Sovereign and Private Default Risks over the Business Cycle*

Leo Kaas† Jan Mellert‡ Almuth Scholl§

University of Konstanz

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Abstract

Sovereign debt crises are often accompanied by deep recessions and sharp declines in external credit to the private sector. In a sample of emerging economies we find that both, sovereign and private risk premia are countercyclical and that default events are associated by strong recessions and substantial drops in imports. In our paper we present a model of a small open economy that is able to account for these empirical regularities. It includes a production sector, financing a fraction of imports by external debt, and a government which borrows internationally and taxes firms to finance expenditures for public goods. The model gives rise to endogenous private and sovereign credit spreads and a dynamic feedback mechanism from sovereign to private default risks through the endogenous response of fiscal policy to adverse productivity shocks.

JEL classification:
Keywords: Sovereign default; Risk premia

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†leo.kaas@uni-konstanz.de

‡jan.mellert@uni-konstanz.de

§almuth.scholl@uni-konstanz.de

1 Introduction

Sovereign default is a recurrent phenomena in emerging economies. Default episodes are typically associated with severe recessions, characterized by sharp drops in output, investment and imports, and often accompanied by a strong depreciation of the domestic currency. Recent empirical studies further suggest that sovereign default is followed by worsening conditions for external finance for the private sector. Arteta and Hale (2008) show that foreign credit to non-financial firms contracts sharply in the aftermath of sovereign debt crises.[1] Ağca and Celasun (2012) find that higher external sovereign debt in emerging markets translates into higher borrowing costs for the private sector, and much more so in countries that have experienced sovereign default episodes in the past. What is the explanation for these links between sovereign debt and the private sector's access to foreign credit? And how do these relations affect macroeconomic conditions around default episodes?

To address these questions, we investigate in this paper the dynamic interrelations between sovereign and private credit risks in emerging economies and their effects on macroeconomic outcomes. We first document several business cycle facts about risk premia on sovereign and private external debt and their behavior during sovereign debt crises. In line with earlier literature, we find that default crises are accompanied by an increase of sovereign and private risk premia. But while the sovereign premium increases strongly and persistently, the increase in the private premium is less pronounced and more transitory. Over the business cycle private and sovereign premia are countercyclical, which is a robust phenomenon that is independent of the inclusion of default episodes. Moreover, default events are associated with strong recessions and substantial drops in imports, see also Mendoza and Yue (2012).

We then build a dynamic, stochastic model of a small open economy to account for these observations. Our modeling approach follows the recent literature on sovereign debt in incomplete markets economies with an endogenous default choice of the government (e.g. Aguiar and Gopinath (2006), Arellano (2008)). The model has domestic households, domestic firms producing final goods and intermediate goods, a domestic government and foreign lenders. Final goods firms produce the output with imperfectly substitutable domestic and foreign intermediate goods. A fraction of imported intermediate goods must be financed by external credit. Since firms face idiosyncratic and aggregate productivity shocks, their credit is subject to default risk, so that risk-neutral international investors charge a risk premium on private

[1] See also Das et al. (2010) who obtain similar results for a broader data set.

debt. Households value private consumption, leisure and a public good provided by the government. The government acts in the interest of domestic households, it levies a linear sales tax and borrows internationally so as to smoothen the provision of the public good and to balance fluctuations in tax revenues over the business cycle. In any period, the government has the option to default on the outstanding debt, which gives rise to an endogenous risk premium on sovereign debt. In the event of default, the government is temporarily excluded from international financial markets in which case it must finance public expenditures solely from taxes. As another consequence of default, we assume that the domestic exchange rate persistently depreciates, which is in line with existing evidence (Asonuma (2014)) and with our own empirical findings. In a quantitative application to Argentina we show that our theoretical framework mimics the empirical facts of a typical emerging market economy, in particular countercyclical sovereign and private spreads, volatile imports and deep recessions in default. Moreover, fiscal policy is procyclical, in line with the empirical evidence (e.g. Talvi and Vegh (2005), Ilzetzki and Vegh (2008)), and the endogenous policy response is critical for the cyclical dynamics of private spreads in our model.

Similar to Cuadra et al. (2010), the procyclicality of fiscal policy is a direct consequence of countercyclical *sovereign default risk*. If the economy enters a recession, external public debt becomes more expensive due to the higher default risk, and this induces the government to raise taxes so as to finance public expenditures. This procyclicality of fiscal policy is the crucial amplification mechanism for countercyclical *private default risk* in our model: Higher taxes in recessions depress firms' profitability even more and induce more firms to default on their external debt. In turn, higher private spreads reduce import demand and deepen the recession. A similar mechanism is at work in a default episode where the government raises taxes when it loses access to international financial markets. The tax rise, together with the currency depreciation, drives more firms into default, raising the private premium further.

Closely related to our framework, Mendoza and Yue (2012) consider a model in which firms produce final output from domestically produced and imported intermediate goods, where the latter are partly financed by external debt (working capital).[2]

[2]The broader literature on sovereign debt in quantitative macroeconomic models considers political uncertainty (e.g. Cuadra and Sapriza (2008)), debt renegotiations (e.g. Yue (2010)), the maturity structure of debt (e.g. Hatchondo and Martinez (2009), Arellano and Ramanarayanan (2012) and Chatterjee and Eyigungor (2012)), or bailouts (e.g. Roch and Uhlig (2014), Fink and Scholl (2014), Kirsch and Rühmkorf (2013)). In all these papers, there is no credit to the private

Different from ours, however, they assume that firms are always able to borrow at the risk-free rate, which is at odds with the evidence.[3] Furthermore, all firms and the government are simultaneously excluded from international financial markets if the government chooses to default. This in turn causes firms to substitute away from imports towards domestically produced goods, generating an endogenous output cost of sovereign default which is important to account for countercyclical sovereign spreads.[4] Our model also has a contraction in imports and therefore an endogenous output cost of sovereign default, but this factual reaction does not require to shut all firms out of financial markets together with the defaulting government. Instead, we only suppose that the domestic currency depreciates by a magnitude that is typical for actual default events in developing countries. Moreover, our model has a direct impact of sovereign spreads on private spreads via the endogenous reaction of fiscal policy.[5]

We are abstracting from the role of domestically held debt, often on the balance sheet of banks, that is also discussed in the literature. For instance, in theoretical contributions based on finite–horizon economies, Brutti (2011) and Gennaioli et al. (2014) argue that sovereign default harms the balance sheets of domestic banks or private investors, which triggers contractions in credit and investment. Sosa-Padilla (2012) builds a quantitative stochastic general equilibrium model with a similar feature, showing that sovereign default and banking crises often go hand in hand. While this channel is presumably important in countries where a large share of government debt is held domestically, it may be less relevant for many emerging markets. Further, Arteta and Hale (2008) show that the decline in external credit during sovereign debt crises is concentrated in the non-financial sector, which motivates why we abstract from financial intermediaries in our model.

Besides the banking channel, a few other contributions discuss spill-over effects of sovereign default on external credit of firms. Andreasen (2012) suggests a signaling mechanism, based on the idea that the government's repayment decision provides new information regarding the institutional quality (such as recovery rates) which

sector.

[3]In an earlier working paper version (NBER Working Paper No. 17151), Mendoza and Yue (2012) assume that private firms borrow at the same rate as the government and default simultaneously which is also counterfactual.

[4]The earlier contributions of Aguiar and Gopinath (2006) and Arellano (2008) assume ad-hoc output losses after default to generate countercyclical default incentives.

[5]The tax rise in recessions, which is the crucial mechanism of our model, can also stand for other distortions that governments impose on the private sector in slump periods.

affects the financial conditions of private firms. Sandleris (2010) argues that sovereign default can trigger a collapse of private credit even when no debt is held domestically. In his model, a sovereign default reduces the firms' collateral value, which limits their borrowing capacity. Arellano and Kocherlakota (2012) propose a reverse mechanism: due to informational frictions in private credit markets, private default crises can emerge as a coordination equilibrium which possibly triggers a sovereign debt crisis. The remainder of this paper is organized as follows. In the next section, we document empirical evidence about sovereign and private credit risk in emerging market and developed economies. In 3, we describe the model framework, define the recursive equilibrium and explain the main determinants of sovereign and private default risks. In 4 we conduct a quantitative application to the Argentine economy. 5 concludes.

