Business cycles and sovereign defaults: a decentralized approach*

Hernán D. Seoane†
Universidad Carlos III de Madrid

Emircan Yurdagul‡
Universidad Carlos III de Madrid and CEPR

February 21, 2023

Abstract

We develop a theory of sovereign defaults in a decentralized production economy. While default triggers a strong fall in investment that persistently affects the economy, we show that capital accumulation reduces the default risk. However, the competitive firm under-invests in equilibrium because it does not internalize the impact of capital accumulation on the spreads. An optimal investment tax induces firms to invest more during the crisis and reduces spreads, increases the tax base, and improves the value of autarky due to a hedging motive. Hence, the optimal tax reduces consumption and trade balance volatility but does not necessarily imply less default in equilibrium.

Keywords: Sovereign Default; Corporate Investment; Financial Frictions.

JEL Codes: E32; E44; F32; F34; F41.

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*Financial support by MICIN/ AEI/10.13039/501100011033, grants CEX2021-001181-M, and Comunidad de Madrid, grants EPUC3M11 (V PRICIT) and H2019/HUM-5891, is gratefully acknowledged.

†Department of Economics, Universidad Carlos III de Madrid, Calle Madrid 126, 28903 Getafe, Madrid, Spain; E-mail address: hseoane@eco.uc3m.es

‡Department of Economics, Universidad Carlos III de Madrid, Calle Madrid 126, 28903 Getafe, Madrid, Spain; E-mail address: eyurdagu@eco.uc3m.es

1 Introduction

This paper develops a theory of sovereign default and corporate investment to study the long run impact of sovereign debt crises. Sovereign defaults tend to occur around deep recessions with severe contractions in government spending, private consumption and private investment. On top of these short run effects, the sovereign debt crisis affects the long run performance of the economies as it impacts on investment decisions and the capital accumulation. Our theory puts the role of private firms, who invest and borrow in a context of financial frictions, at the core of the transmission of sovereign debt crisis to the business cycle and allows us to provide a complete explanation of their feedback effects as well as the long run impact of sovereign debt crisis on the macroeconomy.

Even though firms' behavior is of first order importance, the feedback effects between sovereign spreads and the private sector have been substantially overlooked by the existing sovereign default literature, which its most simplified approach assumes a representative consumer in an endowment economy.[1] In reality, however, the interaction between the government and private firms is central both during normal times and also to the macroeconomic dynamics around the sovereign debt crisis. Firms' investment decisions depend on the state of the economy determined by the policy stance to a great extent. Kapička et al. (2019) has recently shown that after the Argentinean default crisis, the stock of capital between 2001 and 2005 decreased more than 20%, even when at the same time total factor productivity was increasing and international rates were falling.

The fiscal policy shapes the firms' incentives to produce and grow as the government relies on distortionary taxation and debt to finance public spending, and current debt affects the future tax collection and, hence, future firms' profits. In turn, the private sector's decisions affect sovereign default incentives. This is so because of two channels: first, firms' profits allow the government to collect corporate taxes, affecting the possibility of raising resources in bad times, potentially leading to a procyclical tax collection over the business cycle. For small open economies with

[1] Recent advances include production with fixed capital as in Mendoza and Yue (2012), corporate debt as in Kaas et al. (2020) or centralized capital decision as in Gordon and Guerron-Quintana (2018).

narrow financial markets, the tax burden on the agents in the economy depends on the borrowing capacity of the government in international markets. To the extent that a debt crisis prevents governments from borrowing in desirable conditions, fiscal policy relies heavily on taxes which can potentially be distortionary to the economy. In this way, the pattern of taxes and spending may be affected by the international investors perception of debt sustainability and closely related to the behavior of sovereign spreads. Second, and substantially subtler, the private accumulation of capital increases the costs of default but also increases the value of autarky as it provides a cushion to finance consumption in case of losing access to international asset markets.

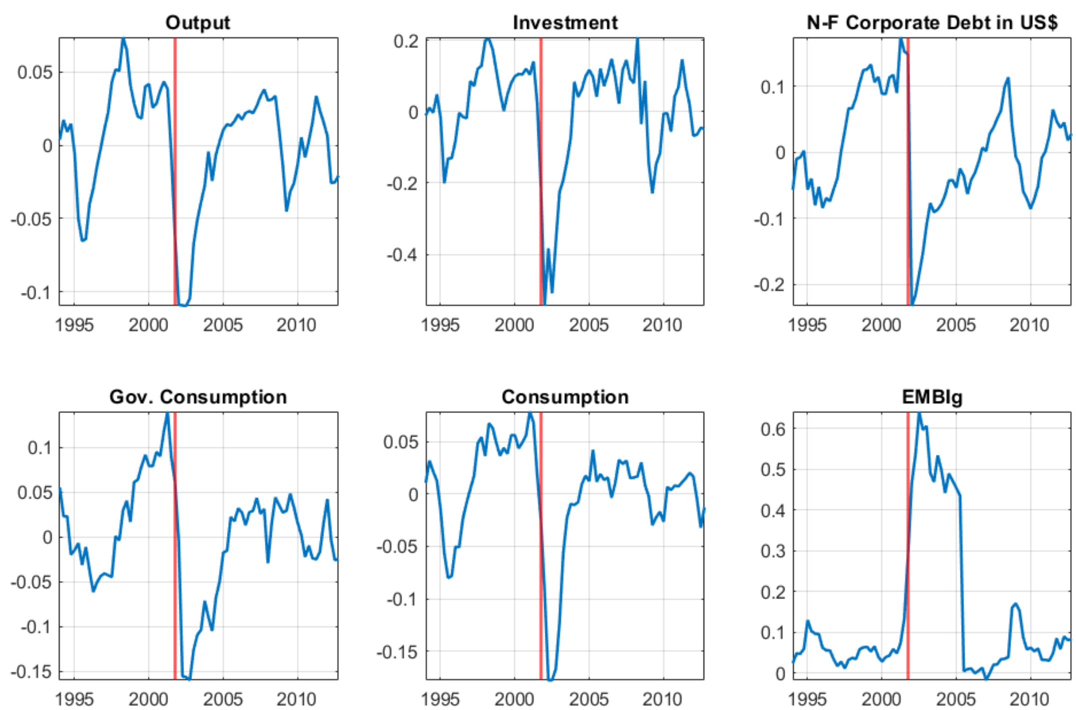


Figure 1: Business cycle dynamics around Argentina's 2001 Sovereign default

Note: Output, investment, Consumption and Government Consumption are in local currency units, measured as log-deviations with respect to the HP filtered (1600) trend. EMBIg is the EMBI Global for Argentina. N-F Corporate Debt is measured as log-deviations with respect to its HP (1600) trend in USD. The red vertical lines indicate the quarter in which sovereign default occurred.

Figure 1 plots national account variables, the non-financial corporate debt and the sovereign spread for Argentina around the 2001 default episode (indicated by the red vertical line). As seen in the figure, the default episode shares the common stylized facts observed for the business cycle in emerging economies, in other words, the standard business cycle in emerging economies remarkably affected by rare events of this sort. Output, investment, consumption and government consumption fall around the default episode, corporate external borrowing (measured in USD) falls too, an indicator that financial conditions for the private sector worsen, and spreads increase.

A glance at the data suggests important interaction between sovereign spreads and private investment. Figure 2 presents the dynamic correlations between EMBI(t+j) with output(t+j), non-financial corporate debt(t+j) and Investment(t) for different values of j, that is, how leads and lags of sovereign spreads correlate with those variables.

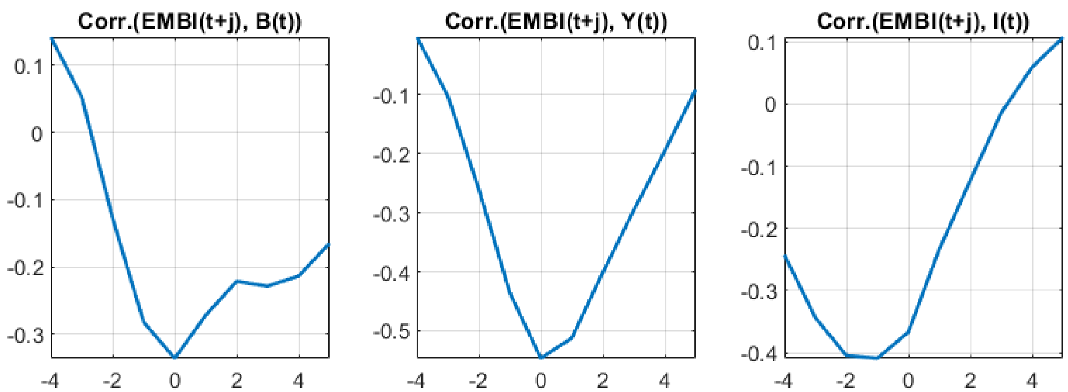


Figure 2: Dynamic correlations with Sovereign spreads

Note: In the horizontal axis we have the lags and leads of the $EMBI$ that denotes the JP Morgan EMBIG index for each economy. Investment is Gross capital formation of the private sector. Both Investment and output are measured at constant local currency in log deviations with the HP trend. Corporate debt (B) is in USD, log linearly detrended from its HP Filtered (1600) trend. The figure plot the averages for Argentina, Brazil, Mexico, Chile, Turkey and Malaysia.

