

Sovereign cocos and the reprofiling of debt payments*

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Abstract

We study a model of equilibrium sovereign default in which the government issues cocos (contingent convertible bonds) that stipulate a suspension of debt payments when the government has lost market access. We quantify the effects of such cocos by comparing simulations of the cocos model with the ones obtained when the government issues non-contingent debt. We find that cocos are more likely to mitigate sovereign risk and generate welfare gains when the suspension of payments is triggered by local shocks and accompanied by conditionality, and when cocos are complemented with fiscal rules. We also find that it may be optimal to complement the reprofiling of debt payments with haircuts.

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1 Introduction

The European sovereign debt crises revived discussions about policies to mitigate the likelihood and the costs of debt crises. The “reprofiling” of sovereign debt plays a central role in these discussions. Reprofileing refers to extending the maturity of sovereign debt instruments in periods of low liquidity. For instance, in the 2014 review of its lending framework (IMF, 2014) the IMF discusses “in circumstances where a member has lost market access and debt is considered sustainable but not with high probability, the Fund would be able to provide exceptional access on the basis of a debt operation that involves an extension of maturities (normally without any reduction of principal or interest).”¹ Similarly, Brooke et al. (2011) and Weber et al. (2011) discuss mandating that governments issue cocos (contingent convertible bonds) with a trigger clause that would extend the maturity of government bonds for a country receiving liquidity (and not solvency) assistance from the official sector. Consiglio and Zenios (2015) recommend sovereign cocos that suspend debt payment when the average sovereign CDS spread is high (Barkbu et al., 2012, present a similar proposal). A maturity-extending trigger clause would allow a reprofiling of debt payments that does not constitute a credit event. Critics of these proposals claim that reprofiling would be unfriendly to creditors, ultimately increasing the likelihood of debt crises and hurting the sovereign (FT, 2013, 2014). This paper presents a formal quantitative analysis of sovereign cocos imposing a debt reprofiling in periods of low liquidity. Would cocos reduce or increase sovereign spreads? Would they benefit governments? Should the reprofiling mandated by cocos be accompanied by face-value haircuts?

Proposals of sovereign cocos are motivated in part by the rapid growth in the issuance of bank cocos (that convert debt into equity after adverse contingencies) after the financial crisis of 2007-2009. For instance, cocos represented one third of new securities issuances by the largest European financial institutions between July 2013 and August 2014 (Avdjiev et al., 2015).

We measure the effects of cocos using a sovereign default framework à la Eaton and Gersovitz (1981). Formally, we analyze a small open economy that receives a stochastic

¹IMF (2014) also explains that “in circumstances where a members debt is unsustainable, a reprofiling would be inappropriate and an upfront debt reduction operation would be pursued”.

endowment stream of a single tradable good. At the beginning of each period, the government observes its endowment and the liquidity shocks. Local liquidity shocks are contingent liabilities. Global liquidity shocks are changes in the lenders' risk aversion. High lenders' risk aversion implies a lower endowment. When the government is not in default, it decides whether to default. While in default, the government suffers an endowment loss and cannot borrow. While not in default, the government can issue sovereign bonds that are priced by competitive foreign investors. In the baseline model, the government issues non-contingent bonds. In the cocos model, the payments of bonds issued by the government are suspended in periods of low liquidity.

We quantify the effects of cocos by comparing simulations of the cocos model with the ones obtained when the government issues non-contingent debt. We measure the effects of cocos under two extreme assumptions. Cocos either have no effect on the endowment cost of high lenders' risk aversion or completely eliminate this cost.

We find that as argued by proponents of sovereign cocos, cocos reduce the frequency of sovereign defaults triggered by liquidity shocks, and increase consumption and welfare in periods of low global liquidity. However, as argued by detractors of sovereign cocos, cocos may increase the cost of borrowing. The higher cost of borrowing with cocos also arises because (i) cocos weaken market discipline and (ii) lenders dislike reprofiling triggered by global liquidity shocks.

Fernández and Martin (2015) study sovereign debt reprofiling in a three-period model with a fixed initial debt level in which debt restructurings (including reprofilings) can avoid costly liquidations and thus improve welfare. They show that a restructuring that does not decrease expected payments to creditors during crises improves ex-ante welfare. In contrast, we study a quantitative model with endogenous debt levels in which creditors do not care only about expected payments but also about the timing of payments, and cocos may not have a positive effect on aggregate income. In our model, cocos greatly increase equilibrium borrowing.

Sanchez et al. (2014) study sovereign debt reprofiling as a possible outcome of endogenous default decisions. Reprofiling triggers a loss of aggregate income but implies a shorter

exclusion from debt markets. In contrast, we study reprofiling automatically triggered by liquidity shocks because of clauses in cocos.

The rest of the paper proceeds as follows. Section 2 introduces the baseline model with non-contingent bonds. Section 3 presents the model with cocos. Section 4 discusses the benchmark calibration. Section 5 presents the results. Section 6 concludes.

2 Model with non-contingent debt

This section presents a dynamic small-open-economy model in which the government issues non-state-contingent defaultable debt. Within each period, the timing of events is as follows. First, aggregate income and liquidity shocks are realized. After observing these shocks, the government chooses whether to default on its debt and borrows subject to constraints imposed by its default decision.

The economy's endowment of the single tradable good is denoted by $y \in Y \subset \mathbb{R}_{++}$. The endowment process follows:

$$\log(y_t) = (1 - \rho) \mu + \rho \log(y_{t-1}) + \varepsilon_t,$$

with $|\rho| < 1$, and $\varepsilon_t \sim N(0, \sigma_\varepsilon^2)$.