2 Empirical Facts on Sovereign and Private Default Risks

2.1 Cyclical Properties

In this section we document empirical regularities of private and sovereign default risks over the business cycle considering emerging market economies as well as developed economies. Our sample of emerging market economies consists of Argentina, Brazil, Chile, Ecuador, Korea, Malaysia, Mexico, Peru, Philippines, Russia and Venezuela, while our sample of developed small open economies includes Australia, Canada, Netherlands, New Zealand, Sweden and Switzerland.[6] Our sample covers the period from the early 1970s (early 1990s) until the second quarter of 2013 for the developed (emerging markets) economies. Due to data availability the sample periods for the individual countries differ in their starting and end dates; the details are provided in Appendix C.

We follow Arellano and Kocherlakota (2012) and calculate private risk premia as the spread between the dollar domestic lending rate and the interest rate on a US bond with similar maturity. If foreign currency lending rates are not available, we use the spread between the local currency domestic lending rate and the local currency

[6] The choice of countries is based on the sample analyzed by Neumeyer and Perri (2005), but we add emerging market economies for which we have at least ten years of data. Moreover, we add Switzerland to the sample of developed economies.

	$E\left(\frac{b}{y}\right)$	$E\left(\frac{b}{B}\right)$	$E(s)$	$E(s^p)$	$\sigma(s)$	$\sigma(s^p)$	$\rho(s,s^p)$	$\rho(s,y)$	$\rho(s^p,y)$
Argentina	27.58	59.85	5.97	8.45	2.75	4.81	0.87***	-0.83***	-0.79***
Brazil	11.55	33.14	4.80	39.72	3.49	9.39	0.54***	-0.59***	-0.21**
Chile	7.16	18.32	1.47	1.96	0.55	0.88	0.63***	-0.40***	-0.34***
Ecuador	52.44	68.05	9.37	7.52	3.71	1.93	0.81***	-0.39**	-0.26
Korea	2.76	9.28	1.94	1.11	1.61	0.87	0.55***	-0.75***	-0.65***
Malaysia	6.24	16.37	1.92	3.10	1.47	0.75	0.38***	-0.47***	0.06
Mexico	15.58	62.49	2.50	6.66	1.03	4.63	0.71***	-0.49***	-0.19
Peru	35.39	80.69	3.58	7.68	1.97	1.69	0.46***	-0.75***	-0.11
Philippines	28.61	60.55	3.43	4.10	1.44	1.07	-0.11	-0.75***	-0.02
Russia	11.85	29.02	3.53	6.97	2.69	2.96	0.81***	-0.53***	-0.25**
Venezuela	110.21	67.98	7.36	8.03	1.48	2.74	0.33	-0.53***	-0.21
Australia	5.75	9.04	1.92	2.63	1.50	1.78	-0.30***	-0.26***	0.20**
Canada	11.35	46.19	0.88	3.36	0.76	0.59	0.13	-0.24***	0.57***
Netherlands	36.09	12.43	-0.23	2.65	0.82	3.20	0.16	-0.09	-0.11
New Zealand	5.64	12.03	2.51	1.74	1.12	0.64	-0.16	-0.16	-0.40***
Sweden	19.47	13.98	0.75	4.27	1.54	1.24	0.81***	-0.73***	-0.91***
Switzerland	4.48	1.89	-2.88	1.91	2.17	1.50	0.34***	0.24***	-0.64***
Emerging Markets	28.12	45.98	4.17	8.66	2.02	2.88	0.54	-0.59	-0.27
Developed Economies	13.80	15.93	0.49	2.76	1.32	1.49	0.16	-0.21	-0.22

Table 1: Sovereign and Private Default Risks over the the Business Cycle

Notes: s denotes the annualized sovereign interest rate spread while s^p refers to the annualized private interest rate spread. y denotes real GDP and b is the level of public external debt. B denotes total external debt. Risk premia are demeaned and GDP is log-linearly detrended before business cycle statistics are calculated. Argentina, Ecuador, Russia and Venezuela had default episodes during the time period that we consider. To calculate business cycle statistics we exclude the default events and consider the following restricted samples: Argentina 1994.1-2001.4, Ecuador 2000.4-2008.3, Russia 2000.4-2012.3, Venezuela 1999.1 - 2004.4. Significance is denoted by stars ('*' 10%, '**' 5%, '***' 1%).

domestic deposit rate.[7] Sovereign risk premia are obtained from the Emerging Market Bond Index (EMBI). We use the risk premium calculated by JP Morgan instead of the difference between the EMBI yield to maturity and a US bond, because JP Morgan's risk premium is adjusted for different payment streams.[8]

In Table 1 we summarize the business cycle properties of sovereign and private interest spreads for our samples of emerging market and developed small open economies. To provide meaningful comparisons we exclude the default events of Argentina, Ecuador, Russia and Venezuela.[9]

The business cycle statistics reveal several empirical regularities. First, public external debt plays a more important role in emerging markets than in developed countries: Public external debt as share of GDP as well as a share of total external debt is higher in emerging markets than in developed countries. Second, the sovereign risk premium tends to be lower and less volatile than its private counterpart, both in emerging markets and developed economies. This result is in line with the hypothesis that the sovereign rating provides a ceiling to private company ratings.[10] Moreover, the risk premia paid by emerging market economies are higher than the ones paid by developed economies. Third, the sovereign interest spread is strongly countercyclical in emerging markets while the cyclical behavior is less pronounced in developed economies. Private interest rate spreads tend to be countercyclical, too, but to a lower extent compared to the sovereign spreads.

2.2 Dynamics Around Default

While our analysis of the cyclical properties of sovereign and private risk premia explicitly abstracts from default events, in the following we focus on the dynamics of key macroeconomic variables during the sovereign default episodes of Argentina

[7] For details see Table 6 in Appendix C.

[8] The difference between EMBI spreads and the difference between the EMBI yield to maturity and a five-year US bond is negligible.

[9] For Argentina we consider the no-default sample to be 1994Q1 – 2001Q4 which coincides with the time period that Arellano (2008) uses in her study. Ecuador defaulted twice in our sample, restricting the no-default period to 2000Q4 – 2008Q3. For Russia we have no data on premia before the default episode of 1998. Thus, we consider the time period 2000Q4 – 2012Q3. Venezuela experienced two domestic defaults in 1995Q3 and 1998Q3 and a technical default on its external debt obligations in 2005Q1. Therefore, the no-default sample ranges from Q1 1999 – Q4 2004. Default dates are taken from Arellano (2008), Mendoza and Yue (2012) and Sturzenegger and Zettelmeyer (2006).

[10] See also Borensztein et al. (2013) who provide further evidence on the sovereign ceiling.