As seen in the figure one year to two quarters lagged increase in sovereign spreads tend to be negatively correlated with a current values of these variables, that is, for instance, if spreads increase today, investment in the future tends to fall. On the other hand, investment, debt and output today tend to be negatively correlated with EMBI in the future. This piece of evidence suggests that firms may have more difficulties investing when the government faces the worst external outlook while investment seems to help relax financial conditions for the government in accessing international financial markets. Moreover, there is a strong comovent between sovereign and private lending rates.

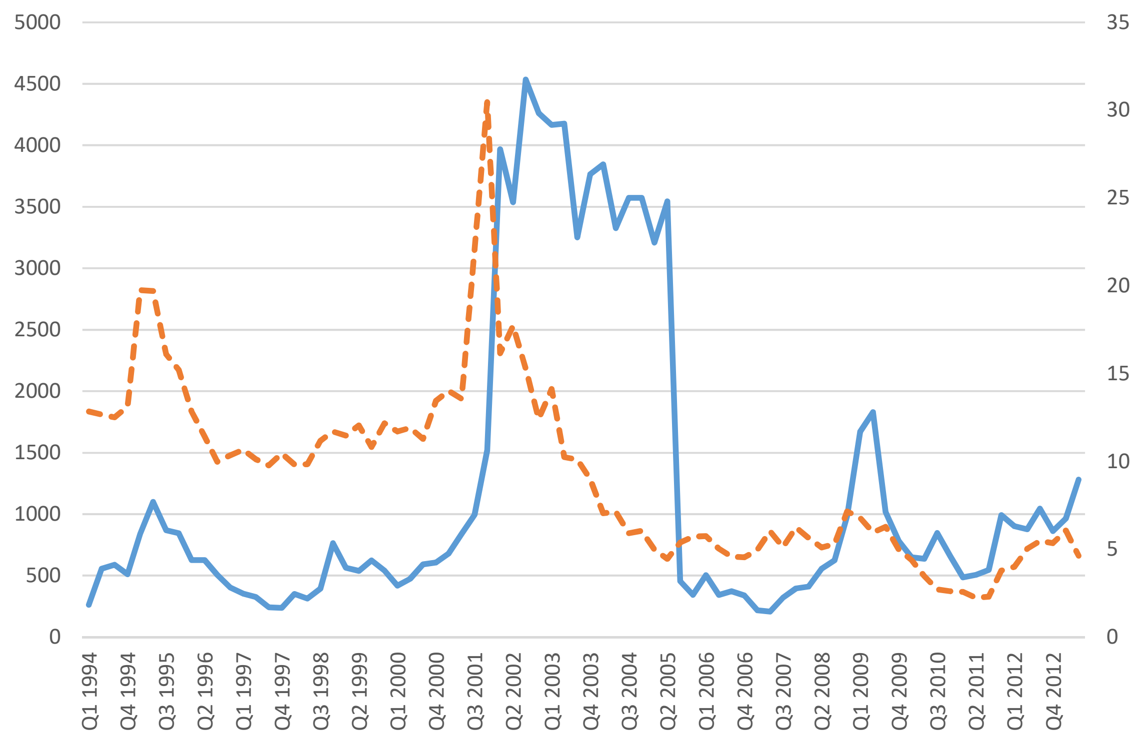


Figure 3: Interest rates

Note: Argentina's data for EMBIG (left axis, blue solid line) and private lending rates in USD (right axis, orange dashed line). Data from Kaas et al. (2020).

As seen in Figure 3 there is a close correlation between the sovereign interest rates (the blue solid line) and the private lending rates (orange dashed line). Outside the default environment the rates comovement is strong. The patters in default differ slightly given that private rates are mostly affected by business conditions and sovereign rates are affected by a political renegotiation process.

In this paper, we rationalize these facts with a model of the business cycle and endogenous sovereign default risk. The model represents a small open economy that is populated by a benevolent government, a representative household, and a continuum of firms, financial intermediaries and international investors. The economy is subject to default risk in the sense of Eaton and Gersovitz (1981). Firms make investment decisions and own the stock of capital. For production, firms combine capital with intermediate inputs that have to be purchased with working capital. The firms in turn borrow the working capital through financial intermediaries that are subject to a financial friction. Households consume and work, they own firms, and derive utility from government spending. International investors price sovereign debt. The government collects corporate taxes and issues defaultable debt to finance government spending in order to maximize households' utility.

The frictional market for corporate debt, in our context, generates an endogenous default cost as we assume that during default, the financial access of firms becomes more limited than in normal times. This default cost behaves endogenously in line with the exogenous output costs of Arellano (2008), that are asymmetric and induce default in bad times, i.e. when output is relative low. Our assumptions are in line with Mendoza and Yue (2012) but are even milder that in this reference given that the firms still have access to financial markets during default, which is true in the data. Nevertheless, during default, the market for corporate debt dries up and corporate debt increases, which represent an endogenous output loss.[2]

Calibrating the model for Argentina we find that investment is procyclical and correlates negatively with the spread as in the data. The model generates excess volatility in consumption, trade balance, and government spending. As the economy approaches default, the firms reduce investment both in levels and as shares of GDP, which means that investment drop prior to the crisis is major. As a consequence of that, capital falls persistently for several years after default. The negative correlation between spreads and investment deserves a careful analysis. In particular, we find that spreads tend to fall with the stock of capital. That is, economies with a larger stock of capital, everything else equal, tend to have lower spreads. An implication of this

[2] Mendoza and Yue (2012) assumes that during default, the economy as a whole looses access to international financial markets and firms cannot purchase imported intermediate inputs as they cannot raise working capital. Instead, we assume that during default the financial conditions worsen and the firms can still borrow from international investors. This is in fact the case as during sovereign defaults firm do not fully loose access to international financial markets.

finding is that corporate investment may operate as a macroeconomic stabilizer. The accumulation of capital at the firm level leads to an externality as the stock of capital affects the sovereign spreads and this is not internalized by the firms. Hence, the firms may under-accumulate capital in the presence of sovereign default risks. In this context, we study how quantitatively important is this under-accumulation and whether it can explain several well-known features of emerging economies such as excess volatility, high spreads, and the frequency of sovereign default. We do it by looking at the constrained optimal investment decision decentralized through capital taxes.

When the government can impose capital taxes the investment dynamics around default changes substantially. Even though the default implies a big investment drop that persistently reduces the stock of capital, prior to default, the investment and investment-to-output ratio increases, accelerating capital accumulation. On average corporate investment in the decentralized economy is low compared to the constrained optimal investment level. The economic intuition is twofold: (1) more capital implies higher default costs as default is assumed to reduce productivity, moreover, it also increases the tax base which makes default less likely. In this way, the government increases the default costs, which contributes to a drop in sovereign spreads; however, (2) investment also increases the value of autarky as higher capital stock allows the economy to guarantee larger consumption during autarky. Hence, the impact on spreads and default incentives is ambiguous. In this case, before default, the government increases tax on profits while reducing tax on capital, to incentivize investment. In the constrained optimal allocation the cyclical properties of investment also change: procyclicality of investment in the constrained optimal economy is seven times lower than in the economy without capital taxes. Moreover, investment is positively correlated with the sovereign spread in this case as the government reduces investment taxes to incentivize the accumulation of capital when spreads are large while increasing the sales tax to compensate for the loss in revenues.

The literature has explored the relationship between investment and sovereign debt and claimed that large levels of sovereign debt are associated with lower investment-to-GDP ratios, see for instance Huang et al. (2018) and Huang et al. (2020). The channels highlighted in the literature through which sovereign debt crowds out private investment operate via interest rates and credit rationing. Increases in government debt push interest rates up and also affects private sector funds availability, which in the end crowds out investment by credit-constrained firms. As expected, when using reduced-form models the literature has had limitations in order to address the direction of causality and the importance of feedback effects.

Bai and Zhang (2012), Gordon and Guerron-Quintana (2018) and Park (2017) are the first ones to introduce capital accumulation in the default environment of Arellano (2008). Bai and Zhang (2012) and Gordon and Guerron-Quintana (2018) assume endogenous production of a unique good that the household can use for consumption or investment. In these papers, there is a motive for the government to accumulate capital for signaling purposes, namely to improve the borrowing conditions by reducing the likelihood of defaulting.[3] Park (2017), instead, assumes that the economy has to combine foreign and domestic investment to produce capital. These papers tend to find that higher capital accumulation implies a lower default probability. Park (2017) finds that conditional on a level of debt, default probability dependence on capital is U-shaped. If the economy accumulates too much capital, having access to international financial markets is less important than for economies with moderate and low levels of capital. The stock of capital provides insurance in this way. However, in all of these papers, the capital accumulation decision is centralized. That is, the benefit of capital accumulation is fully internalized by the planner that decides debt issuance and default decisions.

