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Sovereign Debt Overhang, Expenditure Composition and Debt Restructurings*

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Abstract

Sovereigns' public capital influences sovereign debt crises and resolution. We compile a dataset on public expenditure composition around restructurings with private external creditors. We show that during restructurings, public investment (i) experiences severe decline and slow recovery, (ii) differs from public consumption and transfers, (iii) reduces share in public expenditure, and (iv) relates with restructuring delays. We develop a theoretical model of defaultable debt that embeds endogenous public capital accumulation, expenditure composition, production and multi-round debt renegotiations. The model quantitatively shows severe decline and slow recovery in public investment—"sovereign debt overhang"—delay debt settlement. Data support these theoretical predictions.

JEL Classification Codes: F34, F41, H63

Key words: Debt Overhang; Sovereign Debt; Sovereign Default; Debt Restructuring; Public Investment; Public Capital.

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1 Introduction

Sovereigns' public capital influences sovereign debt crises and resolution. We compile a new dataset on public expenditure composition around debt restructurings with private external creditors. We show that during restructurings, public investment (i) experiences a severe decline and slow recovery, (ii) differs from public consumption and transfers, (iii) reduces its share in public expenditure, and (iv) relates with restructuring delays. To explain these stylized facts, we develop a theoretical model of defaultable debt that explicitly embeds endogenous public capital accumulation, expenditure composition, production and multi-round debt renegotiations. Our model quantitatively replicates these stylized facts and shows that both severe decline and slow recovery in public investment—"sovereign debt overhang"—delay debt settlement. Data support these theoretical predictions.

We start by presenting a comprehensive new dataset on public expenditure composition at 179 privately-held external debt restructurings over 1978–2010. Following a detailed classification by the US Bureau of Economic Analysis (BEA 2005), we newly compile public consumption, investment, transfers and capital. Our dataset provides much a wider coverage of restructuring episodes, time-series and categories, and is thus superior to existing databases (e.g., the IMF World Economic Outlook). We then merge our newly-constructed data with an existing dataset on the duration and strategies of restructurings from Asonuma and Trebesch (2016).

The consolidated datasets provide four new stylized facts. First, public investment experiences a severe decline and slow recovery during restructurings. Second, in contrast to this, public consumption and transfers experience a short-lived decline and quick recovery. Third, public expenditure skews heavily towards consumption and transfers during restructurings. Fourth, the more severe declines in public investment are associated with lengthy delays in restructurings. We confirm these findings through both panel and cross-sectional regressions for 111 post-default restructurings—sovereigns default first and renegotiate their defaulted debt later.

Our empirical findings unveil a new dimension of sovereign debt and default, which the literature has not fully explored yet. In particular, one question emerges from the facts: Why does public investment experience a severe decline and slow recovery in debt crisis, but public consumption and transfers do not? By answering this question, we raise a more fundamental question in the literature: What is the role of public capital and sovereign debt overhang—current high levels of debt negatively influence future investment (Aguiar et al., 2009)—on sovereign debt crises and resolution? These questions challenge the current understanding in the literature that neither public capital nor sovereign debt overhang play the role in sovereign debtors' defaults and restructurings. To our knowledge, we are the first to shed light on the role of public capital and sovereign debt overhang on the sovereign debt crises and resolution.

To address these questions, we construct a theoretical sovereign debt model that explicitly embeds endogenous public capital accumulation, expenditure composition, production and post-default multi-round renegotiations with a risk averse sovereign and its risk-neutral foreign creditors. The model is built on the classical setup of Eaton and Gersovitz (1981) as in the recent

quantitative analysis of sovereign debt (e.g., Arellano 2008; Aguiar and Gopinath 2006).[1] In particular, our model of defaultable debt follows two conventional frameworks in the literature: (i) one with a meaningful role for fiscal policy i.e., when private and public sectors are separated due to both distortionary tax and two types of consumption (Cuadra et al. 2010; Arellano and Bai 2017) and (ii) one with multi-round debt renegotiations after default (Benjamin and Wright 2013; Bi 2008).

The important theoretical innovation is incorporating endogenous public capital accumulation, expenditure composition and production with public capital and labor in the model with endogenous defaults and renegotiations. We explicitly depart from two standard modeling approaches: an exogenous income process (e.g., Arellano 2008; Aguiar and Gopinath 2006) and endogenous production with labor (e.g., Mendoza and Yue 2012; Cuadra et al. 2010). At each period, the sovereign chooses its expenditure composition (public consumption, investment and transfers) together with its choice of repayment and default (settlement and delay), and of external borrowing. Public capital is accumulated through public investment—net of both depreciation and adjustment costs—, which in turn, together with labor determines production.

We emphasize two novel predictions in our theoretical model. First, the model makes predictions about the role of public capital on the sovereign's choice of default, debt settlement and restructuring delays. *After default*, the sovereign is willing to delay renegotiations, ceteris paribus, when public capital is low. It opts to invest in public capital rather than use resources for recovered debt payments given the high marginal product of public capital.[2] As a result, debt settlement and restructuring delays are driven not only by the recovery of repayment capacity (Benjamin and Wright 2013; Bi 2008)—corresponding to recovery of productivity and an associated response of labor in our model—but also the marginal product of public capital. The second driver differentiates our paper from previous studies.

Before default, the sovereign's willingness to repay is independent of level of public capital.[3] On the one hand, ex ante, higher public capital improves the sovereign's repayment capacity, i.e., output ("smoothing channel"). On the other hand, ex post (conditional on default), higher public capital also improves household utility by smoothing consumption in financial autarky ("autarky channel") and achieves the debt settlement ("debt renegotiation channel"). In total, the net effect of public capital through these three channels on repayment and default is balanced. This is because through the debt renegotiation channel, higher public capital reduces default costs (i.e., shorter period of financial exclusion) making default equally attractive as repayment. Our model newly incorporates the debt renegotiation channel, and this differentiates our paper from Gordon and Guerron-Quintana (2018) in which the smoothing channel dominates the

[1] See also the survey by Aguiar and Amador (2014) and Aguiar et al. (2016).

[2] See Ohanian et al. (2018) for the role of marginal product of "total" capital on international capital flows in Asia and Latin America.

[3] Gordon and Guerron-Quintana (2018) and Park (2017) focus on the role of "total capital" on sovereign defaults. In their models, the government chooses only "total consumption" and "total investment" with its choice of default and external borrowing. As there is no fiscal policy—public consumption, investment, transfers and taxation—, the government can allocate resources across sectors without any fiscal constraint.

autarky channel.[4]

Second, the model provides predictions on sovereign debt overhang, which also explain our main empirical findings. Previous studies (e.g., Aguiar et al. 2009) explain the sovereign debt overhang in the pre-default phase, when the sovereign maintains market access by servicing high external debt. We extend our analysis to the restructuring phase, when the sovereign loses market access due to default, thus allowing for a persistent impact of default (i.e., loss in market access) on public investment long after the default initially occurs. *In the pre-default phase*, both low productivity and high external debt payments interact with the sovereign's consumption smoothing motive and impatience. Despite maintaining market access, the interaction of these factors results in a sharp decline in public investment (0.8 percent of GDP). This is because the impatient government, with consumption-smoothing motive, is willing to stabilize public consumption and transfers to improve household utility. This, in turn, leads to debt accumulation, and later to a default (Aguiar et al. 2009).

In the restructuring phase, slow recovery of productivity, prohibition on external borrowing, and the government's consumption smoothing motive and impatience generate both slow public capital accumulation and lengthy renegotiations which interact with each other. Public capital accumulation is slow both because external borrowing is prohibited until the government reaches a settlement with its creditors, and because the impatient government with consumption-smoothing motive continues to be willing to stabilize public consumption and transfers for household utility. Debt renegotiations are delayed because of both the high marginal product of public capital owing to slow accumulation, and slow recovery of productivity. This cycle continues until the sovereign accumulates public capital to a high level and reaches the debt settlement.

Our theoretical predictions are supported by data: both a severe decline and slow recovery in public investment delay debt settlement. First, a panel analysis on debt settlement using 111 post-default episodes at an annual frequency confirms these predictions. Second, the quantitative analysis calibrated to the Argentine default and restructuring in 2001–05 replicates the four stylized facts: (i) a severe decline and slow recovery of public investment, (ii) a short-lived decline and quick recovery of public consumption and transfers, (iii) public expenditure skewing towards consumption and transfers, and (iv) an association between the declines in pubic investment and delays in restructurings.

Literature Review Our paper contributes to both theoretical and empirical literature on sovereign debt overhang. In the theoretical strand of literature, Aguiar et al. (2009) explain that a government's lack of commitment induces a negative correlation between investment and government debt. Similarly, Ostry et al. (2015) show the distortionary impact of high public debt on investment and growth. In the empirical strand of literature, both Reinhart et al. (2012) and Ostry et al. (2015) find that public debt indebtedness is highly associated with low public and private investment and growth in advanced economies. Our paper contributes to both strands of literature by showing both new empirical findings on debt overhang around debt

[4]Hamann et al. (2018) also find similar two opposing effects of oil reserves on the sovereigns' default.

restructurings and theoretical explanations on two distinct mechanisms of debt overhang.

The paper is also related to the theoretical literature exploring interactions between fiscal policy and a sovereign's default and external borrowing choice (e.g., Cuadra et al. 2010; Arellano and Bai 2017; D'Erasmo and Mendoza 2016, 2017; Pouzo and Presno 2015; Hatchondo et al. 2017; Bianchi et al. 2017; Karantounias 2018).[5,6] These studies explicitly embed different fiscal policy instruments on expenditure (e.g., public consumption or transfers) and on revenue (e.g., labor income tax, consumption tax, or lump-sum income tax) in the model with endogenous default and production with labor. Our paper differs from the existing literature in that with public investment newly introduced in the model, it explains the role of public capital on a sovereigns default, debt settlement and restructuring delays.

Lastly, the theoretical work on sovereign debt restructurings models the outcome of default and debt renegotiation as bargaining between a sovereign debtor and its creditors.[7] With multi-round renegotiations, both Benjamin and Wright (2013) and Bi (2008) explain that recovery of the debtor's repayment capacity generates delays, and Asonuma and Joo (2019) show that both the debtor's repayment capacity and its risk averse creditor's consumption-smoothing motive interact and drive longer delays. On the contrary, Bai and Zhang (2012) find that delays arise due to information asymmetry between the debtor and its creditors. We fill a gap in the literature by explaining an additional channel of delays driven by the marginal product of public capital.

[5]Mendoza et al. (2014) explore interactions between fiscal policy, i.e., different taxation methods and external borrowing choice in highly-integrated two-country set-up without the sovereigns' default choice.

[6]For empirical analysis on sovereign debt and fiscal policy, see Kaminsky, Reinhart and Vegh (2005), Ilzetzki, et al. (2013), Frankel et al. (2013), and Ilzetzki (2011).

[7]See also Bulow and Rogoff (1989), Kovrijnykh and Szentes (2007), Yue (2010), Arellano et al. (2013, 2017), D'Erasmo (2011), Hatchondo et al. (2014), Asonuma and Trebesch (2016), Pitchford and Wright (2012), Fernandez and Martin (2014), Sunder-Plassmann (2018), Dvorkin, et al., (2019), and Asonuma (2016).

2 Dataset and Stylized Facts

2.1 New Dataset on Public Expenditure Composition

Confronted with debt crises and restructurings, sovereigns often implement fiscal adjustment programs associated with financing by multilateral sources, e.g., an IMF-supported program. The fiscal adjustment programs feature substantially different treatment in public expenditure composition, particularly large cuts in public investment in contrast with small cuts in public consumption. Representative episodes are Latin American debt crises in the early 1980s. Argentina, Brazil, and Peru implemented partial adjustment programs accompanied by monetization of deficits (Calderon et al. 2003).[8] The momentum towards achieving fiscal austerity under the programs resulted in severe reductions in public investment: 1.1–2.8 percent of GDP on average in 1983–87.[9] The sharp reductions in public investment, which were not completely offset by increases in private investment, resulted in a significant drop in GDP growth.

To explore explicitly the role of public capital and sovereign debt overhang on the sovereign debt crises and resolution, we first need to identify precisely each category of public expenditure and its dynamics during debt restructurings. For this, we code a new dataset on public expenditure composition—consumption, investment, transfers, and capital—at 179 privately-held external debt restructurings over 1978–2010.

One main challenge for this coding exercise was a lack of high quality data on public expenditure composition satisfying criterion for (i) cross-country (in particular defaulting countries), (ii) times series, and (iii) category coverage simultaneously. The IMF World Economic Outlook (WEO) database provides annual data on government spending components, but the database meets only the third criteria. Data are available only for limited years, i.e., since 2000 and for limited sample of countries, i.e., advanced countries. The World Bank (WB) Global Development Finance (GDF) database provides annual consumption data, i.e., general government final consumption. The data meet both the first and second criterion. This is because the indicator covers only one sub-category of public consumption and lacks compensation of general government employees (including employer contributions for government social insurance)—one of the large sub-categories of public consumption—underestimating total public consumption.

To have high quality data on categories of public expenditure, we therefore combine the limited yearly data on public expenditure from the IMF Fiscal Affairs Department (FAD), WEO, and WB GDF with rich information from a new broad range of sources.[10] Important

[8] Sach (1990) explains that in Latin American fiscal adjustment programs, the authorities prioritized cuts in public investment over cuts in public consumption, i.e., reductions in public sector real wage or employment.

[9] Argentina, Brazil, and Peru experienced a sharp fall in public capital of 1.3, 1.1, and 2.8 on average in 1985–97, 1983–86, and 1985–87, respectively.

[10] IMF (2015) measures public investment using gross fixed capital formation (GFCF) of the general government (i.e., central plus subnational governments). The approach allows for the use of the comparable data available for a large number of countries but ignores alternative modes by which governments support overall investment (e.g., investment grants, loan guarantees, tax concessions, the operations of public financial institutions, government-backed saving schemes). Following Kamps (2006) and Gupta et al. (2014), the paper constructs public capital stock based on a dataset of (i) public investment series, (ii) initial public capital stock, and (iii) depreciation rate.

quantitative sources for us in particular are the IMF Staff Reports from the IMF archives (Article IV consultations, requests and reviews for IMF-supported programs, information annexes, etc.). For a detailed classification of public consumption, investment and transfers, we follow US BEA (2005)—explained in Table A1 in Appendix A. The coding outcome is documented in detail for each of the 179 restructuring episodes and backed by the exact sources used for coding. Table A2 in Appendix A shows coding examples and the underlying sources for a few exemplary cases.

Table 1 summarizes our public expenditure composition dataset demonstrating four main advantages compared to existing ones—IMF WEO or WB GDF. First of all and most importantly, it is the first comprehensive public expenditure composition dataset which covers a wide range of categories including transfers—little has been covered in existing datasets. Second, each expenditure category in our dataset covers at least 70 percent of all restructuring episodes (124 cases out of 179 episodes). Third, each expenditure category covers three distinct time periods around restructuring episodes: pre-restructuring, restructuring and post-restructuring periods. Fourth, each expenditure series is comprised of sub-categories; for instance, public consumption series include compensation of general government employees.

Table 1: Public Consumption, Investment, Transfers and Capital for Restructurings in 1978–2010[1/]

	Observation	Mean	Median	Std Dev.	Observation	Mean	Median	Std. Dev.
Restructuring Episodes	179				*Percent of GDP*			
	Pre-restructuring period				**Restructuring period**			
Public Consumption, average[2/]	124	13.1	11.2	9.4	124	12.0	10.6	7.4
Public Investment, average[2/]	151	4.7	3.4	4.3	151	3.7	3.0	3.3
Public Transfers, average[2/]	124	5.3	3.1	6.3	124	3.9	2.4	4.7
Public Capital, average[2/]	151	75.0	58.6	49.3	151	74.2	56.5	50.9
	Post-restructuring period							
Public Consumption, average[2/]	124	11.7	10.1	7.5				
Public Investment, average[2/]	151	4.0	3.2	3.8				
Public Transfers, average[2/]	124	4.6	3.0	4.8				
Public Capital, average[2/]	151	74.9	61.7	48.4				

[1/] For all components of public expenditure, our dataset has both series in real and level (constant 2011 US dollars), and in percent of GDP.

[2/] For each restructuring episode, we take an average of public expenditure series for corresponding periods: (i) pre-restructuring period, i.e., 3 years before the start of restructurings; (ii) restructuring period, i.e., from the start to the end of restructurings; (iii) post-restructuring period, i.e., 3 years after the end of restructurings. Then, we take an average of the obtained statistics across restructuring observations.

2.2 Empirical Findings: Four Stylized Facts

We merge our newly-constructed data with the existing dataset on the duration and strategies (preemptive or post-default) of restructurings from Asonuma and Trebesch (2016). Asonuma and Trebesch (2016) differentiate post-default episodes (111 cases covering 62 percent of all episodes)—the government defaults first and renegotiates its debt—from preemptive exchanges—renegotiations take place prior to a payment default. Our findings for post-default debt restructurings in 1978–2010 can be summarized in four main stylized facts.[11]

- ***Stylized fact 1: Public investment experiences a severe decline and slow recovery around restructurings.***

Figure 1: Public Investment around Restructurings

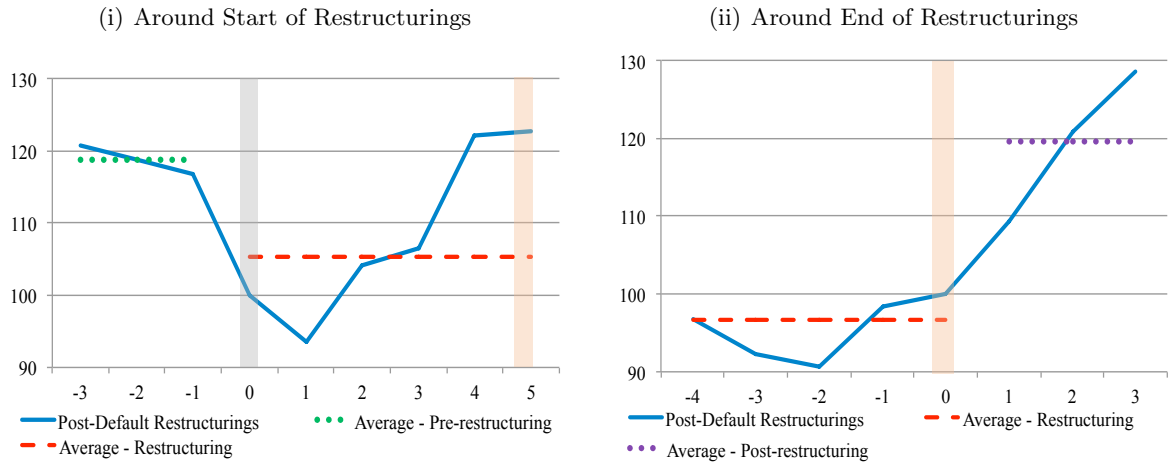


Figure 1 shows the dynamics of public investment around restructurings. In panels (i) and (ii), the start and end of the crisis—the default or restructuring announcement for the start and the debt exchange for the end defined in Asonuma and Trebesch (2016)—are marked by gray and pink vertical bars, respectively. Public investment is in real and level terms and is normalized at levels at the start and end of debt crisis. The blue solid lines show an average for all post-default restructuring episodes for which public investment is available in our dataset. The green dotted (pre-restructuring), red dashed (restructuring), and purple dotted (post-restructuring) lines show an average for all post-default restructuring episodes.

Panel (i) shows that public investment declines markedly at the onset of debt crisis (year 0) and stays below the pre-crisis level in the subsequent years. Public investment only recovers to the pre-crisis level in year 4, leading to the debt settlement in year 5. Average investment in the restructuring period (red dashed line) is significantly lower than that in the pre-restructuring

[11] Our findings relate to empirical literature on sovereign debt restructurings. See Benjamin and Wright (2013), Sturzenegger and Zettelmeyer (2006, 2008), Reinhart and Rogoff (2009, 2011), Cruces and Trebesch (2013), Kaminsky and Vega-Garcia (2016), Reinhart and Trebesch (2016), Asonuma and Trebesch (2016), and Asonuma and Joo (2019).

period (green dotted line). Panel (ii) shows that public investment increases steadily after the settlement (year 0). Average investment in the post-restructuring period (purple dotted line) is significantly higher than that in the restructuring period (red dashed line). When we measure public investment as percent of GDP, we also observe the same pattern: a severe decline and slow recovery in public investment-to-GDP ratio (Figure B1 in Appendix B1). Moreover, private investment and capital growth rate follow the same dynamics as public investment and capital growth rate (Figure B2 in Appendix B2).

- ***Stylized fact 2: Public consumption and transfers experience a short-lived decline and quick recovery around restructurings.***

Figure 2: Public Consumption and Transfers

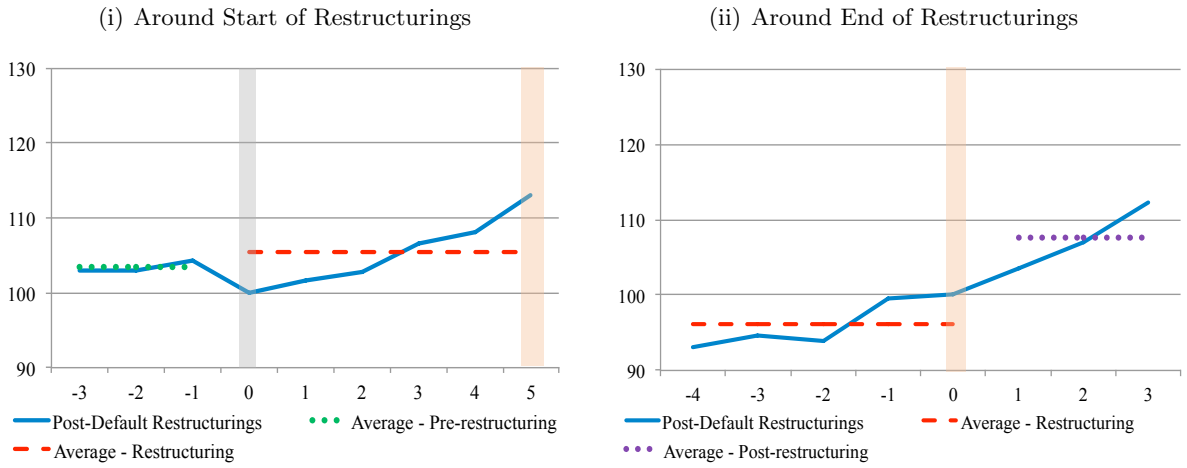


Figure 2 shows the dynamics of public consumption and transfers around restructurings. We follow the same presentation approach as in Figure 1 in terms of time horizon, timing of events (both start and end of debt crisis), scale (real and level), normalization of the series at levels at the two events, and average in the three periods. Panel (i) shows that public consumption and transfers fall temporarily at the onset of default (year 0). At the same time, public consumption and transfers recover quickly and reach the pre-crisis level in year 2. Due to both temporal decline and quick recovery, average public consumption and transfers in the restructuring period (red dashed line) are slightly higher than that in the pre-restructuring period (green dotted line). Panel (ii) shows that public consumption and transfers increase mildly after the settlement (year 0). Average consumption and transfers in the post-restructuring period (purple dotted line) is significantly higher than that in the restructuring period (red dashed line). When we measure public consumption and transfers as percent of GDP, we also observe the same pattern: a temporal decline and quick recovery in public consumption and transfers-to-GDP ratio (Figure B1 in Appendix B1).

A contrast between Figures 1 and 2 shows a substantial difference in the dynamics of public consumption and transfers, and investment. Public investment experiences a severe decline and

slow recovery, while public consumption and transfers experience a short-lived decline and quick recovery.

To obtain more systemic and robust evidence—not contaminated by the effects of business cycles—we apply a standard panel fixed effects regression of public investment, consumption, and transfers (all measured as a deviation from the trend) for post-default restructurings reported in Table 2. We use two measures of public investment: (i) public investment deviation from the trend, and (ii) growth rate of public capital. Main explanatory variables are dummy variables for restructuring and post-restructuring periods, and lagged public and publicly-guaranteed (PPG) external debt (in percent of GDP) from the WB World Development Indicators (WDI) database. GDP deviation from the trend is included to control the effects of business cycles.

Table 2: Public Investment, Captal, Consumption, and Transfers around Restructurings

	Public Investment	Public Capital	Public Consumption	Public Transfers
	deviation from trend, current[3/]	percentage change, current[4/]	deviation from trend, current[3/]	deviation from trend, current[3/]
	(1)	(2)	(3)	(4)
	coef/se	coef/se	coef/se	coef/se
Restructuring period (current, dummy)[1/]	-0.14***	-1.26***	0.007	-0.02
	(0.03)	(0.23)	(0.011)	(0.03)
Post-restructuring period (current, dummy)[2/]	-0.07**	-0.87***	0.003	-0.04
	(0.03)	(0.24)	(0.012)	(0.03)
PPG external debt (lagged, percent of GDP)	-0.0007***	-0.01***	0.00003	0.000005
	(0.003)	(0.002)	(0.0001)	(0.0002)
GDP deviation from trend (current, percent)[3/]	0.03***	0.07***	0.011***	0.012***
	(0.003)	(0.03)	(0.001)	(0.003)
Constant	0.10***	4.18***	-0.008*	0.01
	(0.03)	(0.21)	(0.01)	(0.03)
Episode-specific fixed effects	Yes	Yes	Yes	Yes
Number of restructuring episodes	97	96	92	81
Number of observations	1,043	996	949	747
F-statistics	37.94	21.39	19.59	4.02
R^2	0.139	0.087	0.084	0.024

Notes: The table shows results from fixed effects OLS regressions. The dependent variables are public investment deviation from the trend in column (1), public capital percentage change in column (2), public consumption deviation from the trend in column (3), and public transfers deviation from the trend in column (4). The main explanatory variables are dummy variables for restructuring and post-restructuring periods, and lagged public and publicly-guaranteed (PPG) external debt (in percent of GDP). Significance levels are denoted by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, respectively. All regressions include episode-specific fixed effects. Robust standard errors clustered on the episode level are in parentheses.
[1/] A dummy variable for restructuring period is set 1 in the restructuring period and 0 in both the pre- and post-restructuring periods.
[2/] A dummy variable for post-restructuring period is set 1 in the post-restructuring period and 0 in both the pre-restructuring and restructuring periods.
[3/] A deviation from the trend is a percentage deviation from the trend obtained by applying a Hodrick-Prescott (HP) filter to annual series with filter of 6.25.
[4/] Percentage change of public capital from its level in the previous year.

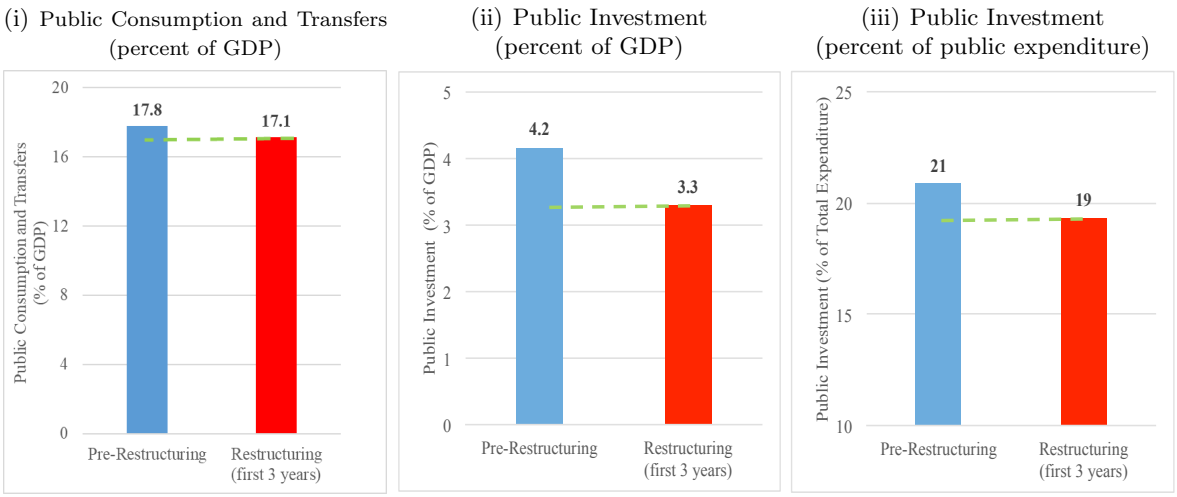
The main result reported in Table 2 is that public investment—measured both as a deviation from the trend and as a percentage change in public capital—is significantly lower in the restructuring period than that in the pre-restructuring period (columns 1 and 2). Quantitatively, on

average, public capital growth rate is lower by 1.3 percent in the restructuring period than that in the pre-restructuring period. Public investment is significantly higher in the post-restructuring period than that in the restructuring period (though lower than that in the pre-restructuring period). The second result concerns the effect of public external debt on public investment: public investment is negatively and significantly correlated with public external debt, i.e., "sovereign debt overhang effects". Our innovation here is to find the evidence of sovereign debt overhang in emerging market and low-income countries (EM and LIC) during debt crisis. Currently, the empirical literature focuses only on sovereign debt overhang phenomena in advanced economies (Reinhart et al. 2012; Ostry et al. 2015).

