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Selective Sovereign Defaults*

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Abstract

Governments issue debt both domestically and abroad. This heterogeneity introduces the possibility for governments to operate selective defaults that discriminate across investors. Using a novel dataset on the legal jurisdiction of sovereign defaults that distinguishes between defaults under domestic law and default under foreign law, we show that selectiveness is the norm and that imports, credit, and output dynamics are different around different types of default. Domestic defaults are associated with contractions of credit and are more likely in countries with smaller credit markets. In turn, external defaults, are associated with a sharp contraction of imports and are more likely in countries with depressed import markets. Based on these regularities, we construct a dynamic stochastic general equilibrium model that we calibrate to Argentina. We show that the model replicates well the behavior of the Argentinean economy and rationalizes these empirical findings.

JEL classification: F34, F41, H63.

Keywords: Sovereign Default, Selective Defaults, Domestic Debt, External Debt, Credit, Imports.

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1 Introduction

Governments issue debt with different characteristics to appeal to different investors. This introduces the possibility of selective defaults in which different classes of investors are treated differently. In this paper, we focus on defaults episodes in which investors are discriminated on the basis of the jurisdiction governing the debt.

Our main contributions are two: First, using a new dataset with both domestic and foreign-law defaults we document a number of stylized facts about domestic defaults and show that selective defaults are not only possible, but the main way in which sovereigns defaults. Second, we propose a theoretical model of selective defaults that rationalizes the empirical finding and improves our understanding of the observed default patterns.

Armed with new dataset containing over one hundred foreign-law defaults and over sixty domestic-law defaults, over the period 1980-2015, we document the following key regularities about sovereign defaults. First, selective defaults exist and are frequent. Since 1980, about two-thirds of the defaults have involved either foreign-law bonds or domestic-law bonds selectively. We also document that the number of domestic-law defaults has steadily increased over time. Second, output, credit, and imports dynamics are different in different default episodes. Domestic defaults are associated with drops in private sector credit. Conversely, external defaults have a strong effect on imports and have less of an impact on credit. Third, we find that domestic defaults are more frequent in countries with small credit markets, while external defaults are more frequent in countries where imports are small.

Based on these empirical regularities, we construct a dynamic stochastic general equilibrium model with endogenous default risk that extends the work of Mendoza and Yue (2012) to include domestic investors and selective defaults. The model is composed of six sectors: a benevolent government, households, domestic investors (bankers), intermediate goods producers, final good producers, and foreign investors. Households supply labor to intermediate goods producers and own firms. The benevolent government issues debt and takes the default decision. Domestic and foreign investors purchase government bonds and supply credit to final good producers that are subject to two working capital constraints: one for the purchase of domestic intermediates, and one for the purchase of foreign intermediates. In this framework, a key trade-off explains governments' borrowing and default decisions: the government can either default on domestic debt thereby hurting domestic investors or it can default on foreign debt thereby hurting foreign investor. We calibrate the model to Argentina and we show that the model replicates and rationalizes the empirical regularities outlined above and generates default and borrowing patterns that are consistent with those observed in the data.

The theoretical literatures on selective defaults is narrow. Until recently, sovereign defaults models á la Eaton and Gersovitz (1981) have primarily focused on external debt therefore neglecting domestic debt and ruling out selective defaults. Following the euro-area sovereign debt crisis, researchers have devoted more attention to domestic debt especially in relation to the "diabolic debt loop" that links the sovereign sector and bank's balance sheets. Sosa-Padilla (2014), Broner et al. (2014), Gennaioli et al. (2014b), and Brutti (2011), among others, have developed endogenous sovereign default models that study governments' borrowing and default decisions when investors are domestic.[1] Along this line, D'Erasmo and Mendoza (2013) have also proposed a model to study the welfare implication of a sovereign defaults for domestic investors and workers. These models, however, are not suited to study selective defaults as they do not envisage the simultaneous presence of domestic and external debt. Mallucci (2015) and Perez (2015) take a first step in this direction proposing two models with both domestic and foreign investors. However, both papers rule out the existence of selective defaults assuming that governments cannot discriminate across lenders. Our paper removes this assumption as it allows for selective defaults.[2]

