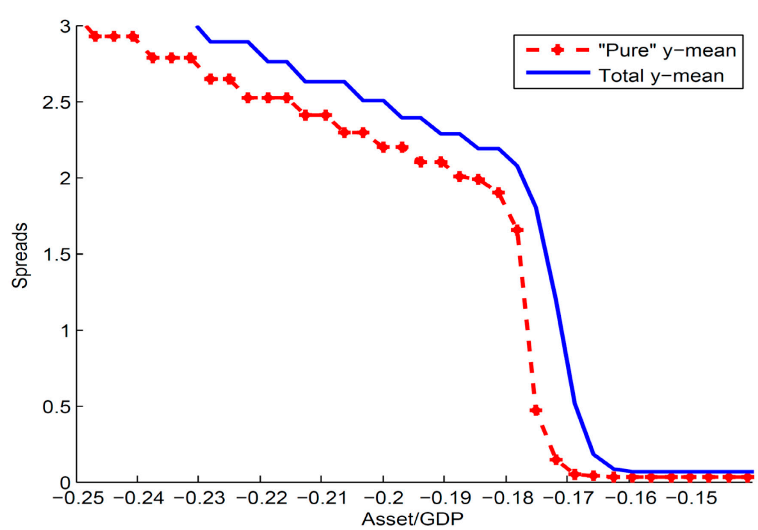
(A) spread components based on “pure” default probability (future defaults),

(B) spread components based on impact of additional spread premia (past defaults).

The former which is simply calculated based on "pure" probability of future defaults is totally irrelevant to the credit history. It is the measure of interest spreads used in Yue (2010). The latter is how much the term $\phi(b_t, h_t, y_t)$, increases total spreads both directly and indirectly through default probability as explained in Section VI.B. It can be regarded as spread components associated with the past default history.

Figure 7 displays both the total spreads and spread components measured with "pure" default probability. The spread components measured with "pure" default probability is equal to (A). The total spreads is defined by the above equation. The difference between these two corresponds to (B), which can be interpreted as spread components associated with the past default history. It is clear that total spreads deviate from spread components measured with "pure" default probability when debt-to-GDP ratio is above the threshold value 0.175 in the mean income state.

Figure 7. Total Spreads and Spreads Based on “Pure” Default Probability



E. Brief Summary of the Quantitative Analysis

Our major findings can be summarized as follows. First of all, by incorporating additional spread premia, the model accommodates the observed pattern of lower recovery rates (larger haircuts) associated with larger increases in yield spreads. Second, we show that default probability is weakly increasing with credit history, given the same debt-to-GDP ratio. Third, our model accounts both business cycle and non-business cycle regularities in the post-default periods. More importantly, we replicate that average spans between defaults are weakly decreasing as the debtor country experiences more defaults. Finally, interest spreads in our model can be decomposed into two parts: spread components of future defaults and of past default history.

VII. Model implications

In this section, we explore the determinants of the slope of the contract curve. Moreover, we consider possible implications derived from both changes in length of creditors' memory and size of additional spread premia.

A. Determinants of the Slope of the Contract Curve

We focus on factors which affect the value of the slope of the contract curve. Table 8 shows the values of the slope under different values for the discount factor, the maximum level of additional spread premia, output cost, risk-free rate and probability of upgrading in credit history.[30] The impact of a change in one parameter, leaving all other parameters fixed is indicated.

Table 8. Values of the Slope of the Contract Curve under Different Parameter Values

Data	-0.01		
Discount Factor	Slope	Max, level of add. spread premia	Slope
$\beta = 0.81$	-0.03	$\phi_{max} = 0.025$	-0.03
$\boldsymbol{\beta = 0.75}$	**-0.07**	$\boldsymbol{\phi_{max} = 0.01}$	**-0.07**
		$\phi_{max} = 0.005$	-0.12
Output cost	Slope	Probability of upgrading in credit history	
$\lambda_d = 0.025$	-0.10	$\chi = 0$	-0.07
$\lambda_d = 0.0225$	-0.08	$\boldsymbol{\chi = 0.025}$	**-0.07**
$\boldsymbol{\lambda_d = 0.02}$	**-0.07**	$\chi = 0.075$	-0.07
Risk-free interest rate			
$r = 0.03$	-0.08		
$r = 0.017$	**-0.07**		
$r = 0.01$	-0.05		

Source: author's calculation.

