Fire Sales and Debt Maturity*

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Abstract

How does debt maturity structure affect fire sales? I show how debt maturity could trigger financial crises by introducing debt maturity in a Fisherian deflation model. In particular, using a stock/flows analysis, I find that (i) an excessive reliance on short-term debt exacerbates the risk of financial crises through fire sales and (ii) this risk is driven by a rise in the term premium. I confirm these two testable predictions with an empirical study based on 69 emerging and developing countries from 1970 to 2017. I highlight that debt maturity structure is a good early-warning indicator of financial crises, which provides information that adds up to the level of external debt. Overall, this paper shows that the optimal policies against fire sales mechanism are jointly determined by the risk of current and future solvency concerns, as well as liquidity concerns.

JEL classification: E44, E5, F34, G01, G28

Keywords: Fire sales, Debt maturity, Fisherian deflation, Stock-flow relationship.

1 Introduction

The level of private and public debt stock is unambiguously linked to financial crises (Schularick and Taylor, 2012; Mendoza and Terrones, 2012; Gourinchas and Obstfeld, 2012). This stock is both affected by debt inflows and outflows, which crucially depend on the choice between short and long-term debt. The

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former influences the current and future debt flows through complete debt service in one period, while the latter affects both debt flows and stock over long horizons. The current empirical and theoretical litterature is however quite silent on this stock-flow relationship of debt, with the notable exception of Drehmann et al. (2017) that focus on the lead-lag relationship of the household debt between new borrowing and debt service.

This paper aims to fill this gap by answering the following three questions. First, in light of the financial amplification mechanism *à la* Fisher (1933) that allows one to undesrtand financial crises, how does the debt maturity structure affect fire sales ? Second, is the debt level or the debt maturity structure the best predictor of financial crises? Third, what is the optimal policy according to the stock-flow relationship between the debt level and the debt maturity?

Fire sales appear when collateral constraint tightens. This collateral is based on the market value of assets that determines the borrowing ability of economic agents. When they are not able to repay their debt and/or when they want to increase their consumption above this borrowing limit, agents may sell their assets. However, if many borrowers act in the same way, it may result in a well-known feedback loop between binding collateral constraints, a drop in asset prices and agents' wealth, as described by Korinek and Mendoza (2014) and Bianchi and Mendoza (2018), among others. These so-called *Fisherian deflation* models use occasionally binding financial constraints with pecuniary externality, which means that decentralized agents do not internalize the effect of their decisions on asset markets. Therefore, there is a wedge between private and social marginal utilities of both asset and debt. As a conventional result, policy intervention via taxes and subsidies could fill the gap. Nevertheless, these recent theoretical foundations of Fisher (1933) remain quite mute on debt maturity structure.

By constrast to the existing literature, I empirically show that a debt maturity structure essentially based on short-term debt is an appropriate early-warning indicator of financial crises for developping countries over the period 1970-2017. This indicator has a higher predictive power than debt levels and complements the information obtained from country and year fixed effects. Because of endogeneity issues, I distinguish two cases on the basis of the level and movements in estimated US Treasury term premium from Adrian et al. (2013). It turns out that it is only in the case of high term premium that debt maturity affects the probability of crisis. In other words, (i) debt maturity matters for financial crisis, and (ii) certainly via an increase in the term premium.[1]

[1]It potentially creates a reverse causality issue, because it suggests that debt maturity must fall in countries where a crisis is expected. It is not the case with the identification strategy: the rise in US Treasury term premium cannot be attributed to these idiosyncratic risks.

I then rationalize these two empirical insights into a *Fisherian deflation* model in which domestic borrowers choose a mix of short and long-term debts. This debt maturity structure potentially multiplies the risk of fire sales due to the binding collateral constraints. I show that the level and the composition of the debt chosen by the agent follows a suboptimal path, which amplifies both liquidity risk (i.e. the rise in term premium) and solvency risk (i.e. the rise in risk premium), and then triggers fire sales. It differs from the social planner's optimal path of debt, and more broadly from the social planner allocation including the capital assets.

The main feature of the model lies in the fact that the social planner can replicate its optimal equilibrium via a set of taxes and subsidies, where all prices and term premium are still market-determined. Following Korinek and Dávila (2018), the social planner implements taxes on debts and subsidies on capital but with two key differences. First, the taxes on debt are both *ex-ante* and *ex-post* policies, close to the results of Jeanne and Korinek (2013) and Bianchi and Mendoza (2018). The latter papers focus on moral hazard issues, while I specify the level of taxes and subsidies at various times. Second, these policies are contingent to three key elements: (i) the current and future risk of fire sales, (ii) the liquidity concern proxied by the term premium and (iii) the efficiency of the capital investment.

Mechanism With only a *one-period* debt, the standard result of the literature holds. Crucially, the decentralized agent is prone to overborrowing. He also under-invests in capital assets that makes the collateral constraint more vulnerable to asset fire sales. This financial amplification mechanism works for public, household and firm borrowing, despite obivous differences in their role. Given the debt maturity structure, this mechanism is still valid and the rational borrower chooses his path of debt, while the lender distinguishes between short from long-term bonds. The concerns about liguidity and solvency risks are indeed quite different. The lender charges a term premium, since an excessive short-term debt causes liquidity troubles and exacerbates the risk of default with a lower debt amortization process.

Because of the pecuniary externality and their *unanticipated* shock on capital price, the level and the structure of debt of the decentralized agent could bind one or two collateral constraints, i.e. *flows* and *stock* collateral constraints. On the one hand, if there is too much short-term debt, the current *flows* collateral constraint becomes tight. As a consequence, fire sales occur and an *unanticipated* term premium appears, thus further reducing the agents' debt capacity. On the other hand, the choice of too much long-term debt alleviates the risk of a current binding collateral constraint, but generates future binding collateral constraints over long horizons. When the borrower goes to the worst configuration with the two binding collateral constraints, it pays a term premium (from a binding *flows* constraint) and a risk premium (from a binding *stock* constraint) and suffers from multiple binding collateral constraints over time.

This stock-flow analysis of the debt is key to understand the likelihood of fire sales mechanism. My findings are complementary to those of Drehmann et al. (2017) who point out the relationship of new borrowing and debt service as a new transmission channel of financial crises. Using an empirical methodology close to the one presented in this paper and data of the Bank for International Settlements (BIS) on advanced economies over 1970-2015, the authors show that debt service is a good predictor of financial crises. By contrast, I highlight that the debt maturity structure matters for the developing world. I develop a *Fisherian deflation* model including both short and long-term debts which permits to balance the benefits of new borrowing and the future troubles generated by the debt service. By putting the focusing on low- and middle-income countries, this paper highlights that the borrower is a price-taker in world financial markets which makes more credible the standard model assumptions.

Related Literature The model complements the findings of Jeanne and Korinek (2018) and Bianchi and Mendoza (2018), but differs in the channel through which it generates fire sales. Focusing on advanced economies, these papers do not use debt maturity structure and they refer to other determinants than the three elements I describe in this paper: Jeanne and Korinek (2018) highlight the key role of the collateral constraint parameter and of the vulnerability to a new bust, while Bianchi and Mendoza (2018) put forward the equity premium[2], as well as the lack of credibility for future policies. As surveyed by Mendoza (2017), the recent theoretical foundations of Fisher (1933) investigate many different directions[3], but the debt maturity structure has been largely unexplored. Jeanne and Korinek (2018) extend their framework by including changes in the duration of debt. It is however only based on one sort of bond. By contrast, I focus on the stock-flow relationship of debt in which an excessive dependence on short or on long-term debt is possible. This is in line with the study of Zhou (2018). Her small open economy model generates time-varying term premium through risk-averse international creditors and shocks in their discount factor, whereas I disentangle debt service and debt stock concerns. My result is also complementary to their

[2]It is defined as the *"expected excess return on assets relative to bonds"*.

[3]Some papers such as Bianchi and Mendoza (2018), Jeanne and Korinek (2018) or Korinek and Dávila (2018) link collateral constraint and asset prices, whereas Bianchi (2011), Benigno et al. (2016), Schmitt-Grohé and Uribe (2017), among others, use a collateral constraint depending on real exchange rate and notably triggers sudden stop syndrome in emerging countries. The scope of policy intervention is also widely discussed: see Benigno et al. (2013), Jeanne and Korinek (2013) and Bianchi and Mendoza (2018) on ex-ante versus ex-post policies debate; or Korinek and Sandri (2016) on the simultaneous use of capital controls and macroprudential regulation.

results, as she introduces a state-contingent and maturity-dependent capital inflow controls, while I focus on the simultaneous use of both *ex-ante* and *ex-post* policies.

This paper also contributes to the empirical literature studying the key determinants of financial crises. Due to the availability of different datasets and various methodologies, multiple predictors have been discussed, such as the domestic credit growth (Schularick and Taylor, 2012; Mendoza and Terrones, 2012); the domestic credit and real currency appreciation (Gourinchas and Obstfeld, 2012); the currency composition of debt (Bordo et al., 2010); the level and composition of foreign liabilities (Catão and Milesi-Ferretti, 2014); the relative size of the non-tradable sector (Kalantzis, 2015); the domestic asset price bubbles (Jordà et al., 2015); the private versus public debt (Jordà et al., 2016); the domestic versus foreign credit growth (Cesa-Bianchi et al., 2019) and lastly the debt service (Drehmann et al., 2017). The stock-flow relationship of debt is implicit in the study of Catão and Milesi-Ferretti (2014) in which they show that net external debt is a better predictor than gross external debt. By analogy, this peice of work is related to the recent academic papers analyzing the determinants of external debt flows. Bianchi et al. (2018) and Qian and Steiner (2017) draw attention to the relation between the external debt maturity and the level of international reserves. Focusing on 40 economies with relatively high financial development, Avdjiev et al. (2017a) study whether the characteristics of external debt could trigger credit cycles. The authors show that the choice of the debt instrument and the type of lenders appear to be more important than the currency and the maturity of external debt, but they focus on a different sample than in this paper. In addition, my analysis includes global financial forces, which are quantified by Avdjiev et al. (2017b) and Cerutti et al. (2017). According to the sensitivity analysis of Cerutti et al. (2019), the characteristics of the foreign lenders could be even more relevant than borrower's fundamentals, which call for a time-varying term premium.

