Sovereign defaults and optimal reserves management*

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February 2012

******************PRELIMINARY and INCOMPLETE*****************

Abstract

A long-standing puzzle of international capital flows is why countries hold large amount of external debt and foreign reserves at the same time. To address this puzzle, we propose a sovereign default model where the government decides jointly over the accumulation of long-duration bonds and foreign reserves. When calibrated to the data, the model can successfully explain the simultaneous holdings of debt and foreign reserves. We also show that the relationship between reserves and default risk may be non-monotonic.

Keywords:
JEL Codes:

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1 Introduction

One of the most striking features of international capital flows is the large amount of foreign reserves held by emerging markets. In 2010, for example, reserve accumulation reached 20 percent of GDP in Eastern Asian countries. A common explanation for this phenomenon is attributed to a precautionary motive. This view, however, contrasts with the fact that economies holding large amount of foreign reserves, also accumulate considerable amounts of external debt. Given the high spreads from government debt, this raises the question of why not paying down debt instead of accumulating foreign reserves.

Existing models in international macroeconomics are unable to jointly explain the accumulation of foreign reserves and external debt. To address this puzzle, we propose a novel explanation based on the notion of maturity and risk management. We construct a model of sovereign default where the government issues non-contingent long-duration bonds and accumulates reserves to smooth consumption fluctuations over time. As in the Eaton-Gersovitz framework, debt contracts are equilibrium outcomes of the interaction between a benevolent government that cannot commit to repay the debt and investors that lend to the government anticipating the possibility of default.

Formally, we study a model à la Eaton and Gersovitz (1981).[1] We analyze a small open economy that receives a stochastic endowment stream of a single tradable good. The government's objective is to maximize the expected utility of private agents. Each period, the government makes two decisions. First, it decides whether to default on previously issued debt. Second, it decides its debt and reserve holdings. The government can borrow by issuing non-contingent long-duration bonds, as in Hatchondo and Martinez (2009), and can save by investing in a risk-free asset. The cost of defaulting is represented by a stochastic exclusion from debt markets and an endowment loss in every period the economy remains excluded from credit markets. The economy is also subject to sudden stop shock that affects the government's access to credit

[1] This framework has been used in many recent studies. See, for instance, Aguiar and Gopinath (2006), Alfaro and Kanczuk (2009) Arellano (2008), Boz (2011), Cuadra et al. (2010), D'Erasmo (2008), Durdu et al. (2010), Lizarazo (2005, 2006), and Yue (2010). These models share blueprints with the models used in studies of household bankruptcy—see, for example, Athreya et al. (2007), Chatterjee et al. (2007), Li and Sarte (2006), Livshits et al. (2008), and Sanchez (2010).

markets.

The combination of incomplete markets and the possibility of default, together with the inability of investors to seize foreign reserves, imply that reserves and debt are not perfect substitutes. This provides a potential role for holding both reserves and debt at the same time. A key feature of the model is that debt and reserves have different maturity, which introduces a scope for managing risks associated with fluctuations in international market conditions.

Our model can rationalize the joint pattern of reserves and external debt as an equilibrium outcome of the interaction between external creditors and a government that has the option to default on its debt. In particular, the model predicts an asymmetric behavior of reserves in line with the data. That is, during good times countries experience a gradual build-up of reserves, whereas reserves collapse during a sovereign default crisis. This arises because the government finds it optimal to take advantage of low spreads to issue long debt and buy reserves, which are then used to repay the debt in times when the cost of rolling over existing debt increase. Reserves also play an important role to buffer aggregate shocks to income and increases in global risk premia that, the facto, may affect countries' access to debt markets.

We find that the model can generate holding of reserves of 4.5 percent of output and public debt levels of 41.3 percent of output. That is not significantly apart from what was observed in the countries considered in Neumeyer and Perri (2005). The model is also able to generate significant default risk and a countercyclical interest spread, though it mitigates the excess volatility of consumption.

We show that there is a non-monotonic relationship between the price of defaultable bonds and the accumulation of foreign reserves, reflecting a fundamental trade-off in the model. On one hand, the concavity of the utility function imply that an increase in reserves imply that the net benefits from repaying increase. On the other hand, because reserves can be used to smooth consumption during periods of exclusion of financial markets, this implies that accumulating reserves makes debt less sustainable. For low (high??) levels of debt, the first effect dominates making the price of debt *decreasing* in the amount of reserves. Conversely, for high levels of debt, it is the debt-sustainability effect that dominates, making the price of debt *increasing* in the amount of reserves.