Our paper is also related to the literature on inflation and defaults started by Calvo (1988). Works in this area, such as Du and Schreger (2016), Engel and Park (2016), and more recently Sunder-Plassmann (2018), show that governments may operate selective defaults on local-currency debt through inflation and that the credibility of monetary policy is crucial to determine returns in the sovereign debt market. Our paper also investigates default episodes that affect either foreign or domestic investors selectively. However, we concentrate on outright default episodes, as opposed to implicit default payments. That is, we concentrate on default episodes that are triggered by a missed payment of the government, as opposed to inflationary episodes.

[1]Bocola (2016) proposes a model with sovereign risk and domestic investors. Unlike the other papers mentioned here, in this model the default decision is exogenous in this model.

[2]In a recent working paper Paczos (2016) develop an endogenous default model that allows for selective defaults introducing two exogenous shocks in the economy: a productivity shock and a shock affecting the size of the dead-weight loss associated with tax collection. In this framework domestic default happen when the dead-weight loss associated with tax collections is large, while external default happen when productivity is low. Our model, differs as it points to a different trade off to explain the existence of selective defaults. Domestic defaults affect the domestic credit channel while external default affect intermediate imports. In the empirical part, we provide extensive evidence to motivate our modeling choices.

As is the case for the theoretical literature, the empirical literature also overlooked domestic debt until recently. A seminal contribution in this direction can be found in Reinhart and Rogoff (2008). In this paper authors show that on average residents hold almost two thirds of total public debt, and they argue that domestic debt is crucial to understand default dynamics. Sturzenegger and Zettelmeyer (2008) provide evidence of the existence of selective defaults. They analyzes six sovereign debt restructurings and show that there is wide variation in the losses undergone by different types of investors. Kohlscheen (2009), finally, reviews defaults episodes in a sample of 53 countries and notes that default episodes in which the government discriminate between domestic and foreign agents are frequent. Our paper is different from the other papers in the literature in that it does not only document the existence of selective defaults, but it also tries to understand their macro-level determinants and their consequences. Of note, our definition of domestic and external defaults is based on the legal regime governing defaulted instruments as in Reinhart and Rogoff (2008). Domestic defaults involve sovereign bonds governed by the domestic law, while external defaults involved bonds governed by foreign law. Cruces and Trebesch (2013), Erce (2013), and Asonuma and Trebesch (2016) also use the governing law criterion to code their datasets on recent domestic debt restructurings.

The rest of the paper is organized as follows. Section 2 presents some stylized facts about selective defaults. Section 3 introduces the theoretical model. Section 4 formally defines the equilibrium in the model economy. Section 5 explains the calibration of the model. Section 6 studies the optimal debt and allocation decision of the government. Moreover it also reports the results of the model simulation and studies the evolution of the economy around episodes of defaults with a special emphasis on the credit market and on intermediate imports. Section 7 concludes the paper.

2 Stylized Facts

Several studies (i.e. Reinhart and Rogoff, 2008, Kohlscheen, 2009, and Sturzenegger and Zettelmeyer, 2008) have classified domestic and external defaults on the basis of the currency denomination of defaulted instruments. In this paper we exploit a new database that separates defaults according to the legal regime governing bonds. The resulting database contains 182 episodes in 60 countries between 1980 and 2017. Foreign-law defaults are coded using the datasets in Cruces and Trebesch (2013) and Asonuma and Trebesch (2016). Domestic-law defaults are coded using national sources (ministries of finance, debt management offices and parliamentary resolutions), as well as reports from international organizations (IMF, World Bank and other Development Banks), international press, research papers, books and various monographs.[3]