A benevolent government maximizes:

$$\mathbb{E}_t \sum_{j=t}^{\infty} \beta^{j-t} u(c_j),$$

where $\mathbb{E}$ denotes the expectation operator, β denotes the subjective discount factor, and c_t represents consumption of private agents. The utility function is strictly increasing and concave.

As Hatchondo and Martinez (2009), we assume that a bond issued in period t promises an infinite stream of coupons that decrease at a constant rate δ . In particular, a bond issued in period t promises to pay $(1 - \delta)^{j-1}$ units of the tradable good in period $t + j$, for all $j \geq 1$. Hence, debt dynamics can be represented as follows:

$$b_{t+1} = (1 - \delta)b_t + i_t,$$

where b_t is the number of coupons due at the beginning of period t , and i_t is the number of long-duration bonds issued in period t .

The price of sovereign bonds satisfies a no-arbitrage condition with stochastic discount factor $M(y', y, p) = \exp(-r - p[\alpha\varepsilon' + 0.5\alpha^2\sigma_\varepsilon^2])$, where r denotes the risk-free rate at which lenders can borrow or lend, and $p = 1$ ($p=0$) in periods of high (low) investors' risk aversion. Thus, in order to simplify the calibration, we assume that in period of low investors' risk aversion, investors are risk neutral (as in most previous studies of sovereign default). This model of the discount factor is a special case of the discrete-time version of the Vasicek one-factor model of the term structure (Vasicek, 1977; Backus et al., 1998) and has often been used in models of sovereign default (e.g., Arellano and Ramanarayanan, 2012).² The risk-premium shock p follows a Markov process such that a high-risk-premium episode starts with probability $\pi_{LH} \in [0, 1]$ and ends with probability $\pi_{HL} \in [0, 1]$.

We also assume an income loss of $\phi^p(y)$ during periods in which lenders demand a high risk premium. These periods are often associated with currency and banking crises and deep recessions.³

The government may also go through periods of low local liquidity that does not affect the creditors' discount factor. Local liquidity is determined by the shock l , with $l = 1$ ($l=0$) in periods of low (high) liquidity. The shock l follows a Markov process such that a low local liquidity episode starts with probability $\pi_{hl} \in [0, 1]$ and ends with probability $\pi_{lh} \in [0, 1]$. Each period of low local liquidity, resources available to the government are reduced by L . We can interpret L as a contingent liability.

When the government defaults, it does so on all current and future debt obligations. This is consistent with the observed behavior of defaulting governments and it is a standard

²The value of α can be interpreted as capturing the joint effect of lenders' risk aversion and the co-movement between shocks to lenders' wealth and the country's income. This formulation introduces a positive risk premium because bond payoffs are more valuable to lenders in states in which the government defaults.

³For instance, several studies document a loss of income triggered by sudden stops (see Calvo et al., 1993, and the references therein).

assumption in the literature.⁴ As in most previous studies, we also assume that the recovery rate for debt in default (i.e., the fraction of the loan lenders recover after a default) is zero.⁵ A government in default does not pay contingent liabilities L .

A default event triggers exclusion from credit markets for a stochastic number of periods. The government does not have access to debt markets in the default period and then regains access to debt markets with constant probability $\psi \in [0, 1]$.

Income is given by $y - \phi^d(y)$ in every period in which the government is excluded from credit markets because of a default. Thus, the income level of an economy in default is independent from the lenders' risk aversion. This implies that the income loss triggered by a default is effectively lower when the lenders' risk aversion is higher (because in these situations income is $y - \phi^p(y)$ in case the government repays). This assumption is justified because the income losses during both defaults and periods of high investors' risk aversion intend to capture local disturbances caused by difficulties in accessing international credit markets. This assumption also allows the model to capture that some but not all falls in global liquidity trigger defaults.

The government cannot commit to future (default and borrowing) decisions. Thus, one may interpret this environment as a game in which the government making decisions in period t is a player who takes as given the (default and borrowing) strategies of other players (governments) who will decide after t . We focus on Markov Perfect Equilibrium. That is, we assume that in each period the government's equilibrium default, borrowing, and saving strategies depend only on payoff-relevant state variables.

⁴Sovereign debt contracts often contain an acceleration clause and a cross-default clause. The first clause allows creditors to call the debt they hold in case the government defaults on a debt payment. The cross-default clause states that a default in any government obligation constitutes a default in the contract containing that clause. These clauses imply that after a default event, future debt obligations become current.

⁵Yue (2010) and Benjamin and Wright (2008) present models with endogenous recovery rates.

2.1 Recursive Formulation

Let V denote the value function of a government that is not currently in default. For any bond price function q , the function V satisfies the following functional equation:

$$V(b, y, p, l) = \max \{ V^R(b, y, p, l), V^D(y, p, l) \}, \quad (1)$$

where the government's value of repaying is given by

$$V^R(b, y, p, l) = \max_{b', c} \{ u(c) + \beta \mathbb{E}_{(y', p', l') | (y, p, l)} V(b', y', p', l') \}, \quad (2)$$

subject to

$$c = y - b + q(b', y, p, l) [b' - (1 - \delta)b] - p\phi^p(y) - lL. \quad (3)$$

The value of defaulting is given by:

$$V^D(y, p, l) = u(y - \phi^d(y)) + \beta \mathbb{E}_{(y', p', l') | (y, p, l)} [(1 - \psi)V^D(y', p', l') + \psi V(0, y', p', l')]. \quad (4)$$

The solution to the government's problem yields decision rules for default $\hat{d}(b, y, p, l)$, debt $\hat{b}(b, y, p, l)$, and consumption when not in default $\hat{c}(b, y, p, l)$. The default rule $\hat{d}$ is equal to 1 if the government defaults, and is equal to 0 otherwise.