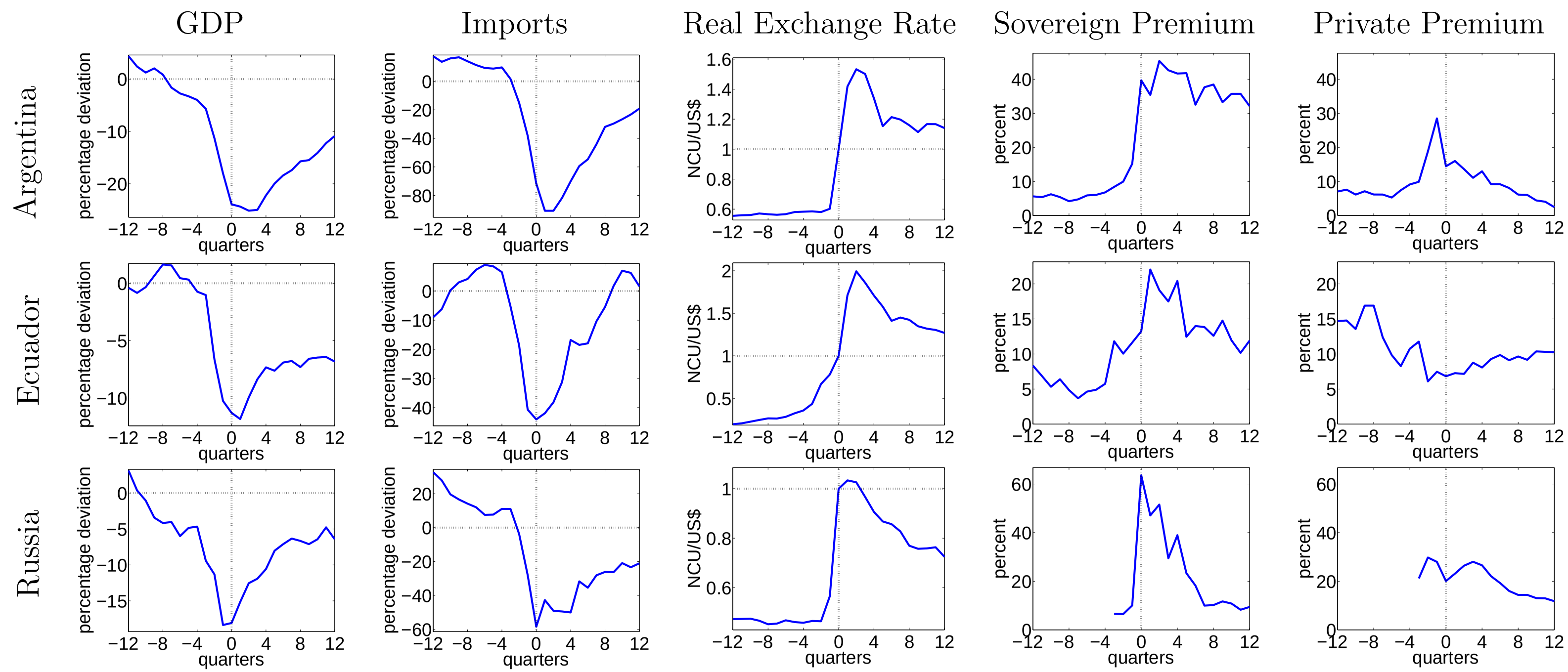

Figure 1: Default Dynamics

Notes: The figure shows the dynamic patterns of GDP, imports, the real exchange rate, the annualized sovereign premium and the annualized private premium 12 quarters before and after the default event. GDP and imports are log-linearly detrended. The real exchange rate is measured in national currency units needed to buy a basket of goods in US$ and is normalized to one in the default quarter. The sovereign premium is the EMBI Global spread, and the private premium is calculated as the difference between short-term bank credit interest rate in US$ and the 3-month US T-Bill in Argentina, and as the difference between the local currency domestic lending rate and the local currency domestic deposit rate in Ecuador and Russia.

(2002Q1), Russia (1998Q4) and Ecuador (1999Q3). We consider GDP, imports, the sovereign and private interest rate spread as well as the real exchange rate (denoted in local currency and normalized to one in the quarter of default).[11] In Figure 1 we plot the patterns of the variables twelve quarters before and after the default event in quarter $t = 0$. GDP and imports are shown as percentage deviations from a linear trend while the premia are depicted in percent.

For all three countries, we observe deep recessions and substantial drops in imports around the default events. In line with our empirical findings, Gopinath and Neiman (2013) show for Argentina that the recession in the course of the default was accompanied by a substitution of imported intermediate goods by domestic intermediate goods. Moreover, sovereign defaults are associated with strong and persistent real depreciations in all three countries. In all cases the exchange rate depreciates by more than 40% in, or one quarter after the default event. The real exchange rate persistently remains above its pre-crisis level after the sovereign default has taken place.

Finally, we observe a strong and persistent increase of the sovereign risk premium during the default episodes in all countries. In Argentina and Russia private credit costs increase as well, but the rise in the private spread is less pronounced and more transitory. These findings are in line with Ağca and Celasun (2012) who show that private credit costs increase during sovereign debt crises. For Ecuador the reaction of the private interest spread is less clear since Ecuador faced a simultaneous sovereign debt and banking crisis.

3 A Model of Sovereign and Private Default Risk

In this section we develop a stochastic dynamic general equilibrium model of a small open economy. The economy is hit by aggregate productivity shocks and has many firms who are subject to idiosyncratic productivity shocks. These firms borrow internationally and decide to default if productivity is sufficiently low, which generates an endogenous premium on private external debt. The government borrows abroad

[11] Ultimately, for the quantitative evaluation of our model, we are interested in imports of intermediate goods, but since data on them is available only on an annual basis, we use overall imports as a proxy. Following Mendoza and Yue (2012) in the definition of intermediate goods, we calculate the share of intermediate goods in imports. On average these imports account for around 58% of total imports in emerging markets and around 48% in developed economies. More details on calculations, data sources and further statistics can be found in Appendix B and Appendix C.

to smoothen the provision of a public good, and it also has the option to voluntarily default on its debt, which gives rise to a risk premium on public debt.

Our small open economy comprises four types of agents: a representative household, final goods firms, intermediate goods firms and the domestic government. Foreign investors lend to the government and to private firms.

The domestic household owns firms and supplies labor. All firms are perfectly competitive. Final goods firms produce output from two differentiated intermediate goods. One of them is an import good, the other is produced domestically by intermediate goods firms employing labor. A fraction of imported intermediate goods are financed by external private debt. After making import and borrowing decisions, final good firms are hit by idiosyncratic productivity shocks. Instead of redeeming their debt, firms can opt to default if the continuation profit is negative.

The representative household enjoys utility from consumption, leisure and from a public good. The government provides the public good, taxes sales[12] and finances deficits by issuing external debt. If the government chooses to default, it is excluded from international borrowing for a stochastic number of periods.

The timing within each period is as follows. First, aggregate productivity is realized, the government decides whether to default on its external debt and it adjusts current policies, i.e. the sales tax, expenditures for the public goods and debt issuance. Final goods firms make import decisions and borrow abroad. Intermediate goods firms hire workers and produce. Second, final goods firms are hit by idiosyncratic productivity shocks and decide whether to default or to repay their outstanding debt obligations. Active (i.e. non-defaulting) firms buy domestic intermediate goods and produce output.

3.1 Households

The representative household has preferences

$$\mathrm{E}_0 \sum_{t \geq 0} \beta^t u(c_t - v(\ell_t), g_t) \ ,$$

where c_t and g_t are consumption of the private and the public good, and ℓ_t is labor supply. $0 < \beta < 1$ denotes the rate of time preference. u is strictly increasing and concave and v is strictly increasing and convex. The household does not borrow or

[12] For simplicity, a sales tax is the only tax instrument of the government. Other distortionary taxes should have similar implications, as long as they reduce the profitability of firms.

lend internationally and thus consumes all labor and profit income. The household's budget constraint is $c_t = \Pi_t + w_t \ell_t$, where Π_t are aggregate profits and w_t is the real wage. As implied by this constraint, the before-tax price of the consumption good is normalized to unity.

3.2 Firms

Intermediate goods firms produce the domestic intermediate good from labor with linear technology $m_t = \ell_t$. Since firms operate under perfect competition, the price of the domestic intermediate good equals the real wage w_t.

Final goods firms produce output from domestic and foreign intermediate goods, m_t and m_t^*, with technology $x_t z_t f(m_t, m_t^*)$. x_t and z_t are idiosyncratic and aggregate productivity, respectively, and f has constant returns to scale and is concave. While z_t follows a Markov process and is known at the beginning of the period, idiosyncratic productivity is realized after firms make import decisions and borrow. Then x_t is drawn i.i.d. from cumulative distribution function $X(.)$. With τ_t denoting the sales tax, we write the firm's net revenue as $x_t \tilde{z}_t f(m_t, m_t^*)$ with $\tilde{z}_t \equiv (1 - \tau_t) z_t$.

Imported intermediate goods are bought at the world price p_t^*. While this price is constant in normal times, we allow it to change in response to exchange rate movements triggered by sovereign default events, which are exogenous to the model. We assume that firms must finance the fraction ξ of imports by external debt and the remaining fraction by domestic funds.[13] International credit markets are incomplete, so that external debt specifies a gross interest rate R_t which is unconditional on idiosyncratic productivity realizations and which reflects the firms' default risk. If a firm imports m_t^*, its external debt is $R_t \xi p_t^* m_t^*$. After idiosyncratic productivity x_t is realized, the firm has two options.

Either it stays in business and repays the international debt. Alternatively, the firm opts to default if the profit value $x_t \tilde{z}_t f(m_t, m_t^*) - w_t m_t - R_t \xi p_t^* m_t^*$ is negative. A continuing firm buys domestic intermediate goods proportional to imports, $m_t = \Phi(\frac{x_t \tilde{z}_t}{w_t}) m_t^*$, where Φ is an increasing function. Its profit before interest payments is also linear in m_t^*, namely $\pi(x_t \tilde{z}_t, w_t) m_t^*$, where π is increasing (decreasing) in the first (second) argument. Then, the firm defaults if $x < \overline{x}_t$ with default threshold defined by

$$\pi(\overline{x}_t \tilde{z}_t, w_t) = R_t \xi p_t^* \ . \tag{1}$$

[13] To keep the model simple, we do not distinguish between domestic equity or debt. Depending on the interpretation, default entails a loss to shareholders (or domestic creditors) equal to $(1 - \xi) p_t^* m_t^*$.