The literature highlights two main channels explaining output contraction around sovereign defaults: the trade channel (Mendoza and Yue, 2012) and the credit channel (Sandleris, 2012). The trade channel operates through intermediate imports: following a default, firms' access to foreign intermediates becomes more difficult restricting the production ability of the private sector. The credit channel, instead, operates through the balance sheet of domestic intermediaries: following sovereign defaults, domestic investors' balance sheet contract leading to a credit crunch. Armed with our database, we show that while both channels are important, they play a profoundly different role in different crises. The credit channel is more active around domestic default episodes, while the trade channel is more active around foreign default episodes.[4]

2.1 The Incidence of Domestic- and Foreign-Law Default

Our sample contains 182 default episodes. We identify 64 domestic default episodes and 118 external default episodes between and we classify them in three categories: local-law defaults, foreign-law default, and non-selective defaults.[5] The complete list of sovereign default episodes including their classification can be found in Table 7 in the Appendix.

Table 1 reports the incidence of each of the three types of default. Selective defaults are the rule. Only about half of the domestic defaults occur in tandem with foreign defaults and only one fourth of external defaults occur in tandem with domestic defaults. Figure 5 provides a bird-eye view of the incidence of domestic and foreign-law defaults overtime. A striking pattern emerges. The increasing relevance of domestic debt issuance appears to have translated also to the restructuring arena (see also Reinhart, 2010). We interpret this finding as an indication that the debt structure has implications for the restructuring approach.

[3]This new database is the outcome of a long-term effort to provide additional empirical evidence on sovereign default episodes. We are currently working on a companion paper that presents the database and describes its sources and features in detail.

[4]Table 8 lists data sources for credit imports and output.

[5]Non-selective defaults are defaults on domestic and external debt that happen either the same year or in two subsequent years

Table 1. Incidence of Sovereign Defaults

Time	Domestic Law	Foreign Law	Joint
Obs.	60	118	28
Pct. of Total	34%	66%	–

Table 1 displays the incidence of sovereign default episodes. Episodes are grouped according to whether defaults occurred on domestic of foreign law sovereign debt. The table also reports the number of episodes on which both types of defaults occurred simultaneously (within a two-year window). The time window considered is between 1980 and 2015.

2.2 Macroeconomic Dynamics around Defaults

Following Gourinchas and Obstfeld (2012) and Broner et al. (2014), we carry out a formal event study analysis of output, imports and credit to the private sector dynamics around default episodes. Following Asonuma and Trebesch (2016), when two defaults of the same type occur simultaneously, we only consider the first of them.[6] We estimate the following equation:

$$Y_{c,t} = \alpha + \sum_{i=-4}^{i=4} \beta_{1,i} \cdot Domestic_{c,t+i} + \sum_{i=-4}^{i=4} \beta_{2,i} \cdot Foreign_{c,t+i} + \sum_{i=-4}^{i=4} \beta_{3,i} \cdot Nonselective_{c,t+i} + \beta_4 Controls + \varepsilon_{c,t}. \quad (1)$$

Where Y stands for the macro variable of interest in country c at time t, while $Domestic_{c,t+i}$, $Foreign_{c,t+i}$, and $Nonselective_{c,t+i}$ are three dummy variables collecting the starting year of default episodes. Finally, $Controls$ is a vector of additional control variables, such as country-trends, and year dummies. In this setting, we can interpret the β_i coefficients as the deviation away from the average value of Y, which is explained by a default at time t.

Table 9 in the Appendix A.3 reports estimates for the coefficients of equation (1) when imports, credit, and per-capita output growth are used as explanatory variable. Results suggest that import, credit and output dynamics are different both before and after defaults.

[6]This leaves us with 70 external-law defaults, 40 domestic-law defaults and 14 non -selective episodes.

Credit contracts around domestic defaults, but it does not move much around external defaults. The opposite is true for imports. Output, instead, contracts around each of the three types of default, but the contraction is more severe around non selective defaults. Import and credit dynamics also appear to differ before defaults. Credit appears to be depressed ahead of domestic defaults, while imports appear to be muted ahead of external defaults. These patterns are confirmed by the findings in the next two sections.