In a rational expectations equilibrium (defined below), investors use the borrowing and default decision rules to price debt contracts. Thus, the bond-price function solves the following functional equation:

$$q(b', y, p, l) = \mathbb{E}_{(y', p', l') | (y, p, l)} \left[M(y', y, p) [1 - \hat{d}(b', y', p', l')] [1 + (1 - \delta)q(\hat{b}(b', y', p', l'), y', p', l')] \right]. \quad (5)$$

2.2 Recursive Equilibrium

A *Markov Perfect Equilibrium* is characterized by

1. rules for default $\hat{d}$, borrowing $\hat{b}$, and consumption $\hat{c}$,

2. and a bond price function q ,

such that:

- i. given the bond price function q ; the policy functions $\hat{d}$, $\hat{b}$, and $\hat{c}$ solve the Bellman equations (1), (2), and (4).
- ii. given policy rules $\{\hat{d}, \hat{b}\}$, the bond price function q satisfies condition (5).

3 Model with cocos

Cocos suspend bond payments in periods of low liquidity ($p = 1$ or $l = 1$). Creditors earn the rate r^C on suspended payments. We also allow cocos to mitigate the direct effect of global liquidity shocks on aggregate income. We denote the aggregate income cost of liquidity shocks with cocos by ϕ^C . Thus, if the government is not in default, consumption during these periods is given by

$$c = y + q(b', y, p, l) [b' - b(1 + r^C)] - p\phi^C(y) - lL \quad (6)$$

instead of by equation (3) in the baseline model with non-contingent bonds. The rate earned by postponed payments is denoted by r^C . The coco price function with is given by

$$\begin{aligned} q(b', y, p, l) = & \mathbb{E}_{(y', p', l')|(y, p, l)} M(y', y, p) \left[1 - \hat{d}(b', y', p', l') \right] \\ & \left[(1 - I') \left[1 + (1 - \delta)q(\hat{b}(b', y', p', l'), y', p', l') \right] \right. \\ & \left. + I'(1 + r^C)q(\hat{b}(b', y', p', l'), y', p', l') \right], \end{aligned} \quad (8)$$

where I is an indicator function equal to one if either liquidity shock is equal to 1, and I is equal to zero otherwise.

The equilibrium definition with cocos differs in two ways with respect to the one for the baseline model: (i) the budget constraint in equation (6) replaces the budget constraint in (3), and (ii) the bond price function in equation (7) replaces the bond price function in equation (5).

It should be emphasized that while there are several variables that could be used as a measure of global liquidity to trigger the contingency in cocos, it is not clear what variable could be used for local liquidity shocks. Thus, the analysis of cocos triggered by local liquidity shocks may be more relevant for proposals in which the official sector plays a role in triggering the clauses in cocos.

4 Calibration for the economy with non-contingent bonds

The utility function displays a constant coefficient of relative risk aversion, i.e.,

$$u(c) = \frac{c^{1-\gamma} - 1}{1-\gamma}, \text{ with } \gamma \neq 1.$$

As Bianchi et al. (2012), we assume that the income loss during a period in which lenders ask for a high risk premium is a fraction of the income loss after a default: $\phi^p(y) = \gamma\phi^d(y)$. With this assumption, we have to pin down only one more parameter value in order to determine the cost of the liquidity shock. Since both sovereign defaults and liquidity shocks are associated with disruptions in the availability of private credit, it is natural to assume that the cost of these events is higher in good times when investment financed by credit would be more productive.

As Arellano (2008), we assume it is proportionally more costly to default in good times. This is a property of the endogenous default cost presented by Mendoza and Yue (2009). In particular, as Chatterjee and Eyigungor (2012), we assume a quadratic loss function for income during a default episode $\phi^d(y) = \max\{0, \lambda_0 y + \lambda_1 y^2\}$. Hatchondo and Martinez (2015) explain how this cost function can be calibrated to match the levels of sovereign debt and spread observed in the data.

		Local shock	Global shock
Risk-free rate	r	1%	1%
Borrower's risk aversion	γ	2	2
Discount factor	β	0.973	0.973
Probability of reentry after default	ψ	0.282	0.282
Income autocorrelation coefficient	ρ	0.94	0.94
Standard deviation of innovations	σ_ϵ	1.5%	1.5%
Mean log income	μ	$(-1/2)\sigma_\epsilon^2$	$(-1/2)\sigma_\epsilon^2$
Debt duration	δ	0.033	0.033
Probability of entering low local liquidity	π_{hl}	0.0375	0
Probability of ending low local liquidity	π_{lh}	0.125	1
Probability of entering low global liquidity	π_{LH}	0	0.0375
Probability of ending low global liquidity	π_{HL}	1	0.125
Income cost of defaulting	λ_0	-0.85	-0.45
Income cost of defaulting	λ_1	1.25	0.87705581
Local liquidity shock	L	0.1	0
Global liquidity shock	α	0	80
Income cost of liquidity shock	γ	0	0.3

Table 1: Parameter Values.

Table 1 presents the benchmark values given to all parameters in the model. A period in the model refers to a quarter. The coefficient of relative risk aversion is set equal to 2, the risk-free interest rate is set equal to 1 percent, and the discount factor β is set equal to 0.973. These are standard values in quantitative studies of sovereign defaults and business cycles in small open economies. As Arellano (2008), we assume an average duration of sovereign default events of one year ($\psi = 0.282$), within the range of empirical estimates (Gelos et al., 2011).