Related literature

Closer to our paper is the work by Alfaro and Kanckuk (2008) and Arellano and Ramanarayanan (2010) who also consider a richer asset structure in models of sovereign default. Alfaro and Kanckuk studied the role of reserves in a model with one-period bonds and found that the optimal policy is not to hold reserves at all. In our framework, however, the availability of long duration bonds allow the government to take advantage of temporarily low interest rates to purchase reserves to be used in times when rolling over existing debt becomes relatively more costly. This is crucial to explain the starking differences in results. Arellano and Ramanarayanan analyze the maturity composition of debt, whereas we study the decision to hold reserves, in addition to long debt.

Our paper also relates to other studies of reserve adequacy.[2] One strand of this literature takes the amount of debt as given and analyze the benefits from holding reserves during a crisis. Another strand of this literature considers a Bewley economy (with a single asset) and analyze the precautionary role of net foreign assets. The key contribution of our paper is to model the joint dynamics of debt and foreign reserves, and to provide an explanation of why countries hold debt and foreign reserves at the same time.

2 The model

There is a single tradable good. The economy receives a stochastic endowment stream of this good y_t, where

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

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

The government's objective is to maximize the present expected discounted value of future utility flows of the representative agent in the economy, namely

[2]See Aizenman and Lee (2007), Jeanne and Ranciere (2006), Durdu, Mendoza and Terrones (2010) among others.

$$E\left[\sum_{t=0}^{\infty}\beta^t u\left(c_t\right)\right],$$

where E denotes the expectation operator, β denotes the subjective discount factor, and the utility function is assumed to display a constant coefficient of relative risk aversion denoted by γ. That is,

$$u\left(c\right)=\frac{c^{(1-\gamma)}-1}{1-\gamma}.$$

The government can issue debt and hold reserves. As in Hatchondo and Martinez (2009), we assume that debt is long-term and a bond issued in period t promises an infinite stream of coupons, which decreases at a constant rate δ. In particular, a bond issued in period t promises to pay one unit of the good in period $t+1$ and $(1-\delta)^{s-1}$ units in period $t+s$, with $s \geq 2$. The government can also save by accumulating a risk-free asset.

Each period, the government makes two decisions. First, it decides whether to default. Second, it decides how much debt and reserve to accumulate.

As in previous studies of sovereign default, the cost of defaulting is not a function of the size of the default. Thus, as in Arellano and Ramanarayanan (2010), Chatterjee and Eyigungor (forthcoming), and Hatchondo and Martinez (2009), when the government defaults, it does so on all current and future debt obligations. This is consistent with the behavior of defaulting governments in practice. Sovereign 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 default on a payment. The cross-default clause states that a default in any government obligation constitute a default in the contract containing that clause. These clauses imply that after a default event, future debt obligations become current. Following many 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.

There are two costs of defaulting. First, a defaulting sovereign is excluded from capital markets. In each period after the default period, the country regains access to capital markets with probability $\psi \in [0,1]$. Second, if a country has defaulted on its debt, it faces an income loss of $\phi\left(y\right)$ in every period in which it is excluded from capital markets. Following Chatterjee and

Eyigungor (forthcoming), we assume a quadratic loss function $\phi(y) = d_0 y + d_1 y^2$.

The economy is subject to—exogenous—sudden-stop shocks that introduce aggregate rollover risk. When a sudden-stop shock hits, the government loses access to markets and cannot issue debt (though it can buy back debt and accumulate reserves). In addition, output falls by $\lambda\phi(y)$ per period for as long as the sudden-stop lasts. Typically, reversals in capital flows not only affect governments' access to international capital markets but also domestic economic activity. For instance, Eichengreen et al. (2008) find that a third of sudden-stop episodes in their sample are associated with currency crises and around half of them are associated with banking crises (part of the correlation may be endogenous). The arrival probability of a sudden-stop is denoted by π. The duration of sudden-stops is stochastic: The economy regains access to capital markets with probability ψ. If the government defaults during a sudden-stop episode, it faces an output cots of $\phi(y)$ in every period it remains excluded from debt markets but does not affect the probability of regaining access to debt markets.