Bai and Zhang (2012) finds that default risk affects negatively the flow of capital. However, this statement relies on a centralized investment decision. We do not study international risk sharing but our approach can shed light on the impact of default risks on the incentives for corporate investment. Our key question is: do firms over-invest or under-invest with respect to the constrained-optimal (centralized) decision?

When investment is decentralized, in the case of sovereign debt overhang, many risks emerge for the private firms, affecting their perception of risk of the overall economy and the consequent investment choices. Debt overhang and political risks, for instance, tend to be associated with higher expropriation risk. This is well-known in the literature and has been recently studied, see Aguiar et al. (2009) and Aguiar and Amador (2011). The vast majority of the studies on sovereign

[3]Similarly, Bianchi et al. (2018) study the foreign reserves, instead of capital, as an instrument that is optimally accumulated by the government to study its role as a signal right incentives to repay the debt.

spreads consider endowment economies after the seminal work of Eaton and Gersovitz (1981). Only recently Mendoza and Yue (2012) introduces an environment with endogenous output and endogenous costs of default. Since then some papers have departed from the endowment economy assumption and included production, mostly assuming that firms combine intermediate inputs with labor. Not many papers have studied the decentralized investment choice besides ours in the context of sovereign risk. A notable exception is Esquivel (2022), who studies the misallocation of households' investment decisions in an environment with default risk in a two-sector economy. With a more theoretical approach, Galli (2021) studies households' investment with default risk to analyze the sovereign debt crisis in the Euro Area in 2012 but does not analyze the role of the investment externality.

Recently, some authors studied the interaction between private and sovereign borrowing. Kaas et al. (2020) studies the role of government taxation in the coordination of sovereign and private defaults. They are the first ones, to our best knowledge, to develop a model with firms' ex-post heterogeneity and joint default in the Eaton and Gersovitz (1981) environment. However, they abstract from capital accumulation at the firm level, a feature that is key to addressing the value of the firm and evaluating the stock market implications of debt overhang and that also has a strong impact on the business cycle.

Our paper also relates to the study of fiscal policy with default risk, in line with Cuadra et al. (2010). This paper analyses the role of fiscal prociclicality in the dynamics of a countercyclical default risk, however, they abstract from investment decisions.

The remainder of the paper goes as follows. In Section 2 we introduce the setup of the benchmark model. Section 3 presents the calibration details for the numerical implementation of the model. Section 4 discusses the quantitative implications of corporate investment in sovereign debt and spreads. Section 5 studies the impact of optimal investment taxation. Section 6 concludes.

2 The model

We build a model for a small open economy in the tradition of Eaton and Gersovitz (1981) and Arellano (2008). Our economy is populated by firms, households, financial intermediaries and the government. The government has direct access to international financial markets and issues defaultable debt. Firms also borrow internationally to finance working capital needed to pay imported inputs in advance. We assume that working capital debt is intraperiod as in Mendoza and Yue (2012) but, in contrast to the assumptions on that paper, firms do not have direct access to international financial markets. Instead, firms borrow from international investors through a competitive market of frictional financial intermediaries. As standard in the literature, the international investors are risk free agents that break even in expectation. The rest of this section describes each agent in detail.

2.1 The households

Households derive utility from private consumption and from the consumption of a public good. As owners of firms and financial intermediaries, the households receive corporate profits in a lump sum fashion and use them to finance their private consumption. Households' do not have access to financial markets and all international borrowing is done by firms and the government. Their present discounted value of lifetime utility is represented by

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

where c_t and g_t denote private consumption and the public good received by the households, respectively. Standard assumptions about $u(\cdot)$ and $v(\cdot)$ apply.

2.2 The corporate sector

We model a continuum of firms with a unit mass. Households are the shareholders of the firms and we assume that the firms do not issue new shares. Firms own the stock of capital, k, and use it to produce the final good. The firm discounts the future with a constant rate r_f, and maximize the present discounted value of profits. Accordingly, we assume that the flow payoff of the firm is the contemporaneous profits. Adopting a stochastic discount factor that reflects the marginal utility of the households does not alter our main results.

We assume that the government makes decisions after the firms. Accordingly, the firm makes its decisions considering the policy function of the government given the aggregate productivity, z, aggregate capital, $\bar{k}$, and public debt, b. To simplify the notation, we assume that the government debt state and choices have to be on a grid $\mathbf{b} = \{b_0, b_1, ...b_N\}$, so that we can denote the state or choice of government default simply as a grid point b_{N+1}, without adding notation with an extra value or policy function for the firm. Under these assumptions, the value of a firm in the beginning of the period is:

$$
\begin{aligned}
V^f(z, k, \bar{k}, b; \tau, b') &= \max_{k',x} \; (1-\tau)zk^{\alpha}x^{\eta} + (1-\delta)k - k' - C(k', \bar{k}) - \bar{p}x(\theta(R_t - 1) + 1) \\
&\quad + \frac{1}{1+R} E_{z'|z} V^f(z', k', \bar{k}', b'; \tau', b'') \\
\text{s.t.} \quad & \bar{k}' = k^*(z, \bar{k}, b) \\
& b'' = \tilde{b}(z', \bar{k}', b') \\
& \tau' = \tilde{T}(z', \bar{k}', b')
\end{aligned}
$$

Here θ captures the financial constraints on firms. Purchasing intermediary inputs is a static decision of the firm that is distorted by the fact that these inputs have to be paid in advance, i.e. before production takes place. Hence, the firm needs to borrow from a financial intermediary in order to finance the acquisition of these inputs. We assume that the fraction of this purchase that has to be paid in advance is determined by θ. The optimality choice of intermediate inputs is given by:

$$
\tilde{x}(z, k, b', \tau) = \left(\frac{\lambda(1-\tau)zk^{\alpha}}{\bar{p}(1+\theta r_t)} \right)^{\frac{1}{1-\eta}}
$$

. Here $r_t = R_t - 1$ is the real net interest rate on corporate, intraperiod loans.

The flow value of the firm is the after-tax firms profits after period t's investment. The continuation value of the firm is $E_{z'|z}V^f(z', k', \bar{k}'; \tau, b')$. τ is the tax rate on corporate sales. We denote the policy functions of a firm for capital accumulation with $\tilde{k}(z, k, \bar{k}; \tau, b')$.

The first order condition with respect to the capital choice of the firm gives:

$$-1 - C_1(k', \bar{k}) + \frac{1}{1+R} E_{z'|z} V_2^f(z', k', \bar{k}', b_{\tilde{n}}) = 0$$

which states the standard result that the cost of one unit of capital including the adjustment costs, in the optimum, equals the present value in expected terms that the unit of capital adds to the firm's value. The envelope condition gives:

$$V_2^f(z, k, \bar{k}, b_n) = \frac{\alpha}{1-\lambda} \frac{(1-\lambda)(1-\tau)^{\frac{1}{1-\lambda}} z^{\frac{1}{1-\lambda}} k^{\frac{\alpha}{1-\lambda}-1}}{\bar{p}(\theta(R_t - 1) + 1)} + (1-\delta)$$

where the subindex 2 in V_2^f indicates the partial derivative with respect to the second argument. The envelope and the first order conditions give the optimality condition for the capital decision:

$$1 + C_1(k', \bar{k}) = \frac{1}{1+R} E_{z'|z} \left[\frac{\alpha}{1-\lambda} \frac{(1-\lambda)(1-\tau)^{\frac{1}{1-\lambda}} z'^{\frac{1}{1-\lambda}}}{\bar{p}(\theta(R_t - 1) + 1)} k'^{\frac{\alpha}{1-\lambda}-1} + (1-\delta) \right]$$

where

$$b'_{\tilde{n}} = \tilde{b}(z', \bar{k}', b_{\tilde{n}})$$

Alternatively:

$$1 + C_1(k', \bar{k}) = \frac{1}{1+r_f} \left(k^{\frac{\alpha}{1-\lambda}-1} A(z, \bar{k}, b_n) + 1 - \delta \right)$$

where

$$A(z, \bar{k}, b_n) = E_{z'|z} \left[\frac{\alpha}{1-\lambda} \frac{(1-\lambda)(1-\tau')^{\frac{1}{1-\lambda}} z'^{\frac{1}{1-\lambda}}}{\bar{p}(\theta(R_t - 1) + 1)} \right]$$

$$\bar{k}' = k^*(z, \bar{k}, b_n)$$

$$b'_{\tilde{n}} = \tilde{b}(z', \bar{k}', b_{\tilde{n}})$$

This shows that the capital decision of each firm can be solved analytically using the policy functions of the government, and the investment rule of the representative firm. Additionally, note that the representative firm in this model behaves as the standard firm in the real business cycle literature when subject to capital adjustment costs. The capital accumulation in the economy is:

$$k^*(z, \bar{k}, b_n) = \tilde{k}(z, \bar{k}, \bar{k}, b_n)$$

The government would take this as given, and make it's decisions to maximize the representative household's value.