2.3 The Consequences of Sovereign Default: A Panel Approach

In this section we try to isolate the consequences of sovereign defaults on output, imports and credit adopting a panel setting. This setting allows us to control for a number of key economic variables. Inspired by the work of Gennaioli et al. (2014a), we run the following regression:

$$\Delta y_{it} = \gamma_0 + \gamma_1 D^{Dom}_{i,t-1} + \gamma_2 D^{Ext}_{i,t-1} + \gamma_3 D^{NonSel}_{i,t-1} + \gamma_4 X_{i,t-1} + \epsilon_{i,t}. \quad (2)$$

Where $\Delta y_{it} = (y_{it} - y_{it-1}/GDP_{it-1})$ is the change in the outcome variable y between time t and time $t-1$ in country i. $D^{Dom}_{i,t-1}$, $D^{Ext}_{i,t-1}$, and $D^{NonSel}_{i,t-1}$ are three dummies that are equal to one when a country defaults on foreign-law debt, on local-law debt, or on the entire stock of debt respectively. $X_{i,t-1}$ is a vector of country-level variables, that we use as control, such as per capita output growth, credit, imports, inflation (to control for monetary policy), US Treasury rate (to control for global factors), exchange rate and income per capita. Finally, $\epsilon_{i,t}$ is the error term. For robustness, we consider three alternative specification of the error term. One where the error term is assumed to be just a shock: $\epsilon_{i,t} = v_{it}$. One in which includes country fixed-effects: $\epsilon_{i,t} = \phi_i + v_{it}$. One which includes country and time fixed-effects: $\epsilon_{i,t} = \mu_t + \phi_i + v_{it}$. In this specification coefficients γ_1, γ_2, and γ_3 capture the average effect of domestic, external, and non-selective defaults on the change in the outcome variable y.

Results are summarized in Table 10 in Appendix A.4. Columns (1) to (3) present results for output growth. We find that the impact of domestic and foreign defaults on growth is negative and similar in size. Output contraction appears, instead to be more pronounced around selective defaults. Columns (3) to (6) present results for credit dynamics. Credit growth contracts around both domestic and foreign defaults, but the contraction is much stronger and more significant around domestic defaults. Finally, columns (7) to (9) present the results for imports. Imports are little affected by defaults on domestic debt, but they are strongly affected by selective defaults on foreign debt.

2.4 Drivers of foreign and domestic-law defaults

In this section we try to isolate countries' characteristics that explain default patterns. Our strategy is to estimate a simple probit model for each type of default:

$$P(D_{i,t}^{t} = 1/X_{i,t-1}) = \beta \dot{X}_{i,t-1} + \epsilon_{i,t}. \tag{3}$$

where $P(D_{i,t}^{t} = 1)$ is the probability that a default of type i occurs in country c and time t. $X_{i,t-1}$ contains the set of default determinants. It includes output growth and lagged values of imports and credit, changes in credit and changes in net capital flows (all expressed as a fraction of GDP). Results are presented below:

Table 2. What drives Selective and Non-Selective Defaults?

	(1) Domestic	(2) Foreign	(3) Non-Selective
GDP pc growth	-0.684	-1.192***	-1.436***
	(0.447)	(0.368)	(0.512)
Lagged credit	-1.213***	0.743**	0.294
	(0.468)	(0.337)	(0.451)
Lagged imports	0.479	-0.660	-1.707*
	(0.319)	(0.432)	(0.874)
Lagged inflation	-0.000	-0.000	-0.000
	(0.001)	(0.000)	(0.001)
Lagged US rate	-0.019	0.089***	0.012
	(0.021)	(0.017)	(0.029)
Lagged exchange rate	-0.000	-0.000	0.000

	(0.000)	(0.000)	(0.000)
GDP pc	0.000	-0.000**	-0.000
	(0.000)	(0.000)	(0.000)
Observations	1969	1969	1969

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The first row in 2 suggests that defaults are more likely during recessions this is especially true for defaults involving external-law debt. The second row shows that selective defaults on domestic-law bonds are more likely in countries where credit is depressed and external-law default is more likely in countries with larger credit markets . The third row shows that non-selective defaults are more likely in countries with small import markets, and suggest the same happens with external-law defaults, although the coefficient is not significant. This result echoes the finding in Gennaioli et al. (2014a) that countries with larger financial sectors are less prone to default.