Foreign investors are risk neutral and assign the value e^{-r} to next-period payoffs. Bonds are priced in a competitive market inhabited by a large number of identical lenders, which implies that bond prices are pinned down by a zero expected profit condition.

The government cannot commit to future default and borrowing decisions. Thus, one may interpret this environment as a game in which the government making the default and borrowing 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 and borrowing strategies depend only on payoff-relevant state variables. As discussed by Krusell and Smith (2003), there may be multiple Markov perfect equilibria in infinite-horizon economies. In order to avoid this problem, we solve for the equilibrium of the finite-horizon version of our economy, and we increase the number of periods of the finite-horizon economy until value functions and bond prices for the first and second periods of this economy are sufficiently close. We then use the first-period equilibrium functions as the infinite-horizon-economy equilibrium functions.

2.1 Recursive formulation of the baseline framework

Let b denote current-period coupon obligations. Let a denote the amount of reserves held at the beginning of the current period. Let d denote whether the government is in default. We assume that d is equal to 1 if the government defaulted in the current period or if it defaulted in the past and has not yet regained access to debt markets. Otherwise, d is equal to 0. The sudden-stop shock is denoted by s, with $s = 1$ ($s = 0$) indicating that the economy is (is not) in a sudden-stop.

Let V denote the government's value function at the beginning of a period (before the default decision is made) if the government is not in default. Let $\tilde{V}$ denote its value function after the default decision has been made. Let F denote the conditional cumulative distribution function of the next-period endowment y'. For any bond price function q the function V satisfies the following functional equation:

$$V(b, a, y, s) = \max_{d \epsilon \{0,1\}} \{d\tilde{V}(1, b, a, y, s) + (1 - d)\tilde{V}(0, b, a, y, s)\}, \tag{1}$$

The dynamic programming problem if the government is in default is the following one.

$$\tilde{V}(1, b, a, y, s) = \max_{a' \geq 0} \left\{ u(c) + \beta \int \left[\psi V(0, a', y', 0) + (1 - \psi)\tilde{V}(1, 0, a', y', s) \right] F(dy' \mid y) \right\}, \tag{2}$$

subject to

$$c = y - \phi(y) + a - e^{-r} a'.$$

If the government is in default, the economy loses $\phi(y)$ units of output regardless of international capital conditions (s). The government can still save in the risk-free asset, which price is given by the discount factor of foreign investors.

The dynamic programming problem after repaying current debt obligations when the sudden-stop shock has not hit is the following one.

$$\tilde{V}(0, b, a, y, 0) = \max_{b', a' \geq 0} \left\{ u(c) + \beta \int [(1 - \pi)V(b', a', y', 0) + \pi V(b', a', y', 1)] F(dy' \mid y) \right\}. \tag{3}$$

subject to

$$c = y - b + a + q(b', a', y, 0)\,(b' - (1-\delta)b) - e^{-r}a'.$$

Finally, the dynamic programming problem after repaying current debt obligations when the economy is in a sudden-stop is the following one.

$$\tilde{V}(0, b, a, y, 1) = \max_{b(1-\delta)\geq b'\geq 0, a'\geq 0} \left\{ u(c) + \beta \int \left[\psi V(b', a', y', 0) + (1-\psi)V(b', a', y', 1)\right] F(dy' \mid y) \right\}. \tag{4}$$

subject to

$$c = y - \lambda\phi(y) - b + a + q(b', a', y, 1)\,(b' - (1-\delta)b) - e^{-r}a'.$$

The bond price is given by the following functional equation:

$$q(b', a', y, s) = \sum Pr(s' \mid s)e^{-r} \int (1 - h(b', a', y', s'))\left[1 + (1-\delta)\, q(b'', a'', y', s')\right] F(dy' \mid y), \tag{5}$$

with

$$\begin{aligned} b'' &= g^b(h(b', a', y', s'), b', a', y', s') \\ a'' &= g^a(h(b', a', y', s'), b', a', y', s') \end{aligned}$$

where h, g^b, g^a denote the future default, borrowing, and saving rules that lenders expect the government to follow. The default rule h is equal to 1 if the government defaults, and is equal to 0 otherwise. The function g^b determines the debt obligations for the following period. The function g^a determines the assets carried to the following period. The first term in the squared brackets in right-hand side of equation (5) equals the expected value of the next-period coupon payments. The second term in the squared brackets equals the expected value of all remaining future coupon payments, which is summarized by the expected price at which the bond could be sold in the next period.