2.3 The financial intermediaries

In contrast to the government, the corporate investors cannot access international financial markets directly, we assume they do it through a continuum of perfectly competitive financial intermediaries. We assume that these intermediares are subject to the financial friction in Gabaix and Maggiori (2015). These agents live for only one period and borrow in international markets to lend to domestic firms. The loans they provide are intraperiod, borrowing at the risk free rate at the beginning of the period and repaying the loan at the end of the period. Hence they maximize,

$$W = \mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right] q$$

As in Gabaix and Maggiori (2015), intermediaries can abscond a fraction of the resources they borrow. We assume the share of resources they can abscond is $\Gamma(d)\left(\left|q\right|\right)^{\mu}$ share of its funds (notice that the share of funds that can be diverted is assumed to be increasing in the exposure of the intermediaries. Gabaix and Maggiori (2015) assumes $\mu = 1$.

We assume that $\Gamma(d)$ is a function of the default status. In normal times, we assume that $\Gamma(d = 0)$ is relatively lower than in periods where the economy is in default, implying relatively low financial friction for the private sector in normal times. This captures the fact that financial conditions worsen for the private sector during sovereign default and is consistent with increases in corporate interest rates in times of sovereign default, as observed in the data. Moreover, as $\Gamma(d)\left(\left|q\right|\right)^{\mu}$ is a share, it is constrained by $\bar{\Gamma}$, this is without loss of generality as the technology process can be scaled up to make this maximum share equal to 1.

Hence, any contract should take into account a incentive compatibility constraint,

$$\mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right]q \geq \left|q\right|\Gamma(d)(\left|q\right|)^{\mu} = \Gamma(d)(q)^{\mu+1},$$

which indicates that the financial intermediary have to have compatible incentives and will not divert funds in equilibrium. Then, the optimization problem is

$$\max W = \mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right]q$$

subject to

$$\mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right]q \geq \Gamma(d)(q)^{\mu+1}$$

and

$$\Gamma(d)|q|^{\mu} < \bar{\Gamma}$$

where $\bar{\Gamma}$ is the maximum share the intermediary can divert. The incentive constraint will always bind so, replacing W we can solve for the optimal q:

$$\mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right]q = \Gamma(d)(q)^{\mu+1},$$

as long as the share is below $\bar{\Gamma}$. Hence,

$$q = \left(\frac{1}{\Gamma(d)}\mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right]\right)^{\frac{1}{\mu}}.$$

In equilibrium, $-q = \bar{p}\theta x(z,k,b',\tau)$. Hence, the last equation pins down R_t. Then,

$$\bar{p}\theta\tilde{x}(z,k,b',\tau) = \bar{p}\theta\left(\frac{\eta(1-\tau)zk^{\alpha}}{\bar{p}(\theta(R_t-1)+1)}\right)^{\frac{1}{1-\eta}},$$

$$\left(\frac{1}{\Gamma(d)}\mathbb{E}\left[\beta\left(R_t - R_t^f\right)\right]\right)^{\frac{1}{\mu}}\left(\bar{p}(\theta(R_t-1)+1)\right)^{\frac{1}{1-\eta}} = \bar{p}\theta\left(\eta(1-\tau)zk^{\alpha}\right)^{\frac{1}{1-\eta}}.$$

Now, as seen from the previous expression, the right hand side is increasing in z and k. The left hand side is increasing in R_t. Then, R_t is an increasing function of productivity as higher productivity implies larger demand of intermediate inputs. Graphically, we can represent the equilibrium in the loans' market as shown in Figure 4.

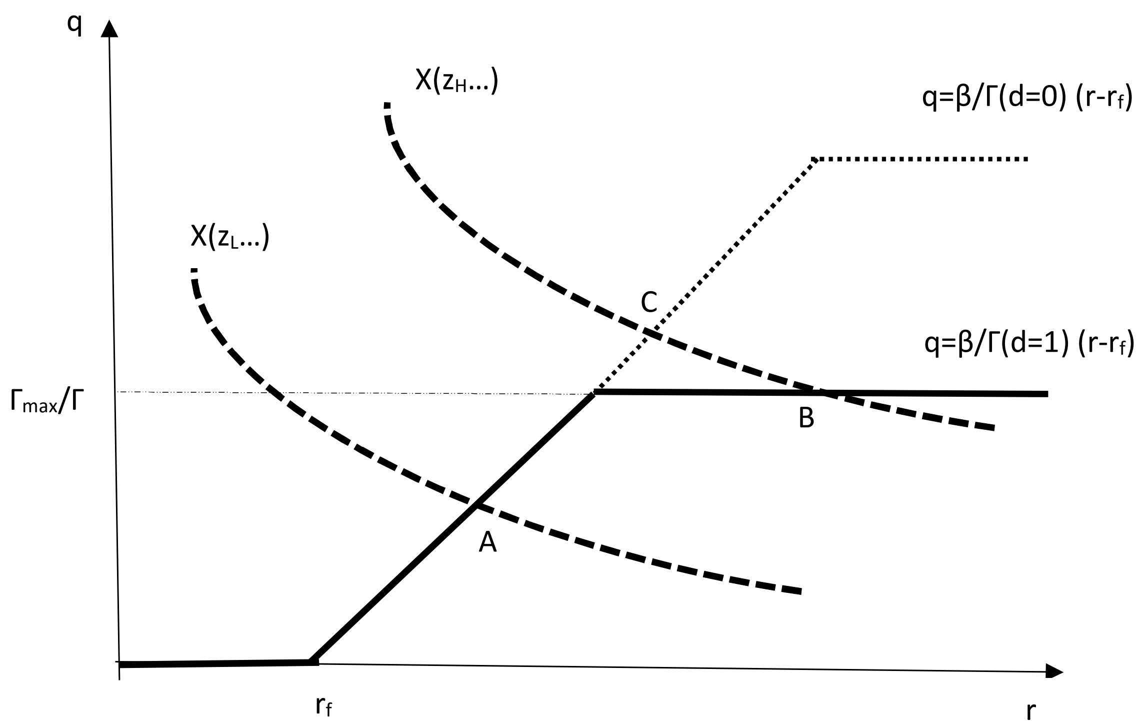


Figure 4: Demand and supply of corporate loans

Note: Equilibrium outcomes in the private sector financial market. The dashed lines represent credit demand for low and high TFP. The solid line in the credit supply when the government is in default. The dotted line is the credit supply when the government is in repayment status.

Figure 4 represents the partial equilibrium in the private credit market in normal times and in default. The dashed lines represent the credit demand functions for low TFP $x(z_L, ...)$ and high TFP $x(z_H, ...)$, clearly, higher TFP realization imply that for any private rate there is a higher demand of intermediary inputs, hence, increases in TFP move the demand of loans to the upper right part of the picture. The solid black line is the supply of credit when the economy is in default and the dotted line is the supply of credit in normal times. Notice that while the private interest rate is below the risk free rate the financial intermediaries supply of funds is zero as intermediaries would incur in losses. Then, the supply of loans is increasing until the upper bound determined by the maximum share of funds that can be diverted. The vertical axis is the supply of loans, as can be seen the maximum amount of loans consistent with the maximum share during default is $q_{max}(d = 1) = \frac{\Gamma_{\max}}{\Gamma(d=1)}$, instead, during normal times (determined by the dotted line) the maximum q is larger are $\Gamma(d = 0) < \Gamma(d = 1)$.

Note that when the economy moves from normal times into default, the Γ increases and the supply of funds becomes flat at a lower value of q, that is, given a $\Gamma_{\max}$ the total amount of funds the financial intermediary can finance is smaller as the maximum share the investor could divert does not change.

This setting implies an endogenous default cost from financial intermediation, that is, a cost that operates directly through the decentralized corporate investment problem. When the economy is a bad fundamental situation (low TFP) default costs are nill, equilibrium both in default and normal times happen in point A. However, in good times, the deterioration of financial conditions move the equilibrium from point C to point B in the case of default. In this case the firms face a higher interest rate and are constrained in the amount of intermediate inputs they can purchase.

Mendoza and Yue (2012) also assume a similar type of endogenous default cost. As in our case, their setup also endogenizes the default costs assumed by Arellano (2008). In their setting, firms have access to international financial markets during normal times, but they fully loose it in default. Our setting instead implies that international funds are more scarce to the private sector during default, but firms can still issue foreign debt, which is a more realistic assumption.