[30]Changes in the value for bargaining power has limited and non-monotonic impacts on the slope of the contract curve. Rather than the slope, the intercept (levels of recovery rates at 0 basis point increase in spreads) is substantially influenced by changes in the value of bargaining power.

First, the slope gets steeper as the discount factor decreases. As the country is more willing to default in the future, foreign creditors opt to demand higher recovery rates at the current reneogtiation rather requesting higher spread premia, tilting the constract curve steeper. Similarly, when the maximum level of additional spread premia is reduced to 50 basis points ($\phi_{\max} = 0.005$), the absolute value of the slope increases. Since foreign creditors can only demand lower spread premia, they instead request higher recovery rates at the current renegotiation resulting steeper contract curve.

In contrast, an increase in output cost leads to an increase in the absolute value of the slope. As the country is less willing to default due to higher output cost, payments on future spreads become more costly for the country. Thus, the country prefers to pay higher recovery rates at the renegotiton to reduce future spread payments.

The absolute value of slope increases as the risk-free rate increases. As the discount rate for foreign creditors (inverse of risk-free rate) decreases, receipt of future spread returns becomes less worth than one under the baseline. Instead of demanding higher spread premia, foreign creditors request higher recovery rates at the renegotiation. Lastly, probability of upgrading in credit history does not affect the value of slope.

B. Duration and Size of Additional Spread Premia

Determination of both recovery rates and additional spread premia at the debt renegotiation plays an important role in our model. The probability of upgrading in credit history and maximum level of additional spread premia are two key parameters which specify the duration and size of deterioration in long-term credit. Table 9 reports how changes in these parameter values influence the non-business cycle statistics.[31]

The increase in probability of upgrading reduces the average debt-to-GDP ratio in post-default period. As the probability of upgrading in credit history gets higher, length of deterioration in long-run credit gets shorter. The sovereign tends to accumulate lower level of debt.

On the contrary, not only the average debt-to-GDP, average bond spreads in post-default periods, but also the default probability increases as the upper limit of additional spread premia gets higher. The maximum level of additional spread premia identifies the size of deterioration in long-term credit, given the fixed duration. Associated with the increase in borrowing costs, the sovereign accumulates more debt leading to increases in both spreads and default probability.

[31]Changes in parameter values of both probability of upgrading in credit history and maximum level of additional spread premia do not affect the business cycle statistics significantly.

Table 9. Statistics for Different Levels of Upgrading in Credit History and Additional Spread Premia

	Prob. of Upgrading (χ)			Max. level—spread premia (ϕ_{max})		
Parameter Value	0	**0.025**	0.075	0.005	**0.01**	0.025
Default Probability	2.67	**2.65**	2.65	2.55	**2.65**	3.04
Average Recovery Rate (%)	31.9	**31.3**	31.9	32.2	**31.3**	31.5
Before Default						
Average Debt/GDP ratio	10.4	**9.5**	10.4	10.4	**9.5**	11.8
Corr. (Spreads, Output)	-0.08	**-0.06**	-0.08	-0.05	**-0.06**	-0.13
Average Bond Spreads. (%)	3.4	**3.0**	3.4	3.2	**3.0**	4.0
Bond Spreads Std Dev. (%)	1.9	**1.9**	1.9	1.8	**1.9**	2.4
Corr. (Debt/GDP, Spreads)	0.82	**0.72**	0.82	0.81	**0.72**	0.82
After Default						
Average Debt/GDP ratio	10.9	**12.3**	10.9	10.9	**12.3**	12.4
Corr. (Spreads, Output)	-0.25	**-0.41**	-0.27	-0.29	**-0.41**	-0.21
Average Bond Spreads. (%)	3.9	**3.9**	3.9	3.6	**3.9**	4.6
Bond Spreads Std Dev. (%)	2.0	**2.0**	2.0	1.9	**2.0**	2.6
Corr. (Debt/GDP, Spreads)	0.90	**0.90**	0.90	0.88	**0.90**	0.89

Source: author's calculation.