We use data from Mexico, a common reference for studies on emerging economies, for choosing the parameters that govern the endowment process, the level and duration of debt,

and the mean spread (Mexico displays the same properties that are observed in other emerging economies; see Aguiar and Gopinath, 2007; Neumeyer and Perri, 2005; and Uribe and Yue, 2006). Unless we explain otherwise, we compare simulation results with data from Mexico from the first quarter of 1980 to the fourth quarter of 2011. The parameter values that govern the endowment process are chosen to mimic the behavior of GDP in Mexico during that period.

We set $\delta = 3.3\%$. With this value and our target for the average spread, bonds have an average duration of 5 years in the simulations, which is roughly the average debt duration observed in Mexico according to Cruces et al. (2002).⁶ The parameters of the income cost of defaulting λ_0 and λ_1 are calibrated targeting an average debt-to-GDP ratio of 44 percent and a mean spread of 3.4 percent.

We calibrate the model with either a local or a global liquidity shock. We assume there are three low liquidity episodes every twenty years and that each episode lasts on average for two years. Looking at the EMBI spread for all available countries not in default (according to Fitch) since 1994, one can identify three episodes of high average sovereign spreads (when spreads were higher than the sample mean plus one standard deviation) in the last twenty years: 1994-1995 (Tequila crisis), 1998-2001 (debt crises in emerging economies), and 2009 (Global Financial Crises). The average EMBI spread was more than 3 percentage points higher in those episodes than in normal periods. The use of sovereign spreads to trigger the suspension of payment of sovereign cocos is consistent with the proposal of Consiglio and Zenios (2015).

We calibrate the income cost of defaulting and global liquidity shocks (λ_0 , λ_1 , and γ), and the lenders' risk premium parameter (α) or contingent liability shock (L) to target four moments: a mean spread of 3.4 percent, a mean public debt to (annual) GDP ratio of 44 percent, an average accumulated income cost of low global liquidity of 14 percent of annual income, and an increase in spread during low-liquidity periods of 3 percentage points. The target for the income cost of low global liquidity is at the lower end of the range of estimated

⁶We use the Macaulay definition of duration that, with the coupon structure in this paper, is given by $D = \frac{1+r^*}{\delta+r^*}$, where r^* denotes the constant per-period yield delivered by the bond. Using a sample of 27 emerging economies, Cruces et al. (2002) find an average duration of foreign sovereign debt in emerging economies—in 2000—of 4.77 years, with a standard deviation of 1.52.

income costs of sudden stops (Becker and Mauro, 2006; Hutchison and Noy, 2006; Jeanne and Ranciere, 2011).

In order to compute the sovereign spread implicit in a bond price, we first compute the yield i an investor would earn if it holds the bond to maturity (forever) and no default is declared. This yield satisfies

$$q_t = \sum_{j=1}^{\infty} \frac{(1-\delta)^{j-1}}{(1+i)^j}.$$

The sovereign spread is the difference between the yield i and the risk-free rate r . We report the annualized spread

$$r_t^s = \left(\frac{1+i}{1+r} \right)^4 - 1.$$

Debt levels in the simulations are calculated as the present value of future payment obligations discounted at the risk-free rate, i.e., $b_t(1+r)(\delta+r)^{-1}$.

We solve for the equilibrium of the finite-horizon version of our economy as in Hatchondo et al. (2010). That is, the approximated value and bond price functions correspond to the ones in the first period of a finite-horizon economy with a number of periods large enough that the maximum deviation between the value and bond price functions in the first and second period is no larger than 10^{-6} . The recursive problem is solved using value function iteration. We solve the optimal borrowing in each state by searching over a grid of debt levels and then using the best portfolio on that grid as an initial guess in a nonlinear optimization routine. The value functions V^D and V^R and the function that indicates the equilibrium bond price function conditional on repayment q are approximated using linear interpolation over y and cubic spline interpolation over debt and reserves positions. We use 20 grid points for debt, and 25 grid points for income realizations. Expectations are calculated using 50 quadrature points for the income shocks.

5 Results

First, we show that simulations of the baseline model with non-contingent bonds produce plausible implications. Second, we present simulations of the model with cocos and discuss the effects of cocos by comparing these simulations with the ones of the baseline model.

	Data	Global shock	Local shock
$E(r^s)$	3.40	2.94	3.33
Mean debt-to-income ratio	0.44	0.42	0.41
Income loss with $p = 1$	0.14	0.13	na
Spread increase with shock	3.00	3.04	2.13
Average debt duration	5.0	5.1	5.0
$\sigma(c)/\sigma(y)$	1.2	1.1	1.5

Table 2: Simulations with non-contingent debt. The third (fourth) column presents results with non-contingent debt and the global (local) liquidity shock. The standard deviation of x is denoted by $\sigma(x)$. Moments are computed using detrended series. Trends are computed using the Hodrick-Prescott filter with a smoothing parameter of 1,600. Moments for the simulations correspond to the mean value of each moment in 250 simulation samples, with each sample including 120 periods (30 years) without a default episode. Simulation samples start at least five years after a default. Default episodes are excluded to improve comparability with the data. Consumption and income are expressed in logs. Default frequencies are computed using all simulation periods. For cocos, the yield (and spread), the debt duration, and the debt stock are computed using expected payments and thus incorporate uncertainty about the time of payment.

Third, we discuss the negative effect of cocos on market discipline. Fourth, we argue that haircuts may help restore market discipline. Fifth, we show that conditionality and debt limits may improve outcomes with cocos. Sixth we show that cocos with conditionality may generate substantial welfare gains. We also show that an exchange of non-contingent bonds for cocos may generate significant losses for debt holders.