Equations (1)-(4) illustrate that the government finds its optimal current default and borrowing decisions taking as given its future default and borrowing decision rules h and g. In equilibrium, the optimal default and borrowing rules that solve problems (1)-(4) must be equal to h and g for all possible values of the state variables.

Definition 1 *A Markov Perfect Equilibrium is characterized by*

1. a set of value functions $\tilde{V}$ and V,

2. a default rule h, borrowing rule g^b, and saving rule g^a,

3. a bond price function q,

such that:

(a) given h and g, V and $\tilde{V}$ satisfy equations (**??**) and (2) when the government can trade bonds at q;

(b) given h, g^b, and g^b, the bond price function q is given by equation (**??**); and

(c) the default rule h, borrowing rule g^b, and saving rule g^a solve the dynamic programming problem defined by equations (1)-(4) when the government can trade bonds at q.

3 Parameterization

Table 1 presents the parameterization. We assume that the representative agent in the sovereign economy has a coefficient of relative risk aversion of 2, which is within the range of accepted values in studies of business cycles. A period in the model refers to a quarter. The risk-free interest rate is set equal to 1%. The parameter values that govern the endowment process are chosen so as to mimic the behavior of GDP in Argentina from the fourth quarter of 1993 to the third quarter of 2001, as in Hatchondo et al. (2009). The parameterization of the output process is similar to the parameterization used in other studies that consider a longer sample period (see, for instance, Aguiar and Gopinath (2006)).

Borrower's risk aversion	γ	2
Interest rate	r	1%
Output autocorrelation coefficient	ρ	0.9
Standard deviation of innovations	σ_ϵ	2.7%
Mean log output	μ	$(-1/2)\sigma_\epsilon^2$
Duration	δ	0.0341
Discount factor	β	0.975
Default cost	d_0	-0.86
Default cost	d_1	1.12
Output cost of sudden stops / output costs of defaulting	λ	0.3
Pr (reentry to debt markets / no access in previous period)	ψ	0.125
Pr (sudden stop / no sudden stop in previous period)	π	0.03

Table 1: Parameter values.

With $\delta = 3.41\%$, bonds have an average duration of 5 years in the simulations, slightly above the average duration observed in emerging economies (see Cruces et al. (2002)).[3] 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.

We chose a value for the subjective discount factor that is close to the value assumed in business cycle analysis of emerging economies (Uribe and Yue (2006) assume a value of 0.973 and Neumeyer and Perri (2005) use two parmaterizations: one with a subjective discount of 0.93 and one with a value of 0.98). The process for output losses that follow after a default is parameterized to approximate mean public debt, and the mean and standard deviation of the interest rate spread. The targets for the spread distribution are taken from Neumeyer and Perri (2005) and we computed the target for debt level using the same sample of countries used in Neumeyer and Perri (2005). Once the government loses access to the debt market, it takes two years on average to regain access to that market ($\psi = 0.125$). The length of the exclusion period is similar to the one assumed in Aguiar and Gopinath (2006) (2.5 years).

[3] We use the Macaulay definition of duration, which 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.

	Neumeyer & Perri (05)	Argentina 1993-2001	Model All periods	Model 32 periods before a default
$E(R_s)$	5.04	7.44	2.83	3.93
$\sigma(R_s)$	2.32	2.51	1.32	1.65
$\sigma(y)$	2.79	3.17	4.58	3.02
$\sigma(c)/\sigma(y)$	1.30	0.94	1.12	0.99
$\sigma(TB/Y)$	2.40	1.35	2.19	0.98
$\rho(c,y)$	0.80	0.97	0.90	0.96
$\rho(TB/Y,y)$	-0.61	-0.69	-0.01	0.12
$\rho(R_s,y)$	-0.55	-0.65	-0.30	-0.77
$\rho(R_s,TB/Y)$	0.51	0.56	0.04	0.27
Debt/output*	36.0	38.0	41.3	44.8
Reserves / output*	23.3	6.5	4.5	3.5
Defaults per 100 years			1.79	

Table 2: Business cycle statistics. The second column is taken from Neumeyer and Perri (2005), with the exception of the debt-to-output and reserves-to-output ratios. We computed those ratios using data of federal government debt and international foreign reserve positions from 1990 to 2001, depending on data availability. The third column reports Argentina data from 1993 to 2001. We consider samples of 1,500 periods in the simulations. The fourth column reports the mean of the value of each moment in the last 500 periods of each sample. The fifth column reports the mean of the value of each moment using samples that consist of 32 periods before a default episode and without any interruption in the access to debt markets. Ratios to output are computed using annual output. All moments are expressed in percentage terms with the exception of correlation coefficients.