On the contrary, neither public consumption nor transfers in the restructuring period differs significantly from that in the pre- or post-restructuring periods (columns 3 and 4). Furthermore, both consumption and transfers are positively and insignificantly correlated with public external debt.

- ***Stylized fact 3: Public expenditure skews heavily towards consumption and transfers during restructurings.***

Figure 3: Public Expenditure Composition around Restructurings



Panels (i) and (ii) in Figure 3 show average changes in public consumption and transfers, and investment, respectively—measured as percent of GDP—between the pre-restructuring and restructuring periods for all post-default restructuring episodes. To be comparable with average in the pre-restructuring period, we take the average over the first 3 years during debt restructurings. Public consumption and transfers-to-GDP ratio differs only marginally, i.e., 0.7 percent of GDP on average between the pre-restructuring and restructuring periods—equivalent to 4 percent of pre-restructuring consumption and transfers-to-GDP ratio. On the contrary, public investment-to-GDP ratio differs substantially, i.e., 0.9 percent of GDP on average between the pre-restructuring and restructuring periods—equivalent to 21 percent of pre-restructuring investment-to-GDP ratio.

Panel (iii) in Figure 3 shows that the share of public investment in public expenditure is reduced to 19 percent in restructuring period—the decline is equivalent to 7 percent of pre-restructuring share of public investment. Public expenditure skews heavily towards consumption and transfers during debt restructurings.

Table 3: Public Expenditure Composition around Restructurings

	Public Investment	Public Consumption	Public Transfers	Public Investment
	percent of GDP, current	percent of GDP, current	percent of GDP, current	percent of expenditure, current
	(1)	(2)	(3)	(4)
	coef/se	coef/se	coef/se	coef/se
Restructuring period (current, dummy)[1/]	-0.85***	-0.79*	0.38**	-2.23***
	(0.18)	(0.44)	(0.18)	(0.80)
Restructuring period*PPG external debt	-0.003**	-0.005	-0.009	-0.004
(lagged, percent of GDP)[2/]	(0.001)	(0.003)	(0.001)	(0.005)
Post-restructuring period (current, dummy)[3/]	-0.47*	-1.04	0.38	-0.58
	(0.27)	(0.65)	(0.26)	(1.19)
Post-restructuring period*PPG external debt	-0.006*	-0.015**	-0.0006	-0.008
(lagged, percent of GDP)[4/]	(0.003)	(0.007)	(0.003)	(0.013)
GDP deviation from trend (current, percent)[5/]	0.03**	0.02	0.03*	0.08
	(0.02)	(0.04)	(0.02)	(0.08)
Constant	4.23***	13.08***	2.99***	22.58***
	(0.12)	(0.31)	(0.12)	(0.56)
Episode-specific fixed effects	Yes	Yes	Yes	Yes
Number of restructuring episodes	95	93	93	91
Number of observations	1,028	882	882	863
F-statistics	13.47	7.46	1.89	3.79
R^2	0.068	0.045	0.012	0.024

Notes: The table shows results from fixed effects OLS regressions. The dependent variables are public investment (percent of GDP) in column (1), public consumption (percent of GDP) in column (2), public transfers (percent of GDP) in column (3), and public investment (percent of public expenditure) in column (4). The main explanatory variables are dummy variables for restructuring and post-restructuring periods, and interactive terms of dummy variables for restructuring and post-restructuring periods and lagged PPG external debt (percent of GDP). Significance levels denoted by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, respectively. All regressions include episode-specific fixed effects. Robust standard errors clustered on the episode level in parentheses.
[1/] A dummy variable for the restructuring period is set 1 in the restructuring period and 0 in both the pre- and post-restructuring periods.
[2/] An interactive term of dummy variable for the restructuring period and lagged public and publicly guaranteed debt (percent of GDP).
[3/] A dummy variable for the post-restructuring period is set 1 in the post-restructuring period and 0 in both the pre-restructuring and restructuring periods.
[4/] An interactive term of dummy variable for the post-restructuring period and lagged public and publicly guaranteed debt (percent of GDP).
[5/] A deviation from the trend is a percentage deviation from the trend obtained by applying a Hodrick-Prescott (HP) filter to annual series with filter of 6.25.

Table 3 provides econometric support for this stylized fact. It reports results of panel fixed effects regression of public expenditure components (both in percent of GDP and percent of public expenditure) for post-default restructurings. We also use GDP deviation from the trend to control the effects of business cycles.

Public investment, on average, is significantly reduced in the restructuring period (column 1): by 0.9 percent of GDP equivalent to 20 percent of estimated average public investment. Moreover, the reduction in public investment is larger when public external debt is high. The sum of these two terms correspond to "sovereign debt overhang effects during debt restructurings".

This is a new finding in the empirical literature on sovereign debt overhang.

Public consumption, on average, is less remarkably reduced in the restructuring period (column 2): by 0.8 percent of GDP equivalent to 6 percent of estimated average public consumption. The reduction in public consumption is not significantly associated with level of public external debt. In contrast, public transfers, on average, are significantly increased in the restructuring period: by 0.4 percent of GDP equivalent to 13 percent of estimated average public transfers. The increase in public transfers is not significantly associated with level of public external debt. These are consistent with scatter plots on public external debt and public expenditure components in Figure B4 in Appendix B.3.

Most importantly, as a result of these changes in public expenditure components, column 4 shows that share of public investment in public expenditure is significantly lower (by 2.2 percent of public expenditure) in the restructuring period than that in the pre-restructuring period.

- ***Stylized fact 4: Sharp declines in public investment are associated with longer delays in restructurings.***

Figure 4: Declines in Public Investment and Duration of Restructurings

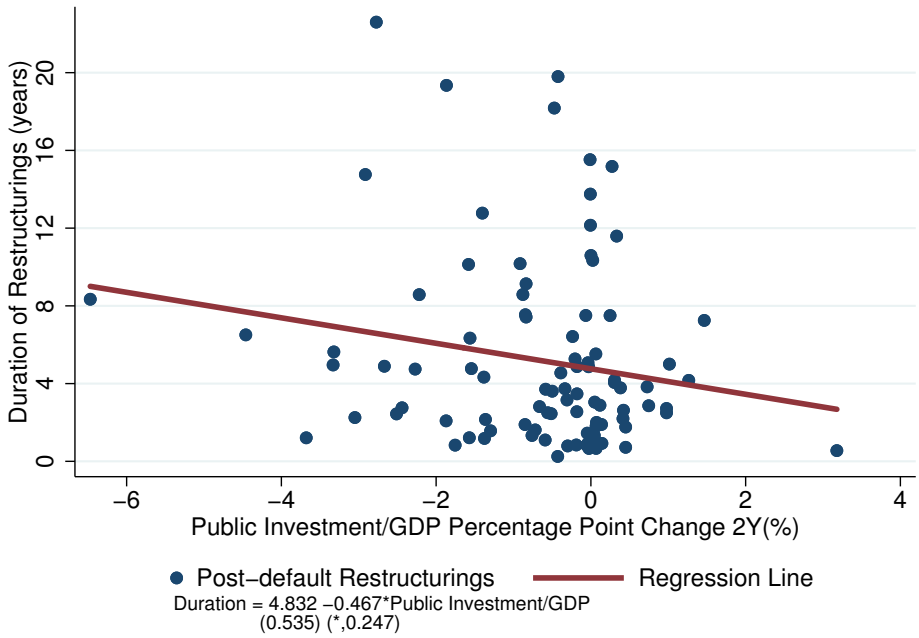


Figure 4 shows a scatter plot of the duration of restructurings and the declines in public investment at the start of restructurings—measured in percentage point change of public investment-to-GDP ratio over two years from the pre-restructuring year (year -1) to one year after the start of restructurings (year 1).[12] Duration of restructurings and the declines in pub-

[12]The stylized facts presented in this subsection are not necessarily causal. We do not claim to identify an effect from the sovereign's public expenditure choice to the outcome of restructurings i.e., duration.

lic investment are negatively correlated as shown by a downward-sloping fitted line. It shows that restructurings are protracted when sovereign debtors experience severe declines in public investment.

The negative correlation is also supported by Table B1 in Appendix B.4 which reports cross-sectional regression results of restructuring duration for all post-default restructuring episodes. We use several measures of declines in public investment: (i) percentage point changes in public investment-to-GDP ratio over the first two and one years, respectively; (ii) a percentage change in public investment (level) over the first two years. Column (1) shows results for a bare-bones model with declines in public investment. In columns (2)–(4), we add a conventional set of controls for duration of restructurings used in the empirical literature on sovereign debt (Kohlscheen 2010; Trebesch 2018; Bai and Zhang 2012; Asonuma and Joo 2019). The set includes (i) the debtors' macroeconomic variables—GDP deviation from the trend obtained by applying a Hodrick-Prescott (H-P) filter, external debt-to-GDP ratio, export-to-debt service ratio (all at the end of restructurings), and a dummy variable for an IMF-supported program—; (ii) pre-restructuring level of public capital. (iii) a global variable, e.g., London Interbank Offered Rate (LIBOR), and (iv) a restructuring method variable such as a dummy variable for bond exchanges.

Regression results confirm the robustness of the negative correlation between the declines in public investment and duration of restructurings for alternative measures of declines in public investment. Moreover, the negative correlation between the declines in public investment and duration of restructurings is approximately the same under cases where we deal with outliers in the sample of duration and declines in public investment as reported in Table B2 in Appendix B.4.

3 Theoretical Model

3.1 Summary of Theoretical Findings

Our theoretical model is built for shedding light on the role of public capital and sovereign debt overhang on sovereign debt crises and resolution. In particular, our model of sovereign debt embeds explicitly both endogenous public capital accumulation, expenditure composition and production, and post-default multi-round renegotiations with a risk averse sovereign and its risk-neutral creditors. It replicates the aforementioned stylized facts. To account for different economic situations for sovereign debtors, we take a two-step approach. At the first stage, we use a conventional small open economy model with sovereign debt and fiscal policy—private and public sectors are separated by distortionary consumption tax and two different consumption goods (Cuadra et al. 2010; Arellano and Bai 2017)—as benchmark and derive main results in Sections 3, 4, and 5. At the second stage, we incorporate each of the specific assumptions used in the previous studies (Aguiar and Gopinath 2006; Yue 2010; Benjamin ad Wright 2013; Arellano and Bai 2017) in our framework and show robustness of our model in Appendix C.

First, the model makes predictions about the role of public capital on the sovereign's choice of default, debt settlement, and restructuring delays. *After default*, the sovereign is willing to delay renegotiations, ceteris paribus, when public capital is low. It opts to invest in public capital rather than use resources for recovered debt payments given the high marginal product of public capital. As a result, debt settlement and restructuring delays are driven not only by the recovery of repayment capacity (Benjamin and Wright 2013; Bi 2008)—corresponding to recovery of productivity and an associated response of labor in our model—but also the marginal product of public capital.[13] The second driver differentiates our paper from previous studies.

Before default, the sovereign's willingness to repay is independent of level of public capital. On the one hand, ex ante, higher public capital improves the sovereign's repayment capacity, i.e., output ("smoothing channel"). On the other hand, ex post (conditional on default), higher public capital also improves household utility by smoothing consumption in financial autarky ("autarky channel") and achieves the debt settlement ("debt renegotiation channel"). In total, the net effect of public capital through these three channels on repayment and default is balanced. This is because through the debt renegotiation channel, higher public capital reduces default costs (i.e., shorter period of financial exclusion) making default equally attractive as repayment. The debt renegotiation channel, newly introduced in our model, differentiates our model from Gordon and Guerron-Quintana (2018).

Second, the model provides predictions on sovereign debt overhang, which also explain our main empirical findings. Previous studies (e.g., Aguiar et al. 2009) explain the sovereign debt overhang in the pre-default phase, when the sovereign maintains market access by servicing high external debt. We extend our analysis to the restructuring phase, when the sovereign loses

[13]There is no immediate settlement with new lending due to limited commitment (Benjamin and Wright 2013). This is because when the sovereign's repayment capacity has not fully recovered due to low productivity, the creditors anticipate that the sovereign is more likely to default on newly issued debt and thus, are less willing to settle and lend to the sovereign.

market access due to default, thus allowing for a persistent impact of default (i.e., loss in market access) on public investment. *In the pre-default phase*, both low productivity and high external debt payments interact with the sovereign's consumption-smoothing motive and impatience. Despite maintaining market access, the interaction of these factors results in a sharp decline in public investment. This is because the impatient government, with consumption-smoothing motive, is willing to stabilize public consumption and transfers to improve household utility. This, in turn, leads to debt accumulation, and later to a default (Aguiar et al. 2009).[14]

In the restructuring phase, slow recovery of productivity, prohibition on external borrowing, and the government's consumption smoothing motive and impatience generate both slow public capital accumulation and lengthy renegotiations which interact with each other. Public capital accumulation is slow both because external borrowing is prohibited until the government reaches a settlement with its creditors, and because the impatient government with consumption-smoothing motive continues to be willing to stabilize public consumption and transfers for household utility. Debt renegotiations are delayed because of both the high marginal product of public capital owing to slow accumulation, and slow recovery of productivity. This cycle continues until the sovereign accumulates public capital to a high level and reaches the debt settlement.

3.2 General Points

There are four agents in the model: a household, a firm, a sovereign (government), and foreign creditors.[15] The sovereign is risk averse and cannot affect the global risk-free interest rate (r^*). Foreign creditors are risk neutral. They can borrow or lend as much as needed at the constant risk-free interest rate in the international capital market.

In each period, a stochastic productivity shock a_t materializes. It is stochastic, drawn from a compact set $A = [a_{min}, a_{max}] \subset R$. $\mu(a_{t+1}|a_t)$ is a probability distribution of a shock a_{t+1} conditional on its previous realization a_t. In addition, the sovereign has a credit record $h_t \in [0, 1]$, which indicates whether it has maintained access to the market ($h_t = 0$) or whether it has lost market access due to default ($h_t = 1$).

After observing the productivity shock, the sovereign receives consumption tax revenues and decides expenditure composition—public consumption, investment and transfers—together with its choice of repayment and default (settlement and delay), and of external borrowing. Consumption tax revenues are determined by the household's optimal choice of private consumption given a constant consumption tax rate. Public consumption and transfers are provided to the household to improve his utility directly or indirectly by smoothing private consumption, respectively. Public capital rented to the firm is accumulated through net investment and is subject to both depreciation and adjustment costs (Gordon and Guerron-Quintana 2018).

The household receives profits from the firm, and public consumption and transfers from the government, respectively. He then chooses private consumption and labor supply, and pays

[14]The government's impatience can be explained by political myopia (Amador 2012; Cuadra and Sapriza 2008; Chatterjee and Eyigungor 2019).

[15]In this theoretical and quantitative analysis, the term sovereign corresponds to the government.

taxes to the government. The firm chooses labor demand, produces consumption goods using labor and public capital—private capital is assumed to be constant (e.g., Mendoza and Yue 2012; Azzimonti 2015)—, and pays profits to the household.

The sovereign bond market is incomplete. The sovereign can borrow and lend only via one-period, zero-coupon sovereign bonds.[16] b_{t+1} denotes the amount of bonds to be repaid in the next period whose set is shown by $B = [b_{min}, b_{max}] \subset R$ where $b_{min} \leq 0 \leq b_{max}$. We set the lower bound for the sovereign's bond holding at $b_{min} > -y_{max}/r^*$, which is the largest debt that the sovereign can repay. The upper bound b_{max} is the high level of assets that the sovereign may accumulate.[17] We assume $q(b_{t+1}, k^g_{t+1}, 0, a_t)$ to be price of sovereign bonds with the sovereign's asset position b_{t+1}, public capital k^g_{t+1}, a good credit record ($h_t = 0$), and a productivity shock a_t. The bond price is determined in equilibrium.

We assume that the creditors always commit to repay their debt. However, the sovereign is free to decide whether to repay its debt or to default. If the sovereign chooses to repay its debt, it will preserve access to the international capital market in the next period. On the contrary, if it chooses to default, it is then subject to both exclusion from the international capital market and direct productivity loss.[18,19] When a default occurs, the sovereign and the creditors negotiate a reduction of unpaid debt via multi-round bargaining. At the renegotiation, one party, who is randomly selected with exogenous and constant probability, chooses whether to propose an offer with haircuts (recovery rates) or to pass its option. The other party decides whether to accept or reject the offer. If the offer with haircuts is proposed and accepted, then the sovereign regains access to the international capital market in the next period ($h_{t+1} = 0$), and the creditors receive recovered debt payments. Otherwise, both parties continue the negotiation over debt in arrears in the next period.

In order to avoid permanent exclusion from the international capital market and direct productivity loss, the sovereign has an incentive to renegotiate over haircuts. Similarly, the creditors are also willing to renegotiate over the reduction of unpaid debt because they prefer

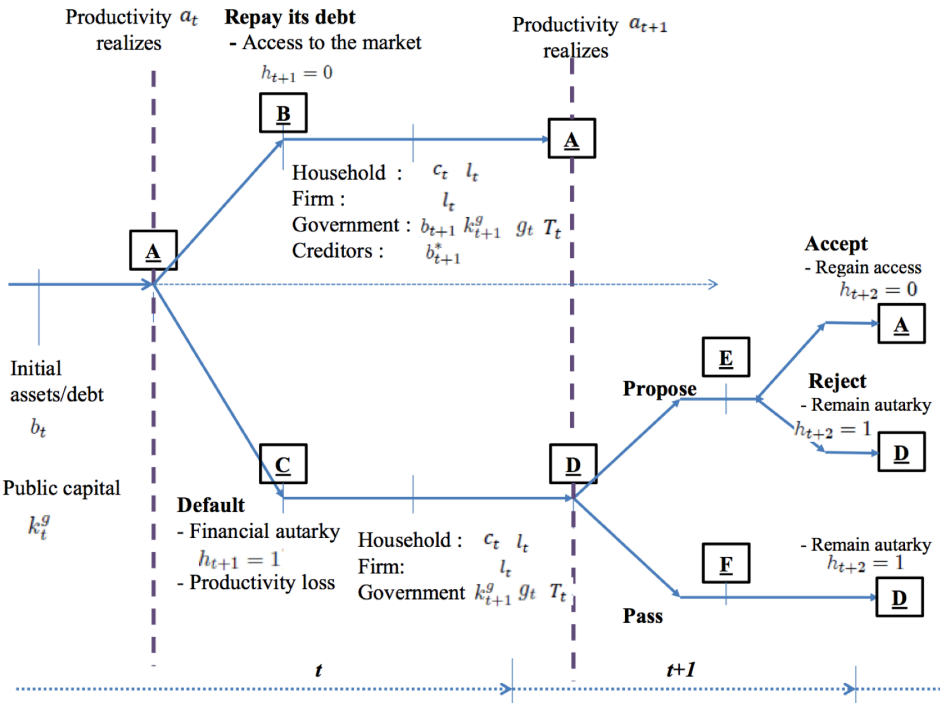
[16]Our model of debt renegotiations with one-period bonds follows Benjamin and Wright (2013), Bi (2008), and Yue (2010). Relaxing the model to include long-duration bonds does not provide additional insights but increases technical difficulty to track the model. This is because old bonds are exchanged with new bonds with the same maturity and smaller outstanding (debt stock), i.e., no change in maturity structure of bonds due to an exchange (Hatchondo et al. 2014; Sunder-Plassmann 2018). See Hatchondo and Martinez (2009), Arellano and Ramanarayanan (2012), and Chatterjee and Eyingungor (2012) for long-duration bond models without debt renegotiations, and Sanchez et al. (2018) and Dvorkin et al., (2019) for endogenous maturity choice.

[17]b_{max} exists when the interest rate on the sovereign's savings is sufficiently low compared to the discount factor, which is satisfied as $(1 + r^*)\beta < 1$.

[18]The direct productivity loss assumption in our production model is conceptually equivalent to "output costs" assumption in the conventional endowment model (e.g., Arellano 2008; Aguiar and Gopinath 2006; Yue 2010). In this regard, the direct production loss is widely accepted in the sovereign debt literature with endogenous production (Cuadra et al. 2010; Arellano and Bai 2017; Gordon and Guerron-Quintana 2018). Both assumptions are broadly in line with empirical estimates of output loss at the time of default and restructuring (Sturzenegger 2004; Tomz and Wright 2007, Borensztein and Panizza 2009; De Paoli et al. 2009; Levy-Yeyati and Panizza 2011; Asonuma and Trebesch 2016; Trebesch and Zabel 2017; Asonuma et al. 2019).

[19]Mendoza and Yue (2012) provide micro-foundation of this conventional assumption that exclusion from credit markets leads to losses in production efficiency due to a lack of imported inputs and labor reallocation away from final goods production.

Figure 5: Timing of Model



to maximize the recovered debt payments.

3.3 Timing of the Model

Figure 5 summarizes the timing of decisions within each period.

1. The sovereign starts the current period with initial assets/debt and public capital. We are in node (A).

2. A productivity shock (a_t) realizes. The sovereign decides whether to repay its debt or to default.

3. (a) In node (B) (repayment node), if repayment is chosen, we move to the upper branch of a tree. The sovereign maintains market access ($h_{t+1} = 0$) and chooses assets/debt, public consumption, capital and transfers. Default risk is determined and foreign creditors choose sovereign bonds in the next period. The sovereign bond price is determined in the market. The household chooses his private consumption and labor supply, and the firm chooses labor demand. We proceed to node (A) in the next period.

   (b) In node (C) (default node), if default is chosen, we move on to the lower branch of a tree. The sovereign loses access to the international capital market ($h_{t+1} = 1$), suffers the direct productivity loss, and chooses public consumption, capital and transfers.

The household chooses his private consumption and labor supply, and the firm chooses labor demand.

4. A productivity shock (a_{t+1}) realizes.

5. In node (D) (default node), with constant probability, the sovereign has an opportunity to propose an offer to its creditors. Otherwise, the creditors have an opportunity to propose an offer to the sovereign. The proposer decides whether to propose an offer or to pass.

6. (a) In node (E) (propose node), if the proposer chooses to propose, the counterpart decides whether to accept or reject the offer. If the counterpart accepts the offer, the sovereign regains market access in the next period ($h_{t+2} = 0$). We move back to node (A) in the next period. On the contrary, if the counterpart rejects the offer, the sovereign remains in autarky ($h_{t+2} = 1$). We move back to node (D).

   (b) In node (F) (pass node) if the proposer chooses to pass, the sovereign remains in autarky ($h_{t+2} = 1$). We move back to node (D).

4 Recursive Equilibrium

4.1 Household's Problem

This section defines the stationary recursive equilibrium of our model. A representative household maximizes a standard time-separable utility function:

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t, l_t, g_t)$$

$$where \quad U(c_t, l_t, g_t) = (1-\lambda)u(c_t, l_t) + \lambda v(g_t)$$

where $0 < \beta < 1$ is a discount factor and c_t, l_t, g_t denote private consumption, labor supply and public consumption in period t, respectively. $U(\cdot)$ is the period utility function, which is separable between a multiple of private consumption and labor supply, and public consumption. Both $u(\cdot)$ and $v(\cdot)$ are continuous, strictly increasing, strictly concave, and satisfy the Inada conditions. λ denotes the weight on public consumption in the household's utility function.

The household takes as given the wage rate w_t, profits paid by a firm π_t^F, public transfers T_t, public consumption g_t and a consumption tax rate τ, and chooses private consumption and labor supply.[20] He does not borrow directly from abroad, but the government borrows, provides public consumption and transfers, and makes default decisions internalizing the household's utility.[21] The household's optimization problem is written as:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t [(1-\lambda)u(c_t, l_t) + \lambda v(g_t)] \tag{1}$$

$$s.t. \quad (1+\tau)c_t = w_t l_t + \pi_t^F + T_t \tag{2}$$

The consumption tax rate is assumed to be constant (Arellano and Bai 2017; Alfaro and Konczuk 2016)—also supported by empirical findings on value-added taxes in developing countries in Gunter et al. (2017).

The optimality condition of the household is shown as follows:

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{w_t}{1+\tau} \tag{3}$$

[20] Relaxing the model to include labor income tax does not provide additional insights (Arellano and Bai 2017; Mendoza et al. 2014) as shown in Figure C5 in Appendix C. This is because, labor income tax is conceptually identical to consumption tax; both labor income tax and consumption tax affect the household's intra-temporal substitution between consumption and labor as reported in equation (3), but not the sovereign's inter-temporal substitution between consumption—public consumption and transfers—and saving (i.e., public investment).

[21] Though the household lacks access to the international capital market as in the conventional sovereign debt models, there are still three methods available for him to improve utility: (i) private consumption through public transfers, (ii) public consumption and (iii) the choice of labor supply.

4.2 Firm's Problem

A representative firm chooses labor demand l_t for goods production given the productivity shock a_t, public capital stock k_t^g, and fixed private capital stock $k^p(=1)$. The production function is Cobb-Douglas shown as:

$$y_t = a_t(l_t)^{\alpha_l}(k_t^g)^{\alpha_k}(\bar{k}^p)^{1-\alpha_l-\alpha_k} \tag{4}$$

where $0 < \alpha_l, \alpha_k < 1$. Appendix C relaxes the assumption of fixed private capital stock allowing for the production function to have either decreasing or constant returns to scale, and shows that our main qualitative results remain robust.

The firm's optimization problem is written as follows:

$$\max_{l_t} \pi_t^F = a_t(l_t)^{\alpha_l}(k_t^g)^{\alpha_k}(\bar{k}^p)^{1-\alpha_l-\alpha_k} - w_t l_t \tag{5}$$

The optimality condition of the firm is shown as follows:

$$w_t = \alpha_l a_t(l_t)^{\alpha_l-1}(k_t^g)^{\alpha_k}(\bar{k}^p)^{1-\alpha_l-\alpha_k} \tag{6}$$

4.3 Sovereign's Problem

The sovereign maximizes its expected lifetime utility, and its value function is denoted by $V(b_t, k_t^g, h_t, a_t)$. First, we start with the problem when the sovereign has a good credit record ($h_t = 0$).

For $b_t \geq 0$ ($h_t = 0$) where the sovereign has savings, it receives tax revenues from the household and debt repayments from the creditors, and determines public consumption, capital and transfers, and the level of assets/debt in the next period.[22]

$$V(b_t, k_t^g, 0, a_t) = \max_{g_t, b_{t+1}, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V(b_{t+1}, k_{t+1}^g, 0, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{7}$$

$$s.t. \quad g_t + k_{t+1}^g + T_t + q(b_{t+1}, k_{t+1}^g, 0, a_t)b_{t+1} = \tau c_t + (1-\delta^g)k_t^g - \frac{\Omega}{2}\left(\frac{k_{t+1}^g - k_t^g}{k_t^g}\right)^2 k_t^g + b_t \tag{8}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{\alpha_l a_t(l_t)^{\alpha_l-1}(k_t^g)^{\alpha_k}(\bar{k}^p)^{1-\alpha_l-\alpha_k}}{1+\tau} \tag{10}$$

$$(1+\tau)c_t = y_t + T_t \tag{11}$$

[22] In this case, two assets—external bonds with risk-free returns and investment with state-dependent their returns—co-exist due to a state-dependent difference in returns, and the sovereign optimally allocates its savings according to their returns.

where equation (8) is the budget constraint for the sovereign where it receives consumption tax revenues τc_t, post-adjustment cost public capital stock $(1-\delta^g)k_t^g - \frac{\Omega}{2}(\frac{k_{t+1}^g - k_t^g}{k_t^g})^2 k_t^g$—non-linear adjustment costs are assumed and δ^g is the depreciation rate of public capital—and savings b_t, and allocates to public consumption g_t, capital k_{t+1}^g, transfers T_t and assets/debt in the next period $q(b_{t+1}, k_{t+1}^g, 0, a_t)b_{t+1}$.[23] Equation (9) is the "non-lump sum taxation constraint"—which corresponds to "fiscal constraint" in Arellano and Bai (2017)—indicating a limitation of the government from transferring resources from the private sector. Mechanically, the government can freely transfer positive net borrowing through transfers, but cannot extract more resources from the private sector beyond the distortionary consumption tax revenues. Equations (10) and (11) denote the combined optimality condition and budget constraint for both the household and the firm, respectively.