VIII. Conclusion

This paper explores theoretically and empirically serial sovereign defaults and debt restructurings. The empirical section of our paper presents new stylized facts on serial sovereign defaults and debt restructurings. To explain observed stylized facts, we build a theoretical model of sovereign debt and defaults that explicitly models debt renegotiations between a defaulting country and its creditors. Quantitative analysis of the model reveals that the equilibrium probability of default for a given debt-to-GDP level is weakly increasing with the number of past defaults, consistent with empirical observations. The equilibrium of the model also corresponds with the observed stylized fact: lower recovery rates are associated with larger increases in yield spreads. This mechanism drives the equilibrium serial default behavior in the model, and it is a plausible explanation of the pattern of repeat defaults observed in the data.

So far, we have considered the debt renegotiation under symmetric information between the country and investors. It might be possible that some of the information concerning the country's profile remains unrevealed to investors at the time of renegotiation, such as the country's government type as in Hachondo and others (2009) and D'Erasmo (2010) or actual level of output costs. In constrast, degree of coordination among the creditors or creditor composition is uninformed to the country at the renegotaition. A comparison of renegotiation outcomes under two asymmetric information cases will be a potential research topic in the future.

Appendix I. Computation Algorithm

Procedure to compute the equilibrium distribution of the model is the following. Note that the additional spread premia are pinned down by both current level of debt (b_t) and income (y_t) together with credit history (h_t) as the credit history keeps track of timing of default and debt renegotiation and is reverted with exogenous probability. Thus, value functions of sovereign do not need the additional spread premia as an additional state.

(1) First, we set discrete grids on the space of credit history as $H = [0,1,2,3]$ corresponding to $h_{max} = 3$.

(2) Second, we set finite grids on the space of endowment and asset holdings as $B = [-0.3, \ldots \ldots, 0]$. The limits of asset space are set to ensure that the limits do not bind in equilibrium. The limits of endowment space are big enough to include large deviations from the average value of shocks. We approximate the sovereign's stochastic income process using a discrete Markov chain of 21 equally spaced grids. Moreover, we calculate the transition matrix based on the probability distribution $\mu(y_{t+1}, y_t)$.

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(3) Third, we set finite grids on the space of recovery rate and additional spread premia. Limits of both recovery rates and additional spread premia are set to ensure that they do not bind in equilibrium.

(4) Fourth, we set the initial values for equilibrium bond price, recovery rate, and interest spreads. We use the risk-free bond price ($q_1 = q^f = (1 + r)^{-1}$) for the baseline value of equilibrium bond price. We use $\alpha_0 = 0.5$, and $\phi_0 = 0.01$ for the baseline recovery rate and additional spread premia.

(5) Fifth, given the baseline equilibrium bond price ($q_0 = q^f$), recovery rate ($\alpha_0 = 0.5$), and additional spread premia ($\phi_0 = 0.01$), we solve for the country's optimization problem for each credit history ($h_t = 0,1,2 \ldots$). This procedure finds the value function and asset choice as well as the default decisions. We first guess the value functions ($V^0, V^{D,0}, V^{R,0}$) and iterate them using the Bellman equation to find the fixed values ($V^*, V^{D,*}, V^{R,*}$), given the baseline bond price, recovery rate, and spreads. By iterating the Bellman function, we also derive the optimal asset policy function for every value (a', a'^D, a'^R). For each credit history, we also obtain choices of default, which requires comparison of the values of defaulting and non

defaulting. By comparing these two values, we calculate the corresponding default set. Based on default set, we also evaluate the default probability using the transition matrix.