The study of debt maturity is not new to the literature related to the banking system (Chang and Velasco, 2000) or to the severeign debt (Cole and Kehoe, 1996; Cole and Kehoe, 2000). Existing studies analyse how debt level and debt maturity structure could generate self-fulfilling runs, while I investigate an alternative channel. Arellano and Ramanarayanan (2012), Fernández and Martin (2015) and Debortoli et al. (2017), among others, discuss the role of debt maturity on sovereign debt crises. By contrast with the collateral constraint used in this paper, they focus on another financial friction, namely limited commitment for repayment. Following Broner et al. (2013), the sovereign debt literature on the trade-off between short and long-term debt investigates two main channels. On the one hand, demand-side arguments put emphasis on the "disciplinary" role of short-term debt to reduce the incentive to dilute their debt (Jeanne, 2009). On the other hand, supply-side arguments stress the role of the potential uncertainty and the loss of information on the default probability over longer horizons, which calls for the modelling of a posititve term premium. Arellano and Ramanarayanan (2012) and Broner et al. (2013) confirm that emerging countries promotes short-term debt, especially during crises, because of higher spreads. This is in line with the feedback loop between liquidity and solvency concerns which is included in the theoretical model developed in this paper.

The remainder of the paper is structured as follows. Section 2 describes the empirical strategy and shows that the debt maturity structure is a good predictor of financial crises. Section 3 presents the baseline model and describes the debt maturity structure. Section 4 analyzes the optimal social planner intervention. Section 5 concludes.

2 Empirical Analysis: the Role of Debt Maturity Structure

The purpose of this paper is to identify how debt level and term structure affect the likelihood of financial crisis at the country-level. This section first provides details on data sources, including details on various types of debt inflows and outflows. Second, I underline how a debt maturity structure too short-term oriented could play the role of a good early-warning indicator of financial crises.

The unbalanced panel database consists of 69 countries from 1970 to 2017 with 39 years per country on average.[4] Table A.1 in Appendix provides a list of the countries, while Table A.2 and Table A.3 give the data sources and descriptive statistics. The long time coverage is sufficient to catch regularities with various cases of maturity mismatches. The sample covers almost all emerging countries and some relevant developing economies, which contrasts with the current literature largely focused on advanced economies such as Schularick and Taylor (2012) and Cesa-Bianchi et al. (2019). The use of some specific countrol variables ensures that fire sales mechanism is at play: the debt relationship works through market mechanisms and private debt is quite substantial in the country. Another motive is that sensitivities of debt maturity structure to international financial markets should depend on the depth of domestic financial markets and the country's credibility.

2.1 Data

Financial Crises The definition of precise dates for asset fire sales is quite challenging. Campbell et al. (2011) and Bian et al. (2018) use high-frequency microeconomic data. By contrast, the well-known dataset

[4]This mean is for regressions including the 5 years-lag of each variable, following the baseline specification.

of Laeven and Valencia (2018) is used to assess systemic banking, currency and sovereign debt crises during the period 1970-2012. Over 3.4 percent (92) of the sample represents a systemic banking crisis. I assume that systemic banking crises are closely linked to the fire sales mechanism. Alternatively, I could use banking crises, systemic banking crises and stock market crashes as defined by Reinhart and Rogoff (2009) and Reinhart et al. (2016).

External Debt: Stock-Flow Relationship & Market Mechanisms I use the *International Debt Statistics* from the World Bank. This data has been recently employed by Qian and Steiner (2017). They provide a wide range of information. First, they distinguish public and publicly guaranteed debt (PPG), private nonguaranteed debt (PNG) and IMF credit. Second, they distinguish (i) stock and net flows, (ii) debt service and new debt, (iii) principal and interest payments. Third, the debt is also decomposed into short and long-term. As the main explanatory variable, I employ their measure of short-term external debt over total stock of external debt. This measure directly assesses debt structure, whereas Gourinchas and Obstfeld (2012) use the ratio of short-term external debt relative to GDP.

I also rely on ratios of debt stock over gross national income, both with the distinction between public and publicly guaranteed debt (PPG), private nonguaranteed debt (PNG) and IMF credit. This distinction highlights the potential role of private debt, which is related to fire sales mechanism. In addition, the data from World Bank provides the stock of debt owed to multilateral creditors and the level of debt forgiveness grants, distinguishing between market mechanism and multilateral process.

The Global Financial Cycle Another key factor of fire sales is constituted by the international financial forces, because international lenders are potentially affected by various shocks. International financial crises or even domestic economic crises could play a role through multiple transmission channels, such as cross-border bank flows and volatile risk premia. Various measures could be employed, such as the VIX (Rey, 2015), but Adrian et al. (2013) clearly provide a global risk premium from US Treasury bonds. I generate a dummy in order to capture the threshold value of this risk premium that potentially trigers the transmission channel. This dummy is equal to 1 if the risk premium is higher than its median of the distribution, that is 2.

2.2 Sources of Financial Instability: Debt Size & Debt Maturity

The empirical setting used follows the current literature on early-warning indicators of financial crises, notably the seminal paper by Schularick and Taylor (2012) and more recently Cesa-Bianchi et al. (2019). I investigate the predictive ability of debt maturity structure on the likelihood of systemic banking crisis, which shed light on the causal link between the debt maturity structure and fire sales. The dependent variable is a dummy equal to 1 when systemic banking crisis occurs. I consider a logit model of systemic banking crisis event with the following specification:

$$logit(p_{it}) \quad = \quad \sum_{s=1}^{5} \beta_{it-s} \frac{ST}{ST+LT}_{it-s} + \sum_{s=1}^{5} \delta'_{it-s} X_{it-s} + \alpha_i + \gamma_t + \epsilon_{it} \tag{1}$$

where $\frac{ST}{ST+LT}_{it}$ is the ratio of short-term external debt stock over the total external debt stock, $logit(p) = ln(p/(1-p))$ is the log of the odds ratio and X_{it} is a vector of control variables including external debt stock, debt reduction and share of multilateral creditors. Following formal lag selection procedures (AIC and BIC), I consider 5 annual lags for all variables, which is consistent with Schularick and Taylor (2012), Drehmann and Juselius (2014) and Cesa-Bianchi et al. (2019). α_i denotes country fixed effects, and γ_t represents year dummies. The presence of country fixed effects catches the specific behavior and reputation of some developing countries. The global trend captured by year fixed effects, concerning both risk and term premia, clearly determines the likelihood of financial crisis, in line with Rey (2015), Cerutti et al. (2019) and Avdjiev et al. (2017b).

Table 1 reports the baseline logit specification. Column (1) relies on the debt maturity structure, while column (2) analyzes the potential predictive ability of debt stock. Columns (3) to (5) go one step further by investigating multiple models. Table 1 shows that the debt maturity is a strong predictor of financial crisis: a reliance on short-term debt triggers financial vulnerabilities. The results remain quantitatively identical, whatever the specification used. Thus, I adopt column (5) as the baseline specification.

Regarding other control variables, Table 1 also reveals that the ratio of external private debt stock over gross national income is positively associated with the likelihood of financial crisis. It is in line with the recent literature (Schularick and Taylor, 2012; Cesa-Bianchi et al., 2019), whereas I focus here on emerging countrries and some developing countries displaying a sufficient level of development. The share of debt owed by multilateral creditors or the ratio of debt reduction over gross national income effectively help to capture all non-market mechanisms.

Finally, the predictive power of this model is evaluated by the Receiver Operating Characteristic

Table 1: External debt level and structure

	Dependent variable: Systemic Banking Crisis. Logit Estimates.							
							US Term Premium	
							> 2	< 2
Sum of 5 lags	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\frac{ST}{ST+LT}$	3.800*		3.602*	4.398**	4.274*		8.835**	-1.982
	(1.972)		(2.028)	(2.136)	(2.195)		(3.499)	(4.888)
$\frac{Debt\ Stock}{GNI}$		-0.190						
		(0.237)						
$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			-0.460		-0.289	-0.287	-0.205	-1.712*
			(0.337)		(0.487)	(0.473)	(1.098)	(0.755)
$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			3.854*		5.051**	4.772**	3.962	4.294
			(2.258)		(2.551)	(2.437)	(6.485)	(3.674)
$\frac{IMF\ Credit}{GNI}$				-3.390	-3.753	-4.366	-7.166	-3.015
				(5.258)	(6.277)	(6.180)	(12.04)	(10)
Multilateral Creditors (%)				-2.622	-2.202	-2.550	-1.632	-4.286
				(1.787)	(1.875)	(1.854)	(2.919)	(4.700)
$\frac{Debt\ Reduction}{GNI}$				19.73**	26.83**	25.48**		
				(8.122)	(10.72)	(10.45)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	2691	2691	2691	2691	2691	2691	913	772
Countries	69	69	69	69	69	69	43	39
Pseudolikelihood	-234.3	-240.8	-230.6	-225.3	-221.4	-226.9	-98.21	-66.76
R^2	0.260	0.239	0.272	0.288	0.301	0.283	0.311	0.471
AUROC	0.842	0.815	0.848	0.847	0.853	0.847	0.818	0.891
Standard error	0.0145	0.0156	0.0146	0.0133	0.0134	0.0137	0.0232	0.0165

Standard errors in parentheses. Following formal lag selection procedures, I consider 5 lags of all variables. Table A.4 provide complete specification with all lags. *, ** and *** denote respectively significance at the 10, 5 and 1% levels.

(ROC) curve. Since Schularick and Taylor (2012), this methodology is common in this literature. It generates a statistic AUROC, namely *area under the curve ROC*. This statistic between 0 and 1 provides a simple information to assess the predictive power of the indicator. An AUROC equal to 0.5 means that it is completely uninformative. Symmetrically, an AUROC equal to 1 means that the early-warning indicator perfectly anticipates future financial crisis. Table 1 reports ROC statistics for each model and reveal that the debt maturity structure is a better early-warning indicator of financial crises than debt level.