For $b_t < 0$ ($h_t = 0$), where the sovereign has debt, it decides whether to repay or to default after observing its productivity shock. If the sovereign decides to repay its debt, it determines public consumption, capital and transfers, and the level of assets/debt in the next period. In contrast, if the sovereign chooses to default, it will be excluded from the international capital market and its credit record deteriorates to $h_{t+1} = 1$, with debt in arrears $b_{t+1} = (1+r^*)b_t$ in the next period. After suffering the direct productivity loss, the sovereign determines public consumption, capital, and transfers.

$$V(b_t, k_t^g, 0, a_t) = \max\left[V^R(b_t, k_t^g, 0, a_t), V^D(b_t, k_t^g, 0, a_t)\right] \tag{12}$$

where $V^R(b_t, k_t^g, 0, a_t)$ is its value associated with repayment:

$$V^R(b_t, k_t^g, 0, a_t) = \max_{g_t, b_{t+1}, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V(b_{t+1}, k_{t+1}^g, 0, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{7a}$$

$$s.t. \quad g_t + k_{t+1}^g + T_t + q(b_{t+1}, k_{t+1}^g, 0, a_t)b_{t+1} = \tau c_t + (1-\delta^g)k_t^g - \frac{\Omega}{2}(\frac{k_{t+1}^g - k_t^g}{k_t^g})^2 k_t^g + b_t \tag{8}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{\alpha_l a_t (l_t)^{\alpha_l - 1} (k_t^g)^{\alpha_k} (\bar{k}^p)^{1-\alpha_l - \alpha_k}}{1+\tau} \tag{10}$$

$$(1+\tau)c_t = y_t + T_t \tag{11}$$

and $V^D(b_t, k_t^g, 0, a_t)$ is its value associated with default:

$$V^D(b_t, k_t^g, 0, a_t) = \max_{g_t, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V((1+r^*)b_t, k_{t+1}^g, 1, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{13}$$

[23] Non-linear adjustment costs are assumed to replicate to smooth investment dynamics. Replacing with quadratic adjustment costs (i.e., Gordon and Guerron-Quintana 2018) provides the same qualitative results.

$$s.t. \quad g_t + k^g_{t+1} + T_t = \tau c_t + (1-\delta^g)k^g_t - \frac{\Omega}{2}(\frac{k^g_{t+1}-k^g_t}{k^g_t})^2 k^g_t \tag{8a}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t,l_t)}{u_c(c_t,l_t)} = \frac{\alpha_l \tilde{a}_t(l_t)^{\alpha_l - 1}(k^g_t)^{\alpha_k}(\bar{k}^p)^{1-\alpha_l-\alpha_k}}{1+\tau} \tag{10a}$$

$$(1+\tau)c_t = \tilde{y}_t + T_t \tag{11a}$$

where $\tilde{a}_t$ and $\tilde{y}_t = \tilde{a}_t(l_t)^{\alpha_l}(k^g_t)^{\alpha_k}(\bar{k}^p)^{1-\alpha_l-\alpha_k}$ denote the direct productivity loss and its associated output.

The sovereign's default policy can be characterized by default set $D(b_t, k^g_t, 0) \subset A$. It is a set of productivity shocks a_t at which default is optimal:

$$D(b_t, k^g_t, 0) = \{a_t \in A : V^R(b_t, k^g_t, 0, a_t) < V^D(b_t, k^g_t, 0, a_t)\} \tag{14}$$

Next comes the sovereign's problem with a bad credit record with debt in arrears ($h_t = 1$ & $b_t < 0$). The sovereign is currently excluded from the international market, suffers the direct productivity loss, and may settle on recovery rates through renegotiations with the creditors. The renegotiation process determines endogenously both recovery rates and length of financial autarky. Its value, denoted by $V(b_t, k^g_t, 1, a_t)$, is an expected payoff that the sovereign obtains from the bargaining which starts in period t:

$$V(b_t, k^g_t, 1, a_t) = \Gamma(b_t, k^g_t, a_t) \tag{15}$$

4.4 Debt Renegotiation

The debt renegotiation takes the form of a two-player stochastic bargaining game with complete information as in Merlo and Wilson (1995).[24] It is a multi-round stochastic bargaining game in that both the productivity process of the sovereign debtor and the identity of the proposer are stochastic. The creditors' incentive to delay the settlement is identical to that in previous studies on multi-round renegotiations (Benjamin and Wright 2013; Bi 2008): the risk-neutral creditors (with constant discount rate), who care only about recovery rates in present value terms, prefer to wait for the sovereign's willingness to repay high recovered debt payments.[25]

More importantly, however, the sovereign's incentive to delay the settlement clearly differentiates our model from these previous papers: in their models, the sovereign is willing to wait for recovery of repayment capacity, i.e., output which follows an exogenous process. In contrast, in our model, what determines the sovereign's choice of settlement and delay are not only the recovery of repayment capacity but also state-dependent benefits and costs of public

[24]While the bargaining game between two parties can be modeled in other different forms, we follow the conventional bargaining game in Merlo and Wilson (1995) for their simplicity and tractability.

[25]Asonuma and Joo (2019) consider the risk averse creditor whose consumption-smoothing motive is state-dependent. In their framework, the creditor's state-dependent consumption-smoothing motive influences not only the outcome, but also equally importantly, the timing of debt settlement.

investments, i.e., the marginal product of public capital. The sovereign opts to postpone the settlement because it prioritizes public capital accumulation over debt settlement—benefits of public investment outweigh costs—until public capital reaches a high level.

In every round, a state is realized and the proposer is randomly selected. For simplicity, each player has a constant probability of being selected as the proposer in each round of the negotiation. That is, the identity of the proposer is independent of the sovereign's productivity process. Let ϕ denote the probability that the borrower, B, can propose and $1-\phi$ denote the probability that the lender, L, can propose. The probability with which one of the players is selected as the proposer is a parsimonious way to reflect the bargaining power obtained through one's ability to enjoy the first-mover advantage. The proposer may either propose recovery rates (haircuts) or pass. If he proposes, then the counterpart chooses to accept or to reject the proposal.[26] If the proposal is accepted, then the sovereign repays its reduced debt arrears and resumes access to the international capital market in the next period ($h_{t+1} = 0$) with no outstanding debt. If the proposal is rejected, both parties repeat the bargaining game in the next period. If the proposer passes, both parties proceed to the next period and continue the bargaining game.

First, we define some basic concepts of the game. A stochastic bargaining game is denoted by $(C, \beta, 1/(1+r^*))$, where for each productivity process $a \in A$, $C(a)$ is the set of feasible utility vectors that may be agreed upon in that state. β and $1/(1+r^*)$ are the discount factors for B and L, respectively.[27] A payoff function is an element $\Delta(a) \in C(a)$, where $\Delta_i(a)$ is the utility to player i for $i = B, L$.

As in Merlo and Wilson (1995), we focus on a game with stationary strategies, that is, the players' actions depend only on the current state $(b_t, k_t^g, 1, a_t)$ where $h_t = 1$ and the current offer. In equilibrium, the proposer's strategy is to propose when the counterpart would accept for certain and to pass otherwise. In contrast, the counterpart's strategy is to accept when the proposal is made and to reject otherwise. Therefore, we can denote the proposer i's and the counterpart j's equilibrium strategies as follows: (a) $\theta_i(b_t, k_t^g, 1, a_t) = 1$ (propose) when the proposer i proposes and $\theta_j(b_t, k_t^g, 1, a_t) = 1$ (accept) when the counterpart j accepts the offer, or (b) $\theta_i(b_t, k_t^g, 1, a_t) = 0$ (pass) when the proposer i passes and $\theta_j(b_t, k_t^g, 1, a_t) = 0$ (reject) when the counterpart j rejects the offer.[28]

A stationary subgame perfect (SP) equilibrium is defined as the players' equilibrium stationary strategies θ and θ^*, and the payoff functions, Γ and Γ^* associated with these strategies for

[26] We assume that the proposer makes an offer that the counterpart accepts when the value of proposing is higher or equal to the value of passing, and passes otherwise. This assumption can get rid of trivial sources of multiplicity. See Merlo and Wilson (1995) and Ortner (2013) for the same treatment.

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

[28] Benjamin and Wright (2013) theoretically prove both existence and uniqueness of the equilibrium in the multi-round bargaining over defaulted debt.

player B and L. The expected payoffs for the borrower B and lender L in period t, are shown as:

$$\Gamma(b_t, k_t^g, a_t) = \phi\Gamma^B(b_t, k_t^g, a_t) + (1-\phi)\Gamma^L(b_t, k_t^g, a_t) \tag{16}$$

$$\Gamma^*(b_t, k_t^g, a_t) = \phi\Gamma^{*B}(b_t, k_t^g, a_t) + (1-\phi)\Gamma^{*L}(b_t, k_t^g, a_t) \tag{17}$$

Here, the superscript denotes the identity of the proposer: $\Gamma^B(\Gamma^{*B})$ represents the borrower's (lender's) payoff when the borrower is the proposer and $\Gamma^L(\Gamma^{*L})$ refers to the borrower's (lender's) payoff when the lender is the proposer.

First, we start with the case when the borrower B is the proposer. We denote the proposed debt recovery rates as δ_t^B, the borrower's values of proposing and passing as V^{PRO} and V^{PASS}, and the lender's values of accepting and rejecting as V^{*ACT} and V^{*REJ}, respectively. When the borrower B proposes and the proposal is accepted, the sovereign repays reduced debt arrears $-\delta_t^B b_t$ and resumes access to the international capital market in the next period with no outstanding debt as in Bi (2008). Appendix C and F relax the assumption of fully recovered debt payments at settlement allowing for net issuance as in Benjamin and Wright (2013) and show that our main qualitative and quantitative results remain robust.

$$V^{PRO}(b_t, k_t^g, a_t) = \max_{g_t, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V(0, k_{t+1}^g, 0, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{18}$$

$$s.t. \quad g_t + k_{t+1}^g + T_t = \tau c_t + (1-\delta^g)k_t^g - \frac{\Omega}{2}(\frac{k_{t+1}^g - k_t^g}{k_t^g})^2 k_t^g + \delta_t^B b_t \tag{8b}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{\alpha_l \tilde{a}_t (l_t)^{\alpha_l - 1} (k_t^g)^{\alpha_k} (\bar{k}^p)^{1-\alpha_l-\alpha_k}}{1+\tau} \tag{10a}$$

$$(1+\tau)c_t = \tilde{y}_t + T_t \tag{11a}$$

$$V^{*ACT}(b_t, k_t^g, a_t) = -\delta_t^B b_t \tag{19}$$

When the borrower B passes, both parties proceed to the next period with accumulated arrears $(1+r^*)b_t$.

$$V^{PASS}(b_t, k_t^g, a_t) = \max_{g_t, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V((1+r^*)b_t, k_{t+1}^g, 1, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{20}$$

$$s.t. \quad g_t + k_{t+1}^g + T_t = \tau c_t + (1-\delta^g)k_t^g - \frac{\Omega}{2}(\frac{k_{t+1}^g - k_t^g}{k_t^g})^2 k_t^g \tag{8a}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{\alpha_l \tilde{a}_t (l_t)^{\alpha_l - 1} (k_t^g)^{\alpha_k} (\bar{k}^p)^{1-\alpha_l-\alpha_k}}{1+\tau} \tag{10a}$$

$$(1+\tau)c_t = \tilde{y}_t + T_t \tag{11a}$$

$$V^{*REJ}(b_t, k_t^g, a_t) = \frac{1}{1+r^*} \int_A \Gamma^*((1+r^*)b_t, k_{t+1}^g, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{21}$$

In equilibrium where off-equilibrium paths are eliminated, the agreed recovery rates δ_t^{B*} satisfy the following:

$$\begin{aligned} \delta_t^{B*} &= argmax V^{PRO}(b_t, k_t^g, a_t) \\ s.t. \quad & V^{PRO}(b_t, k_t^g, a_t) \geq V^{PASS}(b_t, k_t^g, a_t) \\ & V^{*ACT}(b_t, k_t^g, a_t) \geq V^{*REJ}(b_t, k_t^g, a_t) \end{aligned} \tag{22}$$

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

$$\Gamma^B(b_t, k_t^g, a_t) = V^{PRO}(b_t, k_t^g, a_t) \tag{23}$$

$$\Gamma^{B*}(b_t, k_t^g, a_t) = V^{*ACT}(b_t, k_t^g, a_t) \tag{24}$$

Otherwise,

$$\Gamma^B(b_t, k_t^g, a_t) = V^{PASS}(b_t, k_t^g, a_t) \tag{23a}$$

$$\Gamma^{B*}(b_t, k_t^g, a_t) = V^{*REJ}(b_t, k_t^g, a_t) \tag{24a}$$

The renegotiation settlement can be characterized by settlement set $R^B(b_t, k_t^g) \subset A$. It is a set of productivity shocks a_t at which both parties reach an agreement:

$$R^B(b_t, k_t^g) = \left\{ \begin{array}{c} a_t \in A : V^{PRO}(b_t, k_t^g, a_t) \geq V^{PASS}(b_t, k_t^g, a_t) \\ V^{*ACT}(b_t, k_t^g, a_t) \geq V^{*REJ}(b_t, k_t^g, a_t) \end{array} \right\}. \tag{25}$$

Second, we consider the case when the lender L is the proposer. We denote the proposed debt recovery rates as δ_t^L, the borrower's values of accepting and rejecting as V^{ACT} and V^{REJ}, and the lender's values of proposing and passing as V^{*PRO} and V^{*PASS}, respectively. When the lender L proposes and the proposal is accepted,

$$V^{*PRO}(b_t, k_t^g, a_t) = -\delta_t^L b_t \tag{26}$$

$$V^{ACT}(b_t, k_t^g, a_t) = \max_{g_t, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V(0, k_{t+1}^g, 0, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{27}$$

$$s.t. \quad g_t + k_{t+1}^g + T_t = \tau c_t + (1-\delta^g)k_t^g - \frac{\Omega}{2}(\frac{k_{t+1}^g - k_t^g}{k_t^g})^2 k_t^g - \delta_t^L b_t \tag{8c}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{\alpha_l \tilde{a}_t (l_t)^{\alpha_l - 1} (k_t^g)^{\alpha_k} (\bar{k}^p)^{1-\alpha_l-\alpha_k}}{1+\tau} \tag{10a}$$

$$(1+\tau)c_t = \tilde{y}_t + T_t \tag{11a}$$

When the lender L passes,

$$V^{*PASS}(b_t, k_t^g, a_t) = \frac{1}{1+r^*} \int_A \Gamma^*((1+r^*)b_t, k_{t+1}^g, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{28}$$

$$V^{REJ}(b_t, k_t^g, a_t) = \max_{g_t, k_{t+1}^g, T_t} (1-\lambda)u(c_t, l_t) + \lambda v(g_t) + \beta \int_A V((1+r^*)b_t, k_{t+1}^g, 1, a_{t+1}) d\mu(a_{t+1}|a_t) \tag{29}$$

$$s.t. \quad g_t + k_{t+1}^g + T_t = \tau c_t + (1-\delta^g)k_t^g - \frac{\Omega}{2}(\frac{k_{t+1}^g - k_t^g}{k_t^g})^2 k_t^g \tag{8a}$$

$$T_t \geq 0 \tag{9}$$

$$\frac{u_l(c_t, l_t)}{u_c(c_t, l_t)} = \frac{\alpha_l \tilde{a}_t (l_t)^{\alpha_l - 1} (k_t^g)^{\alpha_k} (\bar{k}^p)^{1-\alpha_l-\alpha_k}}{1+\tau} \tag{10a}$$

$$(1+\tau)c_t = \tilde{y}_t + T_t \tag{11a}$$

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

$$\begin{aligned} &\delta_t^{L*} = argmax V^{*PRO}(b_t, k_t^g, a_t) \\ s.t. \quad &V^{*PRO}(b_t, k_t^g, a_t) \geq V^{*PASS}(b_t, k_t^g, a_t) \\ &V^{ACT}(b_t, k_t^g, a_t) \geq V^{REJ}(b_t, k_t^g, a_t) \end{aligned} \tag{30}$$

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

$$\Gamma^{*L}(b_t, k_t^g, a_t) = V^{*PRO}(b_t, k_t^g, a_t) \tag{31}$$

$$\Gamma^{L}(b_t, k_t^g, a_t) = V^{ACT}(b_t, k_t^g, a_t) \tag{32}$$

Otherwise,

$$\Gamma^{*L}(b_t, k_t^g, a_t) = V^{*PASS}(b_t, k_t^g, a_t) \tag{31a}$$

$$\Gamma^{L}(b_t, k_t^g, a_t) = V^{REJ}(b_t, k_t^g, a_t) \tag{32a}$$

The renegotiation settlement can be characterized by settlement set $R^L(b_t, k_t^g) \subset A$. It is a

set of productivity shocks a_t at which both parties reach an agreement:

$$R^L(b_t, k_t^g) = \left\{ \begin{array}{c} a_t \in A : V^{*PRO}(b_t, k_t^g, a_t) \geq V^{*PASS}(b_t, k_t^g, a_t) \\ V^{ACT}(b_t, k_t^g, a_t) \geq V^{REJ}(b_t, k_t^g, a_t) \end{array} \right\}. \tag{33}$$

4.5 Foreign Creditors' Problem

When the sovereign has a good credit record $h_t = 0$, given the sovereign bond price, foreign creditors who can borrow from the international capital market with the risk-free rate (r^*) choose the amount of assets/debt in the next period (b_{t+1}) to maximize the expected profit, shown as

$$\pi^c(b_{t+1}, k_{t+1}^g, 0, a_t) = \begin{cases} q(b_{t+1}, k_{t+1}^g, 0, a_t) b_{t+1} - \frac{1}{1+r^*} b_{t+1}, & \text{if } b_{t+1} \geq 0 \\ [\frac{1-p^D(b_{t+1}, k_{t+1}^g, 0, a_t)}{1+r^*} + & \\ \frac{p^D(b_{t+1}, k_{t+1}^g, 0, a_t) \int_A \gamma(b_{t+1}, k_{t+1}^g, 1, a_{t+1}) d\mu(a_{t+1}|a_t)}{1+r^*}](-b_{t+1}) & \\ -q(b_{t+1}, k_{t+1}^g, 0, a_t)(-b_{t+1}), & otherwise \end{cases} \tag{34}$$

where $p^D(b_{t+1}, k_{t+1}^g, 0, a_t)$ and $\gamma(b_{t+1}, k_{t+1}^g, 1, a_{t+1})$ are the expected probability of default and expected recovery rates, respectively.

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

$$q(b_{t+1}, k_{t+1}^g, 0, a_t) = \begin{cases} \frac{1}{1+r^*} & \text{if } b_{t+1} \geq 0 \\ \frac{1-p^D(b_{t+1}, k_{t+1}^g, 0, a_t)}{1+r^*} & \\ + \frac{p^D(b_{t+1}, k_{t+1}^g, 0, a_t) \int_A \gamma(b_{t+1}, k_{t+1}^g, 1, a_{t+1}) d\mu(a_{t+1}|a_t)}{1+r^*} & otherwise \end{cases} \tag{35}$$

When the sovereign buys bonds from foreign creditors $b_{t+1} \geq 0$, the sovereign bond price is equal to the price of a risk-free bond, $\frac{1}{(1+r^*)}$. When the sovereign issues bonds to foreign creditors $b_{t+1} < 0$, there is default risk and the bonds are priced to compensate foreign creditors for the risk. Since $0 \leq p^D(b_{t+1}, k_{t+1}^g, 0, a_t) \leq 1$ and $0 \leq \gamma(b_{t+1}, k_{t+1}^g, 1, a_{t+1}) \leq 1$, the bond price $q(b_{t+1}, k_{t+1}^g, 0, a_t)$ lies in $[0, \frac{1}{(1+r^*)}]$.

4.6 Equilibrium

A recursive equilibrium is defined as a set of functions for (a) the sovereign's value function, public consumption, capital, transfers, assets/debt, default set, (b) the household's private con-

sumption, labor supply, (c) the firm's labor demand, (d) the sovereign's and the foreign creditor's decision functions, payoffs, recovery rates, settlement sets (all depending on who is the proposer), (e) bond price for sovereign bonds such that

[1]. the sovereign's value function, public consumption, capital, transfers, assets/debt, and default set satisfy its optimization problem (7)–(15);

[2]. the household's private consumption and labor supply satisfy his optimization problem (1)–(3);

[3]. the firm's labor demand satisfies its optimization problem (4)–(6);

[4]. both parties' decisions, payoffs, recovery rates, and settlement sets solve the multi-round debt renegotiation problem (16)–(33);

[5]. sovereign bond price satisfies the foreign creditors' optimization problem (34)–(35).

In equilibrium, the probability of default is defined by using the sovereign's default set:

$$p^D(b_{t+1}, k^g_{t+1}, 0, a_t) = \int_{D(b_{t+1}, k^g_{t+1})} d\mu(a_{t+1}|a_t), \tag{36}$$

Similarly, the probability of settlement is defined by using the two settlement sets:

$$p^R(b_{t+1}, k^g_{t+1}, 0, a_t) = \phi \int_{R^B(b_{t+1}, k^g_{t+1})} d\mu(a_{t+1}|a_t) + (1-\phi) \int_{R^L(b_{t+1}, k^g_{t+1})} d\mu(a_{t+1}|a_t), \tag{37}$$

Expected recovery rates conditional on the sovereign's default choice is shown as:

$$\begin{aligned}
\gamma(b_{t+1}, k^g_{t+1}, 1, a_t) = & \int_A \gamma(b_{t+1}, k^g_{t+1}, 1, a_{t+1}) d\mu(a_{t+1}|a_t) \\
= & \int_A \left[\begin{array}{c} \phi \mathbb{1}_{a_{t+1} \in R^B(b_{t+1}, k^g_{t+1})} \delta^{B*}_t(b_{t+1}, k^g_{t+1}, a_{t+1}) \\ +(1-\phi) \mathbb{1}_{a_{t+1} \in R^L(b_{t+1}, k^g_{t+1})} \delta^{L*}_t(b_{t+1}, k^g_{t+1}, a_{t+1}) \\ + \left(\begin{array}{c} \phi \mathbb{1}_{a_{t+1} \notin R^B(b_{t+1}, k^g_{t+1})} \\ +(1-\phi) \mathbb{1}_{a_{t+1} \notin R^L(b_{t+1}, k^g_{t+1})} \end{array} \right) \gamma(b_{t+2}, k^g_{t+2}, 1, a_{t+1}) \end{array} \right] d\mu(a_{t+1}|a_t)
\end{aligned} \tag{38}$$

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

$$s(b_{t+1}, k^g_{t+1}, 0, a_t) = \frac{1}{q(b_{t+1}, k^g_{t+1}, 0, a_t)} - (1 + r^*) \tag{39}$$

5 Quantitative Analysis

This section provides the quantitative analysis of our model applied to the Argentine default and restructuring in 2001–05. We have three main findings. First, our model predicts that after default, the sovereign is more willing to settle, ceteris paribus, as public capital increases, while before default (ex ante), the sovereign's willingness to repay remains constant, ceteris paribus, as public capital increases. Second, we newly explain sovereign debt overhang in the restructuring phase, when the sovereign loses market access due to default. Third, our simulation exercise successfully replicates the four stylized facts: (i) a severe decline and slow recovery of public investment, (ii) a short-lived decline and quick recovery of public consumption and transfers, (iii) public expenditure skewing towards consumption and transfers, (iv) an association between decline in public investment and delays in restructurings.

5.1 Parameters and Functional Forms

All the parameter values and functional forms follow closely those in previous studies on sovereign debt and fiscal policy. We assume the following constant relative risk aversion (CRRA) functions for private consumption and labor, and for public consumption:

$$u(c_t, l_t) = \frac{(c_t - \frac{l_t^{1+\psi}}{1+\psi})^{1-\sigma}}{1-\sigma}, \qquad v(g_t) = \frac{g_t^{1-\sigma_g}}{1-\sigma_g} \tag{40}$$

As in conventional sovereign debt models (e.g., Mendoza and Yue 2012; Cuadra et al. 2010), $u(\cdot)$ follows Greenwood et al. (1988)'s specification, which provides the marginal rate of substitution between private consumption and labor orthogonal to the level of private consumption. Thus, this implies no wealth effects on labor supply. We set both risk aversion for private and public consumption as $\sigma = \sigma_g = 3$, as previous studies (Cuadra et al. 2010, Arellano and Bai 2017; Hatchondo et al. 2017) to maintain the same degree of consumption smoothing between two types of consumption.[29] The risk-free interest rate is $r^* = 0.01$ corresponding to the average quarterly interest rate on the 3-month US Treasury bills (Aguiar et al. 2016; Yue 2010). Labor elasticity ψ is set to 0.48 following Mendoza (1991). Labor and public capital income share is assumed to be 0.64 and 0.058, respectively, based on Gordon and Guerron-Quintana (2018) and public capital income share in Argentina in 1993–2005 from our dataset. Public capital depreciation rate is set to 0.04 following US BEA (1999). Effective consumption tax rate $\tau = 0.33$ is from Argentine tax revenues in 1993–2005 from the IMF WEO.

The productivity process is calibrated to match quarterly seasonally adjusted GDP data from the Ministry of Economy and Production in Argentina (MECON). As in previous work (Gordon and Guerron-Quintana 2018), we assume the productivity process a follows a log normal AR (1)

[29] Hatchondo et al. (2017) assume asymmetric risk aversion between two types of consumption ($\sigma = 2, \sigma_g = 3$) because there are no public transfers in their paper. However, with public transfers included in our model, the same degree of risk aversion to improve household utility is necessary to have both fiscal instruments available for the sovereign (Cuadra et al. 2010; Arellano and Bai 2017).

Table 4: Model Parameters

Parameter	Value	Source
Risk aversion for private consumption	$\sigma = 3$	Hatchondo et al. (2017)
Risk aversion for public consumption	$\sigma_g = 3$	Hatchondo et al. (2017)
Risk-free interest rate	$r^* = 0.01$	Aguiar et al. (2016), Yue (2010) - US Treasury bill rate
Labor elasticity	$\psi = 0.48$	Mendoza (1991)
Labor income share	$\alpha^L = 0.64$	Gordon and Guerron-Quintana (2018)
Public capital income share	$\alpha^K = 0.058$	Computed - Argentine public capital income share
Public capital depreciation rate	$\delta = 0.04$	US BEA (1999)
Effective consumption tax rate	$\tau = 0.33$	Computed - Argentine tax revenues (IMF WEO)
Auto-correlation of productivity shock	$\rho = 0.85$	Computed - Argentine GDP (MECON)
Standard deviation of productivity shock	$\sigma^a = 0.017$	Computed - Argentine GDP (MECON)
Direct productivity loss	$\lambda_d = 0.02$	Computed
Weight on public consumption	$\lambda = 0.8$	Computed
Public capital adjustment costs	$\Omega = 10$	Computed
Discount rate	$\beta = 0.90$	Computed
Bargaining power	$\phi = 0.90$	Computed

process,

$$\log(a_t) = \rho \log(a_{t-1}) + \epsilon_{a,t}, \tag{41}$$

where a productivity shock $\epsilon_{a,t}$ is $i.i.d\ N(0, \sigma^{a,2})$. We obtain auto-correlation and standard deviation of the productivity shock: $\rho = 0.85$ and $\sigma^a = 0.017$. We approximate the stochastic process as a discrete Markov chain of equally spaced grids by using the quadrature method in Tauchen (1986).

The direct productivity loss due to default follows the functional form in Arellano and Bai (2017) which is originally from Arellano (2008)'s asymmetric output costs:

$$\tilde{a}_t = \begin{cases} (1-\lambda_d)E(a_t) & \text{if } a_t \geq (1-\lambda_d)E(a_t) \\ a_t & otherwise \end{cases} \tag{42}$$

where λ_d is set to 0.02 to produce average GDP deviation from the trend during debt restructurings of -4.45%. The weight on public consumption in the household's utility and public capital adjustment costs are set as $\lambda = 0.8$ and $\Omega = 10$ to replicate average public consumption and transfers-to-GDP ratio of 20.0% and standard deviation of public investment relative to that of output of 5.1 for Argentina in 1993–2005, respectively.