2.4 The government

The government issues foreign debt without commitment in order to finance government spending. If the sovereign starts the period out of default with a debt level b_n for $n \leq N$, then its value is:

$$V(z,\bar{k},b_n) = \max_{\tilde{n}\in\{0,1,..,N+1\}} \{\tilde{V}(z,\bar{k},b_n;b_{\tilde{n}})\}$$

Here, choices $\tilde{n}$ less than $N+1$ correspond to repayment, and the choice $\tilde{n} = N+1$ corresponds to default. In case of repayment, the value is:

$$\tilde{V}(z,\bar{k},b_n;b_{\tilde{n}}) = \max_{g}\ u(c) + v(g) + \beta E_{z'|z}\Big[V(z',\bar{k}',b_{\tilde{n}})\Big]$$
$$g = q(z,\bar{k},b_{\tilde{n}})b_{\tilde{n}} - b + \tau z f(\bar{k},x)$$
$$c = (1-\tau)zf(\bar{k},x) - \bar{k}' + \bar{k}(1-\delta) - C(\bar{k}',\bar{k})$$
$$\bar{k}' = k^*(z,\bar{k},b_n).$$

Here, $q(z,\bar{k},b_{\tilde{n}})$ denotes the real value of debt issued at a discount that promises to repay one unit of good in $t+1$. The first constraint is the budget constraint of the government, the second is the balance of payments and the third equation states that the government optimizes conditional to the competitive response of the corporate sector. Instead, the value when default is chosen is:

$$\tilde{V}(z,\bar{k},b_n;b_{N+1}) = \max_{g}\ u(c) + v(g) + \beta E_{z'|z}\Big[\theta V(z,\bar{k},b_n) + (1-\theta)V(z,\bar{k},b_{N+1})\Big]$$
$$g = \tau z f(\bar{k},x)$$
$$c = (1-\tau)zf(\bar{k},x) - \bar{k}' + \bar{k}(1-\delta) - C(\bar{k}',\bar{k})$$
$$\bar{k}' = k^*(z,\bar{k},b_n).$$

Here, if the economy is in default, it loses access to international financial markets and the financial conditions of the corporate sector deteriorate, represented by an increase in Γ. The government can access financial markets every period with a probability θ. The most standard assumption about default costs is to impose them in terms of TFP or income (see Arellano (2008)). Mendoza and Yue (2012) rationalizes them with a model where, in the case of default, firms cannot import intermediate inputs due to autarky and, hence, have to substitute them with domestic imperfect substitutes. In our case we rationalize them by assuming a worsening in the financial conditions of the firms that impose costs associated to the investment and intermediate input decisions. In contrast to Mendoza and Yue (2012) we only need to assume that financial conditions of the firms worsen but they can still access international financial markets, which is a realistic assumption. Moreover, in contrast with Arellano (2008) private sector interest rates and corporate debt dynamics allow us to discipline the default costs derived from financial intermediaries.

Given r, the international risk-free interest rate, there is a continuum of risk neutral lenders that incorporate in the bonds price the probability of default. These lenders face the zero-profit condition:

$$q(z, \bar{k}, b_{\tilde{n}}) = E\left\{ \frac{1 - \mathbb{I}(\tilde{b}(z, \bar{k}, b_n) = b_{N+1})}{1 + r} \right\}.$$

Where we denote the debt policy function of the government as $\tilde{b}(z, \bar{k}, b_n)$. Default corresponds to $\tilde{b}(z, \bar{k}, b_n) = b_{N+1}$.

Potentially we can interpret the corporate tax rate, in line with the introduction, as follows: we can think of the impact of default on τ as an expropriation of private investment in the case of sovereign risk/default. Expropriation risk is the risk that firms will lose their investment (capital and returns). Expropriation is not necessarily a sovereign intervention of firms' stock of capital.[4]

3 Calibration and functional forms

For the calibration and functional forms we take the standard assumptions in the literature. The production function only has capital as the endogenous input, with diminishing returns: $y = zf(k) = zk^{\alpha}x^{\eta}$.

Households' preferences for private and public goods are both represented in CRRA form as

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma}, \quad \text{and} \quad v(g) = \nu \frac{g^{1-\mu}}{1-\mu},$$

respectively.

[4]For instance, the literature sometimes refers to inflation as a way of expropriation.

In contrast to Arellano (2008), we avoid modelling direct productivity losses from default as in our case they arise endogenously from the private investment and financial intermediaries setup. As standard in the business cycle literature in open economies, the capital accumulation technology has convex adjustment costs to prevent counterfactual current account volatility,

$$C(k', \bar{k}) = \kappa \bar{k} \left(\frac{k'}{k} - 1 \right)^2 .$$

We fix some parameters following the existing literature, and calibrate the remainder parameters to match first and second order moments in the data. Panel A in Table 1 presents the parameter values calibrated following the literature. The CRRA coefficient on private good consumption, γ, is set to 2, quarterly depreciation rate of capital is 2% and the risk free rate is 1.7% annually. The parameter θ determines the frequency with which a country in autarky returns to asset markets. The capital and intermediate input shares follow Mendoza and Yue (2012).

Table 1: Parameters

Parameter	**Value**	**Basis**
Panel A: Outside the model		
γ	2	Standard
δ	0.02	Standard
α	0.33	Standard
r	0.017	Arellano (2008)
θ	0.282	Arellano (2008)
η	0.30	
$\bar{\lambda}$	0.054	Re-scaling
Panel B: Calibrated		
β	0.9	Debt service / Output
κ	0.5	$\sigma(i)/\sigma(y)$
μ	1.1	$E(g/y)$
ν	0.25	$\sigma(g)/\sigma(y)$
ρ_z	0.89	Autocorr. output
σ_z	0.014	Sd. output
Γ_L	0.08	Avg. corporate spread
Γ_H	0.3	Def. rate 2% per year

Panel B of Table 1 presents the parameters that are calibrated to match the targets in Table 2. We target Argentina's data for the period 1992 to 2019, at quarterly frequency. κ determines the adjustment cost of capital and has a direct impact on the volatility of investment. μ shapes the households preferences regarding the public good. To replicate the low volatility that g has in the data, we need a high risk aversion in that dimension, the low value of ν, as in Kaas et al. (2020), guarantees that the level is right in order to avoid this term dominate the role of c in the utility function. ρ_z and σ_z, everything else equal, allow us to capture the output persistence and volatility. Similarly, β is on the order of magnitude of the discount factor for strategic default models and the default costs allow us to get realistic default incentives.

As seen in Table 2, the model accounts for the targeted moments. As expected, the model does not get the debt levels observed in the data, which is a standard issue for models without debt maturity or renegotiation. Besides this, the order of magnitude of the remainder of the moments coincides with that in the data.

Table 2: Targeted moments

Moment	**Data**	**Model**
$\sigma(i)/\sigma(y)$	3.73	4.27
$\sigma(g)/\sigma(y)$	1.53	1.55
$E(g/y)$	13.3%	11.2%
Autocorr. output	0.91	0.91
Sd. output	4.0%	4.4%
Debt service / output	5.5%	11.2%
Default rate (annual)	2%	1%
Private spread	8.5%	7.7%

Notes: The data statistics are based on Argentina. All moments computed with log-detrended data with HP(1600). Moments are at quarterly levels unless noted otherwise. Debt to output ratio is General government gross debt, Percent of GDP, Annual, Not Seasonally Adjusted, from the Federal Reserve Bank of St. Louis period 1992-2019 (GGGDTAARA188N). Corr. stock market-private debt is computed for pre-default data.

4 Results

Table 3 presents the data and model counterpart of non-targeted moments. As seen in the table, the model captures fairly well some key moments in the small open economy literature. First, the correlations of the components of aggregate demand with output is consistent with the one in the data. Additionally, the correlation of the sovereign spreads in the model is also consistent with the countercyclical behavior the spreads. The model also captures the overall behavior of the government consumption. In a nutshell, our economy appropriately reflects the comovement observed in the data for the key variables of our theory.

Table 3: Non-targeted correlations

Moment	**Data**	**Model**
$\rho(i, y)$	0.92	0.73
$\rho(c, y)$	0.93	0.93
$\rho(tb/y, y)$	-0.63	-0.16
$\rho(EMBI, y)$	-0.65	-0.21
$\rho(g, y)$	0.60	0.93
$\rho(g, EMBI)$	-0.67	-0.24

Notes: The data statistics are based on Argentina. Government expenditure volatility and average share is taken from Kaas et al. Argentinean data is from 1994Q1-2012Q4. (*) Moments for EMBI in the data includes default periods. In the data, EMBIg is measured in annualized terms

More to the core of our contribution, as seen in Figure 5 the model captures the right comovement between EMBI and investment at various leads and lags in qualitative terms. It shows, however, a mild relationships between investment and the sovereign spreads. Past values of spreads are mildly negatively correlated with investment. Investment in period t is also negatively correlated with future spreads, suggesting a role for private investment in the foreign debt market of the government. We show below that the price of debt is increasing in the stock of capital.