4 Results

Following Hatchondo et al. (2010), we solve the models numerically using value function iteration and interpolation.[4] We compare the outcome of the model with data using the 5 emerging countries studied in Neumeyer and Perri (2005): Argentina, Brazil, Mexico, Korea, and Philippines. The start of the sample period ranges from 1980 to the early 1990's depending on data availability. The end of the sample period is the fourth quarter of 2001.[5] We also present data for Argentina, given that most quantitative studies on sovereign default use Argentina as a case study.

[4]We use linear interpolation for endowment levels and spline interpolation for debt and reserve choices. The algorithm finds two value functions, $\tilde{V}(1,\cdot,\cdot)$ and $\tilde{V}(0,\cdot,\cdot)$. Convergence in the equilibrium price function q is also assured.

[5]Aguiar and Gopinath (2007) study a more comprehensive list of countries and find similar results regarding business cycles in emerging countries.

Table 2 illustrates that our model is able to account for the simultaneous holdings of debt and reserves. The stock of reserves is smaller than in the data but the model abstracts from other motives that are likely to influence reserve decisions. For instance, reserves may be needed to support exchange rate policies, or to provide liquidity to domestic banks that borrow and lend in foreign currencies.

The table illustrates that our model is able to generate a significant default premium, albeit smaller than the one in the data. The annual interest rate spread is higher in pre-default periods than in all periods but it still lower than the levels observed in the run up to the 2001 Argentine default. The volatility of the spread is lower than the one in the data but our model abstracts from other sources of shocks that may affect bond prices. González-Rozada and Levy Yeyati (2008) and Longstaff et al. (2011) find that more than half of the volatility in country risk spreads can be accounted by global factors. The model generates a default frequency of 1.8 defaults every 100 years. Around of 22 percent of those defaults are explained by sudden-stop shocks, i.e., 22 percent of the defaults would not have happened if the economy had not been in a sudden-stop in the period the default was recorded.

The table shows that our model with reserves can broadly replicate business cycle patterns in emerging economies. When all sample periods are considered, consumption is more volatile than income, the trade balance displays a volatility comparable to the one in the data, and the interest rate spread is countercyclical. The difference is that the trade balance is acyclical in our model and countercyclical in the data. In pre-default samples without sudden-stop periods, the trade balance becomes procyclical and consumption volatility is not larger than income volatility. The better insurance properties derived from reserve holdings enable the government to buffer shocks that would have affected domestic consumption otherwise. In the remainder of the paper we illustrate the mechanics of the model and compare it with an economy in which the government cannot hold reserves.

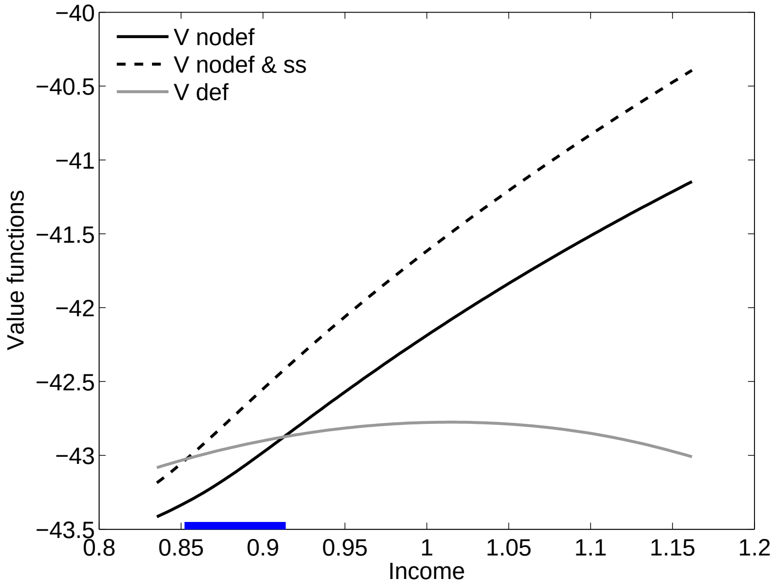

Figure 1: Value functions when initial the initial debt and reserve levels equal the mean level in the simulations. The blue region correspond to endowment shocks for which the government would only default if the economy is in a sudden stop.