Sturzenegger and Zettelmeyer (2006) report that Argentina experienced 6 defaults/restructurings in 1820–2004. Moreover, Struzenegger and Zettlemeyer (2008) find that the recovery rate (haircut) in Argentina 2001-05 debt restructuring was 25.0% (75.0%). We specify the sovereign's discount factor $\beta = 0.90$—similar to that in Gordon and Guerron-Quintana (2018)—and bargaining power $\phi = 0.90$ (the debtor - Argentina) to replicate the average default frequency

of 3.26% and a recovery rate of 25.0%. Table 4 summarizes the model parameters and our computation algorithm is reported in Appendix D.

5.2 Numerical Results on Equilibrium Properties

We start from providing the qualitative equilibrium properties of our theoretical model for the case when the sovereign proposes. Similarly, Appendix E.2 discusses the equilibrium properties for the case when the creditors propose—underlying mechanisms apply symmetrically and generate identical results. Moreover, Appendix C explores the equilibrium properties for key assumptions in the model: output costs, net issuance at settlement, private capital, and taxation methods (two-stage consumption tax and labor income tax).

Figure 6 reports the sovereign's choice between repayment and default, and between settlement and delay—the agreed recovery rates are reported in Figure E1 in Appendix E.1. To emphasize our new findings, two panel charts are classified as follows: panel A: the debtor TFP at the mean/low level, and panel B: debt at 47% of the mean GDP, respectively. The horizontal axis is public capital/mean TFP ratio in both panels A and B. The vertical axis is debt/mean GDP ratio in panel A and the debtor TFP in panel B, respectively. Both panels A-(i) and B-(i) are divided into two regions corresponding to the sovereign's choice of "repayment" in white color and "default" in black color. Similarly, both panels A-(ii) and B-(ii) are divided into two regions corresponding to the sovereign's choice of "settlement" in gray color and "delay" in black color.

First, we focus on the sovereign's decision when the debtor TFP is at the mean/low level in panel A. More importantly, on its choice between settlement and delay reported in panel A-(ii), what our model explains newly is that the sovereign opts to delay (settle), ceteris paribus, when public capital is low (high). A new driver—a choice between investment in public capital and use of resources for debt settlement—determines the sovereign's choice between settlement and delay in our model differentiating our model from previous studies. In the case of low public capital, the sovereign opts to invest in public capital and refrains from using resources for recovered debt payments given the high marginal product of public capital (i.e., high shadow value of public capital). The sovereign's willingness to delay is reflected in the enlarged "delay" region in black color and the shrunk "settlement" region in gray color.

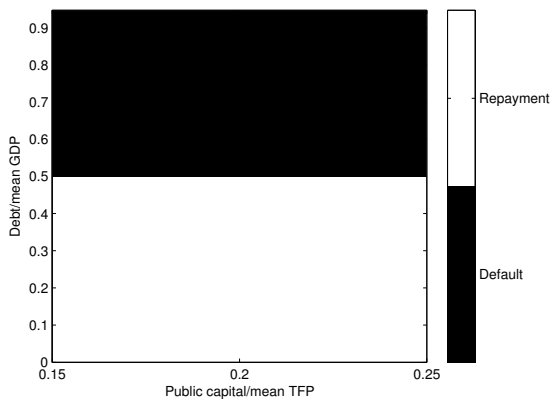
In contrast, in the case of high public capital, the sovereign hesitates to invest in public capital and chooses to use resources for recovered debt payments given the low marginal product of public capital (i.e., low shadow value of public capital). The sovereign's willingness to settle is highlighted in the enlarged "settlement" region in gray color and the shrunk "delay" region in black color.

Moreover, on its choice between repayment and default reported in panel A-(i), the net effect of public capital on repayment and default is balanced. On the one hand, an increase in public capital increases benefits of repayment—improving the sovereign's repayment capacity, i.e., output. On the other hand, an increase in public capital also increases benefits of default—improving household utility by smoothing consumption and achieves the debt settlement after

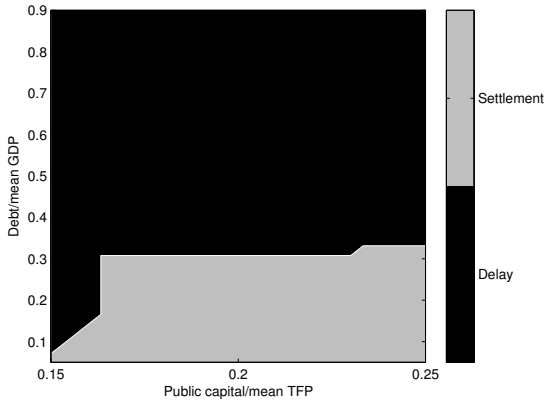
Figure 6: Debtor's Choice between Repayment and Default, and between Settlement and Delay

A: Mean/Low TFP

(i) Good Credit Record

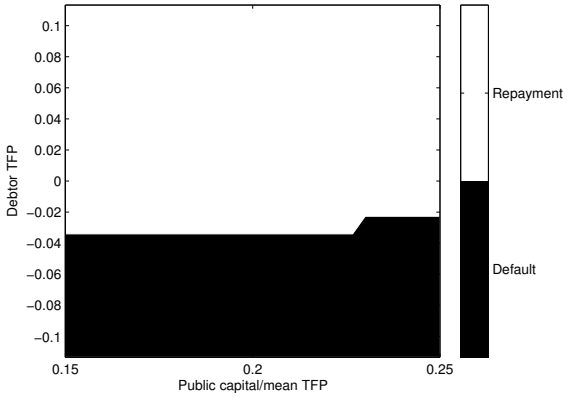


(ii) Bad Credit Record

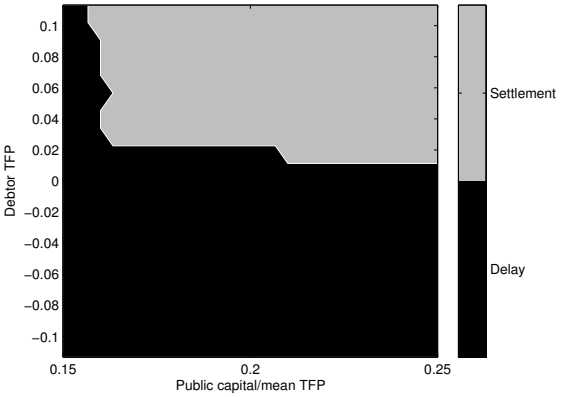


B: Debt/Mean GDP Ratio of 47%

(i) Good Credit Record



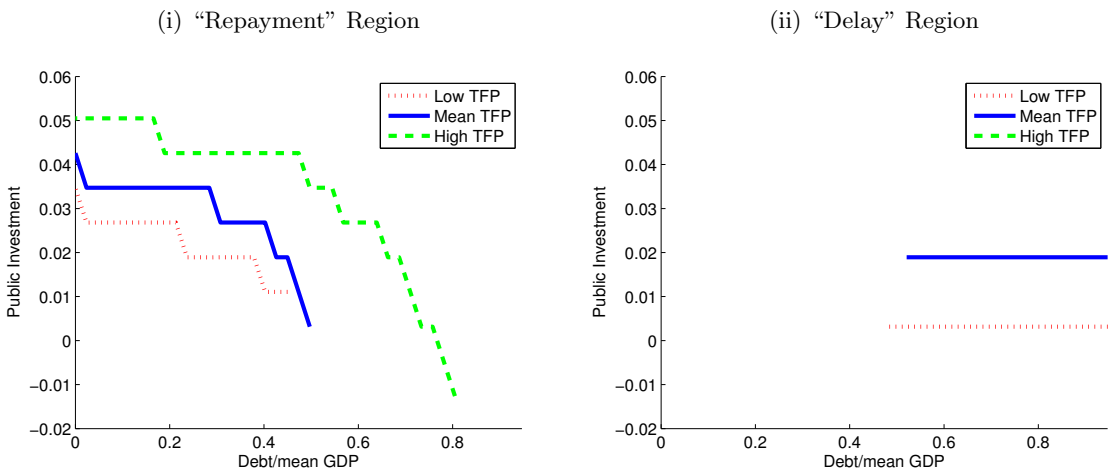
(ii) Bad Credit Record



default. As a result, the sovereign's willingness to repay remains constant as public capital increases—presented in the unchanged "repayment" and "default" regions in white and black color.

Second, we explore the sovereign's decision when debt is at 47% of the mean GDP in panel B. On its choice between settlement and delay reported in panel B-(ii), when public capital is high (low), the sovereign is more (less) willing to settle at a moderate level of debtor TFP. This is reflected in the enlarged (shrunk) "settlement" region in gray color and the shrunk (enlarged) "delay" region in black color. On its choice between repayment and default in panel B-(i), the sovereign's willingness to repay remains constant as public capital increases as reflected in the unchanged "repayment" and "default" regions in white and black color. In addition, panel B-(ii) shows that on its choice between settlement and delay, when the debtor TFP is high, the

Figure 7: Public Investment—Mean Public Capital



sovereign is more willing to settle as shown by the enlarged "settlement" region in gray color (Benjamin and Wright 2013; Bi 2008).

We next explore the sovereign's choice of public investment at the mean public capital in Figure 7—its choice of public consumption and transfers is reported in Figure E2 in Appendix E1. We differentiate the public investment choice in two phases: that in the "repayment" region (panel i) and that in the "delay" region (panel ii). Both panels (i) and (ii) demonstrate two different phases of "sovereign debt overhang" driven by different drivers. First, in the "repayment" region (panel i), public investment declines sharply when external debt is high (blue solid line), i.e., the "pre-default phase" of sovereign debt overhang. Despite maintaining market access, a combination of low productivity, high external debt payments, and the government's consumption-smoothing and impatience results in a sharp decline in public investment. This is because the impatient government, with consumption-smoothing motive, is willing to stabilize public consumption and transfers to improve household utility (Aguiar et al. 2009).

Second, in the "delay" region (panel ii), public investment remains low (blue solid line), i.e., the "restructuring phase" of debt overhang. Slow recovery of productivity, prohibition on external borrowing, and the government's consumption smoothing motive and impatience generate both slow public capital accumulation and lengthy renegotiations which interact with each other. Public capital accumulation is slow both because external borrowing is prohibited, and because the impatient government, with consumption smoothing motive, continues to be willing to stabilize public consumption and transfers. Debt renegotiations are delayed because of both the high marginal product of public capital owing to slow accumulation, and slow recovery of productivity. Moreover, in both regions (panels i and ii), public investment increases proportionally to the level of productivity because of the marginal product of public capital.

5.3 Simulation Exercise

Next, we provide simulation results to show how precisely our theoretical model predicts the Argentine default and restructuring in 2001–05. Following a conventional approach, this subsection applies 1000 rounds of simulations, with 2000 periods per round and extracts the last 200 observations. In the last 200 samples, we withdraw 40 observations before and observations during the last default/restructuring event at the stationary distribution to compute moment statistics.[30]

For private sector data for Argentina, output, consumption and the trade balance are all seasonally adjusted from the MECON for 1993Q1–2001Q4 (prior to default) and 2002Q1–2005Q2 (during restructuring). The trade balance is measured as a share of GDP. For public sector data for Argentina, consumption, investment, transfers and capital are at annual frequency from our dataset for 1993–2001 (prior to default) and 2002–05 (during restructuring), while Argentine external debt data are from the IMF WEO for 1993–2001 (prior to default) and 2002–05 (during restructuring). Average external debt is also measured as a share of GDP. Bond spreads are from the J.P. Morgan's Emerging Markets Bond Index Global (EMBIG) for 1997Q1–2001Q4 (prior to default, based on data availability). We compare our non-target statistics with those in (i) a model with fixed public capital (Arellano and Bai 2017; Cuadra et al. 2010; Hatchondo et al. 2017) and (ii) a model without separation between private and public sectors (Gordon and Guerron-Quintana 2018)—(iii) models with no public capital are reported in Table F1 and F2 in Appendix F. We add specific features, respectively in our model of multi-round debt renegotiations keeping the same parameter values.

Panel (i) in Table 5 reports business cycle statistics for both private and public sectors. For private sector statistics, our model matches closely with the data. We replicate three prominent private sector features in EMs as in conventional models of sovereign debt with/without debt renegotiations (Aguiar and Gopinath 2006; Arellano 2008; Yue 2010): volatile consumption, and volatile and countercyclical trade balance.[31] One caveat applies to balanced (constant) trade account due to the financial autarky assumption during debt restructurings in our model.

For public sector statistics, our simulated moments also fit the data well. Our model successfully replicates notable public sector characteristics in EMs: procyclical and volatile public consumption and transfers. This is in line with previous models of sovereign debt with fiscal policy as Arellano and Bai (2017), Cuadra et al. (2010) and Hatchondo et al. (2017).

Most importantly, our calibration results provide four novelties contributing to the literature.

[30] See also Arellano (2008) and Yue (2010) for this treatment of simulation.

[31] Models with multi-round debt renegotiations, an exogenous income process and symmetric output costs (Bi 2008; Asonuma and Joo 2019) fail to generate a negative correlation between trade balance and output. This is because when output is high, the sovereign is still willing to default, taking merits of low default costs due to short restructuring duration. This results in an increase in borrowing costs (high spreads) and a reduction in external borrowing equivalent to an improvement in trade balance. However, in our model with multi-round debt renegotiations, endogenous output dynamics and asymmetric productivity loss, we account for the negative correlation between trade balance and output. The assumption of asymmetric productivity loss generates high default costs when output is high, and this, in turn, results in a reduction in borrowing costs (low spreads) and an increase in external borrowing equivalent to a deterioration in trade balance.

First of all, our model successfully replicates lower average public investment during restructurings than that in the pre-default periods (1.5 vs. 1.6 percent in the model and 1.2 vs 1.3 percent in the data). More specifically, we explain both downward and upward trends of public investment during restructurings as we observe in the data. Moreover, our model accounts for sizable public capital accumulation during restructurings consistent with the data (1.7 percent in the model and 2.3 percent in the data). The model with fixed public capital (Arellano and Bai 2017; Cuadra et al. 2010) replicates none of these features. Though the model without separation of private and public sectors (Gordon and Guerron-Quintana 2018) replicates lower average "total" investment during restructurings than that in the pre-default periods, it fails to account for both downward and upward trends of "total" investment and public capital accumulation.

Second, our model replicates lower investment share in public expenditure during restructurings than that in the pre-default periods (5.8 vs. 6.4 percent in the model and 5.7 vs. 6.2 percent in the data). While public consumption and transfers-to-GDP ratio is marginally higher during restructurings than the pre-default periods (23.3 and 23.1 percent), public investment-to-GDP ratio is lower during restructurings than in the pre-default periods (1.47 and 1.60 percent). In contrast, the model with fixed public capital (Arellano and Bai 2017; Cuadra et al. 2010) generates higher investment share in public expenditure during restructurings than that in the pre-default periods (9.5 and 8.0 percent) because of both fixed investment level and endogenous output dynamics.

Third, the model replicates average restructuring duration of 11.1 quarters which is close to the data (14.0 quarters). Contrary to conventional models of multi-round renegotiations with exogenous income process, what generates longer duration of restructurings are both endogenous public capital accumulation (both downward and upward trends) and distortional consumption tax. In contrast, the model with fixed public capital (Arellano and Bai 2017; Cuadra et al. 2010) and the model without separation of private and public sectors (Gordon and Guerron-Quintana 2018) result in shorter duration (8.7 and 8.9 quarters, respectively) because they include either distortional consumption tax or endogenous "total" capital accumulation, respectively, but not both.

Fourth, we generate a negative correlation between a decline in public investment and restructuring duration as observed in the data (-0.12 in the model and -0.08 in the data). Low level of public capital due to the sharp decline in public investment around the start of restructurings results in restructuring delays as explained in Section 5.2. Despite the different dynamics of "total" investment, the negative correlation can be generated by the model without separation of private and public sectors (Gordon and Guerron-Quintana 2018).

Table 5: Simulation Results of Models

(i) Business Cycle Statistics

	Data	Baseline Model	Model with Fixed Public Capital[1/]	Model without Separation of Private/Public Sectors[2/]
Target statistics				
Pre-default periods				
Average public consumption & transfers/GDP ratio (%)	20.0	23.1	22.5	-
Public investment (std dev.)/output (std dev.)	5.1	5.2	-	5.1
Non-target statistics				
Pre-default periods				
Private sector				
Private consumption (std dev.)/output (std dev.)	1.11	1.03	1.01	1.03
Trade balance/output: std dev. (%)	1.28	0.86	0.48	1.01
Corr.(trade balance, output)	-0.87	-0.18	-0.07	-0.23
Public sector				
Public consumption & transfers (std dev.)/output (std dev.)	1.26	1.39	1.22	-
Corr.(public consumption & transfers, output)	0.52	0.84	0.94	-
Average public investment/GDP ratio (%)	1.31	1.60	2.01	*1.58*[7/]
Average public investment/public expenditure ratio (%)	6.20	6.40	8.04	-
Corr.(public investment, output)	0.51	0.63	-	*0.66*[7/]
Renegotiation periods				
Private sector				
Private consumption (std dev.)/output (std dev.)	1.17	1.01	1.00	0.99
Trade balance/output: std dev. (%)	0.45	0.00	0.00	0.00
Corr.(trade balance, output)	-0.97	0.00	0.00	0.00
Debtor output deviation (diff. btw start and end, %)[6/]	12.6	21.2	22.6	21.5
Public sector				
Public consumption & transfers (std dev.)/output (std dev.)	0.99	2.23	1.07	-
Corr.(public consumption & transfers, output)	0.99	0.77	0.67	-
Average public consumption & transfers/GDP ratio (%)	20.2	23.3	22.4	-
Average public investment/GDP ratio (%)	1.19	1.47	2.36	*1.24*[7/]
Average public investment/GDP ratio (downward trend, %)[3/]	0.73	0.76	-	*1.41*[7/]
Average public investment/GDP ratio (upward trend, %)[3/]	1.64	1.65	-	*0.91*[7/]
Average public investment/public expenditure ratio (%)	5.7	5.8	9.5	-
Corr.(public investment, output)	0.99	0.84	-	*0.91*[7/]
Public capital (percent change from the trough to the end, %)	2.31	1.70	-	*0.50*[8/]

(ii) Non-business Cycle Statistics

	Data	Baseline Model	Model with Fixed Public Capital[1/]	Model without Separation of Public/Private Sectors[2/]
Target statistics				
Default probability (%)	3.26	3.08	2.71	3.29
Average recovery rate (%)	25.0	27.1	22.4	35.2
Average debtor output deviation during debt renegotiation (%)	-4.45	-3.73	-4.50	-4.23
Pre-default periods				
Average debt/GDP ratio (%)	45.4	43.9	45.6	50.8
Bond spreads: average (%)	9.4	1.60	1.20	1.55
Bond spreads: std dev. (%)	7.6	2.28	1.60	2.20
Corr.(spreads, output)	-0.88	-0.10	-0.31	-0.13
Corr.(debt/GDP, spreads)	0.92	0.21	0.37	0.26
Corr.(debt/GDP, output)	-0.97	-0.69	-0.70	-0.65
Renegotiation periods				
Average debt/GDP ratio (%)	130.5	50.6	53.7	59.8
Corr.(debt/GDP, output)	-0.95	-0.99	-0.99	-0.99
Duration of renegotiations/ exclusion (quarters)	14.0	11.1	8.3	8.8
Corr.(cumulative change in public investment to GDP, duration)[4/]	-0.12	-0.08	-	*-0.15*[7/]
Corr.(cumulative pecent change in public investment, duration)[5/]	-0.16	-0.10	-	*-0.14*[7/]

Sources: Datastream, IMF WEO, MECON.
Notes: [1/] Model with fixed public capital corresponds to our model (with the same parameter values) with fixed public capital (Arellano and Bai 2017; Cuadra et al. 2010; Hatchondo et al. 2017).
[2/] Model without separation of private and public sectors corresponds to our model (with the same parameter values) without separation of private and public sectors by both distortional consumption tax and two distinct consumption goods (Gordon and Guerron-Quintana 2018).
[3/] Average public investment-to-GDP ratio in its downward trend since the start of restructurings and its upward trend since its trough.
[4/] A correlation between cumulative percentage point change in public investment-to-GDP ratio from t-4 to t+4 and duration of restructurings.
[5/] A correlation between cumulative percent change in public investment (level) from t-4 to t+4 and duration of restructurings.
[6/] A difference in the sovereign's output deviation at the the end and at the start of restructurings.
[7/] "Total" investment in the model without separation of private and public sectors.
[8/] "Total" capital in the model without separation of private and public sectors.

Table 5: Simulation Results of Models (Cont.)

(iii) Logit Regression Results on Debt Settlement—Baseline Model

	Debt Settlement (binary, current)			
	(1)	(1')	(2)	(2')
	coef/ se	dy/dx / Delta-method se	coef/ se	dy/dx / Delta-method se
Public investment (lagged, percent of mean TFP)	3.833***	0.471***	-	-
	(0.452)	(0.055)		
Public capital growth rates, annual (lagged, percent)	-	-	0.055***	0.008***
			(0.019)	(0.003)
External debt (lagged, percent of GDP)	-0.085***	-0.010***	-0.026***	-0.004*****
	(0.007)	(0.001)	(0.001)	(0.0001)
Constant	-	-	-	-
Episode-specific fixed effects		No		No
Number of episodes		76		76
Number of observations		831		831
Wald χ^2		327.9		470.8
Prob.> χ^2		0.000		0.000

Notes: The table shows results from random effects multinomial logit regressions. The dependent variable is debt settlement in the current year (binary). The main explanatory variables are public investment and public capital growth rates. Public investment, public capital growth rates and external debt (percent of GDP) are lagged by one year. Significance levels denoted by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, respectively. Robust standard errors (Delta-method standard errors) in parentheses.

Lastly, we use simulated data series obtained from our baseline model and apply a logit regression on debt settlement (binary). Our main explanatory variables are either public investment or capital—measured as lagged public investment in percent of mean TFP or lagged growth rate of public capital—, and external debt-to-GDP ratio. Logit regression results reported in panel (iii) in Table 5 show that an increase in both lagged public investment and lagged public capital growth rates significantly decreases the likelihood of settlement. Therefore, our theoretical model shows that a slow recovery of public investment delays the settlement of restructurings.

To emphasize the aforementioned novelties of our model, Figures 8 and 9 report the dynamics of public investment, consumption and transfers, and public expenditure composition and its

relation with restructuring duration in the Argentine debt restructuring in 2001–05, respectively. For Figure 8, we follow the same presentation approach as in Figures 1 and 2 in terms of both time horizon, timing of events—both the start and end of debt crisis denoted as year 0 and 3.5 (14 quarters) and marked by gray and pink (light orange and green) vertical bars—, scale (real and level), and normalization of the series at the pre-default levels (-1). Blue solid, red dashed, and green dotted lines show the Argentine data, our baseline model, and a model with fixed public capital (Arellano and Bai 2017; Cuadra et al. 2010), respectively. For panels (i) and (ii) in Figure 9, we follow the same presentation approaches in Figure 3 and 4, respectively, in terms of both time horizon, periods (pre-restructuring and restructuring), and scale (percent of public expenditure and percent of GDP).

First and most importantly, panel (i) in Figure 8 shows that our baseline model (red dashed line) replicates both downward and upward trends of public investment—a sharp decline in the run up to the restructuring and a gradual recovery of public investment to the pre-restructuring level in the subsequent years—as observed in the data (blue solid line). This is the main driver of longer duration of renegotiations in our baseline model (11.1 quarters), which matches closely with the data (14 quarter). On the contrary, the model with fixed public capital does not replicate the dynamics of public investment because the sovereign fixes public investment to maintain the constant level of public capital. As a result, the duration of renegotiations—driven only by the recovery of repayment capacity (Benjamin and Wright 2013; Bi 2008)—is 8.7 quarters, shorter than that in our baseline model.

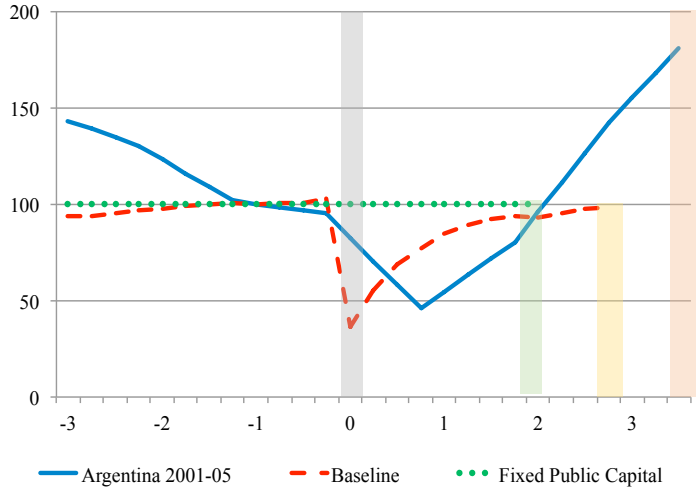
Second, panel (ii) in Figure 8 shows that our baseline model (red dashed line) replicates a small decline and quick recovery in public consumption and transfers as observed in the data (blue solid line). The dynamics of public consumption and transfers differ significantly from those of public investment in panel (i) in Figure 8. Moreover, the model with fixed public capital (green dotted line) also generates the same dynamics of public consumption and transfers with our model until the debt settlement in year 2 (quarter 8).

Third, panel (i) in Figure 9 shows that our baseline model (center panel) generates a skewing of public expenditure towards consumption and transfers as observed in the data (left panel). On the contrary, the model with fixed public capital (right panel) shows a skewing of public expenditure towards investment. This is because the sovereign mildly reduces public consumption and transfers, while maintaining public investment constant.

Fourth, panel (ii) in Figure 9 shows that our baseline model replicates a negative correlation between the declines in public investment and duration of restructurings. This is consistent with what we observe in the sample of post-default restructurings in Figure 4. In contrast, the model with fixed public capital does not replicate this feature due to no decline in investment, i.e., no change in the level of public capital.

Figure 8: Public Investment, Consumptions, and Transfers around Debt Restructuring

(i) Public Investment



(ii) Public Consumption and Transfers

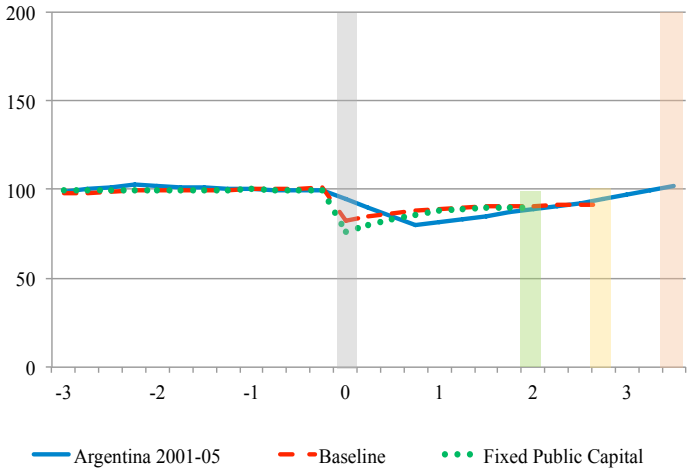
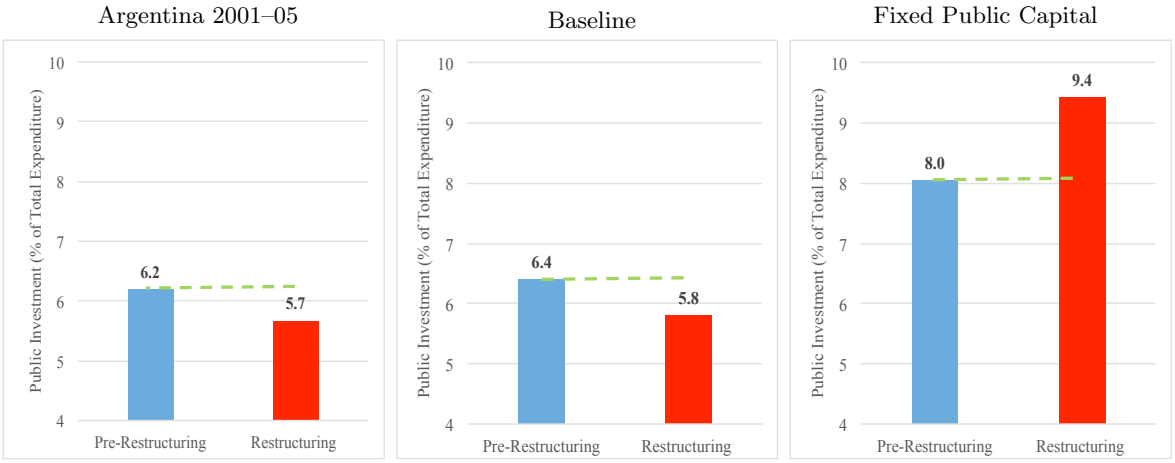
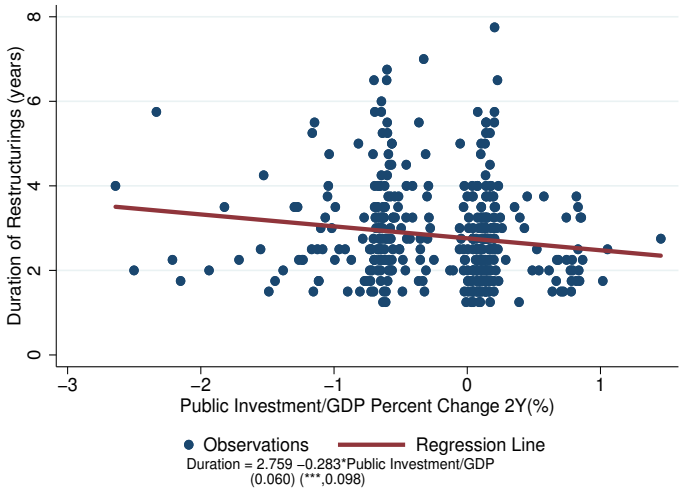


Figure 9: Public Expenditure Composition and Duration of Restructurings

(i) Public Expenditure Composition



(ii) Declines in Public Investment and Duration of Restructurings



5.4 Role of Public Capital

We explore the multiple roles of public capital on the sovereign's choice between repayment and default, and between settlement and delay when the sovereign proposes. Similarly, Appendix E.2 discusses the multiple roles of public capital when the creditors propose—underlying mechanisms apply symmetrically and generate identical results. Panel A in Figure 10 reports value functions of repayment (A-i, upper left panel) and default (A-ii, upper right panel) with a difference between the two (A-iii, lower panel). Panel B in Figure 10 reports value functions of proposing (B-i, upper left panel) and passing (B-ii, upper right panel) with a difference between the two (B-iii, lower panel). The horizontal axis is public capital/mean TFP and the vertical axis is value function in both panels A and B.