Evidently, $\overline{x}_t$ decreases in $\tilde{z}_t$ and increases in (w_t, R_t, p_t^*), but it is independent of the amount of imports. In general equilibrium, of course, there is an indirect effect of the import volume on default risk via domestic intermediate goods and labor markets.
At the beginning of the period, final goods firms choose imports m_t^* to maximize the expected profit value

$$\int_{\overline{x}_t}^{\infty} [\pi(x\tilde{z}_t, w_t) - R_t \xi p_t^*] m_t^* \; dX(x) - (1-\xi) p_t^* m_t^* \; .$$

Because this objective is linear in m_t^*, the first-order condition implies zero expected profits,

$$(1-\xi) p_t^* = \int_{\overline{x}_t}^{\infty} [\pi(x\tilde{z}_t, w_t) - R_t \xi p_t^*] \; dX(x) \; . \tag{2}$$

While some firms default, new firms may enter the economy in any period. Due to the constant-returns specification, the number of firms is irrelevant. Without loss of generality, we set the mass of firms to one and interpret m_t^* as either aggregate or firm-level imports.

3.3 International Investors and Exchange Rates

Risk-neutral international investors have access to an international bond market with constant gross interest rate $\overline{R}$. They lend to domestic firms if the expected gross return of credit equates the safe return. We assume that in the event of a private default, lenders are still able to recover a fraction η of the value of credit-financed import goods, where parameter η reflects the institutional features of the country, such as the quality of legal enforcement.
The investors' arbitrage condition therefore states that

$$\overline{R} = R_t \Big[1 - X(\overline{x}_t) \Big] + \eta X(\overline{x}_t) \; , \tag{3}$$

where $X(\overline{x}_t)$ is the default probability of final goods firms.
In line with the evidence for emerging market economies, we allow the exchange rate to depreciate in the event of a default which triggers a surge in the import price p_t^*. This assumption is in line with the empirical evidence of strong and persistent depreciations presented in section 2.2. Specifically, while the import price is a constant $p_t^* = \overline{p}^*$ in normal times, a country in a default episode faces an exchange rate that is particularly sensitive to its economic activity. Namely, we consider the possibility that the exchange rate depreciates (i.e., the import price increases) with

higher import quantities in a crisis episode. Hence, we write the import price as $p_t^* = p^*(m_t^*, s)$, where $s = N, D$ is a variable indicating whether the country is in a normal state ($s = N$) or in a default state ($s = D$), and m_t^* is the aggregate import quantity.

3.4 Private Sector Equilibrium

Note that labor supply is $(v')^{-1}(w_t)$ and that labor demand is equal to the demand for domestic intermediate goods. Thus the labor market clears in period t if

$$\int_{\overline{x}_t}^{\infty} \Phi\Big(\frac{x\tilde{z}_t}{w_t}\Big) m_t^* \; dX(x) = (v')^{-1}(w_t) = \ell_t \ . \tag{4}$$

Households consume all their income, and since aggregate profit income is zero,

$$c_t = w_t \ell_t \ . \tag{5}$$

Given current aggregate productivity z_t and the sales tax τ_t, and hence $\tilde{z}_t = (1-\tau_t)z_t$, the private-sector equilibrium $(w_t, \overline{x}_t, \ell_t, R_t, m_t^*, c_t)$ solves the six equations[14] (1)–(5), where $p_t^* = p^*(m_t^*, s)$ and $s \in \{N, D\}$. We write $c_t = \mathcal{C}(\tilde{z}_t, s)$ and $\ell_t = \mathcal{L}(\tilde{z}_t, s)$ for equilibrium consumption and employment, and we assume that a solution of the private-sector equilibrium exists for the range of admissible values for z_t and τ_t.[15] We further write aggregate output as $y_t = \mathcal{Y}(z_t, \tau_t, s)$, which is

$$y_t = \int_{\overline{x}_t}^{\infty} x z_t f\Big(\Phi\Big(\frac{x\tilde{z}_t}{w_t}\Big), 1\Big) m_t^* \; dX(x) \ , \tag{6}$$

and we denote the private sector interest rate by $R_t = \mathcal{R}(\tilde{z}_t, s)$.
Because of our assumption that private credit is repaid at the end of the period, the private sector equilibrium does not depend on any endogenous state variables, such as the firms' net worth, which greatly simplifies the model. Including such state variables would complicate the solution of the model considerably, as it would involve intertemporal decisions of firms that have to forecast future tax policies of the government.

[14]Equation (1) presupposes default in equilibrium. There can also be a boundary solution where $\overline{x}$ is at the infimum of the support of $X(.)$ and (1) holds with inequality.

[15]We also make sure that the equilibrium interest rate is the stable solution of equation (3); namely, deviations to a lower rate may not raise investors' expected return. This requirement is meaningful because (3) typically has two solutions, the larger of which is unstable.

3.5 The Government

The government maximizes expected utility of the representative household without commitment over future policy choices. At the beginning of period t it decides whether to default on its external debt obligation b_t. If it does so, it is excluded from international borrowing in the default period. In any future period, it regains access to international credit with exogenous probability θ. In a period of market exclusion, the government finances expenditures for the public good by the sales tax revenues, $g_t = \tau_t y_t$. If the government can borrow internationally, it issues new debt b_{t+1} at price $q(b_{t+1}, z_t)$, facing the flow budget constraint $g_t = \tau_t y_t - b_t + q(b_{t+1}, z_t)b_{t+1}$. The price of debt reflects the default-risk adjusted rate of return of foreign lenders. The government takes the private sector's responses as given.

The relevant state variables for the government at the beginning of any period are (z, b, s), with $s \in \{N, D\}$. The government's value function in any period with access to international financial markets is

$$V(z, b, N) = \max \left\{ V^N(z, b), V^D(z) \right\} , \tag{7}$$

where V^N (V^D) are continuation utilities after no default (default). If the government stays solvent, the recursive formulation of its problem is

$$V^N(z, b) = \max_{g,\tau,b_+} u(c - v(\ell), g) + \beta \mathrm{E}_z V(z_+, b_+, N) , \tag{8}$$

subject to

$$g = \tau y - b + q(b_+, z)b_+ ,$$

$$c = \mathcal{C}((1 - \tau)z, N), \ \ell = \mathcal{L}((1 - \tau)z, N), \ y = \mathcal{Y}(z, \tau, N) .$$

The first condition is the budget constraint of the government. The other three equations express the private-sector equilibrium in reduced form.

If the government has defaulted in some period and is excluded from international bond markets, the recursive problem is

$$V^D(z) = \max_{g,\tau} u(c - v(\ell), g) + \beta \mathrm{E}_z \Big[\theta V(z_+, 0, N) + (1 - \theta) V^D(z_+) \Big] , \tag{9}$$

subject to $g = \tau y$ and

$$c = \mathcal{C}((1 - \tau)z, D), \ \ell = \mathcal{L}((1 - \tau)z, D), \ y = \mathcal{Y}(z, \tau, D) .$$

The set of default states is

$$\Sigma^D = \left\{ (z, b) \mid V^D(z) > V^N(z, b) \right\} . \tag{10}$$

The government's default probability is

$$\lambda(b_+, z) \equiv \text{Prob}\Big((z_+, b_+) \in \Sigma^D \Big| z\Big) \ .$$

International investors lend to the government if[16]

$$q(b_+, z) = \frac{1 - \lambda(b_+, z)}{\overline{R}} \ . \tag{11}$$

The bond price function reflects the endogenous sovereign default risk.

3.6 Equilibrium Definition

Definition: *A recursive equilibrium is given by*

(i) *value functions* $V(z, b, s)$, $V^D(z)$, $V^N(z, b)$ *and policy functions* $b_+ = \mathcal{B}(z, b, s)$, $\tau = \mathcal{T}(z, b, s)$, $g = \mathcal{G}(z, b, s)$ *of the government, solving problems (7)–(9), and a default set* Σ^D *satisfying (10).*

(ii) *a pricing function* $q(b_+, z)$ *satisfying the arbitrage condition of foreign lenders (11).*

(iii) *a private sector equilibrium, defining consumption* $c = \mathcal{C}(z(1-\tau), s)$*, employment* $\ell = \mathcal{L}(z(1-\tau), s)$*, output* $y = \mathcal{Y}(z, \tau, s)$*, and the private interest rate* $R = \mathcal{R}(z(1-\tau), s)$ *for* $s = N, D$*, satisfying (1)–(5).*

A solution to a recursive equilibrium specifies optimal plans for the government and for all private agents in this economy. It includes situations with and without sovereign default. The bond pricing function and the private sector interest rate reflect the risk premia associated with optimal default choices of the government and of the private sector.