Endogeneity Issues The debt level and debt maturity structure provide different informational contents. Then, endogeneity is a major issue in the proper identification of the underlying mechanism from debt maturity to financial crises. If the term premium is too high because of world or country-specific factors, country is more likely to borrow short-term. In other words, the mechanism works differently depending on whether a country is unwilling or unable to choose more long-term debt. Columns (7) and (8) provide an explicit treatment for this endogeneity issue by controlling for US Treasury term premium (Adrian et al., 2013). Table 1 explores the new information content across subsamples by distinguishing the two cases. The debt maturity structure drives the dynamics of financial vulnerability if and only if the estimated term premium is quite high. To sum up, Table 1 predicts that debt maturity structure is associated with a financial crisis through unwanted excessive reliance on short-term debt. This result does create a reverse causality issue if it is the prospect of a financial crisis that constrains the borrowing countries to short-term debt, rather the other way round. But the use of US treasury bonds sharply limits this concern.

Table 1 is globally consistent with the theoretical framework that generates a wedge between decentralized equilibrium and social planner allocation. The former borrows too much, which will then generate a term premium, whereas the latter is looking for optimal path of debt.

Quantification To document the impact of debt maturity structure in financial crisis, I estimate the predicted probability of the baseline specification (column (5)) with all control variables.[5] Table 2 compares them by differentiating between true-positive signal and false-positive signal of financial crisis. Out of the total 92 observations of financial crises, the average probability is around 11 percent. This is four times higher than the one of the regular cases, without any financial crises.

In addition, Table 2 reports the results of a counterfactual exercise close to Kalantzis (2015). I compare the probability of the baseline specification with the role of debt maturity structure (column (5)) to those without debt maturity structure (column (6)). Overall, the debt maturity structure significantly improves the probability of financial crisis by 0.9 percentage point on average. It contrasts with the false-positive rate in which the debt maturity structure does not really change the likelihood of financial crisis. The same holds for the difference between the predicted and the counterfactual probabilities expressed in absolute terms.[6] Going into more details, Table 2 also highlights specific cases with the highest probability of financial crisis for both true and false alarms. Without the debt maturity structure, the loss of accuracy could be quite substantial. The extreme gap is roughly 15 percentage points for Niger in 1983 or for central European countries.

[5] Alternatively, Catão and Milesi-Ferretti (2014) maximize the ratio of true-positive to the false-positive in order to define an optimal threshold.

[6] Figure A.1 in Appendix reports the difference for all cases.

Table 2: Counterfactual probability of crises without the debt maturity structure

	Nb.	Predicted	Counterfactual	|Difference|
True-Positive Signal	92	0.106	0.097	0.025
False-Positive Signal	2599	0.023	0.023	0.006

Country	Year	Predicted	Counterfactual	Difference
		True-Positive Signal		
Nicaragua	2000	0.852	0.831	0.021
Kazakhstan	2008	0.39	0.42	-0.04
Ukraine	2014	0.364	0.379	-0.015
Guyana	1993	0.325	0.234	0.091
Russia	2008	0.308	0.182	0.126
Paraguay	1995	0.302	0.232	0.07
Ukraine	2008	0.291	0.167	0.124
Niger	1983	0.27	0.107	0.163
Moldova	2014	0.252	0.154	0.098
Costa Rica	1994	0.181	0.145	0.036
		False-Positive Signal		
Swaziland	1998	0.653	0.359	0.294
Romania	1995	0.61	0.384	0.226
Yemen	1995	0.512	0.441	0.071
Moldova	1998	0.408	0.461	-0.053
Mongolia	1997	0.34	0.272	0.068
Russia	1997	0.314	0.276	0.038
Sierra Leone	1994	0.306	0.295	0.011
Bulgaria	1998	0.287	0.232	0.055
Romania	1994	0.279	0.195	0.084
Mongolia	1998	0.275	0.283	-0.08

The sample covers 92 financial crises. The second part of this table only reports the 20 cases with the highest probability of financial crisis.

Furthermore, the high probability of false-positive signals does not necessarily imply a model failure for three reasons. First, the timing for country-year pairs could be misleading. In other words, the financial crisis appears one year later in Yemen and three years later in Romania than pairs listed in Table 2. Second, some specific cases are likely driven by year fixed effects. As a matter of fact, the probability of financial crisis in emerging world substantially increases with the strength of the global financial cycle, as suggested by Rey (2015) and Cesa-Bianchi et al. (2019). Third, the model could also predict currency and/or sovereign debt crises like Mongolia and Yemen. These three types of crises are closely intertwined, which in turn hurt model predictions.[7]

Robustness Tests The Appendix investigates the robustness of my results. First, Table A.5 controls for the duration of the crisis.[8] Second, Table A.6 includes additional control variables. The results are

[7]The potential mechanism related to financial crisis could probably play a role in other types of crisis. Thus, I will use these currency and debt crises as additional control variables, but also as alternative dependent variables.

[8]Caggiano et al. (2016) highlight a *crisis duration bias* in the literature.

globally unaffected by controlling for (i) the level of international reserves, (ii) the inclusion of other types of crises, such as currency and debt crises, (iii) the use of GDP growth and (iv) a proxy of currency mismatch issues. Finally, Table A.7 provides some sensitivity analysis to different measures of financial crises. On the one hand, the dating of banking crises is likely to have a first order effect on the results, but they hold for alternative sources of information (Laeven and Valencia, 2018; Reinhart et al., 2016). On the other hand, I use currency crises as a falsification test, since the underlying mechanism is more related to banking crises.[9]

3 Baseline Model

The model borrows from *Fisherian deflation* models of financial crises, more precisely from Korinek and Dávila (2018). I consider a small open economy model where agents i belong to one of the two following types, named domestic borrowers B or international savers S[10] ($i \in B, S$). Borrowers are potentially more productive than savers at using capital but are subject to collateral constraints that may lead to fire sales. As common in this literature, the market failure generates a difference between the decentralized equilibrium and the social planner, which justifies policy intervention. I introduce the debt maturity structure into this *Fisherian deflation* model, whereas most of the literature uses one-period debt.

3.1 Economic Environment

I resort to a discrete time framework with 3 time periods: $t = 0, 1, 2$. The agent i values consumption of homogenous good c_t^i according to a time separable utility function

$$U^i = \mathbb{E}_0 \sum_{t=0}^{2} \beta^t u^i(c_t^i) \tag{2}$$

where the utility function $u^i(.)$ is a standard concave twice-continuously differentiable function that satisfies the Inada condition and β the time-discount factor. At each period, agents receive an endowment of consumption good. I denote by e_t^i the endowment of consumption good received by the agent i in period t. The two agents consume this homogenous good, which serves both as numeraire and can be transformed

[9] I expect that the reliance of short-term debt is associated with the likelihood of stock market crash, but it is not the case. It could be explained by the year dummies or restricted samples.

[10] This could be extended to the framework of Korinek and Sandri (2016): their economy is described by domestic borrowers, domestic savers and a large set of international agents, the latter who trade bonds with both domestic agents. In all cases, the economy is price taker in world financial markets.

into a capital asset at price q_t. At date 0, he receives a stock of capital assets k_0^i and he decides how much to invest or disinvest in the new period at price q_0. At date 1, all the current capital denoted by k_1^i is employed to produce $F_1^i(k_1^i)$ units of consumption goods, where F is a concave, strictly increasing and continuously differentiable production function which satisfies $F^i(t) = 0, \forall t$. Following the literature on fire sales, I assume that borrowers have a better production technology than savers. Again, agents decide how much to invest or disinvest in the new period at price q_1. At date 2, the current capital denoted by k_2^i produces $F_2^i(k_2^i)$ units of consumption goods. Capital is worthless after this date and fully depreciates.

The two agents trade bonds. At date 0, they have access to two bonds b_{01} and b_{02} denominated in terms of homogenous good, where $b < 0$ corresponds to borrowing. They also have an initial level of bonds denoted by b_0^i.[11] The short-term bond b_{01} pays back in period 1 at the gross interest rate R_{01}, while the long-term bond b_{02} pays back in period 2 at the gross interest rate R_{02}. At date 1, they have access to a new short-term bond b_{12} with the gross interest rate R_{12}.

The agent i's budget constraints are given by

$$c_0^i + q_0(k_1^i - k_0^i) + \frac{b_{01}^i}{R_{01}} + \frac{b_{02}^i}{R_{02}} = e_0^i + b_0^i \tag{3}$$

$$c_1^i + q_1(k_2^i - k_1^i) + \frac{b_{12}^i}{R_{12}} = e_1^i + b_{01}^i + F_1^i(k_1^i) \tag{4}$$

$$c_2^i = e_2^i + b_{02}^i + b_{12}^i + F_2^i(k_2^i) \tag{5}$$

Collateral Constraints: Flows and Stock Financial market imperfections that constrain borrowers' choice are commonly depicted as an occasionally binding financial constraint linking bond stock and capital price. It is necessary to include financial frictions in the model because of moral hazard issues between lenders and borrowers. Lenders do not exactly know the household's ability to repay their debt and I assume that lenders can seize up only a fraction Φ of the value of their capital asset holdings in periods 0 and 1. The current literature links one-period debt and current collateral, whereas I explicitly include the debt maturity structure and the stock-flows relationship. To avoid defaults, lenders impose to borrowers the following *stock* collateral constraints

[11] The endowments and the initial level of bonds are distributed such that in periods 0 and 1 borrowers find it optimal to borrow and savers find it optimal to save.

$$\frac{b_{01}^B}{R_{01}} + \frac{b_{02}^B}{R_{02}} > -\Phi q_0 k_1^B \tag{6}$$
$$\frac{b_{02}^B}{R_{02}} + \frac{b_{12}^B}{R_{12}} > -\Phi q_1 k_2^B \tag{7}$$

Because of potential differences in terms of moral hazard problems, lenders generally distinguish short from long-term bonds. Indeed, the concerns about liquidity and solvency risks are not the same. At date 0, lenders anticipate that the current value q_0 of the capital asset and the current accumulation capital k_1^B of the borrower directly play the role of collateral if the borrower defaults for the short-term debt. Thus, I assume that lenders impose to borrowers the following additional *flows* constraint

$$\frac{b_{01}^B}{R_{01}} > -\kappa q_0 k_1^B \tag{8}$$

The tightening of the stock constraints (6)-(7) yield a risk premium, while that of the liquidity constraint (8) yields a positive term premium between the two interest rates R_{01} and R_{02}. Lenders charge a term premium because an excessive short-term debt creates liquidity troubles and exacerbates the risk of default with lower debt amortization process. There is no similar liquidity constraint at date 1 because all debt (i.e. short-term bond issued at date 1 and long-term bond issued at date 0) is repaid in date 2. κ and Φ appear as pledgeability parameters that determine the level of the market incompleteness, where $(\kappa, \Phi) \in [0,1]^2$. The set of parameters $\{\kappa, \Phi\}$ allow a distinction between short and long-term debt.[12] For each combination of feasible $\{\kappa, \Phi\}$, there are four possibilities: (i) no constraint binds; (ii) only the debt flows constraint binds; (iii) only the debt stock constraint binds; (iv) both debt flows and stock constraints bind.