4.1 Default, borrowing, and saving decisions

Figure 1 illustrates the value functions of deciding not to default when the economy is not in a sudden stop, the value function of not defaulting when the government is in a sudden stop, and the value function of defaulting. The value functions are plotted as a function of the endowment shock realization ($log(y)$). The value of not defaulting when the economy is in a sudden stop is below the value of defaulting when the economy is not in a sudden stop. The reason is that in the first case i) the government services maturing debt obligations without issuing new debt, which leads to transitorily lower consumption levels, and ii) aggregate income is lower than aggregate income when the economy is not in a sudden stop. This implies that there is an intermediate region of moderately low endowment shocks for which the government finds it optimal to default only when the economy is in a sudden stop (blue region in Figure 1). For endowment shocks that lie to the left (right) of the blue region, the government finds it optimal to (not) default independently of whether it has access to debt markets or not.

Current choices of foreign reserves affect default incentives in the future periods. Figure 2

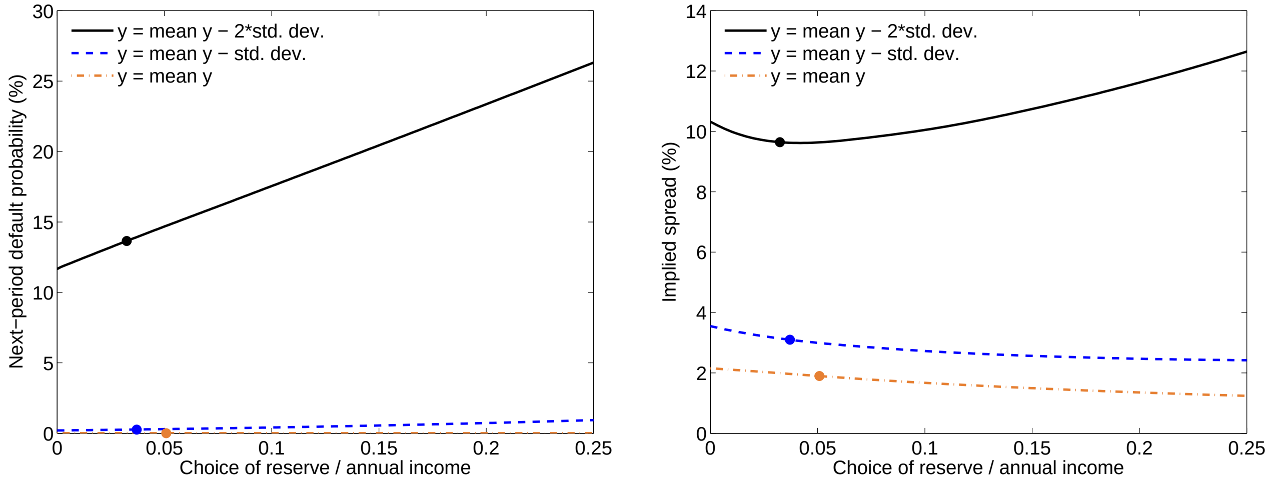

Figure 2: The left panel plots the implied default probability for the next period for different current reserve choices (a') when the government i) starts the period with debt and reserve levels equal to the mean debt and reserve levels in the simulations, ii) starts the period with different income levels, iii) has access to debt markets, and iv) the end-of-period debt (b') equals the optimal debt choice for each income case considered in the graph. The solid dots illustrates the implied default probability for the next period for the optimal current choice of reserves. The right panel illustrates the implied interest rate spread.

illustrates off-equilibrium outcomes when the debt level at the beginning of the period equals the mean level in the simulations and the government has access to debt markets. The left panel illustrates the implied default probability for the next period for different choices of reserve holdings (a'). The right panel illustrates interest rate spread implied by different choices of reserve holdings. Ceteris paribus, if the government chooses to start the next period with a higher debt stock it increases the default probability for the next period. Higher reserves enable the government to mitigate the cost of defaulting by smoothing out the fall in private consumption. Given that reserves can be put to a more productive use when the government is in default than when the government is not in default, having more reserves increases the option value of defaulting by more than it increases the option value of not defaulting, making defaulting more likely in the following period.