(6) Sixth, using the default set in step (5), and the zero profit condition for foreign investors, we compute the new price of discounted bond (q_1). Then we iterate step (5) to have the fixed value of equilibrium bond price.

(7) Seventh, given the value functions ($V^*, V^{D,*}, V^{R,*}$), value of autarky (V^A), the payment of bonds (R^*) derived from the iterations above and the price of discounted bond (q^*), we solve the bargaining problem and compute the new debt recovery schedule (α') and additional spread premia (ϕ') for every (b, h, y). Then, we iterate step (5), (6) to have the fixed optimal debt recovery rate (α^*), and the optimal additional spread premia (ϕ^*).

Appendix II. Yields on Newly Issued Bonds for Defaulters and Non-Defaulters

To complement our findings on EMBIG spreads, we explore how yields on newly issued bonds after defaults or restructurings differ between past defaulters and non-defaulters. Table A1 reports cross-section regression results on newly issued bonds. In the similar approach as EMBIG spreads, we follow closely Eichengreen and Mody (1998) and Ardagna and others (2007). Due to limited sample of non-defaulters with available PPG external debt data, we use external debt-to-GDP ratio. The baseline regression result (1st column) shows that past defaulters suffer higher yields on newly issued bonds after defaults or restructurings by 2.2 percentage points. If sovereigns have higher debt (external debt-to-GDP ratio) and experience larger exchange rate depreciation, they have higher yields on issued bonds. This result is robust even if the shorter interval for past defaults starting from 1990 (2nd column).

Table A1. Yields on Newly Issued Bonds over 2005–11[1/]

	Borrowing costs	
Explanatory variable	**Yields on Newly Issued Bonds Weighted Ave (%)[2/]**	
Past Default Dummy (since 1985)	2.24*** (0.72)	-
Past Default Dummy (since 1990)	-	2.19*** (0.74)
External Debt/GDP ave, 2004-2010 (%)	0.028** (0.012)	0.029** (0.012)
GDP growth rate, ave. 2005-11 (%)	0.23 (0.14)	0.23 (0.14)
Exchange rate depreciation, ave. 2005-11[3/]	0.43*** (0.12)	0.44*** (0.12)
Capital account openness, ave. 2005-11[4/]	-0.22 (0.35)	-0.15 (0.36)
Sample countries	32	32
Adj-R^2	0.77	0.76
Root MSE	2.44	2.47

Sources: Bloomberg, Chinn and Ito (2006), Cruces and Trebesch (2013), IMF WEO, and author's calculation
Note: Standard errors are in parentheses. ***, **, * show significance at 1, 5, and 10 percent levels respectively.

[1/] All regression results are based on least square estimations.
[2/] Yields of newly issued external bonds denominated in foreign currency. Weighted average using issuance amounts in the US dollar. If bonds are denominated in currencies other than the US dollar, we convert issuance amounts by exchange rates at the end of months.
[3/] Change in end of period annual exchange rate from the previous level.
[4/] Capital account openness index from Chinn and Ito (2006) ranges from -1.86 and 2.44 corresponding to the lowest and highest degree of capital openness respectively.

- ***Stylized fact A1: Defaulters suffer higher yields on newly issued bonds after defaults and restructurings than non-defaulters*** (by 2.2 percent).

Appendix III. Extrapolation Method of EMBIG Spreads

We use an extrapolation method to obtain longer series of EMBIG spreads covering 1986–2010 by ICRG ratings and LIBOR. EMBIG spreads data is available from 1999 for most of emerging countries. Using EMBIG stripped yields, LIBOR, and ICRG ratings (all in monthly frequency), for each country, we run a linear time-series regression of EMBIG yields on LIBOR and ICRG ratings for period of 1999M1–2012M12. LIBOR captures influence of global liquidity on sovereign yields and ICRG ratings reflect country-specific variations of investor's risk assessment. As we run a separate regression for each country, a constant aims to capture time-invariant components of yields for each country. Table A2 reports the results for regression of EMBIG yields for some selected countries.