The model, in this way, captures a fraction of the feed back effects between spreads and investment. In terms of unconditional dynamics, the relationship between these variables that the model captures is blended by the behavior of taxes and sovereign debt. In the next section we focus with more detail in the dynamics around default.

Dynamics around default

Default episodes are disruptive. This model captures the impact that sovereign default has on the economy. Particularly for our objective, the model captures the disruptive effect on public finances and on the dynamics of capital and investment.

Figure 6 plots output, TFP, investment and capital, consumption, and fiscal variables. Period 0 denotes the quarter of default. All variables are defined as the difference in each period between

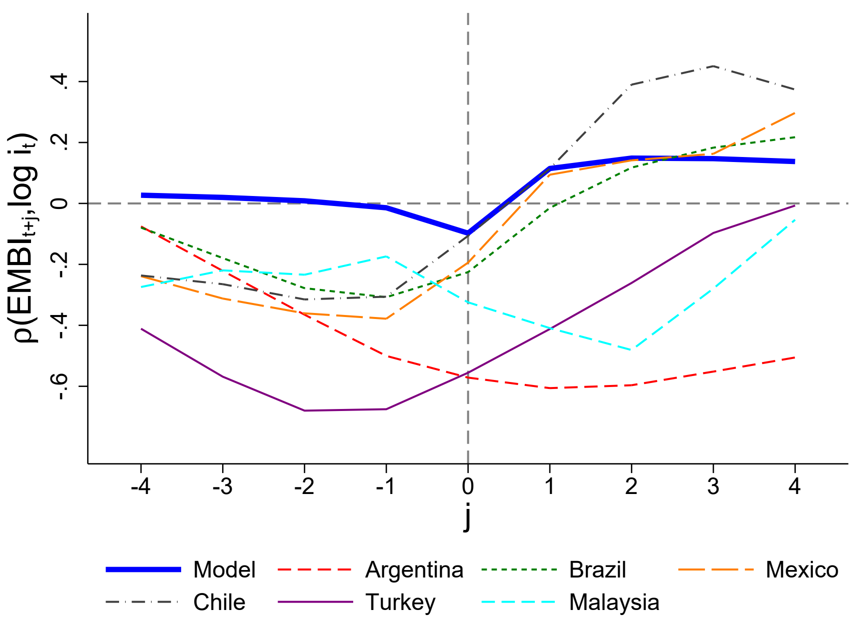


Figure 5: Dynamic correlations between investment and sovereign spreads, model vs. data

Note: In the horizontal axis we have the lags and leads of the $EMBI$ that denotes the JP Morgan EMBIG index for each economy. Investment is Gross capital formation of the private sector at constant local currency in log deviations with the HP trend. We provide details of model simulation procedure in the appendix.

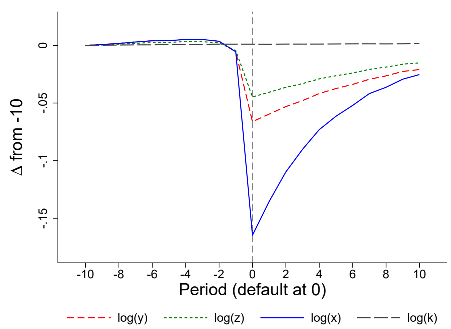
that variable and the value the variable takes in default. For instance, TFP 4 quarters before default is 5% larger than the TFP at the moment of default, all other variables in this picture are represented in the same way.

As seen in the figure, the default is triggered by a sequence of about 4 quarters of bad technology shocks. The dynamics around default implied by the model rely on the following transmission channels. The fall in TFP reduces the return to capital and intermediate inputs which have a negative effect both on the investment and inputs demand. As you can see in the figure, investment starts falling three periods before default. As the economy decelerates, the tax base falls and the government responds with a combination of fiscal adjustment and accelerating debt accumulation as seen in figures (c) and (d). Private consumption also falls due to a drop in households' income as a product of lower corporate dividends. Eventually, the crisis accelerates and the government defaults when suffered a 10pp government adjustment from it's pre-crisis level.

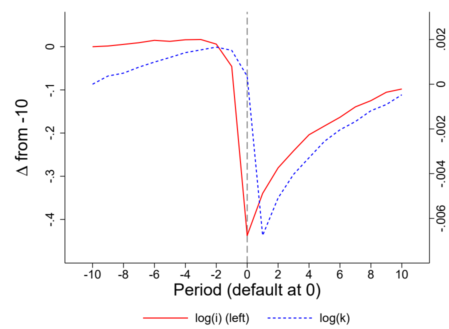
The default episode changes the dynamics of the economy, in this way it is disruptive. Immediately at the moment of default, the government loose access to financial markets and the financial conditions of the corporate sector deteriorates, triggering a strong contraction in inputs demand, an increase in corporate's financing costs and a sudden adjustment in investment and consumption. Financing costs for the private sector deteriorates, this is indeed a milder assumption that the one in Mendoza and Yue (2012) where the authors assume that firms loose access to foreign financing. In our case, the output losses during default are explained by a worsening of the financial conditions which increases the cost of importing inputs.

An interesting impact of default in the stock of capital is the following. Default implies discrete fall in the return of capital. Then, the stock of capital is too large for the new cost of financing for the firm. The marginal product of capital is too low. To restore optimality, the firm lets capital depreciate and, eventually may distributes it as dividends to the household. This explains the persistent output and capital drops. Investment, in turn, recovers in a slow way and does not allow for a quick recovery of the stock of capital. Capital dynamics produce a persistent impact of default on the output level.

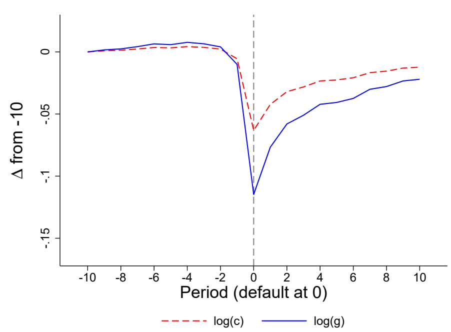
(a) Output and TFP



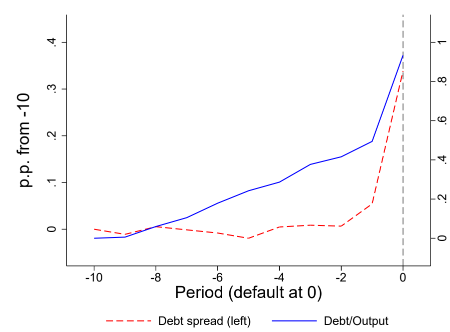
(b) Investment and capital stock



(c) Private and public cons.



(d) Public debt level and spreads



(e) Corporate debt and interest rate

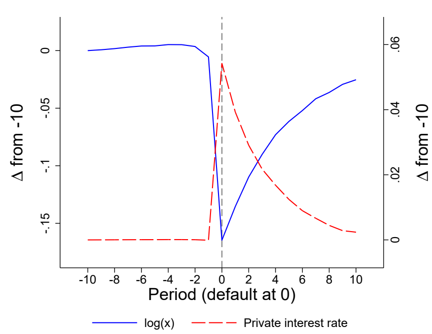


Figure 6: Patterns around default

Notes: To construct the figures, we pick all the default events that do not have another default less than 10 periods before and after. For each $t \in \{0, 1, .., 5\}$, we take averages across these samples for each variable t period before and after the default event. We provide the details on the simulation procedure in the appendix.

About the role of investment on default incentives note that the stock of capital, even being privately own in a competitive allocation, matters for the price of debt and, consequently, matters for the default incentives of the government. As seen in figure 7 the larger the stock of capital the lower are the default incentives of the government, i.e. the higher is the price of sovereign debt.