[16] While the government borrows at the end of period $t-1$ to repay debt in period t, domestic firms borrow within period t. For foreign investors, this difference is irrelevant as long as both loans have the same maturity (i.e. one model period). Even if there was a (small) difference in maturity, this would be reflected in the respective arbitrage conditions, with no further implications for any of our results.

4 Quantitative Analysis

In this section we solve the model numerically to study its quantitative properties. We apply the model to Argentina which is often used as the benchmark for studies on sovereign default given its default history and data availability. We calibrate the model at quarterly frequency and choose parameters to match several empirical targets.

4.1 Calibration

4.1.1 Functional Forms

We choose a CES production function of final goods:

$$f(m, m^*) = \Big[(1-\omega)(m^d)^\rho + \omega(m^*)^\rho\Big]^{1/\rho} \,,$$

with $\rho < 1$ and $\omega \in (0,1)$. This implies that the demand for domestic input per unit of foreign input is

$$\Phi(q) = \omega^{1/\rho}\Big[(q(1-\omega))^{\frac{\rho}{\rho-1}} - 1 + \omega\Big]^{-1/\rho} \,,\ q = \frac{x\tilde{z}}{w} \,.$$

Profits (before interest) per unit of imports are

$$\pi(x\tilde{z}, w) = w\Big(\frac{\omega}{1-\omega}\Big)^{1/\rho}\Big[\Big(\frac{x\tilde{z}}{w}\Big)^{\frac{\rho}{\rho-1}}(1-\omega)^{\frac{1}{\rho-1}} - 1\Big]^{\frac{\rho-1}{\rho}} \,.$$

Both Φ and π are defined for $q = x\tilde{z}/w < (1-\omega)^{-1/\rho}$ if $\rho > 0$ and for $q = x\tilde{z}/w > (1-\omega)^{-1/\rho}$ if $\rho < 0$.

Idiosyncratic productivity is uniformly distributed in the interval $[1-\zeta, 1+\zeta]$, so that $X(x) = \frac{x-1+\zeta}{2\zeta}$.

We employ the GHH preferences (Greenwood et al. (1988)):

$$u(c, l) = \frac{\Big(c - \frac{\psi}{1+\psi}\ell^{\frac{1+\psi}{\psi}}\Big)^{1-\gamma}}{1-\gamma} + \alpha\frac{g^{1-\gamma}}{1-\gamma},$$

where $\gamma > 0$ denotes the parameter of relative risk aversion and $\psi > 0$ is the Frisch elasticity of labor supply. Note that this specification implies that the marginal rate of substitution between private consumption and labor is independent of consumption. $\alpha \geq 0$ is a preference weight.

Aggregate productivity is assumed to follow an AR(1) process:

$$\log(z_t) = \varphi\log(z_{t-1}) + \varepsilon_t,$$

with ε_t is i.i.d. $N(0, \sigma_\varepsilon^2)$.

Parameter		Value	Target/Source
Frisch elasticity	ψ	2.2	Mendoza and Yue (2012)
Risk aversion	γ	2	standard value
Weight on public good	α	2.5	government consumption share
Weight on imports	ω	0.38	Mendoza and Yue (2012)
CES curvature	ρ	0.65	Mendoza and Yue (2012)
Share of credit-financed imports	ξ	0.7	Mendoza and Yue (2012)
Import price	p^N	0.48	import share
Risk-free rate	$\overline{R}$	1.01	standard value
Discount factor	β	0.91	sovereign spread
Reentry probability	θ	0.20	Aguiar and Gopinath (2006), Arellano (2008)
Depreciation after default	p^D/p^N	1.20	exchange rate depreciation in default
Recovery rate	η	0.82	volatility of private spread
Dispersion of idios. shocks	ζ	0.086	private spread
Persistence of z	φ	0.95	autocorrelation of output
Variance of z shocks	σ_ε	0.009	volatility of output

Table 2: Parameter Choices

4.1.2 Parameters

All calibrated parameters and the associated targets and sources are listed in Table 2. The parameters of the CES production function ω and ρ are set at the same values as in Mendoza and Yue (2012), $\omega = 0.38$ and $\rho = 0.65$.

The Frisch elasticity is chosen to be 2.2 which is a standard value in international macroeconomics (see also Mendoza and Yue (2012), Neumeyer and Perri (2005) and Cuadra et al. (2010)). The coefficient of risk aversion is set to $\gamma = 2$.

The share of credit-financed imports is set to the same value as the related parameter in Mendoza and Yue (2012). While Mendoza and Yue (2012) calibrate this parameter to target a 6% share of working capital in GDP, we note that this share is only moderately higher (about 9%) in our model. Lower values of ξ have little effects on our quantitative results.

The choice of the risk-free interest rate corresponds to a standard value in international macroeconomics. The import price in normal times is set to a value that matches a 12% share of imports in Argentine GDP. The parameter ζ which determines the variance of idiosyncratic productivity shocks is chosen to match an annual average private spread of about 8 percent. Since the recovery rate η is critical for the response of the private interest rate with respect to changes in fundamentals, we calibrate this parameter to match the standard deviation of private spreads.

We calibrate a 20% depreciation of the domestic currency in a default event which is in line with the strong real depreciation shown in Section 2.2. We assume that the probability of re-entering international financial markets after a default equals 0.20 which is in the range of what Aguiar and Gopinath (2006) and Arellano (2008) consider. The discount factor β is set to 0.91 to match the annual sovereign private spread.

4.2 Results

In this section we study the quantitative properties of our simulated model economy. First, we analyze the properties of the policy functions to highlight the main economic mechanism that drives the interaction between sovereign and private default risks. Second, we perform an event study and explore the macroeconomic dynamics before and after a sovereign default. Third, we discuss the business cycle properties of the simulated model economy.

4.2.1 Policy Functions

We first shed light on the optimal decision of the government regarding whether to repay or to default on its outstanding external debt and the implied sovereign credit costs. In Figure 2 we consider realizations of aggregate productivity between $\pm$ 4% and show optimal debt and tax policies together with the associated quarterly private interest rate spreads.

The upper left panel of Figure 2 shows the sovereign bond price $q(z, b_+)$. It is evident that, first, the bond price is increasing in debt. For very low levels of debt the government always repays and the bond price is equal to the inverse of the risk-free rate. Higher debt obligations make repayment less attractive and foreign creditors incorporate the rising sovereign default probability in their pricing decision and charge a larger risk premium on public debt. Second, the bond price decreases if the economy is hit by adverse aggregate productivity shocks. The economic intuition is straightforward: Since a government is less able to service its external debt in bad times, the sovereign premium reflects the increased risk of a sovereign default.