Table A2. Regression of EMBIG Yields on LIBOR and ICRG Ratings

$$\mathrm{Yields}_t^i = c^i + \beta_1 \mathrm{LIBOR}_t + \beta_2 \mathrm{Rating}_t^i + \varepsilon_t^i \qquad \text{for } i = 1 \ldots\ldots N$$

Country (i)	Constant	LIBOR	ICRG Ratings	Adj-R^2
Argentina	193.14***	1.94***	-2.60***	0.64
Chile	18.51***	0.50***	-0.19***	0.73
Cote D'Ivore	105.44***	2.84***	-1.61***	0.62
Egypt	18.88***	0.36***	-0.21***	0.15
Jamaica	54.38***	0.65***	-0.71***	0.57
Mexico	36.98***	0.78***	-0.46***	0.82
Peru	51.14***	0.54***	-0.65***	0.58
Russia	89.22***	1.48***	-1.20***	0.80
South Africa	37.40***	0.74***	-0.48***	0.66
Turkey	28.40***	0.30***	-0.34***	0.62

Sources: Bloomberg, Datastream, PRC (2012), and author's calculation.

Since most of coefficients are significant at 1 percent level, we use the estimated coefficients for 1999M1–2012M12 to obtain imputed EMBIG yields for period of 1986M1–1998M12 for each country. The explanatory variables are LIBOR and ICRG ratings available from 1986M1 to 1998M12. We take a difference between imputed EMBIG yields and yields of the US Treasury 10-year bonds for each country to obtain estimates of EMBIG spreads.

Appendix IV. Figures at Steady State Distributions

Figure A1 shows the relationship between the increase in interest spreads and recovery rates conditional on income realization. It is clear that there is a negative relationship between recovery rates and increase in interest spreads in the lowest, mean and highest mean income states. The slope of the contract curve in the lowest income state is steeper than ones in both mean and the highest income states.

Furthermore, Figure A2 presents that the slope of the contract curve is vertical in the case of Yue (2010). Since Yue (2010) does not consider any additional spread premia agreed at the debt renegotiation, there is no increase in spreads.

Figure A1. Relationship between Increase in the Interest Spreads and Recovery Rates

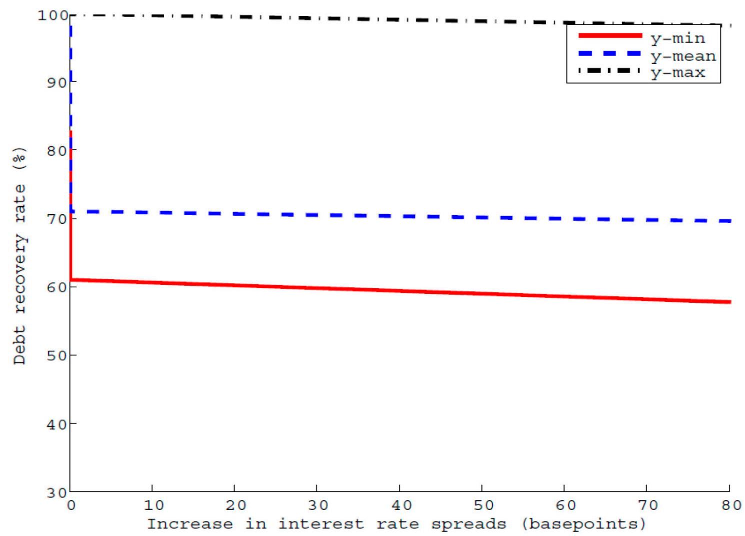
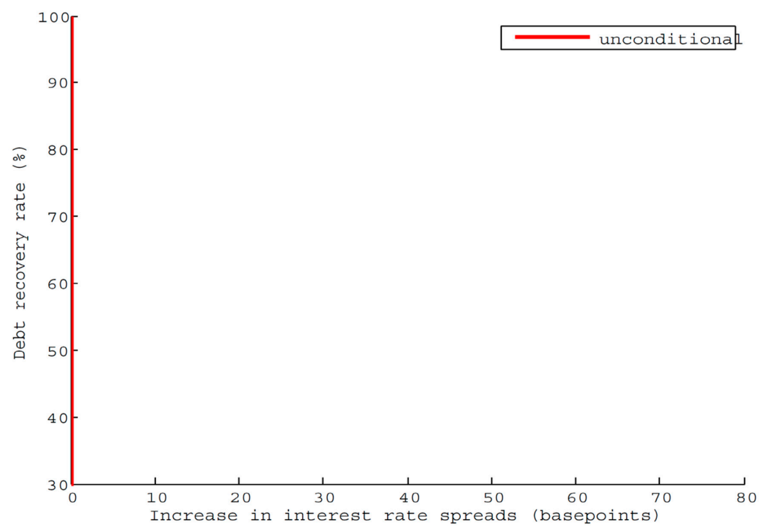