First, we focus on the role of public capital on the sovereign's choice between repayment and default. Panel A-(i) reports that value function of repayment increases as public capital increases. An increase in public capital improves the sovereign's repayment capacity, i.e., output ("smoothing channel" defined in Gordon and Guerron-Quintana 2018). Panel A-(ii) reports that value function of default also increases as public capital increases. An increase in public capital improves household utility by smoothing consumption ("autarky channel" as defined in their paper). Simultaneously, it also achieves debt settlement after default which we newly define as the "debt renegotiation channel".

Panel A-(iii) reports that when debt is equal to or below (above) 45 percent of the mean GDP, the difference between value functions of repayment and default shown by the blue solid line (red dashed line) is above (below) a reference line of zero value at any levels of public capital. That is, smoothing channel of public capital dominates (is dominated by) a combination of the autarky channel and the debt renegotiation channel. The relative importance of these two opposing effects is independent from the level of public capital. The sovereign's willingness to repay and default does not change as public capital increases (panel A-i in Figure 6). What newly determines the relative importance of these two opposing effects is the debt renegotiation channel vis-à-vis multi-round renegotiations.

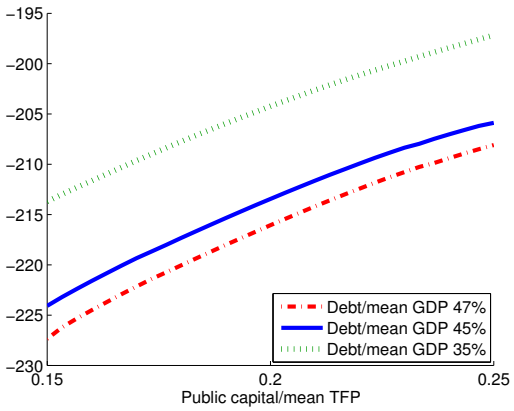
On the contrary, models with exogenous entry and zero recovery rates (Arellano 2008; Gordon and Guerron-Quintana 2018) and with a one-round negotiation (Yue 2010; Arellano and Bai 2017) show different results. The difference between value functions of repayment and default (blue solid line in panel ii and green dotted line in panel iii in Figure E7 in Appendix E.3) is above the reference line of zero value when public capital is high, while below the reference line when public capital is low. That is, the smoothing channel of public capital dominates the autarky channel—the debt renegotiation channel is missing—when public capital is high, while the autarky channel dominates the smoothing channel when public capital is low (Gordon and Guerron-Quintana 2018). The relative importance of these two opposing channels depends on the level of public capital. As a result, the sovereign is more willing to repay debt than to default as public capital increases (panels ii and iii in Figure E6 in Appendix E.3).

Second, we analyze the role of public capital on the sovereign's choice of proposing and passing. Panel B-(i) reports value function of proposing conditional on debt settlement. When

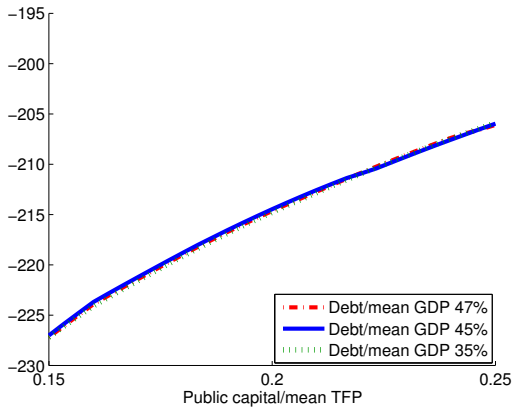
Figure 10: Value Functions at the Mean/Low TFP

A: Value Functions of Repayment and Default

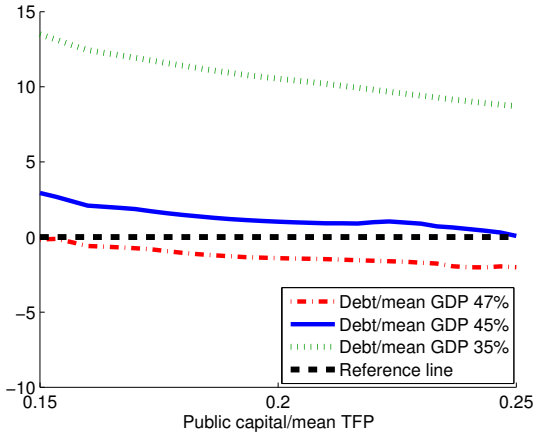
(i) Value Function of Repayment V^R



(ii) Value Function of Default V^D



(iii) Difference between Two Value Functions $V^R - V^D$



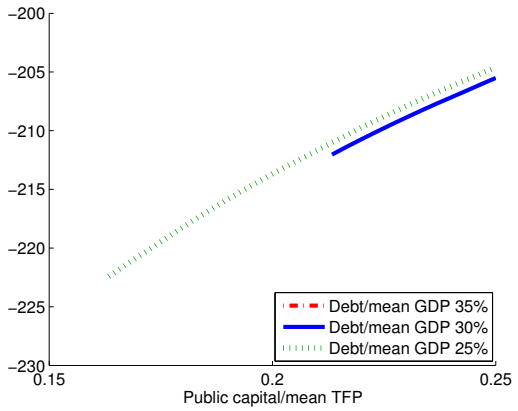
debt settlement is not achieved, value function of proposing is truncated or does not exit (i.e., truncated green dotted and blue solid lines). It shows that as public capital increases, the settlement is more likely to be reached and value function of proposing exists (debt renegotiation channel). Panel B-(ii) shows that value function of passing increases as public capital increases: an increase in public capital improves household utility by smoothing consumption (autarky channel).

Panel B-(iii) reports that when debt is at 30 percent of the mean GDP, as public capital increases, the settlement is more likely to be reached and the difference between value functions of proposing and passing increases and is above zero value (blue solid line). That is, the debt renegotiation channel of public capital dominates the autarky channel when public capital is high. The sovereign is more willing to settle than to delay as public capital increases (panel A-ii in Figure 6).

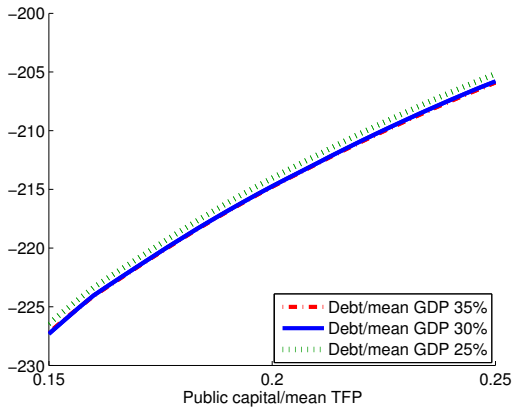
Figure 10: Value Functions at the Mean/Low TFP (Cont.)

B: Value Functions of Proposing and Passing

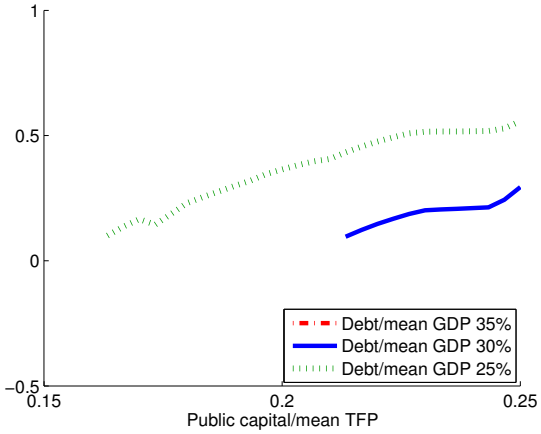
(i) Value Function of Proposing by Borrower V^{PRO}



(ii) Value Function of Passing by Borrower V^{PASS}



(iii) Difference between Two Value Functions $V^{PRO} - V^{PASS}$



5.5 Comparison with Models of Multi-round Renegotiations

Table 6 contrasts non-business cycle statistics in our baseline model with those in models of multi-round renegotiations. Both business and non-business cycle statistics and recalibration results in previous studies of (i) sovereign debt and fiscal policy and (ii) debt renegotiations are reported in Table F1, F2 and F3 in Appendix F. We consider three cases: (i) a model with fixed public capital, (ii) a model with endogenous public capital, and (iii) a model with fixed public capital and no distortional tax as in Benjamin and Wright (2013). To generate moments comparable to ours, we embed an assumption of fixed public capital for case (i), remove separation of public and private sectors or add a lump-sum taxation assumption for case (ii), and apply both assumptions of fixed public capital and no distortional taxation for case (iii) in our model, respectively, leaving all other parameters unchanged.

Table 6: Simulation Results of Models—Non-business Cycle Statistics

	Data	Baseline Model	Model with Fixed Public Capital (case i)[1/]		Model with Endogenous Public Capital (case ii)[2/]		Model with Fixed Public Capital and No Distortionary Tax (case iii)[3/]
			Distortionary tax (case i-a)	Distortionary tax and lump-sum tax on income (case i-b)	No separation of public/private sectors (case ii-a)	Distortionary tax and lump-sum tax on income (case ii-b)	
Target statistics							
Default probability (%)	3.26	3.08	2.71	3.20	3.26	3.50	2.29
Average recovery rate (%)	25.0	27.1	22.4	33.2	39.0	54.9	32.0
Average debtor output deviation during debt renegotiation (%)	-4.45	-3.73	-4.50	-4.60	-4.62	-4.42	-5.41
Pre-default periods							
Average debt/GDP ratio (%)	45.4	43.9	45.6	62.5	40.0	24.5	52.5
Bond spreads: average (%)	9.4	1.60	1.20	1.10	1.25	1.47	1.20
Bond spreads: std dev. (%)	7.6	2.28	1.60	1.05	1.3	1.90	1.26
Corr.(spreads, output)	-0.88	-0.10	-0.31	-0.18	-0.17	-0.05	-0.32
Corr.(debt/GDP, spreads)	0.92	0.21	0.37	0.29	0.24	0.78	0.39
Corr.(debt/GDP, output)	-0.97	-0.69	-0.70	-0.68	-0.64	-0.10	-0.72
Renegotiation periods							
Average debt/GDP ratio (%)	130.5	50.6	53.7	73.5	47.1	30.0	63.7
Corr.(debt/GDP, output)	-0.95	-0.98	-0.99	-0.99	-0.98	-0.99	-0.99
Duration of renegotiations/ exclusion (quarters)	14.0	11.1	8.3	7.8	8.9	8.9	6.8
Debtor output deviation (diff. btw start and end, %)[4/]	12.6	21.2	22.7	22.1	22.2	17.1	21.6
Public capital (percent change from the trough to the end)	2.31	1.70	-	-	0.50	0.00	-
Corr.(cumulative change in public investment to GDP, duration)	-0.12	-0.08	-	-	-0.11	-0.17	-
Corr.(cumulative pecent change in public investment, duration)	-0.16	-0.10	-	-	-0.15	-0.16	-

Sources: Datastream, IMF WEO, MECON.
Notes: 1/ Model with fixed public capital corresponds to our model (with the same parameter values) with public capital fixed at the average (under the baseline model).
2/ Model with endogenous public capital corresponds to our model (with the same parameter values) without separation of public and private sectors or with lump-sum tax on income.
3/ Model with fixed public capital and no distortionary tax corresponds to our model (with the same parameter values) with public capital fixed at the average (under the baseline model) and without distortionary consumption tax.
4/ A difference in the sovereign's output deviation at the the end and at the start of restructurings.

Comparing our model with case (i)—with distortionary tax (case i-a)—, the most striking result is a sizable difference in average duration of renegotiations between our model and the model with fixed public capital (11.1 quarters in our model vs. 8.3 quarters). Distortionary tax on consumption generates delays in renegotiations in both models. However, slow recovery of public investment, followed by a severe decline, is present only in our model generating further delays. Moreover, when the government has two methods of taxation, i.e., distortionary tax on consumption and lump-sum tax on income (case i-b), a constraint on resource allocations between private and public sectors is relaxed—the government can also extract resources through the lump-sum tax on income without generating further distortion. This, in turn, results in both shorter delays (7.8 quarters) and higher debt-to-GDP ratio (62.5 and 73.5 percent).

Next, when we compare our model to case (ii)—without separation of public and private sectors (case ii-a)—, we also see a sizable difference in average duration of restructurings between our model and the model without separation of private and public sectors (11.1 quarters in our model vs. 8.9 quarters). Slow recovery of public investment followed by a severe decline generates delays in renegotiations in both models. On the contrary, the fiscal constraint limiting resource allocation across private and public sectors, is present only in our model generating further delays. Furthermore, if we allow the government to have an additional method of taxation, i.e., lump-sum tax on income (case ii-b), the impact of distortional taxation on resource allocation is relaxed. In the model, average duration of restructurings (8.9 quarters) is the same, but debt-to-GDP ratio is lower (24.5 and 30 percent) than that in our baseline model. This is mostly due

to an interaction between adjustments in public investment and the two methods of taxation.

Lastly, when we contrast our model and case (iii), a difference in average duration of restructurings between our model and a model with fixed public capital and no distortionary tax becomes even more larger (11.1 quarters in our model vs. 6.8 quarters). The large difference arises because neither slow recovery of public investment after a severe decline nor distortionary taxation limiting resource allocation across two sectors is present to generate further delays in case (iii). The delays in renegotiations are driven only by recovery in the debtor's repayment capacity presented by recovery of productivity and an associated response of labor—equivalent to recovery of "exogenous income process" in Benjamin and Wright (2013) and Bi (2008).

5.6 Robustness Checks

Table 7: Sensitivity Analysis

	Adjustment Costs			Depreciation Rate			Weight on Public Cons.			Risk Aversion			Discount Rate		
	5	10	15	0.025	0.04	0.075	0.7	0.8	0.9	2	3	4	0.85	0.90	0.93
Default probability (%)	4.22	3.08	1.90	5.2	3.08	4.90	3.70	3.08	5.2	5.7	3.08	4.90	3.30	3.08	3.90
Average recovery rate (%)	31.9	27.1	25.9	29.7	27.1	25.8	26.9	27.1	45.4	49.1	27.1	33.5	28.5	27.1	31.4
Public investment (std dev.)/output (std dev.)	7.90	6.0	3.80	8.47	6.0	2.70	11.7	6.0	5.2	4.50	6.0	7.6	12.6	6.0	5.8
Non-target statistics															
Pre-default periods															
Public consumption & transfers (std dev.)/output (std dev.)	1.30	1.23	1.18	1.42	1.23	1.50	1.35	1.23	1.50	1.80	1.23	1.10	1.46	1.23	1.23
Corr.(public consumption & transfers, output)	0.83	0.89	0.92	0.78	0.89	0.84	0.87	0.89	0.81	0.78	0.89	0.87	0.85	0.89	0.84
Average public investment/GDP ratio (%)	1.60	1.60	1.60	1.18	1.60	2.58	1.39	1.60	1.91	1.87	1.60	1.40	1.35	1.60	1.92
Corr.(public investment, output)	0.62	0.63	0.69	0.61	0.63	0.42	0.44	0.63	0.76	0.62	0.63	0.52	0.35	0.63	0.61
Average debt/GDP ratio (%)	40.2	43.9	43.6	40.2	43.9	44.9	42.4	43.9	25.0	25.9	43.9	23.4	42.7	43.9	36.4
Renegotiation periods															
Public consumption & transfers (std dev.)/output (std dev.)	2.28	2.23	2.30	2.30	2.23	2.20	2.0	2.23	3.54	3.85	2.23	1.30	2.10	2.23	2.14
Corr.(public consumption & transfers, output)	0.77	0.76	0.53	0.87	0.76	0.86	0.80	0.76	0.88	0.88	0.76	0.86	0.72	0.76	0.80
Average public investment/GDP ratio (%)	1.58	1.47	1.46	0.85	1.47	2.95	1.58	1.47	1.39	1.60	1.47	1.51	1.61	1.47	1.73
Corr.(public investment, output)	0.80	0.84	0.78	0.8	0.84	0.81	0.83	0.84	0.9	0.85	0.84	0.67	0.73	0.84	0.80
Duration of renegotiations/ exclusion (quarters)	11.5	11.1	10.6	11.7	11.1	13.2	12.7	11.1	9.5	9.40	11.1	17.6	13.2	11.1	10.5
Public capital (percent change from the trough to the end, %)	5.0	1.70	0.40	0.56	1.70	7.49	6.4	1.70	0.11	4.21	1.70	7.9	7.1	1.70	0.80

Source: Authors' computation

Adjustment costs and depreciation rate on public capital, together with the household's utility weight on public consumption and risk aversion, are key parameters pinning down the dynamics of public investment. Table 7 reports how changes in these parameter values (keeping other parameter values constant) influence the main moment statistics. An increase in adjustment costs on public capital reduces duration of restructurings (10.6 quarters). In this case, the sovereign is more hesitant to cut public investment severely due to high adjustment costs and achieve a quicker recovery of public investment to its pre-crisis level. Moreover, higher depreciation rate on public capital leads to larger demand for public investment (higher public investment in both pre-default and renegotiation periods than that in our baseline model). This, in turn, results in the longer duration of restructurings (13.2 quarters).

When the household assigns higher weight on public consumption in his utility, the sovereign requires high public consumption and lower public investment ex-ante. This, in turn, results in high default probability, lower debt-to-GDP ratio and shorter duration of restructurings (9.5 quarters). On the contrary, when the household becomes more risk averse, the sovereign opts

to improve household utility by allocating more to public consumption and transfers and less to pubic investment. This, in turn, ends up with longer duration of restructurings (17.6 quarters).

6 Testing the Theoretical Predictions

An important result of the model is that the slow recovery of public investment delays debt settlement. To test this prediction, we assess determinants of debt settlement using a multinomial logit model as in conventional empirical studies on debt restructurings (Asonuma and Joo 2019). Our dataset is an unbalanced panel comprised of 111 post-default restructuring episodes over the duration for each episode i.e., from the start of restructurings to the completion of exchanges. As in previous studies (Cruces and Trebesch 2013; Asonuma and Trebesch 2016), we treat each restructuring as an independent event when both exchanged debt instruments and dates of announcement and of settlement in one restructuring differ from those in other restructurings. In this regard, there are overlapping observations included in our panel.

Following the convention in the literature (e.g., Struzenegger 2004, Asonuma and Trebesch 2016), our data are at an annual frequency due to the data availability of public investment and capital, and external debt for the restructuring countries. The dependent variable captures whether restructurings are settled or not in the current year: 1 for completion of exchanges and 0 otherwise. Our main explanatory variables are either public investment or capital—measured as a lagged deviation from the HP-filtered trend or a lagged cumulative growth rate from the start of restructurings—, public and publicly guaranteed (PPG) external debt (in % of GDP), and a deviation and a growth rate of the HP-filtered GDP trend for restructuring countries, which proxy productivity shocks. We also include world GDP growth rate and London Interbank Offered Rate (LIBOR) to control for growth and liquidity of the world economy.

Table 8 shows the logit regression results. We show that high recovery of public investment or capital accumulation in the previous year increases the likelihood of settlement in the current year (columns 1–1' and 2–2'). Quantitatively, a 1-percent increase in public investment (from the trend) or cumulative public capital growth rate increases the probability of settlement by 8.6 and 0.1 percent, respectively (columns 1' and 2'). Both results are consistent with our theoretical findings reported in panel (iii) in Table 5 in Section 5.3. Moreover, the sovereign countries are more likely to reach settlement when PPG external debt is low, and growth and liquidity of the world economy is high and ample, respectively (columns 1–1' and 2–2'). Neither the deviation nor the growth rate of the HP-filtered GDP trend enters as significant, possibly due to high correlation with public investment and capital accumulation, as discussed in Section 2.2.

Table 8: Public Investment and Capital, and Debt Settlement

	Debt Settlement (binary, current)			
	(1)	(1')	(2)	(2')
	coef/ se	dy/dx / Delta-method se	coef/ se	dy/dx / Delta-method se
Public investment, deviation from the trend (lagged, percent)[2/]	0.347*	0.086*	-	-
	(0.195)	(0.048)		
Public capital, cumulative growth rate (lagged, percent)[1/]	-	-	0.005*	0.001*
			(0.003)	(0.0007)
PPG external debt (lagged, percent of GDP)[3/]	-0.003**	-0.001**	-0.003*	-0.0007***
	(0.002)	(0.0004)	(0.002)	(0.0004)
GDP deviation from the trend (current, percent)[2/]	-0.017	-0.004	0.561	0.139
	(0.951)	(0.236)	(0.864)	(0.215)
GDP, trend growth rate (current, percent)[2/]	-0.045	-0.011	-0.073	-0.018
	(0.042)	(0.010)	(0.045)	(0.011)
LIBOR, 12-month average (current, percent)	-0.061***	-0.051***	-0.058**	-0.014**
	(0.023)	(0.006)	(0.024)	(0.006)
World GDP, growth rate (current, percent)	0.207***	0.051***	0.206***	0.051***
	(0.069)	(0.017)	(0.069)	(0.017)
Constant	-0.705*	-	-0.722*	-
	(0.369)		(0.372)	
Episode-specific fixed effects		No		No
Number of restructuring episodes		90		89
Number of observations		496		492
Wald χ^2		21.01		20.74
Prob.> χ^2		0.002		0.002

Notes: The table shows results from random effects multinomial logit regressions. The dependent variable is debt settlement (binary choice). The main explanatory variables are public investment deviation from the trend and public capital cumulative growth rate. Public investment deviation from the trend, public capital cumulative growth rate and PPG external debt (percent of GDP) are lagged by one year. The other explanatory variables are in the current year. Significance levels denoted by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, respectively. Robust standard errors (Delta-method standard errors) are in parentheses.

[1/] Cumulative growth of public capital since the start of restructurings.

[2/] A deviation from the trend and trend growth rate are a percentage deviation from the trend and annual change in the trend obtained by applying a Hodrick-Prescott (HP) filter to annual series with filter of 6.25.

[3/] Public and publicly guaranteed external debt. Lagged level in terms of GDP.

7 Conclusion

The current paper explores the role of public capital and sovereign debt overhang on sovereign debt crises and resolution. We code a new dataset on public expenditure composition around debt restructurings with private external creditors. We find four new stylized facts on sovereign debt overhang and public expenditure composition around post-default restructurings. To explain these facts, we embed endogenous public capital accumulation, expenditure composition and production with public capital and labor in a conventional model of sovereign debt with default and renegotiations. Our model quantitatively replicates these stylized facts and shows both severe decline and slow recovery in public investment (i.e., sovereign debt overhang) delay debt settlement. Empirical evidence supports our theoretical predictions.

For future work, on the basis of better understanding of the role of public capital and sovereign debt overhang on sovereign debt crises and resolution, we explore the effectiveness of different types of fiscal rules (e.g., debt limit rule, primary balance rule, expenditure rule or revenue rule) depending on purposes (e.g., avoiding a default or achieving quick debt settlement). This future project could contribute to ongoing policy debate on the desirable timing of implementing different types of fiscal rules i.e., ex ante or ex post.

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Appendix A Dataset: Details of Coding

We follow public expenditure classification and definition in US BEA (2005) for our coding (Table A1).