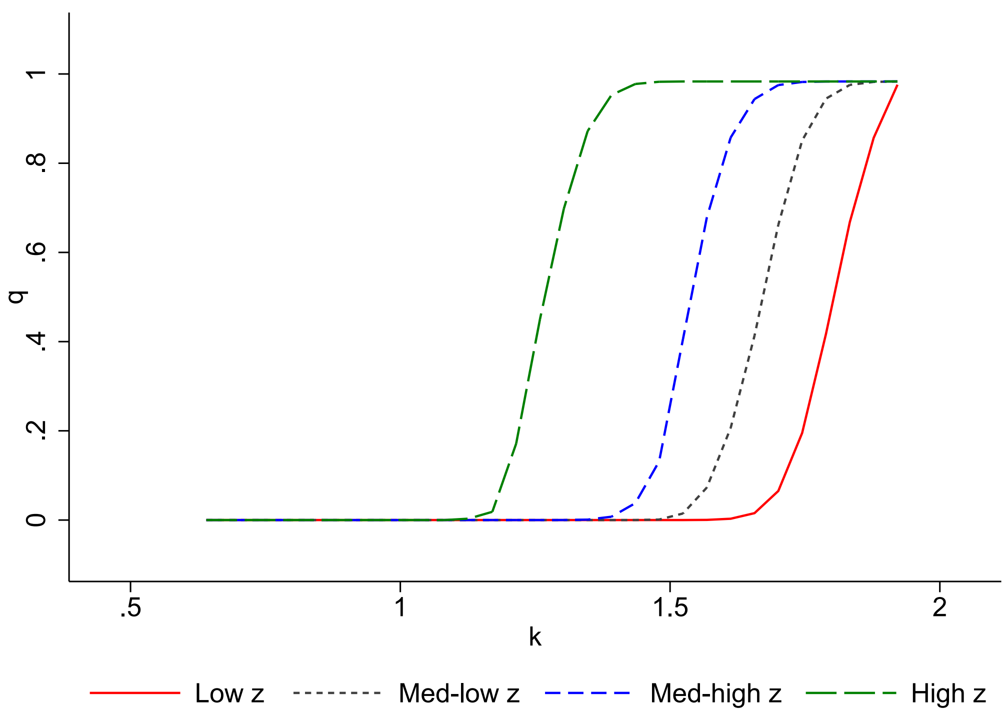


Figure 7: Debt price and capital

Notes: The figure plots the debt price function $q(z, \bar{k}, b_n)$ for mean debt level with levels of productivity, z equal to 0.92, 0.95, 1 (mean) and 1.09.

Why does higher capital contribute to a lower default probability? There are two effects behind the accumulation of capital in the economy. On the one hand, higher capital allows for more production and hence increases the tax base, this increase in the tax base makes default less likely. Additionally, higher capital implies that in the event of default, default costs are also larger. In this model, the severity of default costs is endogenous and depends on the level of capital as it implies that the more capital you have the larger the foregone output in the case of default, so default becomes less likely. On the other hand, too much capital makes autarky a less painful state. For our calibration, this second last channel seems to be quantitatively less important. Park (2017) discusses a hump shaped relationship between spreads and the capital stock in the context of a centralized capital accumulation decision. In the next section, we study this issue in more detail.

5 The role of capital as a macroeconomic stabilizer

Capital is absent in most models of sovereign default. Yet, capital and investment are key variables in address the persistence of output and the business cycle properties. There are variants of the sovereign default models that include capital but assume a centralized decision on capital accumulation. In this section we further study role of the stock of capital in economies subject to default risk when investment is done by firms, as is usually observed in the data. As the stock of capital affects default incentives, there is an effect of private capital accumulation that is not internalized by the firm and affects the pricing of debt through a general equilibrium channel.

This section studies the pattern of capital and investment, compared to a constrained optimal allocation. We contrast our benchmark model with an alternative one that allows the government to tax or subsidize specifically the capital accumulation. In this way, increasing/decreasing tax rates over the state space implies too much/little capital in those states (over/under-investment compared to the constrained optimal allocations). Differently from revenue tax, the government decides on the investment tax in the beginning of the period before the firms make decisions. The idea here is to allow the government to incentivize investment in order to increase the price of debt.

In this alternative model, the corporate problem would be:

$$V^f(z,k,\bar{k},b_n,\tau_k) \;=\; \max_{k',x}\; (1-\tau_y)(zf(k,x)-p_x x)+(1-\delta)k-(1+\tau_k)k'-C(k',\bar{k})$$
$$+\frac{1}{1+r_f}E_{z'|z}V^f(z',k',\bar{k}',b_{\tilde{n}},\tau_k')$$

$$\textbf{s.t.} \qquad \bar{k}'=k^*(z,\bar{k},b_n,\tau_k)$$
$$b_{\tilde{n}}=\tilde{B}(z,\bar{k},b_n,\tau_k)$$
$$\tau_k=\tilde{T}_k(z',\bar{k}',b_{\tilde{n}})$$

Here, the government imposes two taxes (if positive, otherwise subsidies) to the firm, one is the profits' tax described before and the second tax is a tax on the stock of capital built in the current period. The firms' problem is the same as in the baseline model in every other aspect.

The government problem after firm decisions, conditional on the predetermined capital tax would be:

$$V(z,\bar{k},b_n,\tau_k)=\max_{\tilde{n}\in\{0,1,..,N+1\}}\{\tilde{V}(z,\bar{k},b_n,\tau_k;b_{\tilde{n}})\}$$

where the value in case no default is

$$\tilde{V}(z,\bar{k},b_n;b_{\tilde{n}})=\max_{g}\; u(c)+v(g)+\beta E_{z'|z}\Big[V(z',\bar{k}',b_{\tilde{n}})\Big]$$
$$g=q(z,\bar{k}',b_{\tilde{n}})b_{\tilde{n}}-b_n+\tau_y(zf(\bar{k},\bar{x})-p_x\bar{x})+\tau_k\bar{k}'$$
$$c=(1-\tau_y)(zf(\bar{k},\bar{x})-p_x x)-(1+\tau_k)\bar{k}'+\bar{k}(1-\delta)-C(\bar{k}',\bar{k})$$
$$\bar{k}'=k^*(z,\bar{k},b_n,\tau_k)$$

and the value when default is chosen is:

$$\tilde{V}(z,\bar{k},b_n,\tau_k;b_{N+1}) = \max_{g} \; u(c)+v(g)+\beta E_{z'|z}\Big[\theta V(z,\bar{k},b_N)+(1-\theta)V(z,\bar{k},b_{N+1})\Big]$$
$$g = \tau_y(zf(\bar{k},x)-p_x x)+\tau_k\bar{k}'$$
$$c = (1-\tau_y)(zf(\bar{k},x)-p_x x)-(1+\tau_k)\bar{k}'+\bar{k}(1-\delta)-C(\bar{k}',\bar{k})$$
$$\bar{k}' = k^*(z,\bar{k},b_n,\tau_k)$$

In the beginning of the period, the government decides on the optimal investment tax.

$$V^g(z,\bar{k},b_n) = \max_{\tau_k} \; V(z,\bar{k},b_n,\tau_k)$$

Here, we denote the debt/default policy function of the government by $\tilde{b}(z,\bar{k},b_n,\tau_k)$. The policy function for the capital is $\tilde{T}_k(z,\bar{k},b_n)$. The equilibrium price function would go through the expectations over different capital tax realizations, and the default policy conditional on that capital tax:

$$q(z,\bar{k},b_{\tilde{n}}) = E_{z'|z}\left\{\frac{1-\mathbb{I}(\tilde{b}(z',\bar{k},b_{\tilde{n}},\tilde{T}_k(z',\bar{k},b_{\tilde{n}}))=b_{N+1})}{1+r}\right\}.$$

Capital tax in the model shapes the firms' investment decisions to make it consistent with the optimization of the government as the government can use it directly to distort the firms behavior, that is, the government will use the tax on capital to make firms internalize the impact of capital accumulation on debt and spreads.

First of all, compare the first two columns of Table 4. The first column is the baseline economy and the second column is the economy with a tax to capital. First, notice that when the economy has a capital tax, the economy has a lower debt service, $E(b/y)$ decreases from -11 to -6.62 %. This is a small number as on average the optimal capital tax is 0.42%, also a minor average increase.

Interestingly, the optimal capital tax implies less default and more stable consumption and government spending on average. Nevertheless, it has a strong impact on the cyclicality properties of the model. Particularly, the capital taxes decrease when spreads are large and when output is relatively low. The government promotes investment in bad times by decreasing capital taxes. In this way, investment becomes less cyclical and positively correlates with spreads.

The capital stock increases with the optimal subsidy. Hence, there is under-investment on average in the decentralized equilibrium

Table 4: Effects of investment tax

Moment	**Baseline**	**Investment tax**		
		Overall	No signalling	Short exclusion
Def. rate	1.08	0.79	0.60	0.90
$E(b/y)$	-11.00	-6.62	-6.51	-3.29
$\sigma(c)/\sigma(y)$	0.85	0.80	0.78	0.74
$\rho(c,y)$	0.93	0.95	0.94	0.93
$E(EMBI)$	1.15	0.89	0.57	1.03
$\sigma(EMBI)$	1.32	1.21	0.64	1.49
$\rho(EMBI,y)$	-0.21	0.05	-0.18	0.03
$E(g/y)$	11.16	12.30	12.38	12.30
$\sigma(g)/\sigma(y)$	1.55	1.39	1.37	1.36
$\rho(g,y)$	0.93	0.90	0.92	0.93
$\rho(g,EMBI)$	-0.24	-0.06	-0.25	-0.06
$E(\tau_k)$	0.00	-3.93	-3.74	-3.39
$\sigma(\tau_k)$	0.00	0.82	0.79	0.71
$\rho(\tau_k,y)$		-0.49	-0.60	-0.69
$\rho(\tau_k,EMBI)$		-0.40	-0.12	-0.32
$\rho(\tau_k,z)$		-0.58	-0.69	-0.72
$E(i/y)$	7	8	7	7
$\sigma(i)/\sigma(y)$	4.27	9.90	9.56	9.06
$\rho(i,y)$	0.73	0.39	0.44	0.48
$\rho(i,EMBI)$	-0.10	0.30	0.20	0.30
$E(k/(4y))$	0.77	0.95	0.95	0.93

Notes: The table provides statistics from the benchmark, as well as the counterfactual economies with the optimal investment tax imposed by the government. The second column gives the main counterfactual. The third column exogenously forces the debt price conditional on a fixed level of capital (instead of the actual level). The fourth column is similar to the baseline counterfactual, except that the probability of redemption in the financial markets, θ, is set to double of that in the benchmark (0.564 instead of 0.282). The last column sets this probability equal to 1.