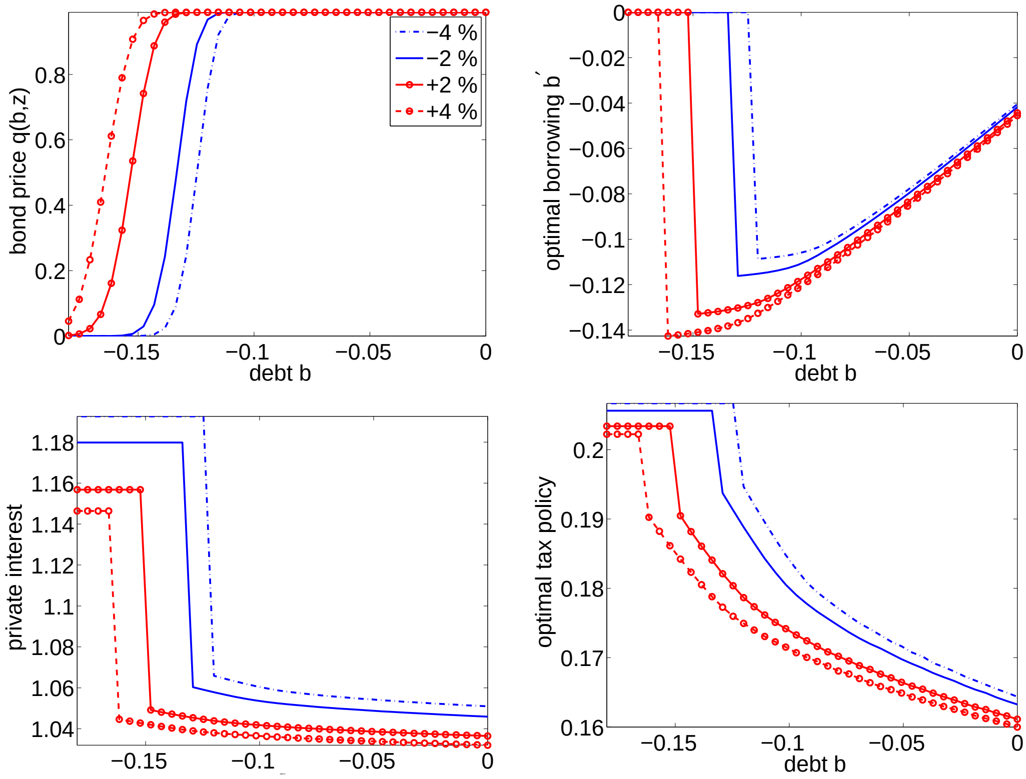

Figure 2: Policy Functions

Notes: This figure shows the sovereign bond price function $q(b_+, z)$, debt policy $\mathcal{B}(z, b, s)$, tax policy $\mathcal{T}(z, b, s)$ and the quarterly private interest rate $\mathcal{R}(z(1-\tau), p^s)$ for realizations of aggregate productivity between $\pm 4\%$.

The upper right panel of Figure 2 shows the government's debt policy. For high levels of public external debt and in times of recessions the government becomes borrowing constrained due to high external credit costs. The lower right panel reveals that the optimal sales tax is increasing in debt and decreasing in aggregate productivity. This pattern implies that fiscal policy is procyclical: in times of recessions the government becomes borrowing constrained and raises higher taxes to finance public expenditures. In recessions the tax rise amplifies private default risk and increases the quarterly private interest rate which is shown in the lower left panel of Figure 2. The theoretical prediction regarding the cyclical properties of taxes is in line with the broad empirical literature that shows that developing countries and emerging market economies are characterized by procyclical fiscal policies, see e.g. Talvi and Vegh (2005), Ilzetzki and Vegh (2008).

4.2.2 Dynamics Around Default

To understand the interaction of sovereign and private default risk and their impact on macroeconomic outcomes, we perform an event study and show the dynamics of the economy eight quarters before and after a sovereign default. We assume that the government is in a good credit standing in $t < 0$ but defaults at date $t = 0$. In Figure **??** we show the percentage deviations from a linear trend for output, labor, consumption, imports and public expenditures while we consider the tax rate as well as the sovereign and private spread in percent.

The dynamic patterns suggest that the economy is in a recession prior to a sovereign default. Low output raises the risk of a sovereign default which is reflected by the sovereign interest spread in the quarters before the default takes place. Due to high credit costs, the government becomes borrowing constrained and raises the tax rate to finance public expenditures. Higher taxes in a recession lower the profitability of private firms so that the risk of private default risk increases. Foreign creditors incorporate the default risk in their pricing decision and charge a larger risk premium on private external debt. In turn, import demand falls and the recession deepens.

When the government defaults on its outstanding external debt obligations at quarter $t = 0$, it loses access to international financial markets and faces a severe real depreciation. Since no external debt can be issued, the government has to fully finance its public expenditures via taxes. This translates into a tax increase but also into a cut of public expenditures. The additional tax rise together with the real depreciation fosters private default risk so that the private risk premium substantially

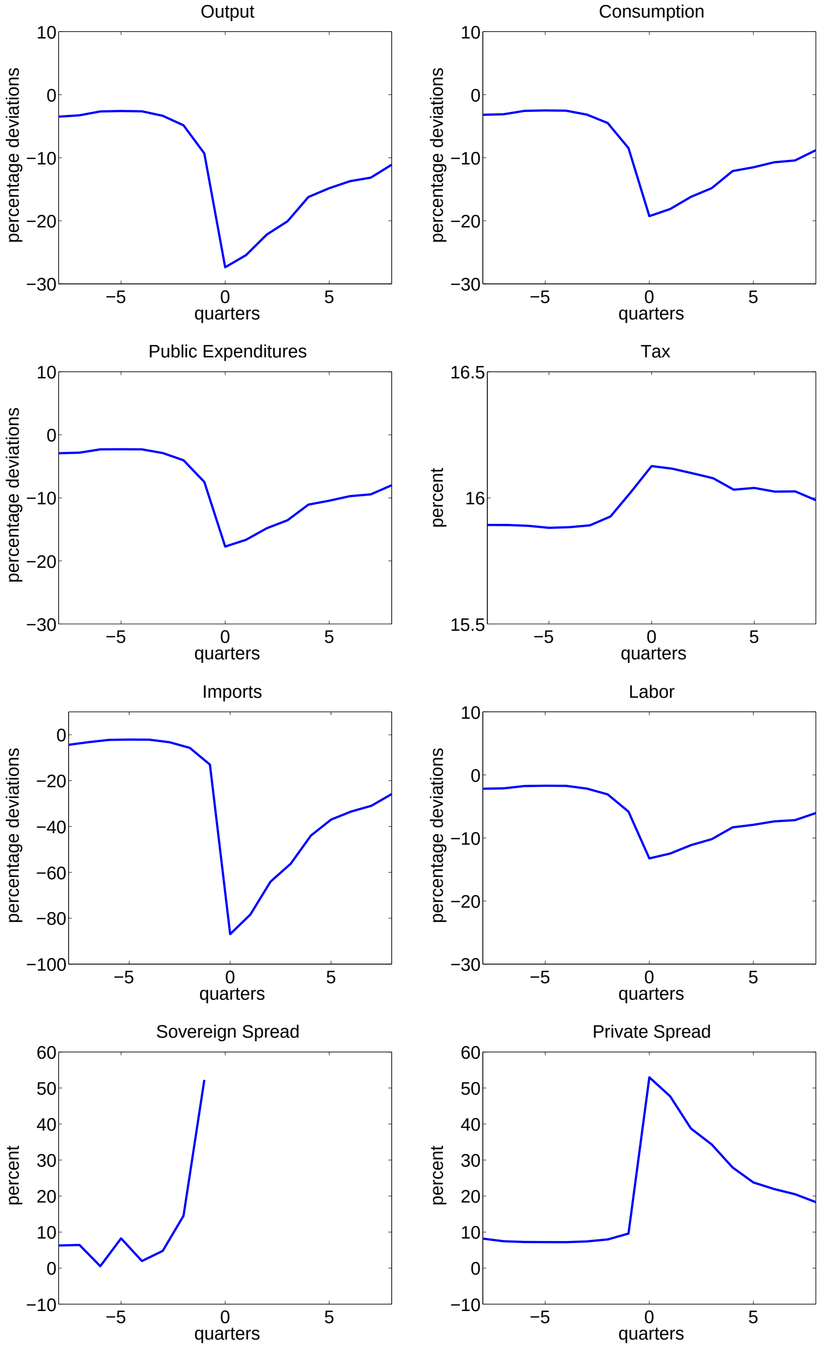

Figure 3: Default Event

Notes: This figure shows the dynamic pattern of output y, consumption c, labor l, public expenditures g, imports m, taxes τ, the annualized sovereign spread s and the annualized private spread s^p eight quarters before and after a default. The government is in a good credit standing in $t<0$ and defaults at quarter $t=0$. All variables are shown as percentage deviations from their linear trend, except the tax rate and the premia which are shown in percent, based on a simulation of 10 000 quarters where the first 1000 quarters are discarded. For all variables the mean values are shown.

increases and import demand strongly falls. Overall, default is associated with a deep recession accompanied by substantial reductions in private consumption.

Our model predicts a 30% drop in output while consumption decreases by 20% from its long-run linear trend at the time of a default. Imports are reduced by 80% and interest spreads increase by approximately 40–50%. These quantitative predictions are in line with the empirical evidence shown in Figure 1 in Section 2.2. Note that our theoretical model assumes that after a default the government is excluded from international financial markets so that the sovereign premium is infinite. The increase in the private premium, however, is of a more transitory nature which is in line with the empirical pattern of the private premium in Argentina after the sovereign default has taken place in 2001.