3 Model

The quantitative model is based on the work of Mendoza and Yue (2012), that we extend along two key dimensions. First, we introduce a banking sector in the economy. This extension enables us to evaluate credit dynamics around defaults. Second, we allow for government bonds to be purchased by both domestic and foreign investors, thus introducing the possibility of selective defaults.

The model economy is composed of six sectors: households, bankers, tradable producers, nontradable producers, external investors and a benevolent government.

3.1 Nontradable Producers

There is a mass one of profit maximizing nontradable producers j. The only input factor is labor N_j which receives wage w. For simplicity, it is assumed that the production of nontradables is not subject to productivity shocks. Let y^{NT} be the production function for nontradable goods and let p_j^{NT} the price of nontradable goods. The maximization problem is

$$\underset{N_j}{max}\ p_j^{NT} y_j^{NT} - w N_j^{NT}; \tag{4}$$

$$y_j^{NT} = (N_j)^{\gamma}. \tag{5}$$

The first-order condition equates the marginal product of labor to real wages:

$$N_j:\ \ w = p_j^{NT} A \gamma \left(N_j\right)^{\gamma - 1}. \tag{6}$$

3.2 Tradable Producers

Tradable goods are produced by a representative firm that combines domestic intermediates m and foreign intermediates m^*. The production function is Cobb-Douglas,

$$y^T = z M^{\alpha_m}, \tag{7}$$

where z is an aggregate productivity shock and M is the bundle of domestic and foreign intermediates:

$$M = \left[(1-\lambda)\left(m^*\right)^{\mu} + \lambda\left(m\right)^{\mu}\right]^{\frac{1}{\mu}}. \tag{8}$$

m and m^* are Dixit-Stiglitz aggregators that combine varieties of domestic goods m_j and imported goods m_j^*:

$$m \equiv \left[\int_0^1 (m_j)^{\nu} dj\right]^{\frac{1}{\nu}}; \qquad m^* \equiv \left[\int_0^1 (m_i^*)^{\nu} di\right]^{\frac{1}{\nu}}. \tag{9}$$

Domestic inputs are nontradable goods, that are purchased at market price p_j^{NT}. Foreign inputs are tradable goods, that are purchased at the time invariant price p_i^*.

Following Mendoza and Yue (2012) it is assumed that a subset Θ^* of imported input varieties defined in the interval $0 < \theta^* < 1$ needs to be paid in advance using working capital financing. Moreover, we extend Mendoza and Yue (2012), making the assumption that a subset Θ of domestic input varieties in the interval $0 < \theta < 1$ also needs to be paid in advance. Hence, tradable producers are subject to two pay-in-advance conditions:

$$\frac{\kappa}{1+r^L} \geq \int_0^{\theta} p_j^{NT} m_j dj; \qquad \frac{\kappa^*}{1+r^*} \geq \int_0^{\theta^*} p_i^* m_i^* di. \tag{10}$$

Working capital loans κ and κ^* are intraperiod loans that are supplied by domestic bankers and foreign creditors against the payment of the interest rates r^L and r^*. Profit-maximizing producers choose κ and κ^* so that the working capital constraints hold with equality. Tradable producers take prices as given. The maximization problem of tradable producers is

$$\begin{aligned} \max_{m_j, m_j^*} z\left(M\right)^{\alpha_m} &- \int_0^1 p_j^{NT} m_j dj - r^L \int_0^{\theta} p_j^{NT} m_j dj \\ &- \int_0^1 p_i^* m_i^* di - r^* \int_0^{\theta^*} p_i^* m_i^* di - wN \end{aligned} \tag{11}$$