The mix of short and long-term bonds for borrowers plays a role in financial amplification. Figure 1 summarizes the feasible states, with term premium at date 0 and risk premia at dates 0 and 1. If one or more collateral constraints in period 0 are binding, the stock collateral constraint in period 1 is not generally slacking but that is not automatic. Indeed, the production function of borrowers F_1^B and the endowment e_1^B may be large enough to avoid another overborrowing case and/or fire sales.

[12] If $\kappa > \Phi$, there is no real *free* choice between these two types of debt and it is at the expense of long-term debt.

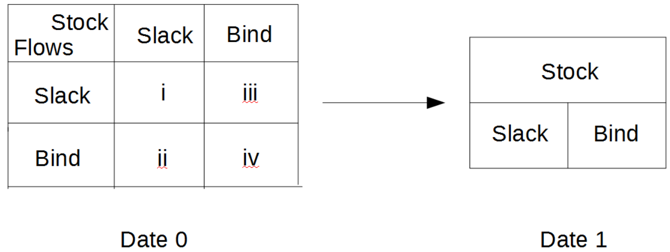

Figure 1: Set of possible states

3.2 Decentralized Equilibrium

A decentralized equilibrium consists of a set of allocations $(c_0^i, c_1^i, c_2^i, k_1^i, k_2^i, b_{01}^i, b_{02}^i, b_{12}^i)$ and prices $(q_0, q_1, R_{01}, R_{02}, R_{12})$ in which each agent $i \in \{B, S\}$ solves his optimization problem, where all markets clear[13]

$$\sum_i b_{01}^i = \sum_i b_{02}^i = \sum_i b_{12}^i \tag{9}$$

Following Korinek and Sandri (2016) and Korinek and Dávila (2018), the decentralized equilibrium is solved via backward induction. The impact of uncertainty on the economy (i.e. on potential binding flows and stock collateral constraints) is fully captured by the financial net worth n_0^i in period 0 and by the financial net worth n_1^i and the capital holdings k_1^i in period 1, which are given by

$$n_0^i = e_0^i + b_0^i + k_0^i \tag{10}$$

$$n_1^i = e_1^i + b_{01}^i + b_{02}^i + F_1^i(k_1^i) \tag{11}$$

In other words, there is no shock but agents suffer from the pecuniary externality. If one or two collateral constraint are binding because of these fire sales, they are not perfectly anticipated at the moment of decisions by the borrower, and the decisions will not be correct.

Date 2 Equilibrium Each agent consumes homogenous good and settles their bond positions, regardless of whether one previous collateral constraint is binding or not.

Date 1 Equilibrium The problem solved by each agent, who behaves competitively and takes prices as

[13] I assume the uniqueness of the equilibrium. See Schmitt-Grohé and Uribe (2016) and Jeanne and Korinek (2018) on the possibility of multiple equilibria.

given, is as follows

$$V^i(n_1^i, k_1^i) \;=\; max\ u^i(c_1^i) + \beta u^i(c_2^i) \quad \text{subject to} \quad (4), (5) \text{ and } (7) \tag{12}$$

where λ_1^i, λ_2^i and μ_2^i respectively denote the Lagrange multipliers on the budget constraints (4), (5) and on the collateral stock constraint (7). By construction, μ_2^S is equal to zero.

As common in this literature, the resulting Euler equation for bonds and the optimal capital accumulation decisions are

$$\lambda_1^i \;=\; R_{12}\lambda_2^i + \mu_2^i \quad \text{with} \quad \lambda_1^i = U_1^{\prime i} \quad \text{and} \quad \lambda_2^i = \beta U_2^{\prime i} \tag{13}$$

$$q_1 \;=\; \frac{\lambda_2^i F_2^{\prime i}(k_2^i)}{\lambda_1^i - \Phi\mu_2^i} = \frac{F_2^{\prime i}(k_2^i)}{R_{12} + \frac{\mu_2^i}{\lambda_2^i}(1-\Phi)} \tag{14}$$

Equation (13) is the standard Euler equation weighting the marginal benefit of higher consumption today against the marginal cost of lower consumption tomorrow. The additional term μ^i is always equal to 0 for lenders, whereas borrowers may be subject to a binding stock collateral constraint. As usual in this literature, this term improves the marginal benefit of higher current consumption of the capital good, that relaxes the collateral constraint. Equation (14) characterizes capital price. If the collateral constraint is slack, the price q_1 reduces to a standard Euler equation for assets whereby it equals the marginal product of capital discounted by the marginal rate of substitution. In turn, this provides a relationship between capital price and interest rate. If instead, the collateral constraint is binding, the effect on capital prices is quite ambiguous if I look the middle-hand side of the equation (14), close to Korinek and Mendoza (2014). On the one hand, the marginal rate of substitution falls. On the other hand, the denominator of this equation is reduced by the extra-term. It reduces the borrowers' disutility of $U_2^{\prime B}$ by relaxing the collateral constraint. The right-hand part of equation (14) highlights that the result of these two effects is rationalized by the parameter Φ, that reflects the strength of financial amplification. At the equilibrium, these optimal conditions (13) and (14) provide the capital price q_1 and the interest rate R_{12}.

Date 0 Equilibrium Following the same way, the agent i takes prices at given, and solves

$$max\ u^i(c_0^i) + \beta \mathbb{E}_0 V^i(n_1^i, k_1^i) \quad \text{subject to} \quad (3), (6) \text{ and } (8) \tag{15}$$

where λ_0^i, μ_1^i and η_1^i denote the Lagrange multipliers on the budget constraint (3), on the stock collateral constraint (6) and on the flows collateral constraint (8), respectively. Again, by construction, μ_1^S and η_1^S are equal to zero.

As in Korinek and Dávila (2018), I denote the term $V_{n1}^i := \frac{\partial V^i}{\partial n_1^i}$ as the private marginal utility of wealth. In the same way, the term V_{k1}^i holds for capital good. Using the envelope conditions $V_{n1}^i = \lambda_1^i$ and $V_{k1}^i = \lambda_1^i q_1$, the maximisation problem yields

$$\lambda_0^i = \beta R_{01}\mathbb{E}_0(\lambda_1^i) + \mu_1^i + \eta_1^i \quad \text{with} \quad \lambda_0^i = U_0^{'i} \tag{16}$$

$$\lambda_0^i = \beta R_{02}\mathbb{E}_0(\lambda_1^i) + \mu_1^i \tag{17}$$

$$q_0 = \frac{\beta\mathbb{E}_0\left[\lambda_1^i(F_1^{'i}(k_1^i) + q_1)\right]}{\lambda_0^i - \Phi\mu_1^i - \kappa\eta_1^i} \tag{18}$$

These conditions are similar to the previous ones, with equations (16) and (17) for the two types of bonds and equation (18) for capital. Two differences appear compared to the period 1 equilibrium. First, the two Euler equations for bonds can be combined to deliver the no-arbitrage condition with a positive term premium if and only if the flows collateral constraint is binding.

$$R_{02} = R_{01} + \frac{\eta_1^i}{\beta\mathbb{E}_0(\lambda_1^i)} \tag{19}$$

Second, the Euler equation (18) at date 0 adds the remaining value q_1 of the capital. In addition, it includes the benefit of relaxing not only the stock collateral constraint but also the flow ones.

Proposition 1 *Following a positive approach, the model provides two main theoretical predictions that are in line with the previous empirical exercise: (i) the excessive level of debt triggers fire sales through the binding collateral constraints; (ii) the bulk of the impact of debt on fire sales is driven by short-term debt. A tightening of the flow collateral constraint generates a positive term premium in equation* (19)*, which reinforces the feedback loop between equations* (16) *and* (18)*.*

4 Normative Analysis

The pecuniary externality generated by the presence of the capital price in collateral constraints may result in fire sales, which generally induces a suboptimal decentralized equilibrium. The benevolent social planner internalizes this pecuniary externality in periods 0 and 1. First, he chooses date 0 and date 1 allocations, respecting that all prices are market-determined. Then, the optimal allocation is restored in the decentralized equilibrium by a set of taxes on short and long-term debts and subsidies on capital.

4.1 Social Planner Problem

The social planner problem is close to the date 0 decentralized equilibrium, with two key exceptions. First, the planner directly includes the pecuniary externality through two implementability constraints at dates 0 and 1, namely the Euler equations for capital (14) and (18). Second, thanks to the previous point, he internalizes the interdependencies between dates 0 and 1. For instance, too many long-term bonds contracted at date 0 could avoid fire sales at date 0 but generates them at date 1. As a consequence, the planner not only chooses the optimal date 0 allocation but also the optimal date 1 allocation, which in turn directly provides the same for date 2, in contrast to Korinek and Sandri (2016) and Korinek and Dávila (2018).[14]

Because the saver is unconstrained and hence behaves optimally[15], I focus on the behavior of the borrower that constitutes another difference between the paper and the two previous ones.

$$max\ u^B(c_0^B) + \beta \mathbb{E}_0 V^B(n_1^B, k_1^B) = u^B(c_0^B) + \beta u^B(c_1^B) + \beta^2 u^B(c_2^B) \quad \text{subject to (3)-(8), (14) and (18)} \tag{20}$$

where λ_t^{SP}, μ_t^{SP}, η_1^{SP} and ξ_t^{SP} denote the Lagrange multipliers for the social planner on the budget constraints, on the stock and flows collateral constraints and on the implementability constraints in period t, respectively. The optimal conditions for the social planner differ from the decentralized equilibrium in various ways.