Table A1: Public Expenditure Classification and Definition (US BEA 2005)

Government consumption expenditure
Gross output of general government
Value added
Compensation of general government employee
Supplement to wages and salaries
(Employer contributions for government social insurance)
Consumption of general government fixed capital
Intermediate goods and Services
Durable goods
Nondurable goods
Services
Less: Own account investment
Sales to other sectors
Government (gross) investment
Structures
Equipment and software
Government (current) transfer payments
Government social benefits
To persons
To the rest of the world
Other current transfer payments to the rest of the world (net)

Table A2: Public Consumption, Investment, Transfers, and Captal for Restructurings in 1978–2019

(A) 1st group – 20 episodes (1–20)

ISO Code	Country	Restructuring Periods		Definition of Fiscal Sector	Public Consumption	Public Investment	Public Transfers	Public Capital	Source
		start	end	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No	
ALB	Albania	Nov-1991	Aug-1995	Fiscal Account	Yes	Yes	Yes	Yes	IMF (1992 EBS/92/121), IMF (1994 EBS/94/39), IMF (1998 SM/98/90), IMF (2015, Policy Paper)
ARG	Argentina	Jul-1982	Aug-1985	Public Sector Operation/ Cetral Government	Yes	Yes	Yes	Yes	IMF (1986, EBS/86/39), IMF (1989, EBS/89/199), IMF (1990, EBS/90/191), IMF (1994, EBS/94/132), IMF (1996, EBS/96/161), IMF (2015, Policy Paper)
ARG	Argentina	Aug-1985	Aug-1987	Public Sector Operation/ Cetral Government	Yes	Yes	Yes	Yes	IMF (1986, EBS/86/39), IMF (1989, EBS/89/199), IMF (1990, EBS/90/191), IMF (1994, EBS/94/132), IMF (1996, EBS/96/161), IMF (2015, Policy Paper)
ARG	Argentina	Jan-1988	Apr-1993	Public Sector Operation/ Cetral Government	Yes	Yes	Yes	Yes	IMF (1986, EBS/86/39), IMF (1989, EBS/89/199), IMF (1990, EBS/90/191), IMF (1994, EBS/94/132), IMF (1996, EBS/96/161), IMF (2015, Policy Paper)
ARG	Argentina	Nov-2001	Jun-2005	Public Sector Operation/ Cetral Government	Yes	Yes	Yes	Yes	IMF (2002, EBS/02/214), IMF (2006, SM/06/235), IMF (2015, Policy Paper)
BGR	Bulgaria	Mar-1990	Jun-1994	Consolidated General Government	Yes	Yes	Yes	Yes	IMF (1991, EBS/91/26), IMF (1995, SM/95/300), IMF (2015, Policy Paper)
BIH	Bosnia and Herzegovian	Jun-1992	Dec-1997	Fiscal Position	Yes	Yes	Yes	Yes	IMF (1998, SM/98/96), IMF (2015, Policy Paper)
BLZ	Belize	Aug-2006	Feb-2007	Central Government	Yes	Yes	Yes	Yes	IMF (2006, SM/06/341), IMF (2015, Policy Paper)
BOL	Bolivia	Apr-1980	Mar-1988	Central Government/ Cetral Administration	Yes	Yes	Yes	Yes	IMF (1986, EBS/86/263), IMF (1992, SM/92/169), IMF (1994, SM/94/291), IMF (1997, SM/97/224), IMF (2015, Policy Paper)
BOL	Bolivia	Apr-1988	Apr-1993	Central Government/ Cetral Administration	Yes	Yes	Yes	Yes	IMF (1986, EBS/86/263), IMF (1992, SM/92/169), IMF (1994, SM/94/291), IMF (1997, SM/97/224), IMF (2015, Policy Paper)
BRA	Brazil	Dec-1982	Feb-1983	Central Administration Account	Yes	Yes	Yes	Yes	IMF (1983, EBS/83/33), IMF (1984, EBS/84/218), IMF (2015, Policy Paper)
BRA	Brazil	Jan-1983	Jan-1984	Central Administration Account	Yes	Yes	Yes	Yes	IMF (1983, EBS/83/33), IMF (1984, EBS/84/218), IMF (2015, Policy Paper)
BRA	Brazil	Jun-1984	Sep-1986	Central Administration Account	Yes	Yes	Yes	Yes	IMF (1983, EBS/83/33), IMF (1984, EBS/84/218), IMF (2015, Policy Paper)
BRA	Brazil	Sep-1986	Nov-1988	Central Administration Account	Yes	Yes	Yes	Yes	IMF (1983, EBS/83/33), IMF (1984, EBS/84/218), IMF (2015, Policy Paper)
BRA	Brazil	Jun-1989	Nov-1992	-	No	Yes	No	Yes	-
BRA	Brazil	Jun-1989	Apr-1994	-	No	Yes	No	Yes	-
CHL	Chile	Jan-1983	Nov-1983	General Government	Yes	Yes	Yes	Yes	IMF (1984, EBS/84/50), IMF (1985, EBS/85/122), IMF (1987, EBS/87/148), IMF (2015, Policy Paper)
CHL	Chile	Jan-1983	Jan-1984	General Government	Yes	Yes	Yes	Yes	IMF (1984, EBS/84/50), IMF (1985, EBS/85/122), IMF (1987, EBS/87/148), IMF (2015, Policy Paper)
CHL	Chile	Aug-1984	Apr-1986	General Government	Yes	Yes	Yes	Yes	IMF (1984, EBS/84/50), IMF (1985, EBS/85/122), IMF (1987, EBS/87/148), IMF (2015, Policy Paper)
CHL	Chile	Oct-1986	Jun-1987	General Government	Yes	Yes	Yes	Yes	IMF (1984, EBS/84/50), IMF (1985, EBS/85/122), IMF (1987, EBS/87/148), IMF (2015, Policy Paper)

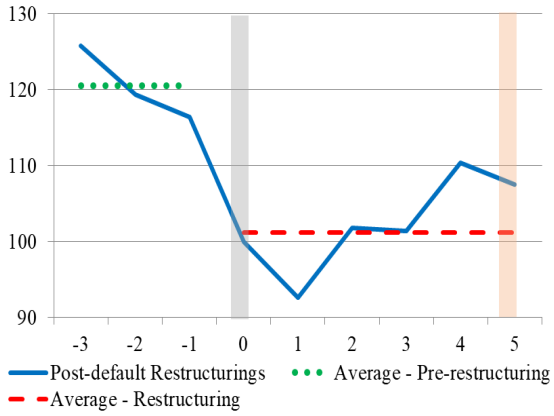
Appendix B Further Empirical Analysis

B.1 Public Consumption, Investment and Transfers

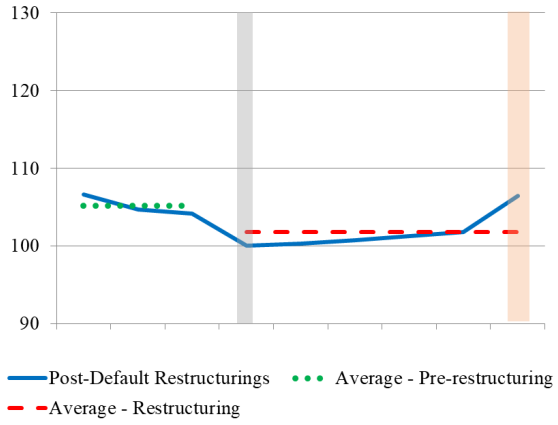
Figure B1 shows the dynamics of public investment, and consumption and transfers—both as percent of GDP—around restructurings. We follow the same presentation approach as in Figure 1 in terms of time horizon, timing of events (both start and end of debt crisis), normalization of the series at levels at the start of restructurings, and average in the pre-default and restructuring periods. Panel (i) shows that public investment-to-GDP ratio follows similar dynamics as the level of public investment (panel i in Figure 1). Similarly, panel (ii) shows that public consumption and transfers-to-GDP ratio follows similar dynamics as the level of public consumption and transfers (panel i in Figure 2).

Figure B1: Public Investment, Consumption and Transfers around the Start of Restructurings

(i) Public Investment (percent of GDP)



(ii) Public Consumption and Transfers (percent of GDP)



B.2 Private and Public Investment and Capital

Figure B2 and B3 show the dynamics of private and public investment and capital around restructurings. We follow the same presentation approach as in Figure 1 in terms of time horizon, timing of events (both start and end of debt crisis), scale (real and level), and normalization of the series at levels at the two events. The blue solid and green dashed lines show an average public investment (capital) and an average private investment (capital) for all post-default restructuring episodes, respectively, for which public investment (capital) or private investment (capital) is available in our dataset.

Both panels (i) and (ii) in Figure B2 show that the dynamics of private investment are identical to those of public investment. Both private and public investment declines sharply at the onset of debt crisis (year 0) and stays below the pre-crisis level in the subsequent years (panel i). Private and public investment only recovers to the pre-crisis level in year 4, leading to

debt settlements in year 5. Private and public investment increases steadily after the settlement (panel ii).

Figure B2: Private and Public Investment around Restructurings

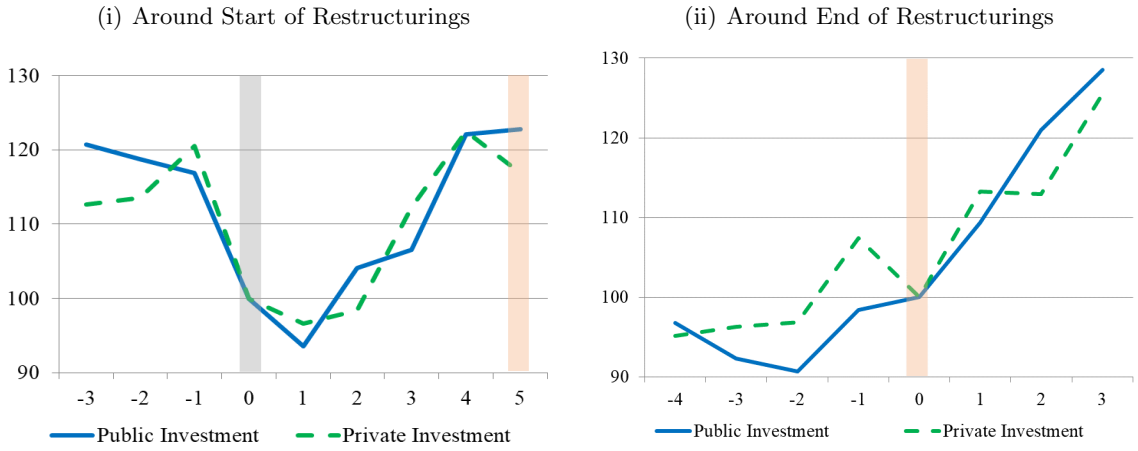
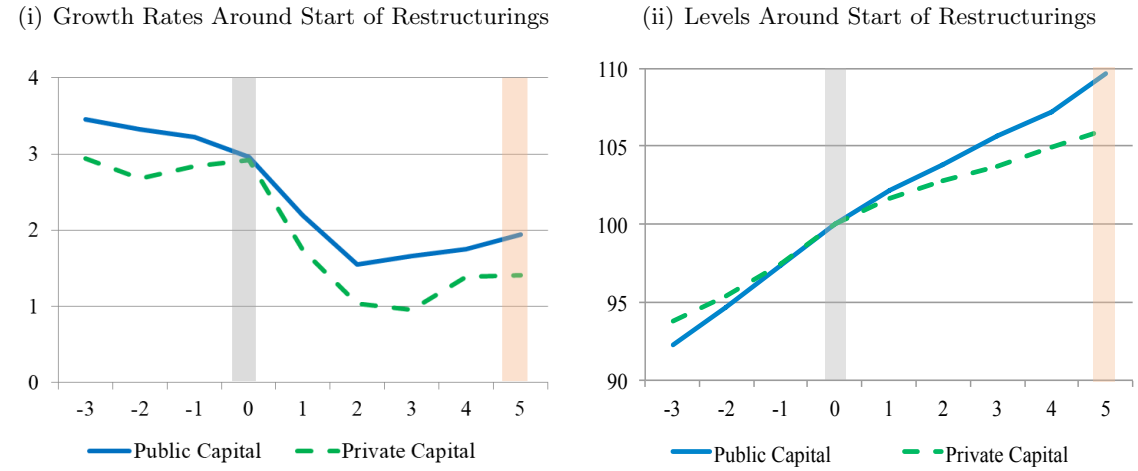


Figure B3 shows that private capital experiences similar dynamics with public capital. Growth rates of private and public capital are significantly lower in restructuring period than those in pre-restructuring period i.e., 1.6 and 2.0 percent in restructuring period on average vs. 2.8 and 3.3 percent (panel i). Private and public capital in restructuring period follows trends with lower growth rates than those in pre-restructuring period (panel ii). As a result, actual levels of both private and public capital are substantially below the levels projected along pre-restructuring trends.

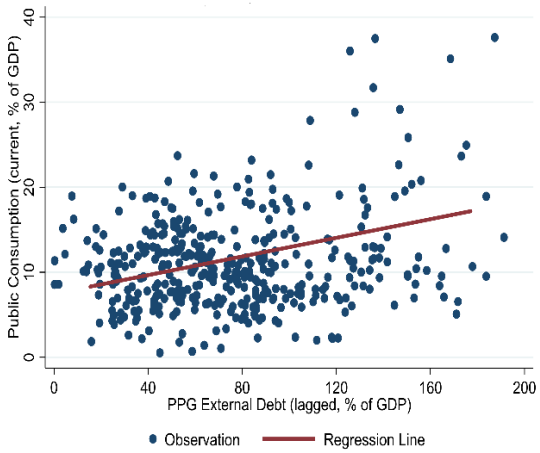
Figure B3: Private and Public Capital around Restructurings



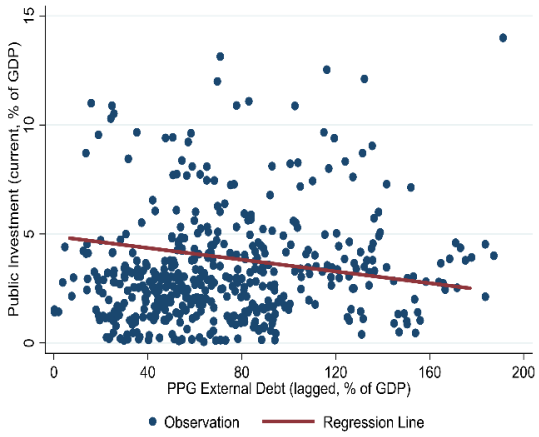
B.3 Public External Debt, and Public Consumption, Investment and Transfers

Figure B4: Public External Debt, and Public Consumption, Investment and Transfers during Restructurings

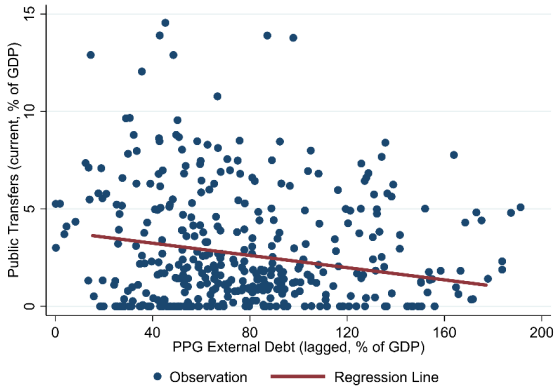
(i) Public Consumption (percent of GDP)



(ii) Public Investment (percent of GDP)



(iii) Public Transfers (percent of GDP)



B.4 Declines in Public Investment and Duration of Restructurings

Table B1: Correlation between Declines in Public Investment and Duration of Restructurings—Baseline

	Duration of restructurings (years)			
	(1)	(2)	(3)	(4)
	coef/se	coef/se	coef/se	coef/se
Public investment/GDP percentage point change over first 2 years (%)[1/]	-0.47*	-0.73**	-	-
	(0.25)	(0.35)		
Public investment/GDP percentage point change over first 1 year (%)[2/]	-	-	-0.53*	-
			(0.29)	
Public investment percentage change over first 2 years (%)[3/]	-	-	-	-0.03*
				(0.01)
Public capital (pre-restructuring, % of GDP)[4/]	-	-0.006	-	0.005
		(0.008)		(0.006)
GDP deviation from trend (end, %)[5/6/]	-	0.11*	0.11*	0.12**
		(0.06)	(0.06)	(0.06)
External debt (end, % of GDP)[6/]	-	0.016	0.018*	0.02*
		(0.01)	(0.01)	(0.01)
Export-to-debt service ratio (end)[6/]	-	0.13	0.12	0.13
		(0.09)	(0.09)	(0.09)
LIBOR 12-month (end, %)[6/]	-	-0.69***	-0.67***	-0.64***
		(0.16)	(0.16)	(0.16)
IMF-supported program (end, dummy)[6/7/]	-	-2.64***	-2.75***	-2.61***
		(0.97)	(0.98)	(0.96)
Bond restructurings (dummy)[8/]	-	-4.33**	-4.53***	-4.47***
		(1.64)	(1.64)	(1.63)
Constant	4.83***	10.66***	10.42***	9.55***
	(0.535)	(1.91)	(1.88)	(1.91)
Number of observations	95	86	86	87
Adjusted-R^2	0.027	0.36	0.35	0.35
Root MSE	4.79	4.05	4.08	4.06

Notes: The table shows results from ordinary least square (OLS) regressions. The dependent variable is duration of restructurings (years). The main explanatory variables are percentage point changes of public investment-to-GDP ratio over first 2 and 1 years, and percentage change of public investment over first 2 years. Significance levels are denoted by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, respectively. Standard errors are in parentheses.

[1/] Percentage point change of public investment-to-GDP ratio over two years from the pre-restructuring year to one year after the start of restructurings.

[2/] Percentage point change of public investment-to-GDP ratio over one year from the pre-restructuring year to the start of restructurings.

[3/] Percentage change of public investment over two years from the pre-restructuring year to one year after the start of restructurings.

[4/] Public capital-to-GDP ratio one year before the start of restructurings.

[5/] GDP deviation from the trend is a percentage deviation from the trend, obtained by applying a Hodrick-Prescott (HP) filter to annual GDP series with a smoothing parameter of 6.25.

[6/] Levels at the end of restructurings.

[7/] A dummy for an IMF-supported program is set to 1 when an IMF-supported program starts at year of the end of restructurings and 0 otherwise.

[8/] A dummy for bond restructurings is set to 1 if a restructuring is a bond exchange.

Table B2: Correlation between Declines in Public Investment and Duration of Restructurings—Robustness Check

	Duration of restructurings (years)		
	(1)	(2)	(3)
	Dropping outliers (duration of restructurings)[6/]	Dropping outliers (duration of restructurings)[6/]	Generalized least square[7/]
	coef/se	coef/se	coef/se
Public investment/GDP percentage point change over first 2 years (%)[1/]	-0.581**	-0.707*	-0.731**
	(0.290)	(0.381)	(0.352)
Public capital (pre-restructuring, % of GDP)[2/]	-0.004	0.001	-0.006
	(0.007)	(0.011)	(0.008)
GDP deviation from trend (end, %)[3/4/]	0.078	0.118*	0.112*
	(0.050)	(0.061)	(0.060)
External debt (end, % of GDP)[4/]	0.017**	0.015	0.016
	(0.009)	(0.010)	(0.010)
Export-to-debt service ratio (end)[4/]	0.106	0.120	0.126
	(0.076)	(0.091)	(0.090)
LIBOR 12-month (end, %)[4/]	-0.459***	-0.687***	-0.688***
	(0.134)	(0.160)	(0.157)
IMF-supported program (end, dummy) [4/5/]	-2.099***	-2.792***	-2.636***
	(0.797)	(0.985)	(0.967)
Bond restructurings (dummy)[6/]	-2.956**	-4.121**	-4.330**
	(1.357)	(1.685)	(1.636)
Constant	7.816***	10.377***	10.658***
	(1.652)	(2.028)	(1.912)
Number of observations	82	84	86
Adjusted-R^2	0.30	0.35	5.73
Root MSE	3.31	4.07	-

Notes: The table shows results from ordinary least square (OLS) regressions. The dependent variable is duration of restructurings (years). The main explanatory variable is percentage point change of public investment-to-GDP ratio over first 2 years. Significance levels are denoted by *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$, respectively. Standard errors are in parentheses.

[1/] Percentage point change of public investment-to-GDP ratio over two years from the pre-restructuring year to one year after the start of restructurings.

[2/] Public capital-to-GDP ratio one year before the start of restructurings.

[3/] GDP deviation from the trend is a percentage deviation from the trend, obtained by applying a Hodrick-Prescott (HP) filter to annual GDP series with a smoothing parameter of 6.25.

[4/] Levels at the end of restructurings.

[5/] A dummy for an IMF-supported program is set to 1 when an IMF-supported program starts at year of the end of restructurings and 0 otherwise.

[6/] A dummy for bond restructurings is set to 1 if a restructuring is a bond exchange.

Appendix C Implications for Key Theoretical Assumptions

We explore model implications for following three key theoretical assumptions; (1) output costs; (2) net issuance at settlement; (3) private capital; (4) taxation methods—two-stage consumption tax and labor income tax. In particular, for each case, we discuss how a change in the assumption keeping other assumptions and parameter values unchanged influences the sovereign's choice between repayment and default, and between settlement and delay. Our main qualitative implications are robust.

Panels (i) and (ii) in Figure C1 repeat panels A-(i) and A-(ii) in Figure 6: the sovereign's choice when the debtor's TFP is at the mean/low level. Panels (i) and (ii) report the sovereign choice at good credit record ($h = 0$) and at bad credit record ($h = 1$), respectively.

Figure C2 reports a case for symmetric output costs for the sovereign debtor. Our baseline results remain robust. Assuming a different type of output costs, i.e., symmetric to the level of TFP shocks (Aguiar and Gopinath 2006; Yue 2010) does not influence the sovereign's choice between repayment and default, and between settlement and delay.[32]

Figure C3 reports a case with net issuance at settlement. When we incorporate net issuance at the time of settlement as in Benjamin and Wright (2013), the sovereign is more willing to settle since the net lending reduces the costs of debt settlement (larger "Settlement" region in panel ii). Due to lower default costs—shorter periods of financial exclusion owing to high likelihood of debt settlement—, the sovereign is more willing to default ex ante (larger "Default" region in panel i).

Figure C4 reports the sovereign's choice in two different assumptions of private capital. Reflecting high correlation between private and public capital reported in Figure B3 in Appendix B.2, we assume following two specifications of private capital; panel A: a linear function of public capital $k_t^p = k_t^g$; panel B: a square root function of public capital $k_t^p = (k_t^g)^{1/2}$. In the case of the linear function of public capital, the production function has constant returns to scale (CRS). Our baseline results on the sovereign's choice between repayment and default, and between settlement and delay remain robust (panels A-i and A-ii). In the case of the square root function of public capital, the production function has decreasing returns to scale (DRS) as in our baseline. Again, our baseline results on the sovereign's choice continue to be robust (panels B-i and B-ii). This is because, under reasonable assumptions of public capital where the production function has constant or decreasing returns to scale, the sovereign allocates available resources among public consumption, investment, transfers, and external debt payments. In contrast, under an extreme assumption of public capital where the production function has increasing returns to scale (IRS), the sovereign concentrates its spending on public investment, and not on external debt payments. In this case, the sovereign opts to default at low debt level and delay renegotiations after default.

Lastly, Figure C5 reports the sovereign's choice in two different assumptions of taxation;

[32] In the case of quadratic function of output costs respect to the debtor's TFP (Chatterjee and Eyigungor 2012; Hatchondo, et al. 2017), the sovereign's choice between repayment and default, and between settlement and delay is similar to that in our baseline model or in model with symmetric output costs.

panel A: two-stage consumption tax; panel B: labor income tax. First, when we allow the sovereign to increase consumption tax rate to raise tax revenues during debt restructurings—equivalent to fiscal consolidation—, the sovereign is more willing to settle because of the improvement in repayment capacity (larger "Settlement" region in panel ii). Due to lower default costs—shorter periods of financial exclusion owing to high likelihood of debt settlement—, the sovereign is more willing to default ex ante (larger "Default" region in panel i).

Second, assuming labor income tax (Arellano and Bai 2017) does not influence the sovereign's choice between repayment and default, and between settlement and delay. This is because, labor income tax is conceptually identical to consumption tax; both labor income tax and consumption tax affect the household's intra-temporal substitution between consumption and labor as reported in equation (3), but not the sovereign's inter-temporal substitution between consumption—public consumption and transfers—and saving (i.e., public investment).

Figure C1: Debtor's Choice between Repayment and Default, and between Settlement and Delay—Baseline Model

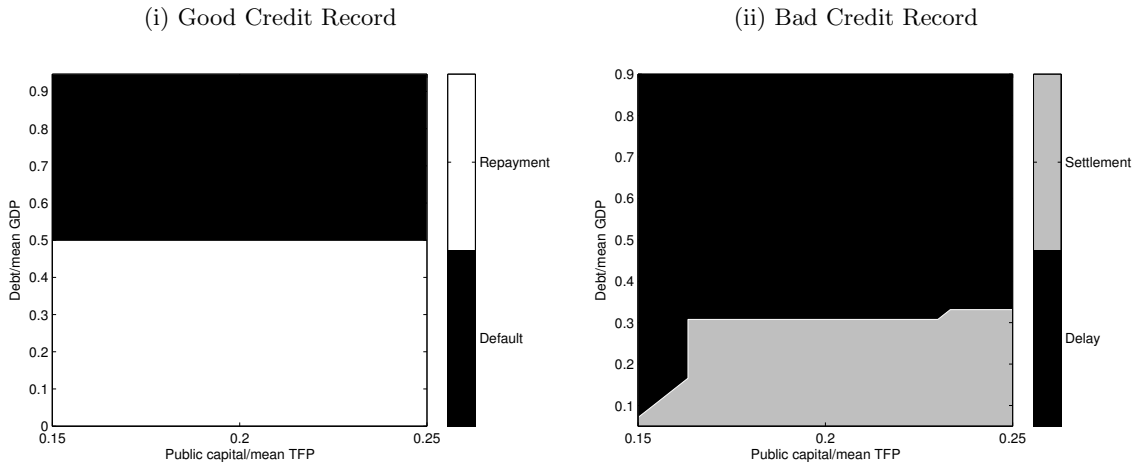
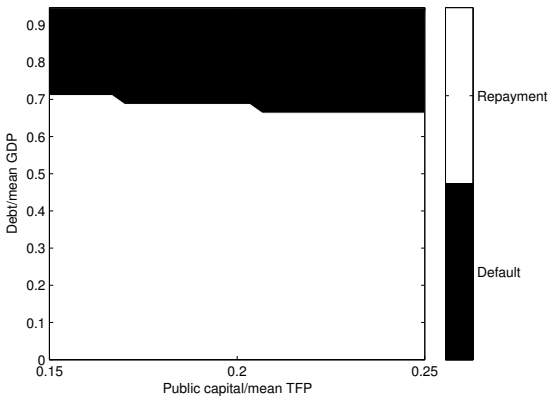


Figure C2: Debtor's Choice between Repayment and Default, and between Settlement and Delay—Symmetric Output Costs

(i) Good Credit Record



(ii) Bad Credit Record

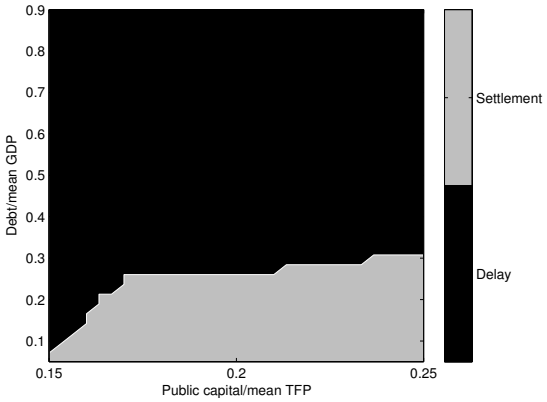
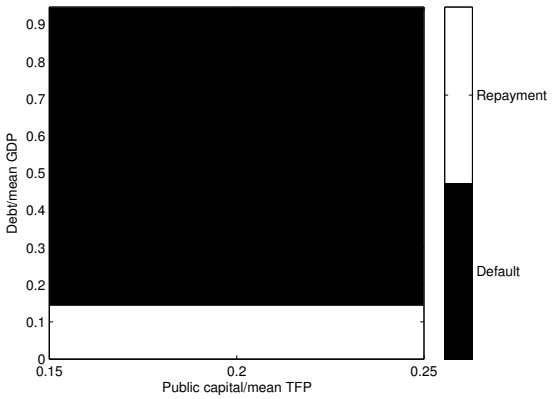


Figure C3: Debtor's Choice between Repayment and Default, and between Settlement and Delay—Net Issuance

(i) Good Credit Record



(ii) Bad Credit Record

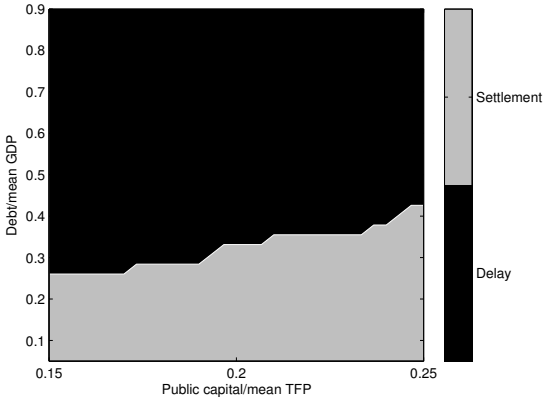
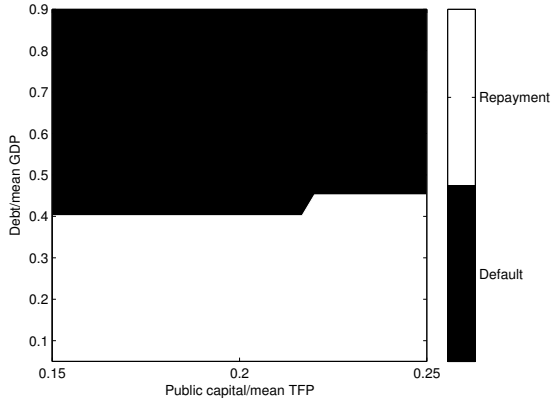


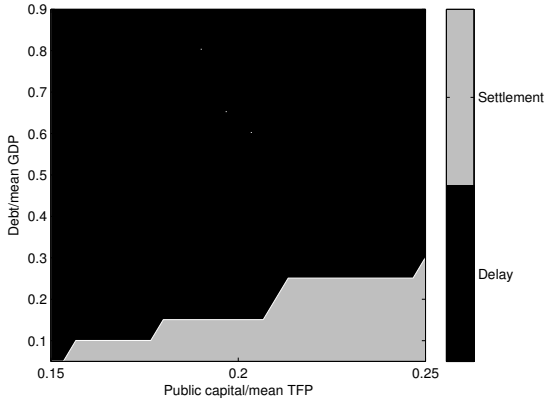
Figure C4: Debtor's Choice between Repayment and Default, and between Settlement and Delay—Private Capital