4.2.3 Business Cycle Statistics

In Table 3 we show the business cycle properties implied by our theoretical framework. We report the statistical moments based on simulated time series that exclude default events. All variables are logged before they are linearly detrended, except the tax rate, the sovereign premium and the private premium.

A comparison of the simulated and the empirical cyclical properties reveals that our model captures fairly well the overall macroeconomic volatility as well as the co-movements between the variables. In particular, the model replicates the countercyclical patterns of the sovereign and private spreads as well as the procyclicality of consumption, imports and public expenditures.

The model also mimics the empirical fact that imports are more volatile than output although it slightly understates the standard deviation compared to the Argentine data. While the model replicates the volatility of the private premium, it overstates the standard deviation of the sovereign premium by a factor of six. The high volatility of sovereign credit costs is due to the occurrence of 'near default states' in which adverse realizations of aggregate productivity substantially increase the default risk so that foreign creditors charge substantial sovereign premia. In spite of high credit costs, the government finds it still optimal to repay since the exclusion from international financial markets as well as the real devaluation pose severe punishments.

Our theoretical framework mimics the mean values of the import share, the share of public expenditures as well as the sovereign and private spreads. The average public external debt share equals 14% which is well below the empirical debt share of 27%. It is a well known feature of sovereign debt models that they predict default at too

	Argentina	Model
$\sigma(y)$	4.94	5.85
$\sigma(c)/\sigma(y)$	1.05	0.85
$\sigma(g)/\sigma(y)$	0.47	0.77
$\sigma(m)/\sigma(y)$	3.09	2.05
$\sigma(s)$	2.75	18.57
$\sigma(s^p)$	4.81	4.38
$\rho(c, y)$	0.99	0.99
$\rho(g, y)$	0.64	0.99
$\rho(m, y)$	0.95	0.93
$\rho(s, y)$	-0.85	-0.10
$\rho(s^p, y)$	-0.80	-0.67
$\mathrm{E}(s)$	5.97	3.58
$\mathrm{E}(s^p)$	8.45	6.46
$\mathrm{E}(b/y)$	-27.59	14.10
$\mathrm{E}(m/y)$	11.86	13.10
$\mathrm{E}(g/y)$	12.89	11.32

Table 3: Business Cycle Statistics

Notes: This table reports the business cycle statistics of output y, consumption c, labor l, public expenditures g, imports m, the annualized sovereign spread s and the annualized private spread s^p. All variables are logged except taxes and premia before they are linearly detrended. Statistics of the theoretical model refer to a simulation of 10 000 quarters where the first 1000 quarters are discarded. Default episodes (including one quarter before the default event and the subsequent quarters without external borrowing) are excluded.

low debt levels. While this criticism also applies to our theoretical framework, the average debt level is substantially higher than in standard models that do not allow for private credit risks, see e.g. Arellano (2008).

5 Conclusions

In this paper we analyze how sovereign and private default risks interact. We develop a stochastic general equilibrium model of a small open economy featuring endogenous private and sovereign default risks. In our model, private sector firms use imperfectly substitutable domestic and imported intermediate goods to produce a final consumption good, where part of the imports need to be financed by external debt. The economy also features a benevolent government supplying a public good, financed by taxing the firms and borrowing from abroad. The model can account for several empirical regularities in emerging market economies, namely countercyclical private and sovereign risk premia, procyclical fiscal policy, and deep recessions with large drops in imports during default events.

Our results suggest that fiscal policy creates a link between sovereign and private default risks and provides an amplification mechanism reinforcing the effects of adverse productivity shocks. Whenever the government faces higher borrowing costs in a recession it raises taxes so as to reduce external credit costs, which decreases firms' profitability and leads to higher private default risk. In turn, firms cut their demand for imported inputs which deepens the recession.

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Appendix A: Numerical Algorithm

The private-sector equilibrium can be calculated on a grid for (z, τ, s), $s = N, D$ without knowing the government's policy functions. These solutions are used to solve for the government's problem and the risk-neutral pricing of government bonds via value function iteration.

The numerical algorithm builds on Hatchondo et al. (2010) and employs cubic spline interpolations so that optimal policies are chosen from a continuous set and productivity realizations are allowed that do not lie on the grid. We approximate the equilibrium as the equilibrium of the finite-horizon economy and iterate simultaneous on the value and the bond price functions.

We define evenly distributed grid vectors for bond holdings $b \in [\underline{b}, \bar{b}]$ and productivity realizations $z \in [\underline{z}, \bar{z}]$. Let $V^{N(0)}(z, b)$ and $V^{D(0)}(z)$ denote the initial guesses for the value functions. For every grid point $(z, b) \in [\underline{b}, \bar{b}] \times [\underline{z}, \bar{z}]$ and given the initial guesses $V^{N(0)}(z, b)$ and $V^{D(0)}(z)$ we first find candidate values for $\tau^{(0)}$ and $b_+^{(0)}$ by employing a global search procedure. These candidate values are then taken as initial guesses for the FORTRAN optimization routine BCPOL from the IMSL library to find $\tau^{(0)}$ and $b(0)_+$ via (8), (9) where $V_{(0)}^0(z, b, s)$ satisfies equation (7). Given the initial guess, equations (10) and (11) determine the the default probability $\lambda^{(0)}(z, b_+^{(0)})$ and the bond price function $q^{(0)}(z, b_+^{(0)})$, respectively. Expected continuation values are computed using gauss-hermite quadrature points and weights. To evaluate the expected continuation values for policies and productivity realizations that do not lie on the grid we employ cubic spline interpolations using the FORTRAN CSDEC routine from the IMSL library. The solutions found at each grid point are used to update the value functions $V^{N(1)}(z, b)$ and $V^{D(1)}(z)$. We iterate until the value functions converge.

Appendix B: Further Empirical Findings

Table 4 reports the business cycle statistics of the countries contained in our sample. Default episodes are excluded. We observe that emerging market economies are more volatile than developed economies. Emerging markets also show excess volatility of private and government consumption, whereas in developed economies only government consumption is more volatile than GDP on average. Furthermore, in both country groups imports and exports are on average two to three times more volatile than GDP. Our observations are in line with results found by Neumeyer and

Perri (2005).

	σ(y)	$\frac{\sigma(c)}{\sigma(y)}$	$\frac{\sigma(g)}{\sigma(y)}$	$\frac{\sigma(m)}{\sigma(y)}$	$\frac{\sigma(x)}{\sigma(y)}$
Argentina	4.94	1.05	0.47	3.09	1.49
Brazil	3.22	1.57	0.92	5.67	3.11
Chile	2.65	1.62	1.30	3.74	2.79
Ecuador	1.93	0.66	0.85	2.98	2.47
Korea	13.08	0.89	0.45	1.13	0.93
Malaysia	4.89	1.23	1.74	2.50	2.68
Mexico	3.05	1.26	1.12	4.48	3.61
Peru	14.34	0.81	1.53	1.70	1.32
Philippines	7.57	0.62	1.71	2.22	1.45
Russia	5.25	1.00	1.13	2.86	1.52
Venezuela	7.71	0.73	0.59	2.59	1.53
Australia	2.35	1.07	1.15	4.71	4.16
Canada	3.22	0.80	1.20	2.85	4.76
Netherlands	4.07	1.37	0.64	1.76	1.60
New Zealand	3.65	1.04	1.02	2.05	1.54
Sweden	3.07	0.60	0.41	2.57	3.01
Switzerland	2.22	0.60	2.67	2.27	2.49
Emerging Markets	6.24	1.04	1.07	3.00	2.08
Developed Economies	3.10	0.91	1.18	2.70	2.93

Table 4: Business cycle statistics.

Notes: y refers to real GDP, c and g denote real consumption and real public expenditures, respectively. m and ex are real imports and exports. All time series are log-linearly detrended.

Appendix C: Data Sources and Calculations

The sample of emerging markets economies is chosen according to JP Morgan's characterization and data availability. More precisely, we restrict the sample of countries to include countries for which at least 10 years of quarterly data are available until 2013Q2. Korea is the only exception from this rule. We add Korea because it is also in the sample of Neumeyer and Perri (2005).

All data is taken from national sources if available, otherwise we use data from international organizations. Only in cases where no other source was available we use commercial data providers like Oxford Economics. Detailed information on data sources and adjustments are summarized in the tables below.

When data are not seasonally adjusted, we employ the Census X12 method from the U.S. Census Bureau. Furthermore most nominal time series are deflated using the GDP deflator. For imports and exports we use the import and export price deflators.