However, the right panel of Figure 4 illustrates that the current implied spread need not follow the same pattern that is followed by the next-period default probability. For sufficiently high income or reserve levels, accumulating more reserves for the following period decreases the

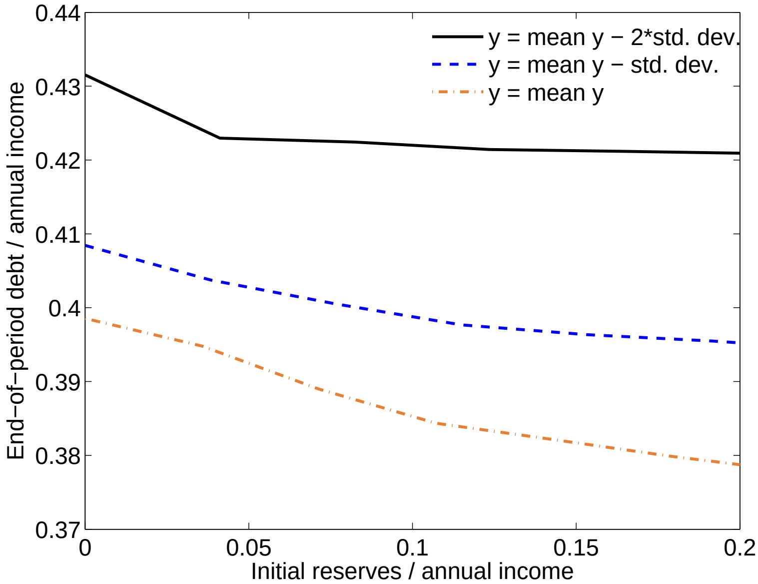

Figure 3: Optimal debt choice for different initial reserve stocks. The graph assumes that the initial debt stock equals the mean debt stock in the simulations and that the government has access to debt markets in the current period.

interest rate at which the government borrows. The reason is that by starting with a higher stock of reserves in the next period, the government decreases the default probability in future periods with the exception of the next one. Figure 3 illustrates the optimal debt choice for different initial reserve positions. Figure 3 shows that the government ends the period with lower debt stocks if it enters the period with a higher stock of reserves. Lower debt stocks at the end of the period decreases the default probability in future periods. The increasing default probability in the next-period and the decreasing default probability starting from two periods ahead affect the current implied spread in opposite directions and may lead to a non-monotonic relationship between current reserve decisions and the spread of government debt.

Differences in the initial stock of reserves affect the menu of debt and interest rates from which the government can choose in the current period. This is illustrated in Figure 4. The graph shows that higher initial reserve stocks improve the price at which the government can borrow in the current period and lead to an allocation with lower end-of-period debt and lower interest rate spreads.

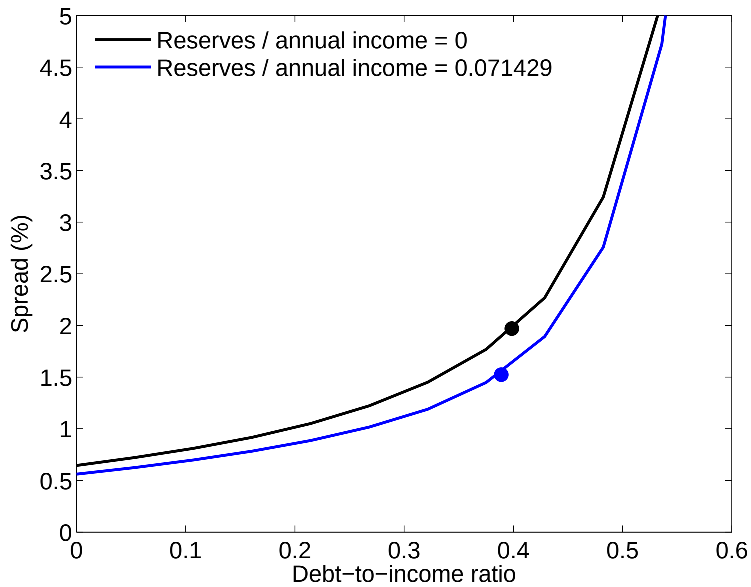

Figure 4: Menu of combinations of spreads and debt to income ratios ($\frac{b'/(\delta+r)}{4y}$) from which the government can choose for two different choices of reserve stocks (a'). Solid dots illustrate the optimal decision of a government that inherits a debt level equal to the average debt observed in the simulations.