A: Linear Function of Public Capital

(i) Good Credit Record

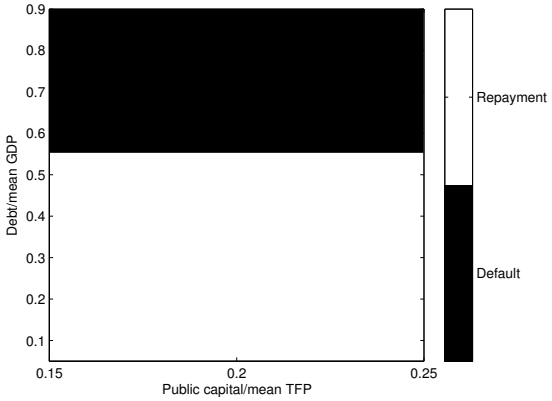


(ii) Bad Credit Record



B: Square Root Function of Public Capital

(i) Good Credit Record



(ii) Bad Credit Record

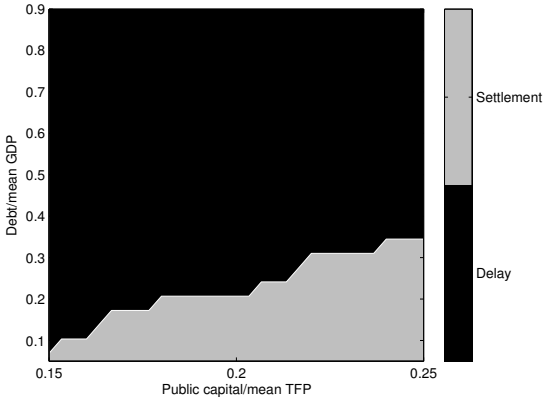
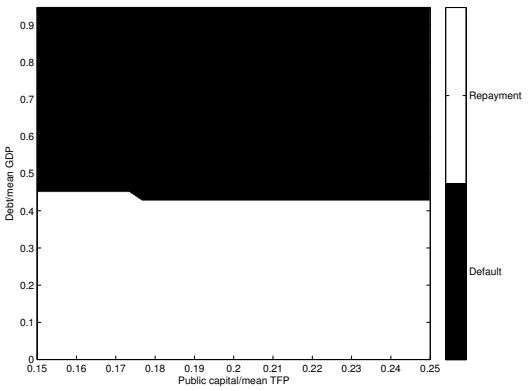


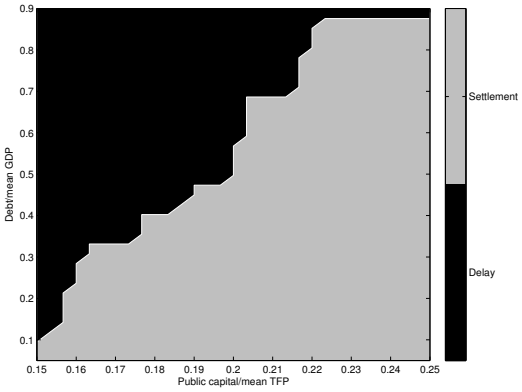
Figure C5: Debtor's Choice between Repayment and Default, and between Settlement and Delay—Taxation Methods

A: Two-stage Consumption Tax

(i) Good Credit Record

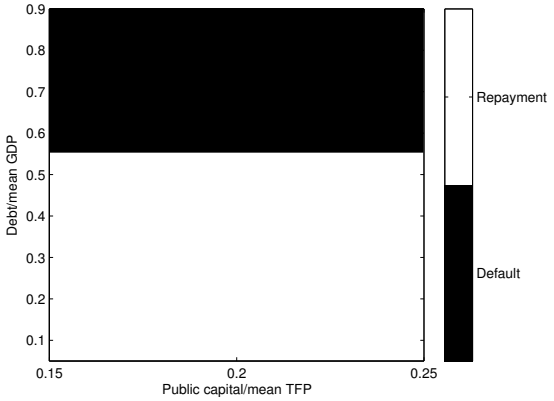


(ii) Bad Credit Record

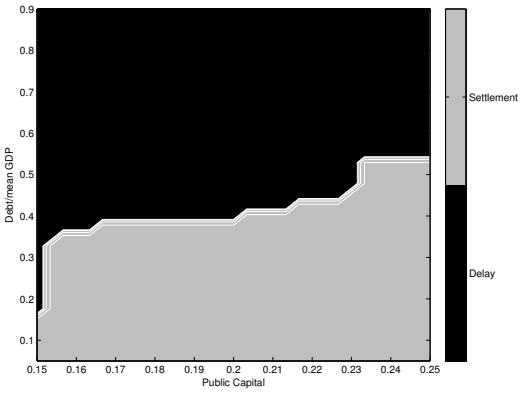


B: Labor Income Tax

(i) Good Credit Record



(ii) Bad Credit Record



Appendix D Computation Algorithm

The procedure to compute the equilibrium distribution of the model is the following:

1. First, we set finite grids on the space of asset/debt holdings, pubic capital and productivity as by $B = [b_{min}, b_{max}]$, $K^g = [k^g_{min}, k^g_{max}]$, and $A = [a_{min}, a_{max}]$. Limits of productivity are large enough to include large deviations from mean value of shocks. We approximate the stochastic productivity process of the sovereign shown by equation (41) using a discrete Markov chain of 21 equally spaced grids as in Tauchen (1986). Moreover, we compute the transition matrix based on the probability distribution $\mu(a_{t+1}|a_t)$.

2. Second, we set finite grids on the space of recovery rates (δ_t). Limits of recovery rates are to ensure that they do not bind in equilibrium.

3. Third, we set the initial values for equilibrium sovereign bond price, payoffs of debt renegotiations for the sovereign and the creditors, and the sovereign's value function. We use the risk-free bond price ($q^0 = (1 + r^*)^{-1}$) for the baseline equilibrium bond price. We set payoffs for debt renegotiations for the sovereign and the creditors as $\Delta^{B,0}_t = \Delta^{L,0}_t = 0$, and the initial value functions for the sovereign as $V^0 = V^{R,0} = V^{D,0} = 0$.

4. Fourth, given the baseline equilibrium bond price, debt renegotiation payoffs and the sovereign's value functions, we solve for the household's and the firm's maximization problems to obtain private consumption, labor supply and labor demand.

5. Fifth, given the baseline equilibrium sovereign bond price, debt renegotiation payoffs, and the private sector's equilibrium policy functions, we solve for the sovereign's optimization problem for both good and bad credit records ($h_t = 0, 1$). This procedure finds the value functions for the sovereign ($V^1, V^{R,1}, V^{D,1}$), the optimal asset/debt functions ($b^1, b^{R,1}, b^{D,1}$), and public capital functions ($k^{g,1}, k^{g,R,1}, k^{g,D,1}$). Furthermore, we obtain the default choice, which requires a comparison of the value functions of defaulting and non-defaulting. By comparing these two value functions, we derive the corresponding default set. Based on the 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 the foreign creditors, we compute the new price of sovereign bonds (q^1).

7. Seventh, given the value functions for the sovereign, we solve the bargaining problem and compute the new payoffs for two cases either the sovereign or the creditors is the proposer ($\Delta^{B,1}_t, \Delta^{L,1}_t$).

8. We iterate steps (4), (5), (6) and (7) to have fixed optimal value functions for the sovereign, debt renegotiation payoffs, bond price and the private sector's policy functions.

Appendix E Further Equilibrium Properties

E.1 Equilibrium Properties in the Case the Debtor Proposes

Figure E1 reports agreed recovery rates when the sovereign proposes. In both panels (i) and (ii), the horizontal axis is public capital/mean TFP ratio and the vertical axis is recovery rate. Two panel charts are classified as follows: panel (i): the debtor TFP at the mean level, and panel (ii): debt at the 70% of mean GDP, respectively. Both panels (i) and (ii) show that agreed recovery rates are independent of the level of public capital—for instance, agreed recovery rates stay constant at 22% when public capital is high, mean or low. What generates this result is the multi-round stochastic bargaining game where the settlement occurs only when the proposer—in this case, the debtor—proposes and the counterpart—in this case, the creditors—accepts the proposal. That is, the agreed recovery rates satisfy participation constraints of both the sovereign and the creditors shown in equation (22). Otherwise, there is no agreement reached by the two parties. To maximize its value of proposing, the proposer (the sovereign) chooses the lowest level of recovery rates among possible recovery rates which do not violate the participation constraints of the sovereign and the creditors. The agreed recovery rates are determined by both fixed outside options for the sovereign and the creditors, i.e., values of passing and rejecting (equations 20 and 21). While the sovereign's value of passing increases as public capital increases, the creditors' value of rejecting is independent of the level of public capital. Therefore, the agreed recovery rates are independent of the level of public capital.

In contrast, both panels (i) and (ii) show that the agreed recovery rates are higher (lower) when debt is lower (higher) and the TFP is higher (lower). These are general patterns of recovery rates as in previous work on debt restructurings (Yue 2010; Bi 2008; Asonuma and Trebesch 2016); recovery rates are increasing with respect to the debtor's assets and repayment capacity, i.e., income.

Figure E1: Agreed Recovery Rates

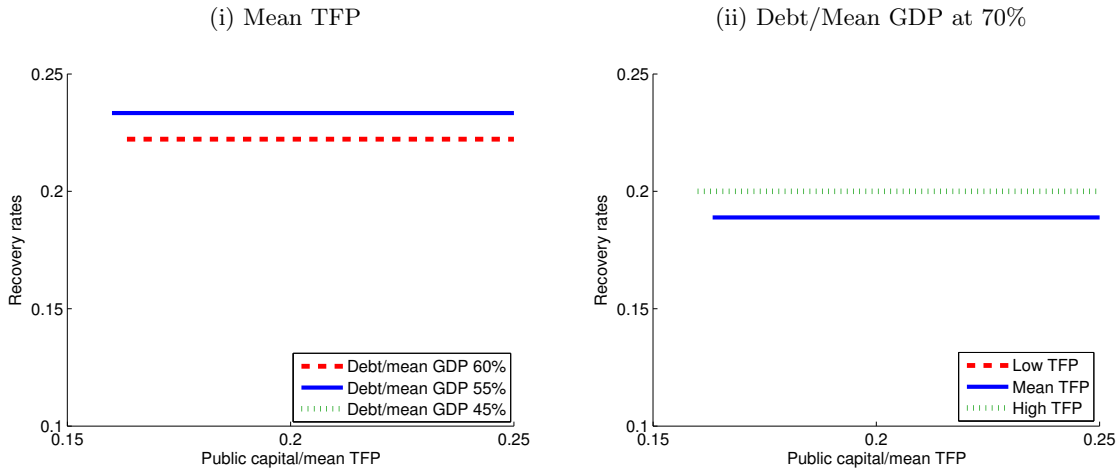
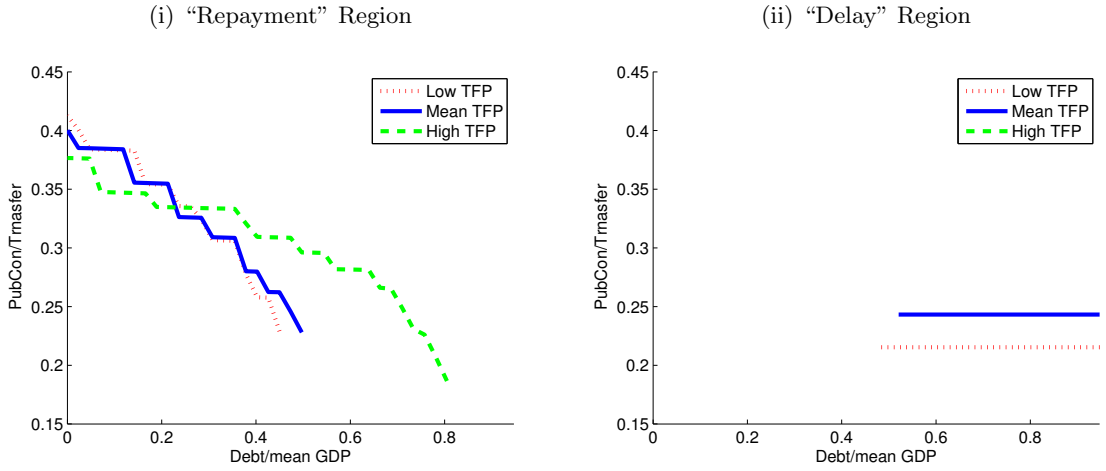


Figure E2 reports the sovereign's choice of public consumption and transfers at the mean

public capital. We follow the same presentation approach as in Figure 7 in terms of both axis and panel classifications. Both panels (i) and (ii) show two features of public consumption and transfers differentiating from those of public investment (in Figure 7). First, panel (i) reports that in the "repayment" region, public consumption and transfers do not differ significantly depending on the level of productivity. This is driven by the sovereign's willingness to improve household utility by smoothing consumption and transfers: despite limited resources due to low productivity, the sovereign is willing to allocate more on public consumption and transfers to improve household utility. Moreover, though public consumption and transfers decrease when debt is high in the "repayment" region (panel i), a size of reduction in consumption and transfers is smaller than that in public investment, i.e., 43% vs. 88%—a change in public consumption and transfers, and investment between at debt at the 0% and 50% of mean GDP.

Second, panel (ii) shows that in the "delay" region, though public consumption and transfers differ between at the mean or low TFP levels due to limited resources, the difference in public capital and transfers is substantially smaller than that in public investment, i.e., 12% vs. 75%—a difference in public consumption and transfers (investment) between at the low and mean TFP levels.

Figure E2: Public Consumption and Transfers—Mean Public Capital



E.2 Equilibrium Properties in the Case the Creditors Propose

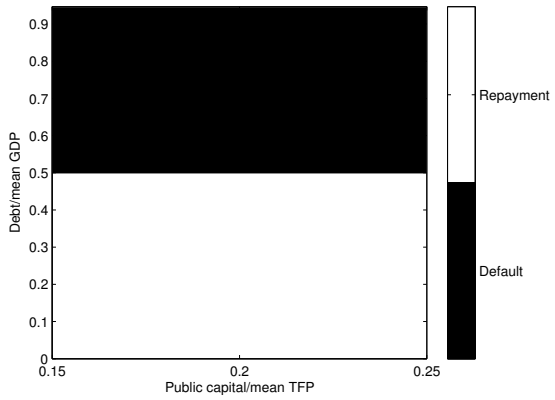
We show the sovereign's choice between repayment and default, and between settlement and delay when the creditors propose in Figure E3. We follow the same presentation approach as in Figure 6 in terms of axis, panel classifications and regions. The sovereign's choice when the creditors propose is exactly identical to that when the sovereign proposes (Figure 6). This is the finding in the literature of multi-round renegotiations (Bi 2008); whether the settlement can be reached in the current period does not depend on the identity of the proposer. Intuitively, if one party proposes recovery rates that make both parties at least weakly better off by settling than

postponing, this offer of recovery rates could identically be proposed by the alternative party and accepted.

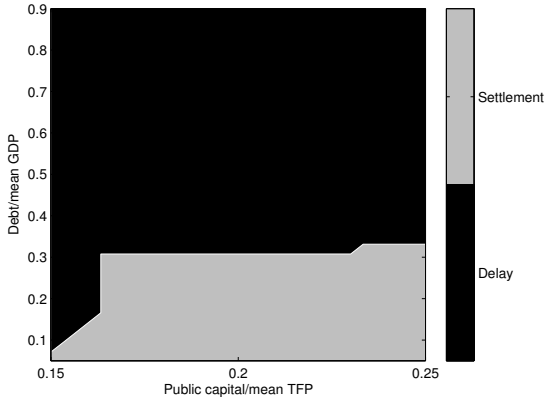
Figure E3: Debtor's Choice between Repayment and Default, and between Settlement and Delay when the Creditors Propose

A: Mean/Low TFP

(i) Good Credit Record

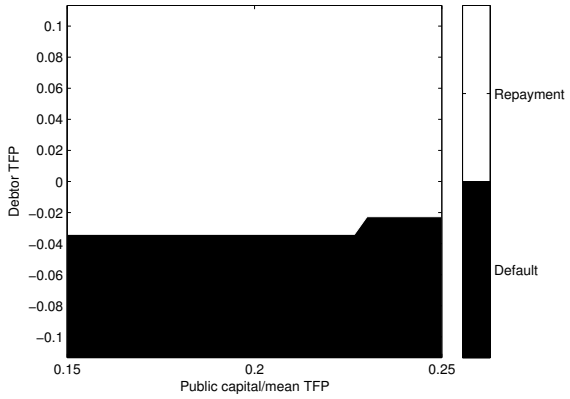


(ii) Bad Credit Record



B: Debt/Mean GDP ratio of 47%

(i) Good Credit Record



(ii) Bad Credit Record

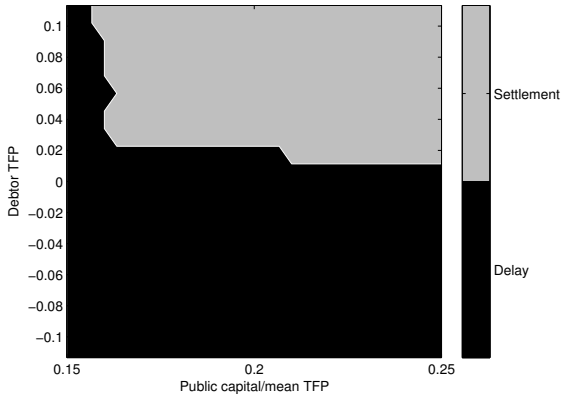
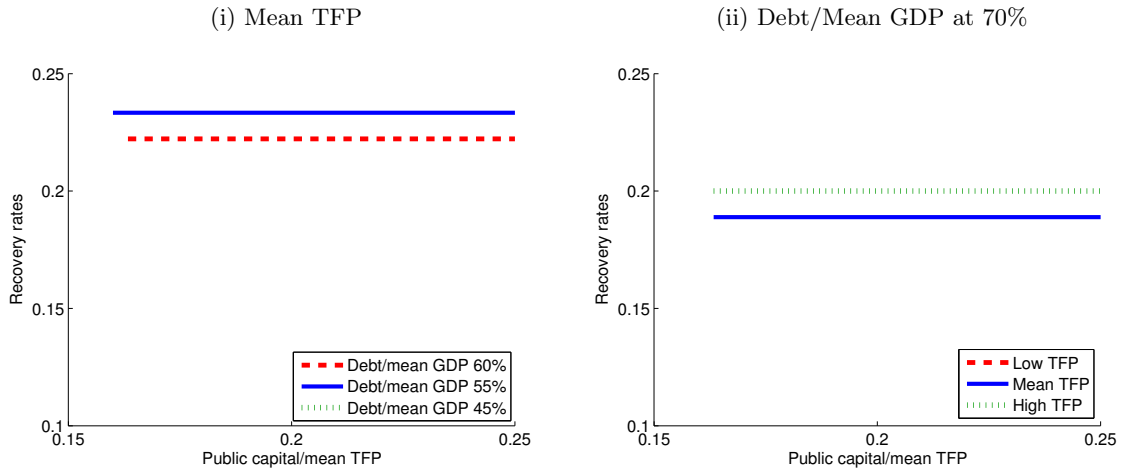


Figure E4 reports agreed recovery rates when the creditors propose. We follow the same presentation approach as in Figure E1 in terms of axes and panel classifications. Our model also shows that in the case where the creditor proposes, agreed recovery rates are independent of the level of public capital—for instance, agreed recovery rates stay constant at 22% when public capital is high, mean or low. The same logic applies as in the case where the debtor proposes: the creditors proposes the highest level of recovery rates among possible recovery rates which do not violate the participation constraints of the sovereign and the creditors. The agreed recovery rates are determined by both fixed outside options for the sovereign and the creditors, i.e., values

of rejecting and passing (equations 28 and 29). While the sovereign's value of rejecting increases as public capital increases, the creditors' value of passing is independent of the level of public capital. Therefore, the agreed recovery rates are independent of the level of public capital.

Agreed recovery rates when the creditors propose are slightly higher than those when the debtor proposes (Figure E1) as in previous studies on multi-round renegotiations (Bi 2008). This is due to the "advantage of the first mover"; the party who proposes can choose the best term of offer from a wide range of recovery rates which the counterpart would accept, while the counterpart can only choose to accept or reject the offer. Therefore, he is willing to offer more favorable term for him than the term of the offer he receives from the alternative party.

Figure E4: Agreed Recovery Rates when the Creditors Propose



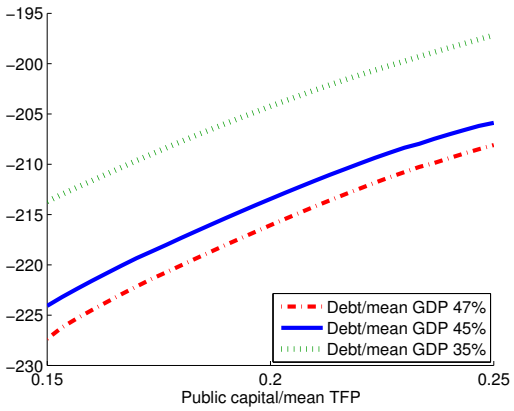
We explore the role of public capital influencing the sovereign's choice between repayment and default, and between settlement and delay when the creditors propose reported in Figure E5. We follow the same presentation approach as in Figure 10 in terms of axis, panel classifications and labels. First, we start from the role of public capital on the sovereign's choice between repayment and default. The sovereign's value functions of repayment and default together with a difference between the two when the creditors propose (panel A in Figure E5) are identical to those when the sovereign proposes (panel A in Figure 10). Default costs, i.e., length of financial exclusion—when both parties settle on debt renegotiations—do not depend on the identity of the proposers. The value function of default is the same with that when the sovereign proposes. The relative importance between the "smoothing channel" and a combination of the "autarky channel" and the "debt renegotiation channel" is independent from the level of public capital as in the case when the sovereign proposes. That is, the sovereign's willingness to repay debt and default does not change as public capital increases.

Second, we move on to the role of public capital on the sovereign's choice of accepting and rejecting. Panel B-(i) reports value function of accepting conditional on debt settlement. When debt settlement is not achieved, value function of accepting is truncated or does not exit (i.e., truncated green dotted line or no blue solid line). It shows that as public capital increases,

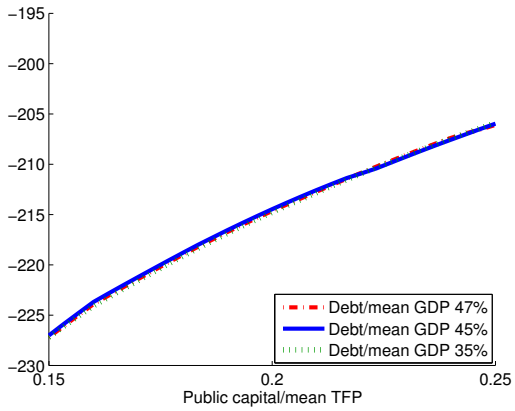
Figure E5: Value Functions at the Mean/Low TFP when the Creditors Propose

A: Value Functions of Repayment and Default

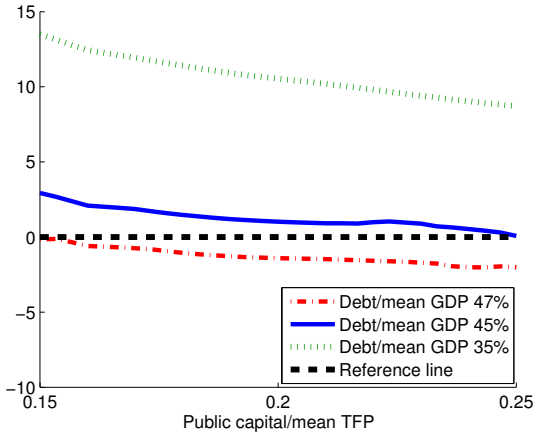
(i) Value Function of Repayment V^R



(ii) Value Function of Default V^D



(iii) Difference between Two Value Functions $V^R - V^D$



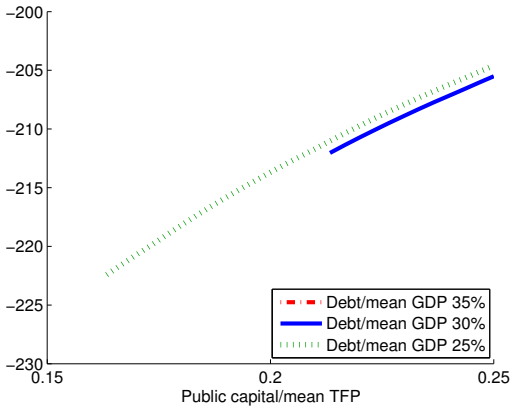
the debt settlement is more likely to occur and value function of accepting exists (the "debt renegotiation channel"). Value function of accepting when the creditors propose is lower than value function of proposing when the sovereign proposes (panel B-i in Figure 10). As explained above, this is due to the "advantage of the first mover"; the party who proposes can choose the best term of offer from a wide range of recovery rates which the counterpart would accept, while the counterpart can only choose to accept or reject the offer. Panel B-(ii) shows that value function of rejecting also increases as public capital increases (the "autarky channel"). Value function of rejecting when the creditors propose is identical to value function of passing when the sovereign proposes (panel B-ii in Figure 10) because no settlement occurs in the current period and both parties continue renegotiations in the next period. Panel B-(iii) shows that at 30 percent of mean GDP, as public capital increases, the debt settlement is more likely to occur and the difference between value functions of accepting and rejecting is above the reference line

of zero value (blue solid line). That is, the debt renegotiation channel of public capital dominates the autarky channel when public capital is high.

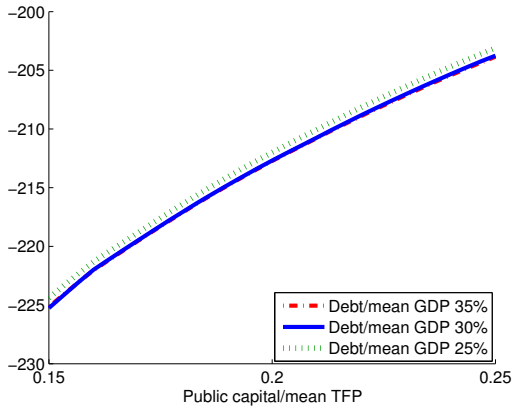
Figure E5: Value Functions at the Mean/Low TFP when the Creditors Propose (Cont.)

B: Value Functions of Accepting and Rejecting

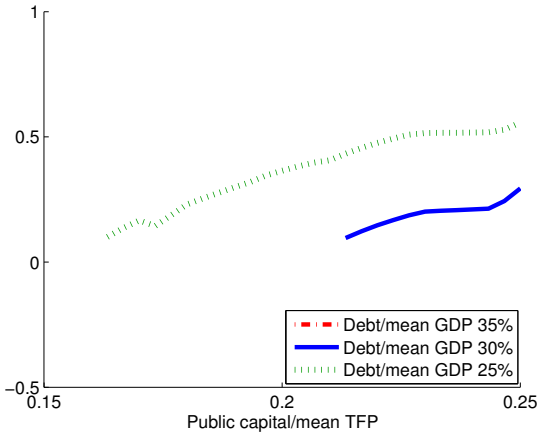
(i) Value Function of Accepting V^{ACT}



(ii) Value Function of Rejecting V^{REJ}



(iii) Difference between Two Value Functions $V^{ACT} - V^{REJ}$



E.3 Equilibrium Properties in Comparison with Models of Sovereign Default

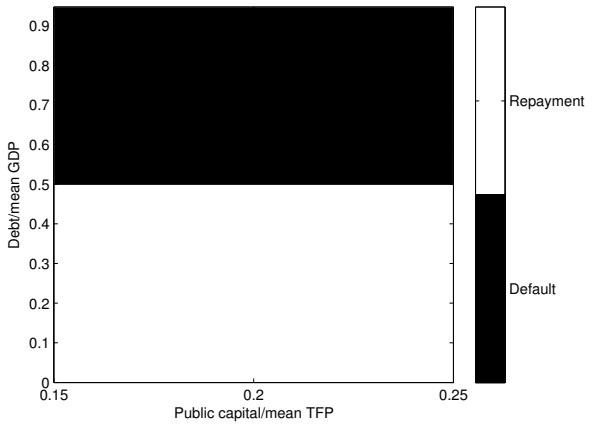
We contrast equilibrium properties in our baseline model with those in previous model of sovereign default. We consider two cases: (i) a model with exogenous reentry and zero recovery rates (Arellano 2008; Gordon and Guerron-Quintana 2018) and (ii) a model with a one-round negotiation (Yue 2010; Arellano and Bai 2017). To generate model features comparable to ours, we embed an assumption of exogenous reentry and zero recovery rates for the case (i), and an assumption of one-round Nash bargaining for the case (ii) in our model, respectively leaving all other parameters unchanged.

Figure E6 contrasts the sovereign's choice between repayment and default at the mean/low TFP in our baseline model (panel i) with that in two models of sovereign default (panels ii and iii). We follow the same presentation approach as in Figure 6 in terms of axis and regions. There are two features in these two models of sovereign default different from those in our baseline paper. First, the sovereign is more willing to repay debt as public capital increases. This is shown in the enlarged (shrunk) "Repayment region" when public capital is high (low) in panels (ii) and (iii). Second, the sovereign is more willing to default at low level of debt due to low default costs—fixed or short periods of financial autarky over which the sovereign suffers productivity loss—than our baseline model. We do not contrast the sovereign's choice of settlement and delay in our baseline model with that in the model with a one-round negotiation. This is because the choice in our model does not correspond one-to-one with the choice in the model with a one-round negotiation due to a difference in the bargaining game.