Where p^{NT} is the CES index $\int_0^1 \left(p_j^{NT}\right)^{\frac{\nu}{\nu-1}} dj$ and p^* is the CES index $\int_0^1 \left(p_i^*\right)^{\frac{\nu}{\nu-1}} di$. As some of the domestic goods carry the cost of working capital, the price index of domestic intermediates is defined as

$$P(r^L) = \left[\int_0^1 \left(p_j^{NT}\right)^{\frac{\nu}{\nu-1}} dj + \int_0^{\theta} \left(p_j^{NT}\left(1+r^L\right)\right)^{\frac{\nu}{\nu-1}} dj\right]^{\frac{\nu-1}{\nu}}, \tag{12}$$

and the price index of foreign intermediates is

$$P(r^*) = \left[\int_0^1 \left(p_i^*\right)^{\frac{\nu}{\nu-1}} di + \int_0^{\theta^*} \left(p_i^*\left(1+r^*\right)\right)^{\frac{\nu}{\nu-1}} di\right]^{\frac{\nu-1}{\nu}}. \tag{13}$$

The maximization problem of tradable producers is solved using a standard two-stage budgeting approach. In the first stage, firms choose the aggregate quantities of domestic and foreign inputs m and m^* that maximize profits given prices $P(r^L)$ and $P(r^*)$:

$$\max_{m, m^*} zM^{\alpha_m} - P(r^L)m - P(r^*)m^*. \tag{14}$$

The associated first-order conditions equate the marginal costs of intermediate inputs to their marginal productivity

$$m^*: \; P\left(r^*\right) = \alpha_m z M^{\alpha_m - \mu}\left(1-\lambda\right)\left(m^*\right)^{\mu-1}; \tag{15}$$

$$m: \; P\left(r^L\right) = \alpha_m z M^{\alpha_m - \mu} \lambda \left(m\right)^{\mu-1}. \tag{16}$$

In the second stage, tradable producers seek to minimize costs choosing quantities m_j and m_i^* and taking m and m^* as given. First-order conditions associated with the second stage are

$$m_j : \; m_j = \begin{cases} \left(\frac{p_j^{NT}}{P(r^L)}\right)^{-\frac{1}{1-\nu}} m & j \in [\theta, 1] \\ \left(\frac{\left(1+r^L\right)p_j^{NT}}{P(r^L)}\right)^{-\frac{1}{1-\nu}} m & j \in [0, \theta]; \end{cases}; \tag{17}$$

and

$$m_i^* : \; m_i^* = \begin{cases} \left(\frac{p_i^*}{P(r^*)}\right)^{-\frac{1}{1-\nu}} m^* & i \in [\theta^*, 1] \\ \left(\frac{(1+r^*)p_i^*}{P(r^*)}\right)^{-\frac{1}{1-\nu}} m^* & i \in [0, \theta^*] \end{cases}. \tag{18}$$

As nontradable production is not subject to productivity shocks, the price index p_j^{NT} of domestic inputs is the same across varieties. Hence $p^{NT} =_j^{NT}$. The price of foreign inputs p_i^* is, instead, used as the numeraire and it is therefore set equal to 1.

3.3 Households

Households are hand-to-mouth agents. They consume a bundle C^h of tradable goods $c^{h,T}$ and nontradable goods $c^{h,NT}$, pay lump-sum taxes T, supply labor N to nontradable producers, and own both tradable and nontradable firms.[7] The maximization problem of households is:

$$V(z, b, b^*) = \underset{c^{h,T}, c^{h,NT}, N}{max} U(C^h, N), \tag{19}$$

subject to:

$$PC^h + T = wN + \pi^T + \pi^{NT}. \tag{20}$$

Where equation (20) is the budget constraint of the economy and the terms π^T and π^{NT} denote profits of tradable and nontradable producers respectively. C^h is the Armington