5.1 Simulations with non-contingent bonds

Table 2 reports moments in the data and in the simulations of the benchmark economy with non-contingent debt. Simulations match the moments targeted in the calibration reasonably well and display excess volatility of consumption relative to income.⁷

⁷These features of these data are also observed in other emerging markets (Aguiar and Gopinath, 2007; Alvarez et al., 2011; Boz et al., 2011; Neumeyer and Perri, 2005; Uribe and Yue, 2006).

	Global shock			Local shock	
	Benchmark	$\phi^C = \phi^p$	$\phi^C = 0$	Benchmark	Cocos
Income loss with $p = 1$	0.13	0.13	0.00	na	na
$\sigma(c)/\sigma(y)$	1.1	0.8	1.4	1.5	1.2
Fraction of defaults triggered by liquidity	0.85	0.00	0.00	0.76	0.16
$E(r^s)$	2.94	6.44	4.88	3.33	5.38
Defaults per 100 years	0.13	0.19	0.06	3.05	3.74
Spread increase with shock	3.04	7.14	3.09	2.13	5.00
Mean debt-to-income ratio	0.42	0.59	0.62	0.41	0.51

Table 3: Simulations with cocos.

5.2 Simulations with cocos

This subsection discusses simulation results for the cocos model and evaluate the effects of cocos by comparing these results with the ones obtained with non-contingent bonds. We assume suspended payments earn the risk-free rate ($r^C = r$) and thus the nominal haircut from triggering the contingency clause in cocos is equal to zero. It has been argued that sovereign cocos could help mitigate the adverse effect of global liquidity shocks on domestic aggregate income (e.g., Fernández and Martin, 2015). We allow for this possibility and shed light on how this would affect our results by considering two extreme cases: cocos either have no influence on the cost of low global liquidity ($\phi^C = \phi^p$), or eliminate this cost ($\phi^C = 0$).

Table 3 shows that, as anticipated by proponents of cocos, cocos are successful in transferring resources to periods of low liquidity. The table shows that cocos can thus achieve a significant reduction in consumption volatility. The exception is the model in which cocos eliminate the negative effect of global liquidity on aggregate income ($\phi^C = 0$). In this model the volatility of income is lower and periods of low liquidity are not necessarily periods of low income.

In addition, cocos greatly decrease the incidence of liquidity shocks in default risk. Table 3 shows that the fraction defaults triggered by liquidity shocks (i.e., defaults that happen because of the low liquidity in that period) decreases substantially with cocos.

Nevertheless, as anticipated by critics of cocos, cocos increase the average spread paid by the government. Table 3 shows that this is consistent with higher default frequencies with cocos, except for the case in which cocos eliminate the negative effect of global liquidity shocks on aggregate income ($\phi^C = 0$). That cocos increase sovereign spreads when we assume that they have a positive effect on aggregate income, make this assumption difficult to justify.

Table 3 also shows that the increase of sovereign spreads during periods of low liquidity is even larger with cocos. This occurs even though, as explained before, cocos reduce the frequency of defaults during low liquidity periods.

Why is there more sovereign risk with cocos? Table 3 indicates that this may be explained by the large increase in indebtedness implied by cocos. But why does intentness increase with cocos? We next search for answers to these questions.

5.3 Cocos and market discipline

Debt levels are higher with cocos because cocos weaken the market discipline that limit indebtedness. To illustrate this, equations (9) and (10) present the first-order conditions for the issuance of non-contingent bonds and cocos in periods of low liquidity, respectively (first-order conditions assume differentiability; we do not impose this assumption when we find numerical solutions):

$$u'(c)q(b', y, p, l) = u'(c) \frac{\partial q(b', y, p, l)}{\partial b'} [b' - (1 - \delta)b] + \beta E [(1 - d')u'(c') [1 + (1 - \delta)q']], \quad (9)$$

$$\begin{aligned} u'(c)q(b', y, p, l) = & u'(c) \frac{\partial q(b', y, p, l)}{\partial b'} [b' - b(1 + r^C)] \\ & + \beta E [(1 - d')u'(c') [(1 - I') [1 + (1 - \delta)q'] + I'(1 + r^C)q']], \quad (10) \end{aligned}$$

where q' , d' , and c' denote the next-period bond price and default and consumption decisions. The first term in the right-hand side of these equations represents the cost of increasing indebtedness implied by market discipline. Since the bond price is a decreasing function of

the level of indebtedness, additional bond issuances lower the price at which the government sells bonds and thus limit its ability to increase current consumption. For any desired next-period debt level b' , the government needs to issue more non-contingent bonds ($b' - (1 - \delta)b$) than cocos ($b' - b(1 + r^C)$). Therefore, market discipline is a stronger deterrent of debt increases with non-contingent bonds. In particular, during reprofiling, the government can let the level of cocos grow at the rate r^C without any concern about market discipline. The weaker market discipline implied by cocos during periods of low liquidity is consistent with the larger increase in sovereign spreads triggered by liquidity shocks in the economies with cocos (Table 3).

Figure 1 illustrates how the level of cocos increases greatly during periods of low local liquidity. In the figure, the government chooses to not default because of the liquidity shock. This is consistent with the low incidence of liquidity shocks on default presented in Table 3. However, after the low liquidity period, the very large increase of indebtedness greatly augments the probability of default, as reflected in low bond prices in Figure 1. This is consistent with the increase in the overall default frequency presented in Table 3. Thus, cocos are likely to only delay defaults triggered by liquidity shocks. And cocos increase the overall default frequency.