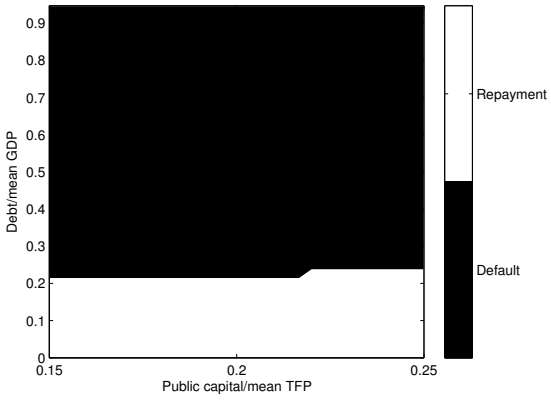
Figure E7 contrasts the difference in the sovereign's value function of repayment and default (at the mean/low TFP) in our model (panel i) with that in two models of sovereign default (panels ii and iii). We follow the same presentation approach as in panel A-(iii) in Figure 10 in terms of axis, lines and labels. In the two models of sovereign default, the difference between value functions of repayment and default (shown in blue solid line in panel ii and green dotted line in panel iii) is above the reference line of zero value when public capital is high, while below the reference line when public capital is low. That is, the smoothing channel of public capital dominates the autarky channel—the debt renegotiation channel is missing—when public capital is high, while the autarky channel dominates the smoothing channel when public capital is low (Gordon and Guerron-Quintana 2018). The relative importance of these two opposing channels depends on the level of public capital. This is consistent with that the aforementioned fact that the sovereign is more willing to repay debt than to default as public capital increases (panels ii and iii in Figure E6 in Appendix E.2).

Figure E6: Debtor's Choice of Repayment and Default at the Mean/Low TFP

(i) Baseline Model



(ii) Exogenous Re-entry with Zero Recovery Rates



(iii) One-round Negotiation

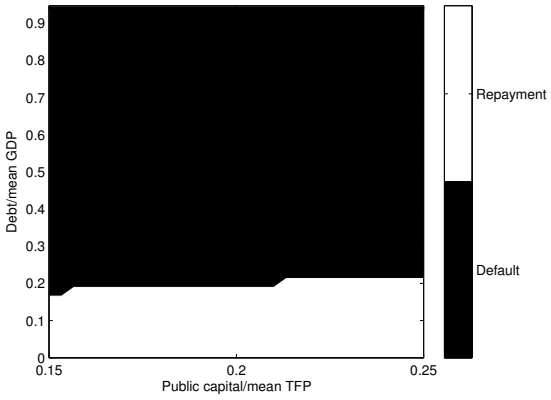
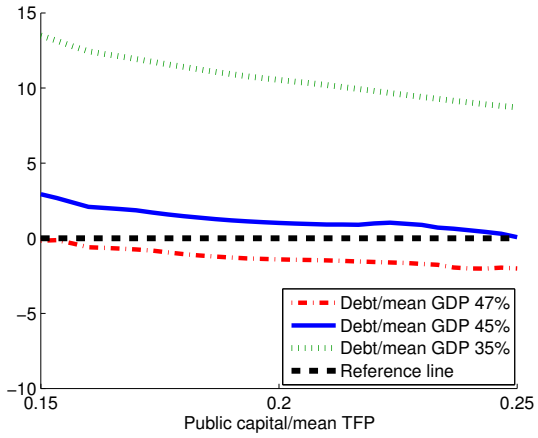
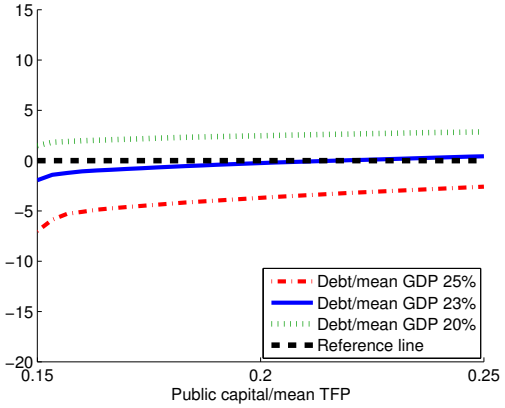


Figure E7: Difference in Value Functions of Repayment and Default at the Mean/Low TFP

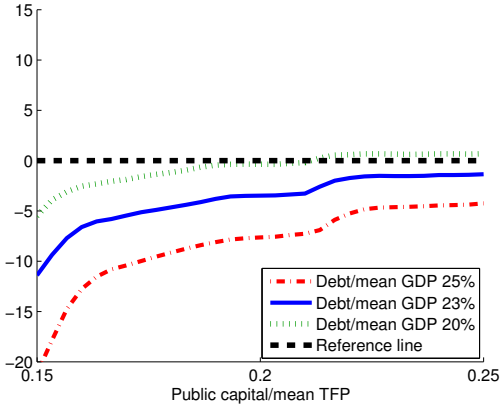
(i) Baseline Model



(ii) Exogenous Re-entry with Zero Recovery Rates



(iii) One-round Negotiation



Appendix F Further Quantitative Analysis

Table F1 compares non-target statistics in our baseline mode with those in previous studies in two streams of literature; sovereign debt and fiscal policy (Cuadra et al. 2010; Hatchondo et al. 2017; Arellano and Bai 2017) and debt renegotiations (Benjamin and Wright 2013; Bi 2008; Yue 2010; Arellano 2008). For the literature on sovereign debt and fiscal policy, we consider two cases; (a) a model with fixed/no public capital and exogenous re-entry and zero recovery (columns 5 and 8 in panel i)—corresponding to Cuadra et al. (2010) and Hatchondo et al. (2017)—; (b) a model with fixed/no public capital and one-round negotiation (columns 4 and 7 in panel i)—corresponding to Arellano and Bai (2017). For the literature on debt renegotiations, we consider three cases; (c) a model with fixed/no public capital and multi-round renegotiations (columns 3 and 6 in panel i)—Benjamin and Wright (2013) and Bi (2008) with our parameters—; (d) a model with fixed/no public capital and one-round negotiation (columns 4 and 7 in panel i)—corresponding to Yue (2010); (e) a model with fixed/no public capital and exogenous re-entry and zero recovery (columns 5 and 8 in panel i)—Arellano (2008). To generate moments comparable to ours, we embed key assumptions in our model for each case, leaving all other parameters unchanged. Since none of previous studies introduces public capital, we consider both cases of fixed and no public capital.

For business cycle statistics reported in panel i in Table F1, our calibration results (column 2) outperforms calibration results of previous studies. Most importantly, our model is the only one which successfully replicates moment statistics of public investment in both pre-default and restructuring periods which match closely with the data: lower public investment-to-GDP ratio and public investment-to-expenditure ratio in restructuring period than those in pre-default period, and a negative correlation between public investment and GDP. This is because our model embeds endogenous public capital accumulation, whereas none of Cuadra et al., (2010), Hatchondo et al., (2017) or Arellano and Bai (2017) has public capital in their models. Introducing fixed public capital in their model is not enough to account for the moment statistics of public investment because both public investment is kept at a fixed level exogenously.

For non-business cycle statistics reported in panel ii in Table F1, our calibration results (column 2) continues to outperform calibration results of previous studies. First, most importantly, our model successfully replicates a negative correlation between declines in public investment and duration of restructurings, while previous studies on sovereign debt and fiscal policy (Cuadra et al. 2010; Hatchondo et al. 2017; Arellano and Bai 2017) do not. As explained above, what drives this difference is endogenous public capital accumulation which is only present in our model, but not in previous models. Second, our model replicates longer duration of renegotiations (11.1 quarters) which is close to the data than that in models of multi-round renegotiations (Benjamin and Wright 2013; Bi 2008; 8.3/9.3 quarters), one-round negotiation (Yue 2010; 2.0 quarters). As explained in Section 5.3, what generates long duration of restructurings in our model are both endogenous public capital accumulation (both downward and upward trends) and distortional consumption tax. Neither of them are missing in conventional models of multi-round renegotiations (Benjamin and Wright 2013; Bi (2008).

Table F2 compares non-target statistics in our baseline model with those in models with net issuance and different taxation methods. For net issuance, we incorporate net issuance at settlement in our baseline model with all parameters unchanged. For taxation methods, we consider three cases; (a) distortionary tax (baseline); (b) distortionary tax and lump-sum tax; (c) no distortionary tax. Previous studies on sovereign debt and fiscal policy (Cuadra et al. 2010; Hatchondo et al. 2017; Arellano and Bai 2017) assume distortional tax to explore the role of fiscal policy. To generate moments comparable to ours, we replace our baseline assumption of distortional tax with a different taxation assumption for each case, leaving all other parameters unchanged. Since none of previous studies embeds public capital, we consider both cases of fixed and no public capital.

For business cycle statistics reported in Panel i in Table F2, moment statistics in models with net issuance and different taxation methods are identical to those in our baseline model.

For non-business cycle statistics reported in Panel ii in Table F2, for net issuance, duration of restructurings is shorter in the model with net issuance than that in our baseline model (column 3). As explained in Appendix C, the sovereign is more willing to settle quickly since the net lending reduces the costs of debt settlement. As a result, debt-to-GDP ratio in the pre-restructuring period is lower than that in our baseline model. For taxation methods, in both cases of fixed and no public capital, duration of restructurings is shorter in models with distortionary tax and lump-sum tax (columns 5 and 8) and without distortionary tax (columns 6 and 9) than that in our baseline model. When we allow the sovereign to have an additional method of taxation, i.e., lump-sum tax on income (columns 4 and 7), the impact of distortional taxation on resource allocation is relaxed. Moreover, when we remove distortionary tax (columns 5 and 8), the impact of distortional taxation on resource allocation is eliminated.

Lastly, Table F3 compares non-target statistics in our baseline model with those obtained from recalibration exercises of Gordon and Guerron-Quintana (2018) with one-period bonds, Arellano and Bai (2017), Cuadra et al. (2010) and Benjamin and Wright (2013), respectively. We follow the same approaches in these models in that we target some statistics (for instance, default frequency, average public consumption and transfers-to-GDP ratio, average recovery rate in case of Arellano and Bai 2017) by setting parameter values accordingly. To have moment statistics comparable to our baseline model, the recalibration of Benjamin and Wright (2013) assumes both constant bargaining power and keeps our Argentine income process. This differs slightly with Benjamin and Wright (2013) which assume both stochastic process of bargaining power, and income process—estimated from 27 emerging market countries and close to that of Thailand. We also include the reported moment statistics in Benjamin and Wright (2013) in column (7).

Our baseline calibration results reported in column (2) continue to outperform the recalibration results of previous studies. First, our model is the only one which successfully replicates two key features of public investment: lower average public investment and investment share in public expenditure during restructurings than those in the pre-default periods. Second, average restructuring duration in our model (11.1 quarters) is remarkably longer than that in the

replication results of Benjamin and Wright (2013) (8.7 quarters). Average duration reported in Benjamin and Wright (2013) (33 quarters) might be possibly due to both stochastic process of bargaining power and its correlation with income process neither of which are explicitly specified—are missing in our model. Third, together with a recalibration of Benjamin and Wright (2013), our model accounts for higher level of debt in both pre-default and restructuring periods owing to larger default costs associated with longer duration of renegotiations. Gordon and Guerron-Quintana (2018) assume long-duration bonds and account for high level of debt, while the recalibration of Gordon and Guerron-Quintana (2018) assumes one-period bonds.

Table F1: Simulation Results of Models of Sovereign Debt and Fiscal Policy

(i) Business Cycle Statistics

	Data	Baseline	Model with Fixed Public capital			Model with No Public Capital		
		Model	Multi-round renegotiations[1/]	One-round negotiation[2/]	Exogenous re-entry and zero recovery rates[3/]	Multi-round renegotiations[1/]	One-round negotiation[2/]	Exogenous re-entry and zero recovery rates[3/]
Target statistics								
Pre-default periods								
Average public consumption & transfers/GDP ratio (%)	20.0	23.1	22.5	22.7	22.7	25.2	24.7	24.8
Public investment (std dev.)/output (std dev.)	5.1	5.2	-	-	-	-	-	-
Non-target statistics								
Pre-default periods								
Private sector								
Private consumption (std dev.)/output (std dev.)	1.11	1.01	1.00	1.00	1.00	1.05	1.00	1.00
Trade balance/output: std dev. (%)	1.28	0.86	0.48	0.10	0.11	0.95	0.10	0.38
Corr.(trade balance, output)	-0.87	-0.18	-0.07	-0.51	-0.15	-0.31	-0.60	-0.37
Public sector								
Public consumption & transfers (std dev.)/output (std dev.)	1.26	1.23	1.22	1.12	1.11	1.10	1.05	1.19
Corr.(public consumption & transfers, output)	0.52	0.86	0.94	0.98	0.98	0.95	0.98	0.93
Average public investment/GDP ratio	1.31	1.60	2.01	2.02	2.20	-	-	-
Average public investment/public expenditure ratio	6.2	6.4	8.0	8.12	8.16	-	-	-
Corr.(public investment, output)	0.51	0.63	-	-	-	-	-	-
Renegotiation periods								
Private sector								
Private consumption (std dev.)/output (std dev.)	1.17	1.01	1.00	-	-	1.00	-	-
Trade balance/output: std dev. (%)	0.45	0.00	0.00	-	-	0.00	-	-
Corr.(trade balance, output)	-0.97	0.00	0.00	-	-	0.00	-	-
Public sector								
Public consumption & transfers (std dev.)/output (std dev.)	0.99	2.23	1.07	-	-	0.98	-	-
Corr.(public consumption & transfers, output)	0.99	0.77	0.67	-	-	0.59	-	-
Average public investment/GDP ratio	1.19	1.47	2.36	-	-	-	-	-
Average public investment/public expenditure ratio	5.7	5.8	9.5	-	-	-	-	-
Corr.(public investment, output)	0.99	0.84	-	-	-	-	-	-

(ii) Non-business Cycle Statistics

	Data	Baseline	Model with Fixed Public Capital			Model with No Public Capital		
		Model	Multi-round renegotiations[1/]	One-round negotiation[2/]	Exogenous re-entry and zero recovery rates[3/]	Multi-round renegotiations[1/]	One-round negotiation[2/]	Exogenous re-entry and zero recovery rates[3/]
Target statistics								
Default probability (%)	3.26	3.08	4.6	4.80	3.40	2.10	3.98	2.93
Average recovery rate (%)	25.0	27.1	22.4	62.3	-	20.5	63.1	-
Average debtor output deviation during debt renegotiation (%)	-4.45	-3.73	-4.50	-	-	-4.35	-	-
Pre-default periods								
Average debt/GDP ratio (%)	45.4	43.9	45.6	3.99	4.01	66.1	3.50	5.3
Bond spreads: average (%)	9.4	1.60	0.20	2.71	1.10	0.20	4.50	1.68
Bond spreads: std dev. (%)	7.6	2.28	0.34	4.56	2.45	0.20	6.30	2.41
Corr.(spreads, output)	-0.88	-0.10	-0.31	-0.49	-0.36	-0.02	-0.63	-0.41
Corr.(debt/GDP, spreads)	0.92	0.21	0.37	0.44	0.37	0.12	0.53	0.36
Corr.(debt/GDP, output)	-0.97	-0.69	-0.70	-0.76	-0.62	-0.78	-0.77	-0.29
Renegotiation periods								
Average debt/GDP ratio (%)	130.5	50.6	53.7	4.10	-	77.1	3.70	-
Duration of renegotiation/ exclusion (quarters)	14.0	11.1	8.3	2.00	-	9.3	2.00	-
Corr.(debt/GDP, output)	-0.95	-0.99	-0.99	-	-	-	-	-
Debtor output deviation (diff. btw start and end, %)	12.6	21.2	22.7	-	-	19.5	-	-
Public capital (percent change from the trough to the end)	2.31	1.70	-	-	-	-	-	-
Corr.(cumulative change in public investment to GDP, duration)	-0.12	-0.08	-	-	-	-	-	-
Corr.(cumulative pecent change in public investment, duration)	-0.16	-0.10	-	-	-	-	-	-

Sources: Datastream, IMF WEO, MECON.

Notes: [1/] Model with fixed/no public capital and multi-round renegotiations corresponds to our model (with the same parameter values) with fixed/no public capital and multi-round debt renegotiations as in Benjamin and Wright (2013) and Bi (2008).

[2/] Model with fixed/no public capital and one-round negotiation (Nash bargaining) corresponds to our model (with the same parameter values) with fixed/no public capital and one-round debt negotiation as in Arellano and Bai (2017) and Yue (2010).

[3/] Model with fixed/no public capital, and exogenous re-entry and zero recovery rates corresponds to our model (with the same parameter values) with fixed/no public capital and without debt renegotiations (e.g., exogenous re-entry) as in Cuadra et al. (2010), Hatchondo et al. (2017) and Arellano (2008)

Table F2: Simulation Results of Models of Multi-round Renegotiations

(i) Business Cycle Statistics

	Data	Baseline Model	Net Issuance	Model with Fixed Public Capital			Model with No Public Capital		
				Distortionary tax[1/]	Distortionary tax and lump-sum tax[2/]	No distortionary tax[3/]	Distortionary tax[1/]	Distortionary tax and lump-sum tax[2/]	No distortionary tax[3/]
Target statistics									
Pre-default periods									
Average public consumption & transfers/GDP ratio (%)	20.0	23.1	23.3	22.5	22.4	-	25.2	24.5	-
Public investment (std dev.)/output (std dev.)	5.1	5.2	7.6	-	-	-	-	-	-
Non-target statistics									
Pre-default periods									
Private sector									
Private consumption (std dev.)/output (std dev.)	1.11	1.01	1.01	1.01	1.01	1.05	1.05	1.01	1.07
Trade balance/output: std dev. (%)	1.28	0.86	0.50	0.48	0.10	0.70	0.95	0.53	0.83
Corr.(trade balance, output)	-0.87	-0.18	-0.41	-0.07	-0.16	-0.14	-0.31	-0.03	-0.17
Public sector									
Public consumption & transfers (std dev.)/output (std dev.)	1.26	1.23	1.77	1.43	1.12	-	1.10	1.12	-
Corr.(public consumption & transfers, output)	0.52	0.86	0.77	0.94	0.85	-	0.95	0.74	-
Average public investment/GDP ratio	1.31	1.60	1.73	2.01	2.02	-	-	-	-
Average public investment/public expenditure ratio	6.2	6.4	7.3	8.0	8.4	-	-	-	-
Corr.(public investment, output)	0.51	0.63	0.51	-	-	-	-	-	-
Renegotiation periods									
Private sector									
Private consumption (std dev.)/output (std dev.)	1.17	1.01	1.00	1.00	1.00	1.01	1.00	1.00	1.00
Trade balance/output: std dev. (%)	0.45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corr.(trade balance, output)	-0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Public sector									
Public consumption & transfers (std dev.)/output (std dev.)	0.99	2.23	2.25	1.07	1.05	-	0.98	0.97	-
Corr.(public consumption & transfers, output)	0.99	0.77	0.40	0.67	0.74	-	0.59	0.74	-
Average public investment/GDP ratio	1.19	1.47	1.21	2.36	2.38	-	-	-	-
Average public investment/public expenditure ratio	5.7	5.8	4.50	9.5	9.6	-	-	-	-
Corr.(public investment, output)	0.99	0.84	0.44	-	-	-	-	-	-

(ii) Non-business Cycle Statistics

	Data	Baseline Model	Net Issuance	Model with Fixed Public Capital			Model with No Public Capital		
				Distortionary tax[1/]	Distortionary tax and lump-sum tax[2/]	No distortionary tax[3/]	Distortionary tax[1/]	Distortionary tax and lump-sum tax[2/]	No distortionary tax[3/]
Target statistics									
Default probability (%)	3.26	3.08	2.71	2.71	3.20	2.29	2.10	3.01	3.24
Average recovery rate (%)	25.0	27.1	93.5	22.4	33.2	32.0	20.5	21.1	32.7
Average debtor output deviation	-4.45	-3.73	-2.65	-4.50	-4.60	-5.41	-4.35	-4.74	-4.61
Pre-default periods									
Average debt/GDP ratio (%)	45.4	43.9	13.5	45.6	62.5	52.5	66.1	56.6	53.6
Bond spreads: average (%)	9.4	1.60	3.50	0.20	0.10	0.15	0.20	0.20	0.20
Bond spreads: std dev. (%)	7.6	2.28	2.90	0.34	0.18	0.20	0.20	0.30	0.30
Corr.(spreads, output)	-0.88	-0.10	-0.66	-0.31	-0.18	-0.32	-0.02	-0.32	-0.29
Corr.(debt/GDP, spreads)	0.92	0.21	0.32	0.37	0.29	0.39	0.12	0.35	0.36
Corr.(debt/GDP, output)	-0.97	-0.69	-0.20	-0.70	-0.68	-0.72	-0.78	-0.73	-0.67
Renegotiation periods									
Average debt/GDP ratio (%)	130.5	50.6	15.0	53.7	73.5	63.7	77.1	67.7	62.9
Duration of renegotiation/ exclusion (quarters)	14.0	11.1	5.0	8.3	7.8	6.8	9.3	8.9	7.7
Corr.(debt/GDP, output)	-0.95	-0.98	-0.95	-0.99	-0.99	-0.99	-0.99	-0.99	-0.99
Debtor output deviation (diff. btw start and end, %)	12.6	21.2	5.1	22.7	22.1	21.6	19.5	23.3	22.0
Public capital (percent change from the trough to the end)	2.31	1.70	0.40	-	-	-	-	-	-
Corr.(cumulative change in public investment to GDP, duration)	-0.12	-0.08	-0.14	-	-	-	-	-	-
Corr.(cumulative pecent change in public investment, duration)	-0.16	-0.10	-0.13	-	-	-	-	-	-

Sources: Datastream, IMF WEO, MECON.

Notes: [1/] Model with fixed/no public capital and distortionary tax corresponds to our model (with the same parameter values) with fixed/no public capital and distortionary tax.

[2/] Model with fixed/no public capital and distortionary tax and lump-sum tax corresponds to our model (with the same parameter values) with fixed/no public capital and distortionary tax and lump-sum tax.

[3/] Model with fixed/no public capital, and no distortionary tax corresponds to our model (with the same parameter values) with fixed/no public capital without distortionary tax as Gordon and Guerron-Quintana (2018).

Table F3: Simulation Results of Models—Recalibration

(i) Business Cycle Statistics

	Data	Baseline Model	Gordon and Guerron-Quintana (2018) recalibration[1/]	Arellano and Bai (2017) recalibration[2/]	Cuadra et al. (2010) recalibration[3/]	Benjamin and Wright (2013) recalibration[4/]	Benjamin and Wright (2013) statistics[5/]
Target statistics							
Pre-default periods							
Private consumption (std dev.)/output (std dev.)	1.11	-	1.12	-	-	-	-
Average public consumption & transfers/GDP ratio (%)	20.0	23.1	-	-	-	-	-
Average public consumption & transfers/private consumption ratio (%)	29.0	-	-	-	32.9	-	-
Public consumption & transfers (std dev.)/output (std dev.)	1.26	-	-	-	1.16	-	-
Public investment (std dev.)/output (std dev.)	5.1	5.2	-	-	-	-	-
Total investment (std dev.)/output (std dev.)	6.4	-	5.05	-	-	-	-
Non-target statistics							
Pre-default periods							
Private sector							
Private consumption (std dev.)/output (std dev.)	1.11	1.01	-	1.06	1.01	1.07	1.02
Trade balance/output: std dev. (%)	1.28	0.86	2.25	1.00	0.70	1.27	-
Corr.(trade balance, output)	-0.87	-0.18	-0.36	-0.56	-0.30	-0.40	-0.10
Public sector							
Public consumption & transfers (std dev.)/output (std dev.)	1.26	1.23	-	1.75	-	-	-
Corr.(public consumption & transfers, output)	0.52	0.86	-	0.86	0.94	-	-
Average public consumption & transfers/GDP ratio (%)	20.0	-	-	24.6	-	-	-
Average public investment/GDP ratio	1.31	1.60	*5.9*	-	-	-	-
Average public investment/public expenditure ratio	6.2	6.4	-	-	-	-	-
Corr.(public investment, output)	0.51	0.63	*0.59*	-	-	-	-
Renegotiation periods							
Private sector							
Private consumption (std dev.)/output (std dev.)	1.17	1.01	-	-	-	1.00	-
Trade balance/output: std dev. (%)	0.45	0.00	-	-	-	0.00	-
Corr.(trade balance, output)	-0.97	0.00	-	-	-	0.00	-
Public sector							
Public consumption & transfers (std dev.)/output (std dev.)	0.99	2.23	-	-	-	0.98	-
Corr.(public consumption & transfers, output)	0.99	0.77	-	-	-	0.99	-
Average public investment/GDP ratio	1.19	1.47	-	-	-	-	-
Average public investment/public expenditure ratio	5.7	5.8	-	-	-	-	-
Corr.(public investment, output)	0.99	0.84	-	-	-	-	-

(ii) Non-business Cycle Statistics

	Data	Baseline Model	Gordon and Guerron-Quintana (2018) recalibration[1/]	Arellano and Bai (2017) recalibration[2/]	Cuadra et al. (2010) recalibration[3/]	Benjamin and Wright (2013) recalibration[4/]	Benjamin and Wright (2013) statistics[5/]
Target statistics							
Default probability (%)	3.26	3.08	-	-	-	3.01	5.2
Average recovery rate (%)	25.0	27.1	-	23.9	-	25.6	50.0
Average debtor output deviation	-4.45	-3.73	-	-	-	-4.13	-
Average debt service/GDP ratio (%)	8.0	-	-	9.0	7.7	-	-
Bond spreads: average (%)	9.4	-	8.9	9.1	-	-	-
Bond spreads: std dev. (%)	7.6	-	11.4	-	-	-	-
Pre-default periods							
Default probability (%)	3.26	-	3.70	4.08	3.03	-	-
Average debt/GDP ratio (%)	45.4	43.9	15.4	-	-	37.2	76.0
Bond spreads: average (%)	9.4	1.60	-	-	1.14	1.17	-
Bond spreads: std dev. (%)	7.6	2.28	-	9.6	1.78	1.42	-
Corr.(spreads, output)	-0.88	-0.10	-0.46	-0.60	-0.41	-0.24	-0.12
Corr.(debt/GDP, spreads)	0.92	0.21	0.15	0.05	0.29	0.37	-
Corr.(debt/GDP, output)	-0.97	-0.69	-0.20	-0.13	-0.28	-0.41	-
Renegotiation periods							
Average debt/GDP ratio (%)	130.5	50.6		-	-	43.2	84.0
Corr.(debt/GDP, output)	-0.95	-0.98	-	-	-	-0.99	-
Duration of renegotiation/ exclusion (quarters)	14.0	11.1	-	2.00	-	8.7	33.2
Debtor output deviation (diff. btw start and end, %)	12.6	21.2	-	-	-	20.1	-
Public capital (percent change from the trough to the end)	2.31	1.70	-	-	-	-	-
Corr.(cumulative change in public investment to GDP, duration)	-0.12	-0.08	-	-	-	-	-
Corr.(cumulative pecent change in public investment, duration)	-0.16	-0.10	-	-	-	-	-

Sources: Datastream, IMF WEO, MECON.

[1/] Gordon and Guerron-Quintana (2018) recalibration corresponds to calibration results with one-period bonds and four target statistics (i) average bond spreads, (ii) standard deviation of bond spreads, (iii) ratio between standard deviation of total investment and standard deviation of output, and (iv) excess consumption volatility.

[2/] Arellano and Bai (2017) recalibration corresponds to calibration results with three target statistics (i) average bond spreads, (ii) debt service-to-GDP ratio, and (iii) average recovery rate.

[3/] Cuadra et al. (2010) recalibration corresponds to calibration results with three target statistics (i) debt service-to-GDP ratio, (ii) ratio between public consumption and transfers and private consumption, and (iii) ratio between standard deviation of public consumption and standard deviation of output.

[4/] Benjamin and Wright (2013) recalibration corresponds to calibration results with three target statistics (i) default frequency, (ii) average recovery rate, and (iii) average debtor output deviation during renegotiations.

[5/] Benjamin and Wright (2013) statistics correspond to their moment statistics in calibration results using average emerging market income process and stochastic bargaining power.