For the calculation of correlations and volatilities we are interested in the cyclical components of the respective series. In order to get the cyclical components of GDP and imports, we subtract a linear trend from the logged series. For the risk premia the raw series are demeaned.

We follow Neumeyer and Perri (2005) and Arellano and Kocherlakota (2012) and use the emerging markets sovereign premia provided by JP Morgan. For developed economies sovereign premia are calculated by subtracting the medium term US bond yield from the respective countries' medium term bond interest rate.

In most cases private premia are calculated by subtracting the local currency deposit rate from the lending rate. Whenever the US$ lending rate is available, a US government debt interest rate with similar maturity is used as the risk-free rate[17].

Tables 5 and 6 give more details on data sources and transformations, where 'SA' stands for 'seasonally adjusted' and 'R' denotes series transformed into real terms.

In order to show that total imports are an acceptable proxy for intermediate good imports we calculate their share in total imports. In this we follow Mendoza and Yue (2012) and define intermediate goods imports as all imports falling into the following product categories of the COMSTAT dataset: (111*) Food and beverages, primary, mainly for industry; (121*) Food and beverages, processed, mainly for industry; (21*) Industrial supplies not elsewhere specified, primary; (22*) Industrial supplies not elsewhere specified, processed; (31*) Fuels and lubricants, primary; (322*) Fuels and lubricants, processed (other than motor spirit); (42*) Parts and accessories of capital goods (except transport equipment); (53*) Parts and accessories of transport equipment. On average these imports are responsible for around 58% of total imports in emerging economies and around 48% in developed economies.

The real exchange rate series depicted in the event studies are calculated from IFS data. We adjust the nominal exchange rate $\left(\frac{\text{NCU}}{\text{US\$}}\right)$ for differences in the inflation rates by multiplying $\frac{\text{CPI}_{\text{USA}}}{\text{CPI}_{\text{LC}}}$. This implies that an increase in the index corresponds

[17]See table 6 for a detailed description of how the risk premia are calculated.

to a real devaluation of the currency.

Country	Data Source	Sample	Currency	Adjustment	Basis Year Deflator	Information
Argentina	Ministero de Economica y Production MECON	Q1 1993-Q2 2013	NCU		1993	
Brazil	Instituto Brasileiro de Geografia e Estatistica	Q1 1995 - Q2 2013	NCU	SA	2005	
Chile	OECD Outlook	Q1 1995-Q2 2013	NCU		2008	GDP deflator is calculated from nominal and real GDP.
Ecuador	Banco Central del Ecuador	Q1 1990-Q1 2012	US-$	SA	2000	Discontinued after Q1 2012
Korea	Bank of Korea	Q2 1972-Q2 2013	NCU		2005	
Malaysia	Department of Statistics, Malaysia	Q1 1991-Q2 2013	NCU	R	2005	GDP deflator is taken from Oxford Economics.
Mexico	Instituto Nacional de Estadistica, Geografia e Informatica, Mexico	Q1 1993-Q2 2013	NCU		2008	
Peru	Central Reserve Bank of Peru	Q1 1980-Q2 2013	NCU	SA	1994	GDP deflator is calculated from nominal and real GDP.
Philippines	National Statistical Coordination Board (NSCB), Philippines	Q1 1981-Q2 2013	NCU	SA,R	2000	
Russia	Federal State Statistics Service, Russia	Q4 1999-Q2 2013	NCU	SA,R	2005	GDP deflator is taken from Oxford Economics.
Venezuela	Banco Central de Venezuela	Q1 1998-Q2 2008	NCU	SA	1997	GDP deflator is taken from Oxford Economics.
Australia	Australian Bureau of Statistics	Q2 1972-Q2 2013	NCU		2011-12	
Canada	Statistics Canada (CANSIM)	Q1 1981-Q2 2013	NCU		2007	
Netherlands	Statistics Netherland (CBS)	Q1 1988-Q2 2013	NCU		2005	
New Zealand	Statistics New Zealand	Q2 1987-Q2 2013	NCU		1995-96	
Sweden	Statistics Sweden	Q1 1993-Q2 2013	NCU		2012	
Switzerland	State Secretariat for Economic Affairs (SECO), Switzerland	Q1 1980-Q2 2013	NCU		2005	

Table 5: Data Sources for GDP and Imports.

Country	Data Source Sovereign Premium	Sample Sovereign Premium	Sample Lending Rate	Sample Deposit Rate	Lending Rate	Risk Free Rate
Argentina	JP Morgan, EMBI Global	Q1 1994- Q2 2013	Q2 1993- Q2 2013	Q2 1993- Q2 2013	US$ denominated with 30 days maturity.	US-Bond with 3 month maturity.
Brazil	JP Morgan, EMBI Global	Q3 1994- Q2 2013	Q1 1997 - Q2 2013	Q4 1982- Q2 2013	Domestic currency with average maturity.	Domestic currency borrowing rate with average maturity.
Chile	JP Morgan, EMBI Global	Q3 1999- Q2 2013	Q3 1992- Q2 2013	Q3 1992- Q2 2013	US$ denominated with 30-89 days maturity.	US-Bond with 3 month maturity.
Ecuador	JP Morgan, EMBI Global	Q2 1995- Q2 2013	Q1 1980- Q3 2008	Q1 1983- Q4 2011	Domestic currency with 90-172 days maturity.	Domestic currency borrowing rate with 30-83 days maturity.
Korea	JP Morgan, EMBI Global	Q1 1994- Q3 2002	Q3 1980- Q2 2013	Q2 1972- Q2 2013	Domestic currency with maturity less 1 year.	Domestic currency borrowing rate with maturity 1-2 years.
Malaysia	JP Morgan, EMBI Global	Q1 1997- Q2 2013	Q4 1986- Q2 2013	Q2 1972- Q2 2013	Domestic currency with 3 month maturity.	Domestic currency borrowing rate with average maturity.
Mexico	JP Morgan, EMBI Global	Q1 1994- Q2 2013	Q4 1993- Q2 2013	Q1 1976- Q2 2013	Domestic currency with unknown maturity.	Domestic currency borrowing rate with 60 days maturity.
Peru	JP Morgan, EMBI Global	Q2 1997- Q2 2013	Q1 1992- Q2 2013	Q1 1992- Q2 2013	US$ denominated with maturity less than 1 year.	US-Bond with 3 month maturity.
Philippines	JP Morgan, EMBI Global	Q1 1998- Q2 2013	Q1 1976- Q2 2013	Q1 1976- Q2 2013	Domestic currency with average maturity.	Domestic currency borrowing rate with 61-90 days maturity.
Russia	JP Morgan, EMBI Global	Q1 1998- Q2 2013	Q1 1998- Q2 2013	Q1 1998- Q2 2013	Domestic currency with less than 1 year maturity.	Domestic currency borrowing rate with less than 1 year maturity.
Venezuela	JP Morgan, EMBI Global	Q1 1994- Q2 2013	Q1 1984- Q2 2013	Q1 1984- Q2 2013	Domestic currency with average maturity.	Domestic currency borrowing rate with 90 days maturity.
Australia	IFS	Q2 1972- Q2 2013	Q2 1972- Q2 2013	Q2 1972- Q2 2013	SP: Government Bond with 15 year maturity	SP: US bond with 10 years maturity.
Canada	IFS	Q2 1972- Q2 2013	Q2 1972- Q2 2013	Q2 1972- Q2 2013	SP: Government Bond with 10 year maturity	SP: US bond with 10 years maturity.
Netherlands	IFS	Q2 1972- Q2 2013	Q1 1980- Q2 2013	Q1 1981- Q2 2013	SP: Government Bond with 10 year maturity	SP: US bond with 10 years maturity.
New Zealand	IFS	Q2 1972- Q2 2013	Q2 1972- Q2 2013	Q2 1972- Q2 2013	SP: Government Bond with 5 year maturity	SP: US bond with 3 years maturity.
Sweden	IFS	Q3 1986- Q2 2013	Q2 1972- Q2 2013	Q2 1972- Q2 2013	SP: Government Bond with 10-15 year maturity	SP: US bond with 10 years maturity.
Switzerland	IFS	Q2 1972- Q2 2013	Q1 1981- Q2 2013	Q1 1981- Q2 2013	SP: Government Bond with more than 10 year maturity	SP: US bond with 10 years maturity.

Table 6: Data Sources for Interest Rates.