First of all, the optimal conditions with respect to consumption of the homogenous good become

$$\lambda_0^{SP} = U_0^{\prime B} - \underbrace{\xi_0^{SP} q_0 \Omega_0 U_0^{\prime\prime B}}_{Intra.\ arbitrage} \tag{21}$$

$$\lambda_1^{SP} = \beta \mathbb{E}_0(U_1^{\prime B}) - \underbrace{\xi_1^{SP} \mathbb{E}_0 \left[q_1 \Omega_1 U_1^{\prime\prime B} \right]}_{Intra.\ arbitrage} + \underbrace{\xi_0^{SP} \beta \Omega_0 \mathbb{E}_0 \left[U_1^{\prime\prime B} (F_1^{\prime B}(k_1^B) + q_1) \right]}_{capital\ accumulation} \tag{22}$$

$$\lambda_2^{SP} = \beta^2 \mathbb{E}_0(U_2^{\prime B}) + \underbrace{\xi_1^{SP} \beta \mathbb{E}_0 \left[\Omega_1 U_2^{\prime\prime B} F_2^{\prime B}(k_2^B) \right]}_{capital\ accumulation} \tag{23}$$

[14] Korinek and Sandri (2016) and Korinek and Dávila (2018) look for the distinction between individual state variables (n^i, k^i) and sector-wide aggregate state variables (n^i, k^i), which can be used to include the pecuniary externality. But this approach does not easily allow for debt maturity structure. This paper introduces the pecuniary externality through implementability constraints. This another approach is close to Bianchi and Mendoza (2018) and Schmitt-Grohé and Uribe (2017).

[15] Nevertheless, the potential fire sales could lead to redistribute wealth among the two types of agents, which are called *distributive externalities* and described in Korinek and Dávila (2018). For simplicity, I put aside this question and the associated potential distortions. See Jeanne and Korinek (2013) about ex-post policies financed by savers.

with $\Omega_0 = \frac{1}{U_0^{\prime B} - \Phi\mu_1^B - \kappa\eta_1^B}$ and $\Omega_1 = \frac{1}{U_1^{\prime B} - \Phi\mu_2^B}$. About the consumption at date 0, there is a wedge between the private (16) and social (21) conditions that the reflect marginal utility of consumption because the social planner includes the risk of potential fire sales and values more the capital asset than the consumption good. This effect is conditional on the degree of concavity in consumption. Because $U_t^{\prime\prime B} < 0$ and $\xi_t^{SP} > 0$ for $t \in \{0, 1\}$, the consumption of the good at date 0 is lower in the social planner allocation than in the decentralized equilibrium if $\xi_t^{SP} > 0$. Lastly, the consumption of the good is also reduced by the potentially binding stock and flows collateral constraints through Ω_0 and the capital price q_0 (equation (18)). The positive level of term and risk premia at date 0 effectively trigger the risk of current fire sales.

Consider now the differences between private (13) and social (22) conditions. The consumption at date 1 as defined by the social planner includes two new terms.[16] The first term follows the same logic as the ones defining the previous period, which includes the effect of a positive level of risk premium at date 1 through the capital price q_1 and Ω_1. The second term represents the positive role of previous capital accumulation on the current consumption as well as in sales and in the function production. It reduces the wedge between good consumption for decentralized equilibrium and social planner allocation. Finally, the net effect of these two terms on the consumption at date 1 is uncertain and depends on an intertemporal arbitrage. Rearranging (22) sheds light on the sign of the shadow values ξ_1^{SP} and ξ_0^{SP} on this issue.

$$\lambda_1^{SP} = \beta \mathbb{E}_0(U_1^{\prime B}) - \underbrace{(\xi_1^{SP}\Omega_1 - \xi_0^{SP}\beta\Omega_0)\mathbb{E}_0\left[q_1 U_1^{\prime\prime B}\right]}_{Inter.\ arbitrage} + \xi_0^{SP}\beta\Omega_0\mathbb{E}_0\left[U_1^{\prime\prime B} F_1^{\prime B}(k_1^B)\right] \tag{24}$$

where the difference $\xi_1^{SP}\Omega_1 - \xi_0^{SP}\beta\Omega_0$ means how the social planner relatively values the potential risk of fire sales in the two periods. If the difference is negative, then the term that reflects this intertemporal arbitrage has the same sign as the effect of capital accumulation. Therefore, the social planner allocation increases the good consumption in period 1. But, if the inequality is positive, then the net impact of these terms is ambiguous, depending on the potential risk of fire sales versus the previous capital accumulation. It is also useful to contrast date 2 conditions (13) and (23), because of the social benefit due to higher capital accumulation at date 1.

[16] Substituting (16) into (13) yields the same first term in (22) and in (13). They reflect the private marginal utility of consumption and are discounted in the same way.

Furthermore, the optimal capital accumulation decisions according to the social planner allocation are

$$q_0 = \frac{\mathbb{E}_0 \overbrace{\left[\lambda_1^{SP}(F_1^{'B}(k_1^B) + q_1)\right]}^{Externality\ term} + \overbrace{\xi_0^{SP}\beta\Omega_0\mathbb{E}_0\left[U_1^{'B}F_1^{''B}(k_1^B)\right]}^{Decreasing\ returns}}{\lambda_0^{SP} - \Phi\mu_1^{SP} - \kappa\eta_1^{SP}} \tag{25}$$

$$q_1 = \frac{\mathbb{E}_0\left[\lambda_2^{SP}F_2^{'B}(k_2^B)\right] + \xi_1^{SP}\beta\mathbb{E}_0\left[\Omega_1 U_2^{'B}F_2^{''B}(k_2^B)\right]}{\lambda_1^{SP} - \Phi\mu_2^{SP}} \tag{26}$$

Again, the comparison between private (14)-(18) and social decisions (25)-(26) provides some differences in the two periods. First, the social planner creates some redistribution between consumption of good and capital, underlined as *Externality term* in equation (25). It normally supports capital price, but this mechanism depends on the values of the shadow prices. Second, this effect in favor of capital is balanced with decreasing returns to scale of the production function. According to these conditions, these two different effects could generate a lower capital price for social planner than the one for decentralized equilibrium, as suggested by Korinek and Dávila (2018). Because of the focus on the inefficient fire sales, I assume that the social planner allocation reduces the risk of overborrowing case and generates an higher capital price than the other allocation.

Proposition 2 *Following a normative approch, the social planner values the potential risk of fire sales for the current and the next periods. The level of debt and the allocation between consumption good and capital depend on (i) the risk of current fire sales, (ii) the risk of fire sales in the next period and (iii) the level and effectiveness of previous capital accumulation.*

Finally, the Euler optimal conditions for bonds are close to those obtained in decentralized equilibrium, the difference comes from the wedge between the Lagrange multipliers for the decentralized equilibrium (13)-(16) and the ones for the social planner (21)-(22)-(23).

$$\lambda_0^{SP} = R_{01}\mathbb{E}_0(\lambda_1^{SP}) + \mu_1^{SP} + \eta_1^{SP} \tag{27}$$

$$\lambda_0^{SP} = R_{02}\mathbb{E}_0(\lambda_1^{SP}) + \mu_1^{SP} \tag{28}$$

$$\lambda_1^{SP} = R_{12}\lambda_2^{SP} + \mu_2^{SP} \tag{29}$$

4.2 Implementation via Taxes

Based on these differences, I highlight that a set of taxes and subsidies replicates the social planner allocation. They affect the debt level at date 0 and 1, in order to avoid an overborrowing case. They also provide capital good subsidies on the capital asset. In fact, tipping the balance between consumption and capital asset in favor of the latter leads to reduced potential fire sales. The social planner implements (i) taxes on short-term bonds τ_0^{ST} and τ_1^{ST}, (ii) a tax on long-term bonds τ_0^{LT} and (iii) subsidies on capital asset τ_0^k and τ_1^k. $\tau^{ST} > 0$ and $\tau^{LT} > 0$ reflect a tax on bonds, while $\tau^k > 0$ is a subsidy. The policy intervention assumes that government budget constraint is balanced at each period t, with the presence of lump-sum transfers T_t.[17]

The borrower's budget constraints at date 0 and 1 are now

$$c_0^B + q_0(1-\tau_0^k)(k_1^B - k_0^B) + \frac{b_{01}^B}{R_{01}}(1-\tau_0^{ST}) + \frac{b_{02}^B}{R_{02}}(1-\tau_0^{LT}) + T_0 = e_0^B + b_0^B \tag{30}$$

$$c_1^B + q_1(1-\tau_1^k)(k_2^B - k_1^B) + \frac{b_{12}^B}{R_{12}}(1-\tau_1^{ST}) + T_1 = e_1^B + b_{01}^B + F_1^B(k_1^B) \tag{31}$$

Interest rates paid by borrowers increases with the level of the corresponding tax in line with the framework of Schmitt-Grohé and Uribe (2017). The corresponding lump-sum transfers/taxes only for borrowers are

$$T_0 = \tau_0^k q_0 k_1^B + \tau_0^{ST}\frac{b_{01}^B}{R_{01}} + \tau_0^{LT}\frac{b_{02}^B}{R_{02}} \tag{32}$$

$$T_1 = \tau_1^k q_1 k_2^B + \tau_1^{ST}\frac{b_{12}^B}{R_{12}} \tag{33}$$

Taxes on Debt At dates 0 and 1, the Euler equations for bonds become

$$\lambda_0^B(1-\tau_0^{ST}) = \beta R_{01}\mathbb{E}_0(\lambda_1^B) + \mu_1^B + \eta_1^B \tag{34}$$

$$\lambda_0^B(1-\tau_0^{LT}) = \beta R_{02}\mathbb{E}_0(\lambda_1^B) + \mu_1^B \tag{35}$$

$$\lambda_1^B(1-\tau_1^{ST}) = R_{12}\lambda_2^B + \mu_2^B \quad \text{with} \quad \lambda_1^B = U_1^{\prime B} \quad \text{and} \quad \lambda_2^B = \beta U_2^{\prime B} \tag{36}$$