4.2 Income and spread in the simulations

Figure 5 illustrates how the model behave in the simulation. The left panel shows that reserves are used to buffer income shocks. In periods with sufficiently high income realizations, the government accumulates reserves, while in periods with low income realizations it reduces its stock of reserves. The right panel show that reserve stocks tend to be negatively correlated with the spread, conditional on income and debt levels taking values around their mean levels.

5 An economy without reserves

In order to gauge the role played by reserves, we computed the same model with the restriction that the government cannot accumulate reserves. This is the case considered in recent sovereign default papers. Table 3 shows that by eliminating the buffer stock role played by reserves, the model is better suited for accounting for the excess consumption volatility and the negative co-movement between income and the trade balance. This suggests that one may have to be

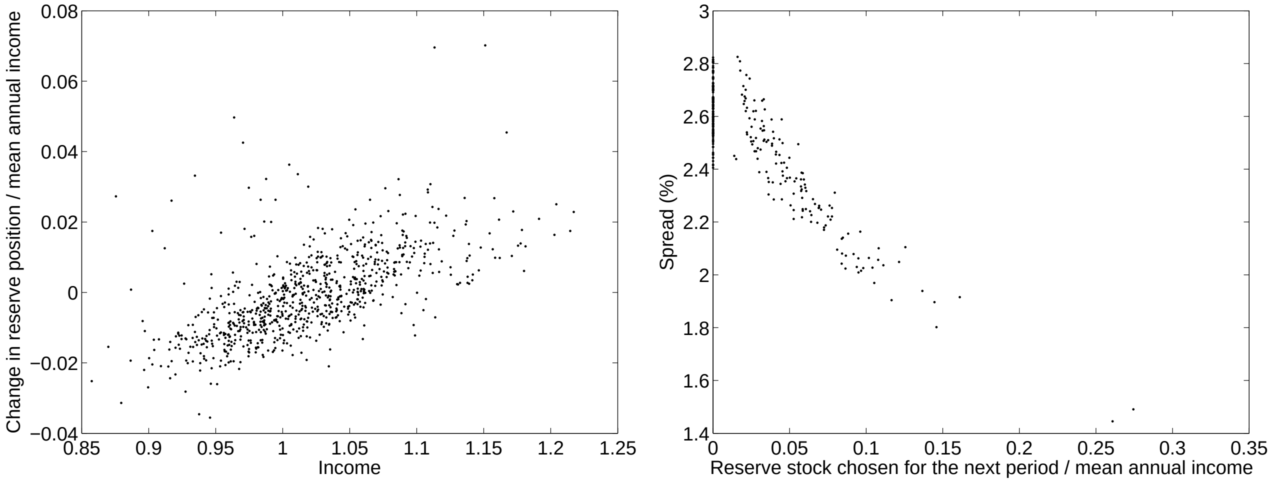

Figure 5: The left panel plots income levels and reserve choices in the simulations. The right panel plots reserve choices and the implied spread in the simulations when the government starts with the mean debt level observed in the simulations, the government has access to debt markets, and current income equals mean income.

cautious regarding the success of previous papers along those two dimensions.

	With reserves		Without reserves	
	All periods	Pre-default	All periods	pre-default
$E(R_s)$	2.83	3.93	2.09	3.63
$\sigma(R_s)$	1.32	1.65	1.17	1.78
$\sigma(y)$	4.58	3.02	4.46	2.99
$\sigma(c)/\sigma(y)$	1.12	0.99	1.26	1.13
$\sigma(TB/Y)$	2.19	0.98	2.24	0.75
$\rho(c, y)$	0.90	0.96	0.93	0.98
$\rho(TB/Y, y)$	-0.01	0.12	-0.33	-0.37
$\rho(R_s, y)$	-0.30	-0.77	-0.32	-0.79
$\rho(R_s, TB/Y)$	0.04	0.27	0.10	0.72
Debt/output*	41.3	44.8	35.6	42.4
Reserves / output*	4.5	3.5	0	0
Defaults per 100 years	1.79		1.28	

Table 3: Business cycle statistics in the baseline case and in an economy in which the government cannot accumulate reserves.

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