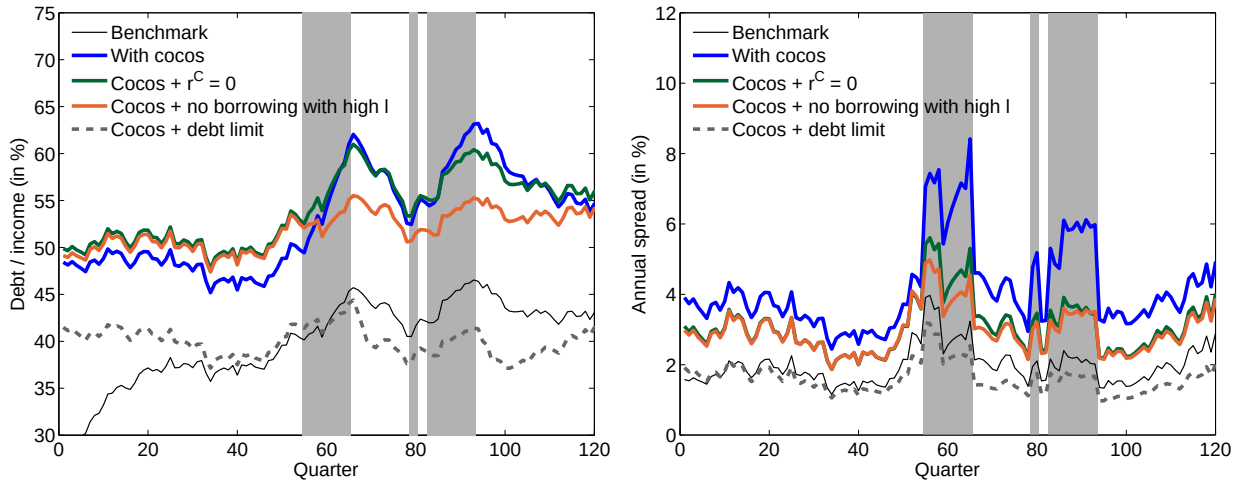


Figure 1: Increase of indebtedness and spreads in periods of low liquidity. Shaded areas indicate periods of low liquidity. The figure corresponds to the model with local liquidity shocks.

Things look different with the global shock. Figure 2 shows that during periods of low global liquidity, debt does not increase more with cocos than with non-contingent bonds. Intuitively, the government does not want to borrow in periods of low global liquidity. Therefore, the negative effect of cocos on market discipline is not important here. Why are debt levels still higher with cocos and global shocks if cocos do not weaken market discipline? The government borrows more with cocos because it does not have to worry about the rollover risk implied by global liquidity shocks.

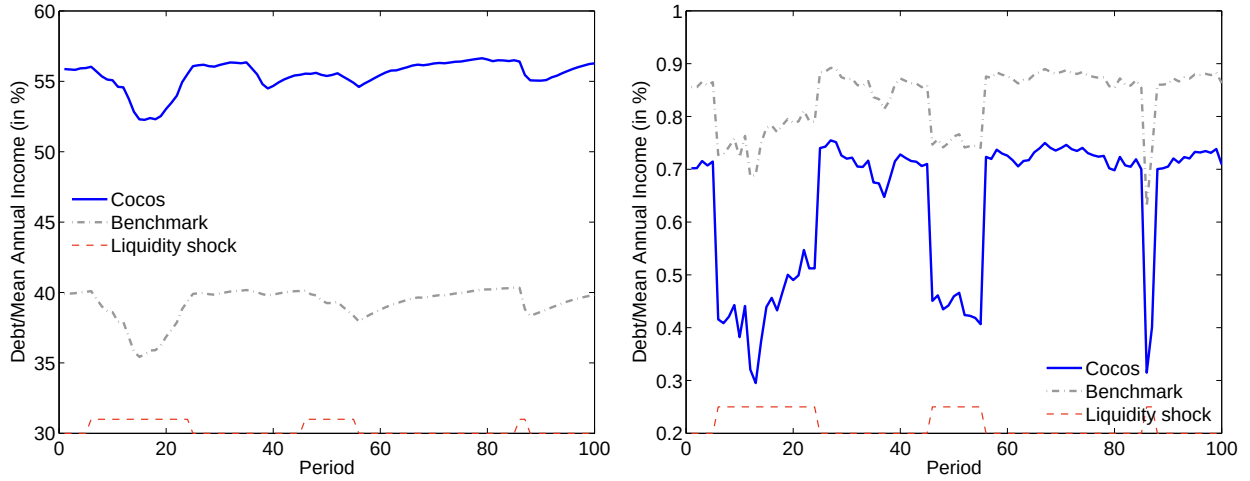


Figure 2: Increase indebtedness and decline of bond prices with low global liquidity.

Figure 2 also show that in periods of low global liquidity, in spite of producing debt dynamics similar to those produced by non-contingent debt, cocos implied much larger declines in bond prices. This occurs because lenders dislike financial instruments that do not pay when they are more eager to be paid (i.e., during low global liquidity periods). Therefore, lenders ask for a higher spread to be compensated for the contingency in cocos, and an even higher spread in periods of low liquidity to be compensated for the imminent delay in cocos payments.