By combining these new equations, the risk premium (19) and the social planner allocation conditions (21) and (22) on the consumption in periods 0 and 1, I obtain

[17] I also assume that there is no time inconsistency problem. The potential break between policymaker's action under commitment and under discretion is widely debated. See Bianchi and Mendoza (2018) and Jeanne and Korinek (2018).

$$\tau_0^{ST} = -\frac{\overbrace{\xi_1^{SP} R_{01} \mathbb{E}_0 \left[q_1 \Omega_1 U_1^{''B} \right]}^{Ex-ante}}{U_0^{'B}} + \frac{\overbrace{\xi_0^{SP} q_0 \Omega_0 U_0^{''B}}^{Ex-post}}{U_0^{'B}} + \frac{\overbrace{\xi_0^{SP} R_{01} \Omega_0 \mathbb{E}_0 \left[U_1^{''B} (F_1^{'B}(k_1^B) + q_1) \right]}^{Ex-post:\ capital\ accumulation\ date\ 0}}{U_0^{'B}} \quad (37)$$

$$\tau_0^{LT} = -\frac{\xi_1^{SP} \overbrace{R_{02}}^{Key\ diff.} \mathbb{E}_0 \left[q_1 \Omega_1 U_1^{''B} \right]}{U_0^{'B}} + \frac{\xi_0^{SP} q_0 \Omega_0 U_0^{''B}}{U_0^{'B}} + \frac{\xi_0^{SP} \overbrace{R_{02}}^{Key\ diff.} \Omega_0 \mathbb{E}_0 \left[U_1^{''B} (F_1^{'B}(k_1^B) + q_1) \right]}{U_0^{'B}} \quad (38)$$

$$\tau_1^{ST} = -\frac{\overbrace{\xi_0^{SP} \Omega_0 \mathbb{E}_0 \left[U_1^{''B} F_1^{'B}(k_1^B) \right]}^{Ex-post\ capital\ accumul.\ date\ 0}}{U_1^{'B}} + \frac{\overbrace{(\xi_1^{SP} \Omega_1 - \xi_0^{SP} \Omega_0)}^{Inter.\ arbitrage} \mathbb{E}_0 \left[q_1 U_1^{''B} \right]}{U_1^{'B}} + \frac{\overbrace{\xi_1^{SP} R_{12} \mathbb{E}_0 \left[\Omega_1 U_2^{''B} F_2^{'B}(k_2^B) \right]}^{Ex-post:\ capital\ accumul.\ date\ 1}}{U_1^{'B}} \quad (39)$$

The set of taxes on short (37) and long-term (38) bonds at date 0 are positively driven by the first (*ex-ante*) component and reduced by the two other (*ex-post*) components. Following the previous condition (22) and the associated benefits of capital accumulation as well as in sales and function production, the *ex-ante* component pushes up both taxes on bonds, which in turn limits the risk of further binding collateral constraint. This argument is in line with countercyclical policies as proposed by Korinek and Sandri (2016) and Jeanne and Korinek (2018). But the sign and the size of the tax level are also challenged by the two other *ex-post* components. First, the risk of current fire sales (at date 0) reduces the level of optimal taxes, because they may amplify the fire sales mechanism. Second, the role of taxes is limited by the effectiveness of the function production: some investment at date 0 could generate a substantial level of capital, which protect against future fire sales.

The taxes on short (37) and long-term (38) bonds are equivalent if and only if the short and long-term interest rates are the same, underlined as *"key difference"* in equation (38). Because the tightening of the flow collateral constraint is the key factor of the interest rate parity (19), the existence of the term premium introduces a difference between these taxes. In other words, if the level of optimal taxes is positive, liquidity concerns generate an higher taxes for long-term bonds than short ones. The social planner internalizes the market mechanism driven by the term premium.

Finally, the tax on short-term (39) at date 1 is conditional on the size of three terms. The first term, underlined as *"ex-post: capital accumul. date 0"*, improves the level of the tax. It depends on the efficiency of the previous capital accumulation at date 0 and how it could fight against fire sales' risk at date 1. The second term is related to the time preference of the social planner and depends on the relative value of fire sales in both times. This balances the choice between ex-ante and ex-post policies period-by-period. The last term follows the same logic as the one for taxes at date 0: it reflects the effectiveness of the function production for investment at date 1.

Subsidies on Capital By using decentralized equilibrium conditions (14)-(18) with the subsidies and the social planner capital accumulation allocations (25)-(26), the tax/subsidy on the capital at dates 0 and 1 are defined by

$$\tau_0^k = \frac{\mathbb{E}_0 \overbrace{\left[(\lambda_1^{SP} - \lambda_1^B)(F_1'^B(k_1^B) + q_1)\right]}^{Externality\ diff.}}{q_0 \lambda_0^{SP}} + \frac{\overbrace{\xi_0^{SP} \beta \Omega_0 \mathbb{E}_0 \left[U_1'^B F_1''^B(k_1^B)\right]}^{Decreasing\ returns}}{q_0 \lambda_0^{SP}} \quad (40)$$

$$\tau_1^k = \frac{\mathbb{E}_0 \overbrace{\left[(\lambda_2^{SP} - \lambda_2^B) F_2'^B(k_2^B)\right]}^{Externality\ diff.}}{q_1 \lambda_1^{SP}} + \frac{\overbrace{\xi_1^{SP} \beta \mathbb{E}_0 \left[\Omega_1 U_2'^B F_2''^B(k_2^B)\right]}^{Decreasing\ returns}}{q_1 \lambda_1^{SP}} \quad (41)$$

These policies on capital complement taxes on debt to ensure that decentralized agents have no incentives to sell too much of their capital. This mechanism crucially depends on the inequality $\lambda_t^{SP} > \lambda_t^B$ with $t = 1, 2$, meaning that the consumption level of the social planner allocation is lower than the one of decentralized equilibrium. In addition, it is weighted by the production function and the efficiency limits due to decreasing returns to scale. To sum up, the social planner should provide a subsidy on capital ($\tau^k > 0$) if and only if the first term is sufficiently large and $\lambda_t^{SP} > \lambda_t^B$. This means that the planner provides subsidies on capital when the capital accumulation is the key to avoid current and future fire sales.

Proposition 3 *Following a normative approach, the optimal allocation is restored in the decentralized equilibrium by a set of taxes on short and long-term debts and subsidies on capital, both at date 0 and date 1. As summarized in table 3, these policy instruments are contingent to various determinants, especially the risk of current and next fire sales, the efficiency of the capital investment and the term premium.*

Table 3: Policy Intervention - Summary

Policy Intervention	Increase	Decrease
τ_0^{ST} and τ_0^{LT}	risk of overconsumption at date 1	risk of overconsumption at date 0 efficiency of the capital acccumulation at date 0
τ_0^{LT}	positive term premium (i.e. liquidity concerns)	
τ_1^{ST}	Intertemporal arbitrage between date 0 and date 1 efficiency of the capital acccumulation at date 0	risk of overconsumption at date 1 efficiency of the capital acccumulation at date 1
τ_0^k and τ_1^k	efficiency of the capital acccumulation	Decreasing returns to scale

5 Conclusion

This paper underlines the role of debt maturity structure as a key early-warning indicator of financial crises for the developing world. An excessive reliance on short-term debt exacerbates the risk of financial crises through a rise in the term premium. These testable predictions are then brought to the model. I introduce debt maturity structure in a *Fisherian deflation* model and I highlight that the mix of these debts chosen by a decentralized agent follows a suboptimal path, which amplifies both liquidity risk (i.e. the rise in term premium) and solvency risk (i.e. the rise in risk premium), and then triggers fire sales. It makes harder the art of policymaking and calls for both ex-ante and ex-post policies. Nevertheless, the optimal corrective policies can be globally designed using three statistics, namely the risk of current and next fire sales, the efficiency of the capital investment and the term premium.

This framework can be extended by including global financial forces, that is called the global financial cycle by Rey (2015). Clearly, the spillover effects from the US monetary policy are large, because it drives global liquidity and this adds up to the high level of comovement in asset prices, credit, and risk aversion around the world. The global financial cycle can be seen in two phases: (i) boom with low US interest rates and high global liquidity and (ii) bust with high US interest rates and low global liquidity. These regime shifts are introduced into a *Fisherian deflation* model by Bianchi et al. (2016). The current framework that includes debt maturity structure can be enhanced to include these regime shifts. This affects the mix of short and long-term bonds chosen by the agent, which in turn could amplify the risk of asset fire sales. More precisely, if the world goes from a high-liquidity regime to a low-liquidity regime and if the borrower has previously accumulated too much long-term debt, both the likelihood and the amplitude of the financial crisis increase.

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Appendix 1: List of Countries and Data Sources

Table A.1: List of countries

	Time Coverage		Time Coverage		Time Coverage
Algeria	1975-2017	Ghana	1975-2017	Niger	1975-2017
Argentina	1975-2016	Guinea	1991-2017	Nigeria	1975-2017
Bangladesh	1978-2017	Guinea-Bissau	1979-2017	Paraguay	1975-2017
Belize	1975-2017	Guyana	1975-2017	Peru	1975-2017
Bolivia	1975-2017	Haiti	1975-2017	Philippines	1975-2017
Brazil	1975-2012	India	1975-2017	Romania	1994-2017
Bulgaria	1986-2017	Indonesia	1975-2017	Russia	1997-2017
Burkina Faso	1975-2017	Ivory Coast	1975-2017	Sao Tome	1982-2017
Burundi	1975-2017	Jamaica	1975-2017	Senegal	1975-2017
Cameroon	1975-2017	Jordan	1975-2017	Sierra Leone	1975-2017
Cape Verde	1986-2017	Kazakhstan	1998-2017	Sri Lanka	1975-2017
Central African Rep.	1975-2017	Kenya	1975-2017	Swaziland	1975-2017
Chad	1975-2017	Lebanon	1975-2017	Thailand	1975-2017
China	1986-2017	Madagascar	1975-2017	Togo	1975-2017
Colombia	1975-2017	Malaysia	1975-2017	Tunisia	1975-2017
Congo, Dem. Rep.	1975-2017	Mali	1975-2017	Turkey	1975-2017
Congo, Rep.	1975-2017	Mauritania	1975-2017	Uganda	1975-2017
Costa Rica	1975-2017	Mexico	1975-2017	Ukraine	1997-2017
Djibouti	1975-2017	Moldova	2000-2017	Venezuela	1975-2015
Dominican Rep.	1975-2017	Mongolia	1997-2017	Vietnam	1994-2017
Ecuador	1975-2017	Morocco	1975-2017	Yemen	1995-2017
Egypt	1975-2017	Nepal	1975-2017	Zambia	1975-2017
El Salvador	1975-2017	Nicaragua	1994-2017	Zimbabwe	1975-2017

Note: this table corresponds to the sample of 69 countries with 2691 points including the 5 years-lag.