Columns labelled by "No signaling" and "Short exclusion" intend to separate two channels behind the role of capital in the economy. First, the accumulation of capital may signal international investors about the repayment capacity of the economy. This column computes the moments for a model where the international investors pricing equation depends on the average stock of capital and not on the aggregate one such that capital accumulation will not affect the equilibrium price of debt. The signaling role of capital is quantitatively relevant in stabilizing the spreads and in shaping its comovement with output. Hence, we can conclude that the accumulation of capital has a substantial impact on the behavior of international investors.

Second, the column of "Short exclusion" tries to quantify the hedging properties of the stock of capital, namely, if the economy has accumulated large amounts of capital, the value of autarky is higher as it can deliver high consumption and government spending. When exclusion is short, capital plays a smaller role of hedging. In some sense, the role of hedging seems, for this calibration, not as important as the role of capital as a signal to international investors.

Figure 8 presents the optimal capital tax dynamic around default. Note that the government finds it optimal to slightly reduce the tax burden on capital before default to induce firms to accumulate more capital. When default occurs, the tax rate on investment increases in order to contribute to consumption smoothing at the cost of a larger fall in output and higher investment volatility.

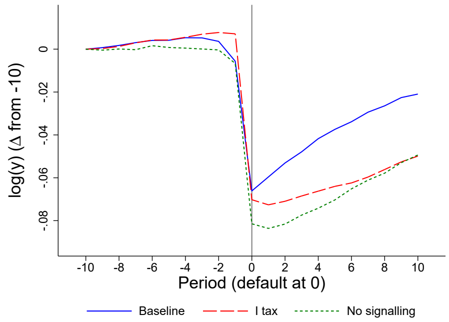
The signalling role of capital around default contributes substantially, to reduce the severity of the crisis after default occurs. As the figures plots the average behavior, economies that re-enter into capital markets after default without a signalling role of capital implies lower capital accumulation and larger output and consumption costs.

6 Final remarks

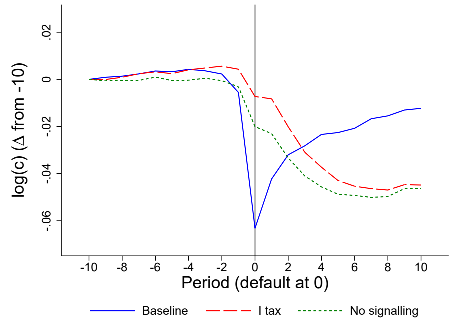
In this paper, we study the interaction between sovereign debt and default incentives with corporate investment and debt dynamics. We design a model of endogenous sovereign default and corporate investment. The model is rich enough to capture the quantitative relationship between sovereign spreads, the macro environment, and the corporate sector dynamics.

Using this model we study the impact of sovereign debt dynamics on the value of the firm and investment decisions, and vice-versa. We study the importance of the financial accelerator channel in the context of sovereign default and the role of corporate taxes. We find that default incentives impact the value of the firm. Our findings suggest that the main reason behind this

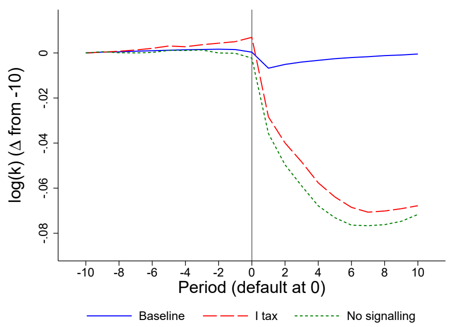
(a) Output



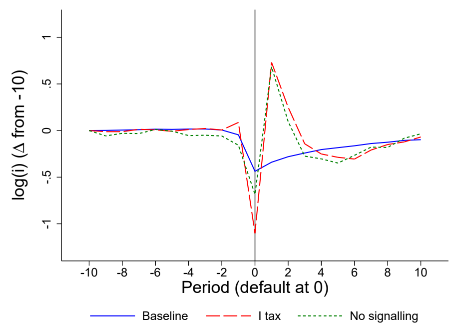
(b) Consumption



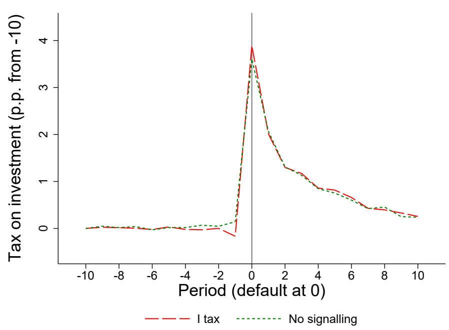
(c) Capital stock



(d) Investment



(e) Investment tax



(f) Intermediate input

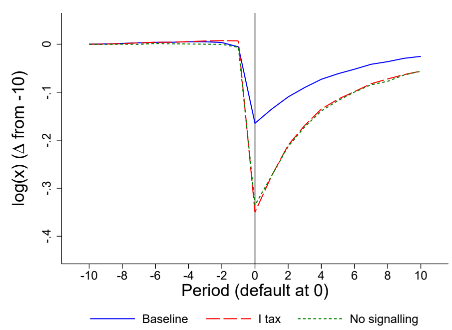


Figure 8: Patterns around default, with investment control

Notes: To construct the figures, we pick all the default events that do not have another default less than 10 periods before and after. For each $t \in \{0, 1, .., 5\}$, we take averages across these samples for each variable t period before and after the default event. We provide the details on the simulation procedure in the appendix. The blue solid line is from the benchmark. The red long-dashed line is from the counterfactual economy with the optimal investment tax imposed by the government. The green short-dashed line is also with the optimal investment tax, with the exception of exogenously forcing the debt price conditional on a fixed level of capital (instead of the actual level).

impact is that the stock of capital falls for a long horizon after the default. Moreover, default incentives induce an insurance role to the optimal tax policy implemented by the government.

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A Computational details

Solution of the model. We solve the model with a discrete debt grid of 121 points, capital grid of 61 points, productivity grid of 61, and when applies, an optimal investment tax grid of 15 points. We introduce taste shocks as in Dvorkin et al. (2021) to smooth out the problem of the government and facilitate convergence. In a nutshell, this means that the government draws a random vector of taste shocks each period, with $J = N + 1$ components, where N is the number of possible discrete debt choices and $+1$ corresponds to the additional discrete choice of default. Each component of this vector shifts the value of a different discrete choice (debt level and default). We assume a Generalized Extreme Value distribution for these shocks and set their volatility parameter as small as possible to allow convergence in all the models included in this draft.

Simulation details. To produce model moments and dynamics we simulate the model 1500 times, each simulation is for 400 periods and we discard the first 100 periods. We include all the data for all the variables except for the sovereign spreads, for which we discard the periods that the economy is in default.

B Additional moments

Table 5: Volatilities

Country	$\mu(I/Y)$ (%)	$\sigma(I/Y)$ (%)	$\mu(G/Y)$ (%)	$\sigma(G/Y)$ (%)
Argentina	19.3	3.83	13.3	1.4
Brazil	18.2	1.97	19.8	1.25
Mexico	19.3	2.6	11.5	0.9
Chile	22.3	3.17	11.5	0.8
Turkey	20.5	2.8	10.3	2.58
Malaysia	28.5	8.5	12.0	1.16

Notes: Data from SGU OEM. These are raw data ratios in LCU

Table 6: All variables Log detrended by HP filter from LCU

Country	$\sigma(C)/\sigma(Y)$	$\sigma(I)/\sigma(Y)$	$\sigma(G)/\sigma(Y)$	$\sigma(Y)\%$	$\rho(Y)$
Argentina	1.26	3.45	1.49	4.04	0.85
Brazil	1.13	3.45	1.67	2.50	0.75
Chile	0.97	2.97	1.01	2.86	0.78
Malaysia	1.53	4.32	2.47	2.69	0.80
Mexico	1.30	3.55	2.11	2.34	0.84
Turkey	1.31	3.27	2.51	3.31	0.75

Notes: Data from SGU OEM. All data is HP filtered in logs.