Figure A2. Relationship between Increase in the Interest Spreads and Recovery Rates in Yue (2010)



References

Aguiar, M., and G. Gopinath, 2006, "Defaultable Debt, Interest Rates and the Current Account," *Journal of International Economics*, Vol. 69 (1); pp. 64–83.

Alfaro, L., and F. Kanczuk, 2005, "Sovereign Debt as a Contingent Claim," *Journal of International Economics*, Vol. 65 (2); pp. 297–314.

Ardagna, S., Caselli, F., and T. Lane, 2007, "Fiscal Discipline and the Cost of Public Debt Service: Some Estimates for OECD Countries," *The B.E. Journal of Macroeconomics*, Vol. 7 (1); pp. 1–35.

Arellano, C., 2008, "Default Risk and Income Fluctuations in Emerging Economies," The *American Economic Review*, Vol. 98 (3); pp. 690–712.

Arellano, C., and Y. Bai, 2014, "Linkage across Sovereign Debt Markets," manuscript, Federal Reserve Bank of Minneapolis.

Asonuma, T., and Hyungseok Joo, 2014, "Soveriegn Debt Restructurings: Delay in Renegotiation and Risk-Averse Creditors," manuscript, International Monetary Fund.

Asonuma, T., Peraza, G., Vitola, K., and T. Tsuda, 2014, "Sovereign Debt Restructurings in Belize: Achievements and Challenges Ahead," IMF Worknig Paper No. 14/132 (Washington: International Monetary Fund).

Asonuma, T., and C. Trebesch, 2016, "Sovereign Debt Restructurings: Preemptive or Post-Default," *Journal of the European Economic Association*, Vol.14 (1); pp.175-214.

Bai, Y., and J. Zhang, 2012, "Duration of Sovereign Debt Renegotiation," *Journal of International Economics*, Vol. 86 (2); pp. 252–268.

Benczur, P., and C.L. Ilut, 2016, "Evidence for Relational Contracts in Sovereign Bank Lending," forthcoming in *Journal of European Economic Association*.

Benjamin, D., and M. Wright, 2009, "Recovery Before Redemption? A Theory of Delays in Sovereign Debt Renegotiations," manuscript, University of Southhampton.

Bi, R., 2008, "Beneficial Delays in Debt Restructuring Negotiations," IMF Working Paper WP/08/38 (Washington: International Monetary Fund).

Bi, R., Chamon, M., and J. Zettelmeyer, 2011, "The Problem that Wasn't: Coordination Failures in Sovereign Debt Restructurings," IMF Working Paper WP/11/265 (Washington: International Monetary Fund).

Bulow, J., and K. Rogoff, 1989, "LDC Debts: Is to Forgive or to Forget?" *The American Economics Review*, Vol.79 (1); pp. 43–50.