Table A.2: Data sources

Variable	Description	Source
	Crises	
Banking Crises	Systemic banking crises. Dummy equal to 1 if crisis.	Laeven and Valencia (2018)
Currency Crises	Currency crises. Dummy equal to 1 if crisis.	Laeven and Valencia (2018)
Debt Crises	Sovereign debt crises. Dummy equal to 1 if crisis.	Laeven and Valencia (2018)
Reinhart Banking Crises	Alternative measure of banking crises. Dummy equal to 1 if crisis.	Reinhart et al. (2016)
Reinhart Systemic Banking Crises	Alternative measure of systemic banking crises. Dummy equal to 1 if crisis.	Reinhart et al. (2016)
Stock Market Crash	Large drop in equity prices. Dummy equal to 1 if crisis.	Reinhart and Rogoff (2009)
	International Debt Securities	
$\frac{ST}{ST+LT}$	Ratio of short-term external debt stock to all external debt stock. Short-term means disbursed outstanding debt with an original maturity of one year or less.	World Bank
$\frac{Debt\ Stock}{GNI}$	Ratio of external debt stock to gross national income. External debt stock decomposed into three blocs: (i) public and publicly guaranteed debt (PPG) (ii) private nonguaranteed debt (PNG) (iii) IMF credit, provided by the IMF Treasurer's Department.	World Bank
$\frac{Debt\ Reduction}{GNI}$	Debt forgiveness grants from bilateral and multilateral creditors.	World Bank
Multilateral Creditors	Ratio of the stock of debt owed to multilateral creditors to external debt. Multilateral creditors are international financial institutions, and other multilateral and intergovernmental agencies whose lending is administered on a multilateral basis.	World Bank
	Endogeneity issues, term premium	
US Term Premium	US Treasury term premium estimates.	Adrian et al. (2013)
	Other Control Variables	
$\frac{Reserves}{Debt\ Stock}$	Ratio of international reserves to external debt stock, including its reserve position in the IMF, its holdings of foreign exchange, and its holdings of gold. resources provided to the private sector by financial corporations.	World Bank
log(GDP)	GDP, current US dollars.	World Bank
	Currency Mismatch Measure	
$\frac{Net\ Debt\ Flows}{Net\ Exports}$	Ratio of net debt flows to net exports of goods, services and primary income.	World Bank

Table A.3: Descriptive Statistics

Variable	Mean	First Quartile	Median	Third Quartile	SD
		Crises			
Banking Crises	0.034	0	0	0	0.182
Currency Crises	0.048	0	0	0	0.214
Debt Crises	0.016	0	0	0	0.125
Reinhart Banking Crises	0.204	0	0	0	0.403
Reinhart Systemic Banking Crises	0.173	0	0	0	0.378
Stock Market Crash	0.321	0	0	1	0.467
		International Debt Securities			
$\frac{ST}{ST+LT}$	0.123	0.053	0.104	0.175	0.112
$\frac{PPG\ Debt\ Stock}{GNI}$	0.496	0.186	0.326	0.597	0.562
$\frac{PNG\ Debt\ Stock}{GNI}$	0.056	0	0.009	0.06	0.124
$\frac{IMF\ Credit}{GNI}$	0.03	0.004	0.015	0.04	0.053
$\frac{Debt\ Reduction}{GNI}$	0.006	0	0	0	0.045
Multilateral Creditors	0.283	0.116	0.224	0.417	0.211
		Endogeneity issues, term premium			
US Term Premium	1.795	0.711	1.962	2.51	1.232
		Other Control Variables			
$\frac{Reserves}{Debt\ Stock}$	0.476	0.078	0.19	0.393	2.067
log(GDP)	23.26	21.82	23.02	24.59	2
		Currency Mismatch Measure			
$\frac{Net\ Debt\ Flows}{Net\ Exports}$	-0.25	-0.59	-0.26	-0.05	12.75

Appendix 2: Additional Tests

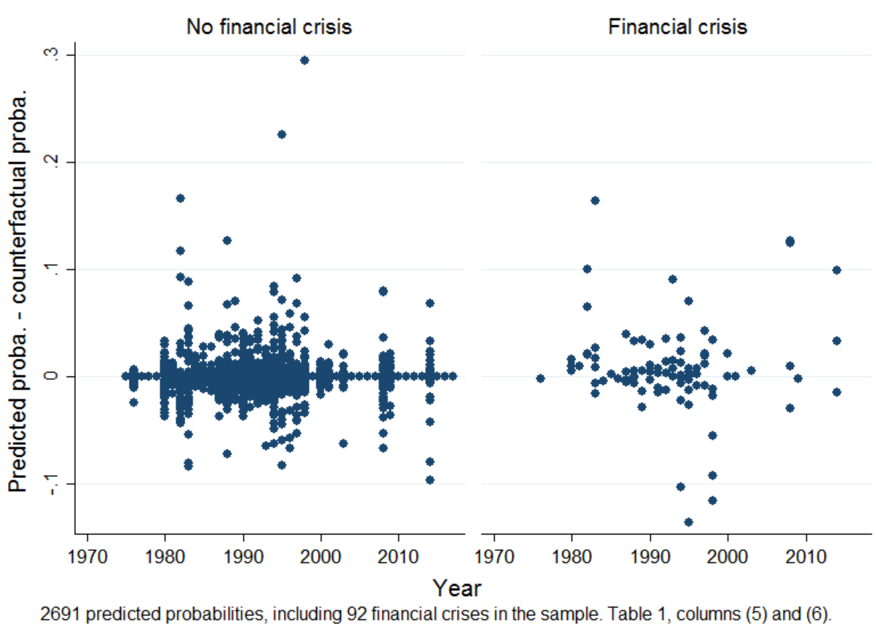

Figure A.1: Difference between predicted and counterfactual probabilities

Table A.4: Full set of results with individual lags - Table 1

	Dependent variable: Systemic Banking Crisis. Logit Estimates.								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
L.$\frac{ST}{ST+LT}$	6.190**		6.346**	5.540*	6.487**		23.69***	-4.068	
	(2.683)		(2.723)	(3.116)	(3.222)		(6.173)	(4.937)	
L2.$\frac{ST}{ST+LT}$	-5.856		-6.269	-5.769	-6.477		-23.11***	-0.0756	
	(3.773)		(3.847)	(4.177)	(4.301)		(7.468)	(7.663)	
L3.$\frac{ST}{ST+LT}$	-1.097		-1.602	-0.566	-0.999		-0.228	-1.366	
	(3.697)		(3.791)	(3.906)	(4.037)		(5.887)	(7.329)	
L4.$\frac{ST}{ST+LT}$	-1.221		-0.726	0.173	0.520		1.837	3.895	
	(3.364)		(3.447)	(3.553)	(3.627)		(5.308)	(6.576)	
L5.$\frac{ST}{ST+LT}$	5.783**		5.853**	5.020**	4.743*		6.654*	-0.368	
	(2.307)		(2.392)	(2.423)	(2.504)		(3.598)	(4.891)	
L.$\frac{Debt\ Stock}{GNI}$		-0.118							
		(0.408)							
L2.$\frac{Debt\ Stock}{GNI}$		0.204							
		(0.548)							
L3.$\frac{Debt\ Stock}{GNI}$		-0.293							
		(0.614)							
L4.$\frac{Debt\ Stock}{GNI}$		0.0636							
		(0.538)							
L5.$\frac{Debt\ Stock}{GNI}$		-0.0463							
		(0.420)							
L.$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			-0.283		0.296	0.192	0.173	1.758	
			(0.568)		(0.750)	(0.728)	(1.710)	(1.707)	
L2.$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			0.0599		-0.416	-0.209	-0.369	-2.041	
			(0.726)		(1.065)	(1.041)	(2.740)	(2.286)	
L3.$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			-0.229		0.373	0.555	2.402	-2.066	
			(0.777)		(0.997)	(0.973)	(2.478)	(2.240)	
L4.$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			0.664		0.151	0.131	-1.054	0.353	
			(0.788)		(1.131)	(1.109)	(3.121)	(1.129)	
L5.$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			-0.671		-0.693	-0.955	-1.357	0.285	
			(0.646)		(0.852)	(0.851)	(1.991)	(0.704)	
L.$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			5.906		7.734	4.883	9.017	1.846	
			(4.832)		(4.851)	(4.242)	(8.557)	(8.314)	
L2.$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			-2.310		-4.251	-1.572	-16.33	-0.968	
			(7.638)		(7.977)	(7.277)	(15.81)	(9.692)	
L3.$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			0.0785		1.890	2.972	17.64	6.995	
			(7.852)		(8.328)	(8.144)	(15.53)	(14.89)	
L4.$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			-7.176		-7.713	-7.240	-16.43	-12.45	
			(8.320)		(8.471)	(8.542)	(14.97)	(17.48)	
L5.$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			7.356		7.392	5.729	10.07	8.875	
			(5.331)		(5.589)	(5.573)	(9.851)	(9.147)	
L.$\frac{IMF\ Credit}{GNI}$				-14.50	-17.57	-17.20*	-9.450	-33.34*	
				(9.644)	(10.70)	(10.36)	(22.18)	(18.87)	
L2.$\frac{IMF\ Credit}{GNI}$				17.12*	19.86	20.21*	9.872	31.58	
				(10.22)	(12.14)	(11.60)	(32.02)	(26.60)	
L3.$\frac{IMF\ Credit}{GNI}$				-12.63	-13.24	-15.27	-25.46	-6.577	
				(9.794)	(10.87)	(10.65)	(30.32)	(21.21)	
L4.$\frac{IMF\ Credit}{GNI}$				14.04	14.97	15.39	51.69*	10.31	
				(9.177)	(10.94)	(10.61)	(29.96)	(18.76)	
L5.$\frac{IMF\ Credit}{GNI}$				-7.428	-7.771	-7.492	-33.83	-4.995	
				(7.433)	(9.190)	(8.815)	(20.92)	(17.39)	
L.$Multilateral\ Creditors$ (%)				-1.543	0.237	-4.379	3.910	-10.25	
				(4.445)	(4.595)	(3.924)	(7.653)	(6.717)	
L2.$Multilateral\ Creditors$ (%)				-0.901	-1.912	4.246	-5.285	2.525	
				(6.169)	(6.307)	(5.296)	(9.546)	(10.32)	
L3.$Multilateral\ Creditors$ (%)				3.850	3.483	3.243	9.807	8.673	
				(5.079)	(5.197)	(4.710)	(7.415)	(9.021)	
L4.$Multilateral\ Creditors$ (%)				0.238	0.897	-0.388	0.819	-6.657	
				(4.673)	(4.740)	(4.414)	(6.541)	(8.999)	
L5.$Multilateral\ Creditors$ (%)				-4.266	-4.907	-5.272	-10.88*	1.424	
				(3.924)	(3.973)	(3.794)	(5.832)	(7.377)	
L.$\frac{Debt\ Reduction}{GNI}$				1.363	3.127	2.258			
				(2.118)	(2.544)	(2.465)			
L2.$\frac{Debt\ Reduction}{GNI}$				0.614	1.878	2.300			
				(3.492)	(3.808)	(4.380)			
L3.$\frac{Debt\ Reduction}{GNI}$				5.454*	7.372**	7.817**			
				(2.960)	(3.369)	(3.420)			
L4.$\frac{Debt\ Reduction}{GNI}$				5.339*	6.599*	6.138*			
				(2.987)	(3.863)	(3.712)			
L5.$\frac{Debt\ Reduction}{GNI}$				6.955*	7.858	6.970			
				(4.025)	(5.233)	(5.028)			
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Obs.	2691	2691	2691	2691	2691	2691	913	772	
Countries	62	62	62	62	62	62	62	62	62