5.4 Cocos and haircuts

We have assumed that cocos do not impose nominal haircuts after low liquidity shocks ($r^C = r$). This is consistent with existing proposals of sovereign debt reprofiling and sovereign

	Benchmark	Cocos	Haircuts
$\sigma(c)/\sigma(y)$	1.5	1.2	1.3
Fraction of defaults triggered by liquidity	0.76	0.16	0.09
$E(r^s)$	3.33	5.38	4.36
Defaults per 100 years	3.05	3.74	2.84
Spread increase with shock	2.13	5.00	3.10
Mean debt-to-income ratio	0.41	0.51	0.53

Table 4: Simulations with cocos and haircuts. The table corresponds to the case of local liquidity shocks.

cocos that preclude haircuts. Nevertheless, equation (10) indicates that the higher the haircut implied by reprofiling (i.e., the lower r^C), the less the government can increase its debt level without facing market discipline. Therefore, imposing haircuts ($r^C < r$) may contain the increase in indebtedness during periods of low liquidity and the overall increase in default risk implied by cocos.

Figure 1 shows that indeed the increase in indebtedness during periods of low liquidity is lower with a nominal haircut ($r^C = 0$). Table 4 shows that compared with no-haircuts cocos, cocos with haircuts ($r^C = 0$) lower the average spread paid by the government and the increase in spread implied by the liquidity shock.

5.5 Cocos and conditionality

This subsection presents the effects of introducing cocos while conditioning government borrowing during reprofiling. We assume that when $l = 1$ and thus debt payments are postponed, the government faces the constraint $b' < b(1 + r^C)$ (with $r^C = r$). That is, the government cannot issue debt while cocos payments are suspended.

Figure 1 shows that during periods of low liquidity, conditionality moderate the increase in debt and the consequently increase in spreads implied by cocos. Table 5 shows that cocos with conditionality mitigate the increase in spreads implied by cocos at the expense of increasing consumption volatility.

	Benchmark	Cocos	Conditionality
$\sigma(c)/\sigma(y)$	1.5	1.2	1.4
Fraction of defaults triggered by liquidity	0.76	0.16	0.02
$E(r^s)$	3.33	5.38	4.17
Defaults per 100 years	3.05	3.74	2.95
Spread increase with shock	2.13	5.00	2.39
Mean debt-to-income ratio	0.41	0.51	0.51

Table 5: Simulations with cocos and conditionality. The table corresponds to the case of local liquidity shocks.

5.6 Cocos and debt limits

This subsection presents the effects of introducing cocos with a debt limit that prevent the government from increasing its debt level beyond the levels observed in the benchmark economy. Thus, the debt limit compensate the loss of market discipline implied by cocos. Formally we add the constraint $b' < \max\{\bar{b}, \exp(r)b\}$ to the government optimization problem, with $\bar{b}$ equal to 42.5 percent of mean annual income. That is, debt can increase above the limit only at the interest rate r . This allows us to shed light on current proposals that envision the use of cocos in economies where fiscal discipline is enhanced by fiscal rules (e.g., in the Eurozone).

Table 6 shows that compared with the benchmark, cocos with a debt limit are successful in lowering consumption volatility and the frequency of defaults triggered by liquidity shocks, while also lowering the overall default frequency, the average spread, and the increase in spreads triggered by the liquidity shock.

Table 7 presents simulation results for the global-liquidity model with a debt limit that does not allow debt levels to go beyond the level observed in the benchmark economy with non-contingent debt. More specifically, we assume debt cannot be higher than 40 percent of the mean annual income. Formally, we impose an additional constraint $b' \leq \bar{b}$ on functional equation (2), with $\bar{b} = 1.6$.

	Benchmark	Cocos	Debt limit
$\sigma(c)/\sigma(y)$	1.5	1.2	1.3
Fraction of defaults triggered by liquidity	0.76	0.16	0.53
$E(r^s)$	3.33	5.38	2.07
Defaults per 100 years	3.05	3.74	1.86
Spread increase with shock	2.13	5.00	1.04
Mean debt-to-income ratio	0.41	0.51	0.42

Table 6: Simulations with cocos and debt limits. The table corresponds to the case of local liquidity shocks.

	Benchmark	$\phi^C = \phi^p$	Debt limit
$\sigma(c)/\sigma(y)$	1.1	0.8	0.9
Fraction of defaults triggered by liquidity	0.85	0.00	0.00
$E(r^s)$	2.94	6.44	2.86
Defaults per 100 years	0.13	0.19	0.00
Spread increase with shock	3.04	7.14	2.74
Mean debt-to-income ratio	0.42	0.59	0.42

Table 7: Simulations with cocos and debt limits. The table corresponds to the case of global liquidity shocks.

Table 7 shows that together with the debt limit, cocos reduce slightly sovereign spreads. Thus, with the debt limit, cocos can achieve higher average consumption in periods with either high or low global liquidity.

Table 7 also shows that the economy with cocos and the debt limit features levels of sovereign spreads very similar to those observed in the benchmark, even though the default frequency is lower in the former economy. This again is indicative of a significant effect on spreads of the lenders' dislike of the contingency in cocos.

5.7 Welfare and debt restructurings

This subsection discusses welfare gains from introducing cocos. We do so without allowing the government to issue both cocos and non-contingent bonds. This would imply solving the model with two endogenous state variables and would also mix the welfare gains from cocos with gains from allowing the government to use two debt instruments instead of one. We thus measure welfare gains from introducing cocos by assuming that all non-contingent bonds are swapped for cocos, assuming that the swap cannot generate capital losses or gains for the creditors. We measure welfare gains as the constant proportional change in consumption that would leave a consumer indifferent between not doing and doing the debt swap.⁸

Figure 3 presents welfare gains from introducing cocos both for the average debt level in the simulations and for zero initial debt. The figure shows that cocos can generate substantial welfare gains when accompanied by a mechanism that overcome the loss of market discipline implied by cocos. The figure also show gains from a “voluntary debt exchange”, as presented by Hatchondo et al. (2014). Hatchondo et al. (2014) show that in a situation of debt overhang, bond holders can forgive some debt to the government without incurring in losses. Thus, gains from a voluntary exchange are a natural benchmark for computing gains from introducing cocos.