Cantor, R., and F. Packer, 1996, "Determinants and Impact of Sovereign Credit Ratings," *Policy Review*, Vol. 2 (October), Federal Reserve Bank of New York, pp. 37–53.

Catao, L.A.V., Fostel, A., and S. Kapur, 2009, "Persistent Gaps and Default Traps," *Journal of Development Economics*, Vol.89 (2); pp.271-284.

Chatterjee, S., Corbae, D., Nakajima, M., and J. V. Rios-Rull, 2007, "A Quantitative Theory of Unsecured Consumer Credit with Risk of Default," *Econometrica*, Vol. 75 (6); pp. 1525–1589.

Chatterjee, S., Corbae, D., and J. V. Rios-Rull, 2008, "A Finite-life Private-information Theory of Unsecured Consumer Debt," *Journal of Econometric Theory*, Vol. 142 (1); pp. 149–77.

Chinn, M.D. and H. Ito, 2006, "What Matters for Financial Development? Capital Controls, Institutions, and Interactions," *Journal of Development Economics,* Vol.81 (1); pp.163-192.

Cruces, Juan, and Christoph Trebesch, 2013, "Sovereign Defaults: The Price of Haircuts," *American Economic Journal: Macroeconomics*, Vol. 5 (3); pp. 85–117.

Das, U., Papaioannou, M., and C. Trebesch, 2012, "Sovereign Debt Restructurings 1950 - 2010: Literature Survey, Data, and Stylized Facts," IMF Working Paper WP/12/203 (Washington: International Monetary Fund).

De Paoli, B., Hoggarth, G., and V. Saporta, 2006, "Cost of Sovereign Defaults," Financial Stability Paper No.1, Bank of England.

D'Erasmo, P., 2010, "Government Reputation and Debt Repayment in Emerging Economies," manuscript, University of Maryland.

Diaz-Cassou, J., Erce, A., J. Vazquez-Zamora, 2008, "Recent Episodes of Sovereign Debt Restructurings: A Case-Study Approach," Banco de Espana Occational Paper No.0804.

Duggar, E., 2013, "The Role of Holdout Creditors and CACs in Sovereign Debt Restructurings," Moody's Sovereign Default Series Compendium, October 7, 2003.

Dreher, A. and S. Walter, 2010, "Does the IMF Help or Hurt? The Effect of IMF Program on the Likelihood and Outcomes of Currency Crises," *World Development*, Vol. 38 (1); pp.1–18.

Eaton, J., and M. Gersovitz, 1981, "Debt with Potential Repudiation: Theoretical and Empirical Analysis," *Review of Economic Studies*, Vol. 48 (2); pp. 289–309.

Eichengreen, B. and A. Mody, 1998, "What Explains the Changing Spreads on Emerging Market Debt?" NBER Working Paper No. 6408, National Bureau of Economic Research.

Eichengreen, B., Hausmann, R., and U. Panizza, 2003, *"The Pain of Original Sin,"* eds. by B. Eichengreen and R. Hausmann in "Debt Denomination and Financial Instability in Emerging Market Economies," (Chicago: University of Chicago Press).

Finger H., and M. Mecagni, 2007, "Sovereign Debt Restructuring and Debt Sustainability—An Analysis of Recent Cross-Country Experience," IMF Occasional Paper No. 255 (Washington: International Monetary Fund).

Hatchondo, J. C., Martinez, L., and H. Sapriza, 2009, "Heterogeneous Borrowers in Quantitative Models of Sovereign Default," *International Economic Review*, Vol. 50 (4); pp. 1128–1151.

Hatchondo, J.C., Martinez, L., and C. Sosa-Padilla, 2014, "Voluntary Sovereign Debt Exchanges," *Journal of Monetary Economics*, Vol.61 (S); pp.32-50.

Kohlscheen, E., 2009, "Sovereign Risk: Constitutions Rule," *Oxford Economic Papers*, Vol. 62 (1); pp. 62–85.