Standard errors in parentheses. Following formal lag selection procedures, I consider 5 lags of all variables.

*, ** and *** denote respectively significance at the 10, 5 and 1% levels.

Table A.5: Crisis years (not only the outbreak of the crisis) - Sensitivity analysis

Dependent variable: Systemic Banking Crisis (All Years). Logit Estimates.								
							US Term Premium	
							> 2	< 2
Sum of 5 lags	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\frac{ST}{ST+LT}$	3.940***		3.678***	3.945***	3.758***		10.10***	-1.472
	(1.216)		(1.247)	(1.281)	(1.310)		(2.321)	(2.848)
$\frac{Debt\ Stock}{GNI}$		-0.0644						
		(0.170						
$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$			−0.433*		-0.435	-0.448	0.859	−1.897***
			(0.255)		(0.307)	(0.303)	(0.742)	(0.488)
$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$			4.145***		4.561***	4.385***	10.09**	5.135***
			(1.301)		(1.429)	(1.371)	(4.430)	(1.853)
$\frac{IMF\ Credit}{GNI}$				0.0809	1.420	0.863	−15.87**	8.490
				(3.200)	(3.559)	(3.457)	(7.856)	(5.802)
$Multilateral\ Creditors$ (%)				−1.917*	-1.161	-1.503	−3.693*	-1.773
				(1.106)	(1.190)	(1.164)	(2.204)	(2.371)
$\frac{Debt\ Reduction}{GNI}$				7.339	14.36**	13.34**		
				(5.411)	(6.145)	(6.213)		
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	2691	2691	2691	2691	2691	2691	1021	1066
Countries	69	69	69	69	69	69	51	53
Pseudolikelihood	-517.7	-518	-502.4	-508.3	-494.3	-500.4	-197	-160.9
R^2	0.253	0.252	0.275	0.266	0.286	0.278	0.335	0.455
AUROC	0.816	0.812	0.831	0.824	0.837	0.834	0.797	0.851
Standard error	0.0113	0.0119	0.0109	0.0106	0.0104	0.0106	0.0162	0.0153

Standard errors in parentheses. Following formal lag selection procedures, I consider 5 lags of all variables. 261 points of crisis regime, including 92 first year crisis regime. *, ** and *** denote respectively significance at the 10, 5 and 1% levels.

Table A.6: Other control variables - Sensitivity analysis

	Dependent variable: Systemic Banking Crisis. Logit Estimates.								
								US Term Premium	
								> 2	< 2
Sum of 5 lags	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$\frac{ST}{ST+LT}$	4.235*	4.6445**	4.647**	4.856*	5.537**	6.933**	6.555*	50.07***	-197.9
	(2.187)	(2.249)	(2.240)	(2.494)	(2.583)	(3.017)	(3.391)	(15.94)	(164.8)
$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$	-0.311	-0.261	-0.286	-1.139	-1.278^{*}	-0.978	-1.471	-0.571	57.07
	(0.485)	(0.495)	(0.490)	(0.739)	(0.761)	(0.960)	(1.096)	(4.132)	(44.52)
$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$	5.058**	5.5085**	5.504**	5.119*	5.832**	4.852	6.662*	14.24	-19.96
	(2.536)	(2.589)	(2.590)	(2.826)	(2.921)	(3.232)	(3.954)	(17.88)	(94.03)
$\frac{IMF\ Credit}{GNI}$	-3.901	-3.471	-3.917	-5.525	-6.728	-7.243	-11.93	-12.59	-586
	(6.305)	(6.368)	(6.378)	(7.708)	(7.780)	(9.144)	(10.49)	(41.71)	(523.8)
Multilateral Creditors (%)	-2.259	-1.921	-1.955	-2.484	-2.189	-2	-1.011	0.173	-106.4
	(1.886)	(1.895)	(1.901)	(2.166)	(2.246)	(2.513)	(2.859)	(9.081)	(105.3)
$\frac{Debt\ Reduction}{GNI}$	26.55**	27.485**	27.04**	32.46**	36.04**	44.72**	47.82**	-4399	3162
	(10.60)	(11.18)	(11)	(13.16)	(14.18)	(17.94)	(20.99)	(751864)	(2755)
Currency Crisis	-0.157		0.586		0.508	2.310	3.169	8.062	145.9
	(1.472)		(1.516)		(1.639)	(1.811)	(2.019)	(6.977)	(131.8)
Debt Crisis		-51.02	-51.45		-60.01	-63.34	-61.14	-95.64	175.3
		(4244)	(4180)		(11965)	(19616)	(11813)	(107986)	(219122)
$\frac{Reserves}{Debt\ Stock}$				-2.793^{**}	-3.386^{***}	-4.981^{***}	-4.315^{***}	-8.080^{**}	-21.68
				(1.148)	(1.245)	(1.553)	(1.618)	(3.732)	(26.06)
Log(GDP)						1.426	1.482	-0.0126	108.7
						(0.905)	(1.138)	(3.791)	(90.08)
$\frac{Net\ Debt\ Flows}{Net\ Exports}$							0.0191	1.575**	-3.797
							(0.0496)	(0.790)	(3.583)
Country FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	2691	2691	2691	2511	2511	2284	1869	617	560
Countries	69	69	69	65	65	62	60	35	35
Pseudolikelihood	-220.5	-215.3	-213.9	-197.5	-187.9	-170.6	-148.6	-39.72	-21.29
R^2	0.304	0.320	0.324	0.343	0.375	0.402	0.404	0.633	0.789
AUROC	0.8547	0.8628	0.8641	0.8649	0.8757	0.8250	0.8077	0.8758	0.6553
Standard error	0.0134	0.0123	0.0125	0.0136	0.0128	0.0169	0.0195	0.0219	0.0456

Standard errors in parentheses. Following formal lag selection procedures, I consider 5 lags of all variables.

*, ** and *** denote respectively significance at the 10, 5 and 1% levels.

Table A.7: Other dependent variable - Sensitivity analysis

	Dependent variable: Various types of crisis. Logit Estimates.				
	(1)	(2)	(3)	(4)	(5)
Dependent variable:	CurrencyLV	SoverDebtLV	BankRR	SystemicBankRR	StockCrash
$\frac{ST}{ST+LT}$	1.379	-1.291	4.009***	4.593***	1.308
	(1.276)	(2.576)	(1.397)	(1.510)	(1.739)
$\frac{Public\ (PPG)\ Debt\ Stock}{GNI}$	-0.270	0.801	1.014**	0.667	1.334
	(0.357)	(1.033)	(0.404)	(0.427)	(1.026)
$\frac{Private\ (PNG)\ Debt\ Stock}{GNI}$	-0.780	-1.726	5.186**	4.419*	3.867
	(1.580)	(3.205)	(2.280)	(2.423)	(3.128)
$\frac{IMF\ Credit}{GNI}$	-6.469^{*}	-17.68^{**}	1.565	9.623*	-6.769
	(3.446)	(9.001)	(4.505)	(5.227)	(5.729)
$Multilateral\ Creditors$ (%)	0.633	-8.670^{**}	1.383	0.208	1.896
	(1.127)	(3.405)	(1.394)	(1.529)	(2.198)
$\frac{Debt\ Reduction}{GNI}$	-19.10	-500.1	-1.149	-17.31	-6.711
	(15.19)	(596.4)	(9.748)	(11.42)	(24.70)
Country FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Obs.	3215	1737	1413	1275	713
Countries	86	43	38	33	21
Pseudolikelihood	-431.7	-116.8	-449.5	-378.5	-265.1
R^2	0.172	0.395	0.225	0.229	0.289
AUROC	0.743	0.889	0.781	0.793	0.802
Standard error	0.0185	0.0152	0.0153	0.0162	0.0171

"LV" refers to Laeven and Valencia (2018) while "RR" refers to Reinhart et al. (2016). Standard errors in parentheses.
Following formal lag selection procedures, I consider 5 lags of all variables.
*, ** and *** denote respectively significance at the 10, 5 and 1% levels.