Table 8 presents the effects of introducing cocos in the economy with global liquidity shocks. We assume the debt level is equal to 42 percent of mean income (the average in the benchmark simulations), and income levels equal to the mean level, and half a standard deviation below and above the mean level. Table 8 shows that introducing cocos in periods of low lenders’ risk aversion generate welfare gains. As discussed before, lenders dislike cocos. Therefore, in order to compensate lenders the government must increase the nominal value of the bonds they held by five percent. The sovereign spread is more than 2 percentage

⁸These welfare gains are given by

$$\left[\frac{\hat{V}^{\text{Non-contingent}}(b, y, p, l)}{\hat{V}^{\text{Cocos}}(b^{\text{Cocos}}, y, p, l)} \right]^{\left(\frac{1}{1-\gamma}\right)} - 1,$$

where the superindex “Non-contingent” refers to the value function in the benchmark economy and the superindex “Cocos” refers to the economy with cocos. The number of cocos received by lenders, b^{Cocos} , assures that they do not suffer capital losses (and do not enjoy capital gains).

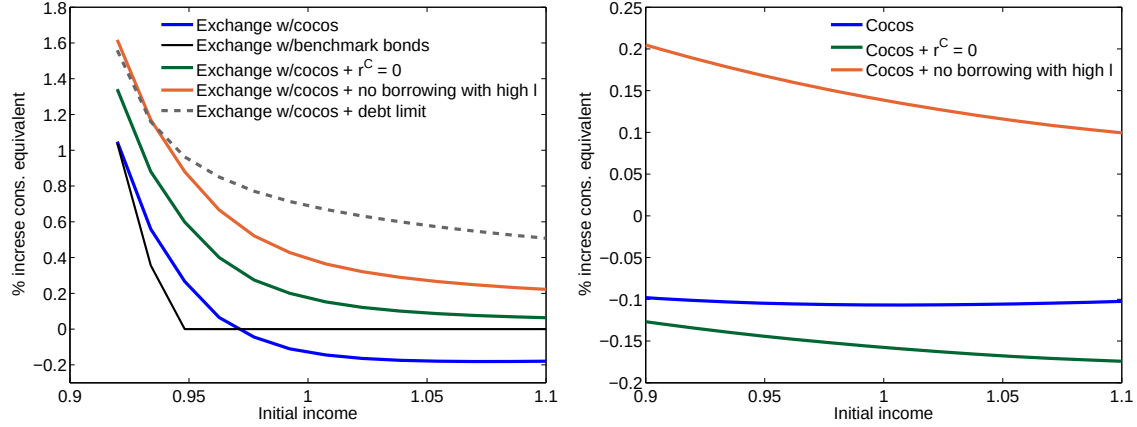


Figure 3: Welfare gains. The left (right) panel assumes voluntary debt exchanges for the average debt level in the economy with non-contingent debt. The right panel presents gains for zero initial debt. The figure corresponds to the model with local liquidity shocks.

Table 8: Introducing cocos without lenders' losses

	Low lenders' risk aversion		
	Low income	Average income	High income
Spread before introducing cocos	2.48%	2.21%	2.00%
Spread after introducing cocos	4.75%	4.75%	4.52%
Nominal haircut	-5.38%	-5.54 %	-5.58%
Welfare gain	0.07%	0.04%	0.03%
Lenders' capital gain	0.00%	0.00%	0.00%

points higher after the introduction of cocos. In periods of high lenders risk aversion, there is no nominal haircut that could compensate lenders for the loss of holding cocos instead of non-contingent bonds (recall that since higher debt levels imply higher default probabilities and thus lower bond prices, the market value of bonds is bounded).

Table 9 presents the effects of introducing cocos with a debt swap that imposes a zero nominal haircut. In periods of high risk aversion, this makes creditors loose more that 64 percent of the market value of their holdings. Sovereign spreads increase six hundred basis points.

Table 9: Introducing cocos without haircuts

	Low lenders' risk aversion		
	Low income	Average income	High income
Spread before introducing cocos	2.48%	2.21%	2.00%
Spread after introducing cocos	4.89%	4.64%	4.42%
Nominal haircut	0.00%	0.00%	0.00%
Welfare gain	0.25%	0.23%	0.21%
Lenders' capital gain	-4.88%	-5.04%	-5.08%

	High lenders' risk aversion		
	Low income	Average income	High income
Spread before introducing cocos	6.48%	5.37%	4.69%
Spread after introducing cocos	12.47%	11.49%	10.71%
Nominal haircut	0.00%	0.00%	-0.00%
Welfare gain	0.74%	0.69%	0.74%
Lenders' capital gain	-64.35%	-64.95%	-65.36%

6 Conclusions

We study a model of equilibrium sovereign default in which the government issues cocos that stipulate a suspension of debt payments in periods of low liquidity. We show that as argued by proponents of sovereign cocos, cocos reduce the frequency of sovereign defaults triggered by liquidity shocks, and increase consumption in periods of low global liquidity. However, as argued by detractors of sovereign cocos, cocos increase the cost of borrowing and the overall default frequency. The higher cost of borrowing with cocos also arises because (i) reprofiling weakens market discipline and thus induce higher debt levels, and (ii) creditors dislike reprofiling triggered by global liquidity shocks. Haircuts can mitigate the negative effect of cocos on market discipline. Together with conditionality or a debt limit that compensate for the loss of market discipline they imply, cocos can reduce sovereign spreads without damaging the government's ability to borrow and while transferring resources to periods of low liquidity.

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