Kovrijnykh, N., and B. Szentes, 2007, "Equilibrium Default Cycles," *Journal of Political Economy*, Vol. 90 (3); pp. 621–639.

J. P. Morgan, 1999, "Introducing the J.P. Morgan Emerging Market Bond Index Global (EMBI Global)," Methodology Brief.

Mendoza. E., and V. Yue, 2012, "A General Equilibrium Model of Sovereign Default and Business Cycles," *Quarterly Journal of Economics*, Vol. 127 (2); pp. 889–946.

Moody's, 2007, "Sovereign Default and Recovery Rates, 1983–2006," *Moody's Special Comments*.

Ozler, S., 1992, "Evolution of Credit Terms: An Empirical Examination of Commercial Bank Lending to Developing Countries," *Journal of Development Economics*, Vol. 38 (1); pp. 79–97.

———, 1993, "Have Commercial Banks Ignored History?" *The American Economic Review*, Vol. 83 (3); pp. 608–620.

Panizza, U., Sturzenegger, F., and J. Zettelmeyer, 2009, "The Economics and Law of Sovereign Debt and Default," *Journal of Economic Literature*, Vol.47 (3); pp.651-698.

Pitchford, R., and M. Wright, 2012, "Holdouts in Sovereign Debt Restructurings: A Theory of Negotiation in a Weak Contractual Environment," *Review of Economic Studies*, Vol. 79 (2); pp.812-837.

PRC Group, 2012, "*Composite Risk Rating*."

Reinhart, C., and K. Rogoff, 2005, "Serial Default and the "Paradox" of Rich-to-poor Capital Flows," *The American Economic Review*, Vol. 94 (2); pp. 53–58.

———, 2009, *This Time is Different: Eight Centuries of Financial Folly*, Princeton: Princeton University Press.

———, 2011, "From Financial Crash to Debt Crisis," *The American Economic Review*, Vol. 101 (4); pp. 1676–1706.

Reinhart, C., Rogoff, K., and M. Savastano, 2003, "Debt Intolerance," *Brookings Papers on Economic Activity*, Vol. 1; (Spring), pp. 1–74.

Rieffel, A., 2003, *Restructuring Sovereign Debt: The Case for Ad Hoc Machinery*, Brookings Institution Press.

Standard and Poor's, 2006, "Default Study: Sovereign Defaults at 26-Year Low, To Show Little Change in 2007," *RatingsDirect*, September 18.

———, 2011, "Sovereign Defaults and Rating Transition Data: 2010 Update," *RatingsDirect*, February 23.

Sturzenegger, F., 2004, "Tools for the Analysis of Debt Problems," *Journal of Restructuring Finance*, Vol.1, pp.201-223. .

Sturzenegger, F., and J. Zettelmeyer, 2006, "Debt Defaults and Lessons from a Decade of Crises," MIT Press.

———, 2008, "Haircuts: Estimating Investor Losses in Sovereign Debt Restructuring, 1998–2005," *Journal of International Money and Finance*, Vol. 27 (5); pp. 780–805.

Sy, A. N. R., 2002, "Emerging Market Bond Spreads and Sovereign Credit Ratings: Reconciling Market Views with Economic Fundamentals," *Emerging Markets Review*, Vol. 3 (4); pp. 380–408.

Tauchen, G., 1986, "Finite State Markov-chain Approximations to Univariate and Vector Autoregressions," *Economic Letters*, Vol. 20 (2); pp. 177–181.

Tomz, M., and M. Wright, 2007, "Do Countries Default in "Bad" Times?" *Journal of the European Economic Association*, Vol. 5 (2–3); pp. 352–360.

———, 2013, "Empirical Research on Sovereign Debt and Default," *Annual Review of Economics*, Vol.5: pp.247-272.

Yue, V., 2010, "Sovereign Default and Debt Renegotiation," *Journal of International Economics*, Vol. 80 (2); pp. 176–187.