[7] Households have no access to the sovereign debt market. It can be easily proved that as long as both households and domestic investors have simultaneous access to the market for bonds and there are efficient secondary market for domestic bonds, this assumption is not restrictive in the current parameter space. Domestic investor, unlike households are risk neutral and have a higher discount factor, hence they bid higher prices for government bonds.

aggregator for consumption, while P is the corresponding price index:

$$C^h \equiv \left[(1-\lambda_c)^{\frac{1}{\mu_c}} \left(c^{h,NT}\right)^{\frac{\mu_c-1}{\mu_c}} + \lambda_c^{\frac{1}{\mu_c}} \left(c^{h,T}\right)^{\frac{\mu_c-1}{\mu_c}}\right]^{\frac{\mu_c}{\mu_c-1}}; \tag{21}$$

$$P = \left[(1-\lambda_c)\left(p^{NT}\right)^{1-\mu_c} + \lambda_c\right]^{\frac{1}{1-\mu_c}}. \tag{22}$$

Parameters λ_c and μ_c determine the bias toward tradable consumption and the elasticity of substitution between tradable and nontradable goods.

The maximization problem of the household is solved in two stages. In the first stage, households choose aggregate consumption C^h, and labor N to maximize their utility. The first-order conditions associated with the first stage are:

$$C^h: \; U_c(c,N) = \lambda P. \tag{23}$$

$$N: \; -\frac{U_N(c,N)}{U_c(c,N)} = \frac{w}{P}. \tag{24}$$

In the second stage, households choose the optimal composition of the consumption basket $c^{h,T}$ and $c^{h,NT}$ that minimizes costs. The first-order conditions associated with the second stage are:

$$c^{h,NT}: \; c^{b,NT} = (1-\lambda_c)\left(\frac{p^{NT}}{P^C}\right)^{-\mu_c} C^h; \tag{25}$$

$$c^{h,T}: \; c^{b,T} = \lambda_c\left(\frac{1}{P^C}\right)^{-\mu_c} C^h. \tag{26}$$

Consumption depends on the bias λ_c toward tradables, the elasticity of substitution $-\mu_c$, and the relative prices of tradable and nontradable goods.

3.4 Bankers

The representative banker is risk neutral. Bankers have access to the domestic market of government bonds, supply credit to tradable producers, and consume tradable and nontradable goods.[8] Each period is composed of two interim periods—morning and afternoon—that

[8] Our model assumes that public debt issues in two perfectly segmented markets: domestic and international. Only domestic banks can act in the domestic bond market and only foreign investors can access

can be analyzed separately.

In the morning, bankers receive payments from maturing bonds b and supply loans l to tradable producers. The resource constraint requires that loan supply does not exceed the resources that are available to bankers in the morning: maturing bonds b and an exogenous income Γ that bankers receive irrespective of the borrowing and default decisions of the government.[9]

$$l \leq b\left(1 - def^H - def\right) + \Gamma. \tag{27}$$

Where def^H is equal to one when the government defaults on domestic debt and def is equal to one when the government defaults non-selectively. Equation (27) highlights the mechanism that explains output contraction around defaults on domestic bonds. Upon default, bankers' ability to supply credit to the economy declines resulting in a credit crunch. Ultimately, both the production of tradable and nontradable goods declines.

In the afternoon bankers receive gross interest rate payments $\left(1 + r^L\right) l$ from tradable producers, purchase government bonds and consume. The budget constraint in the afternoon is

$$PC^b + qb'\left(1 - def^H - def\right) = \left(1 + r^L\right) l, \tag{28}$$

where C^b is the Armington aggregator for tradable and nontradable consumption:[10]

$$C^b \equiv \left[(1 - \lambda_c)^{\frac{1}{\mu_c}} \left(c^{b,NT}\right)^{\frac{\mu_c - 1}{\mu_c}} + \lambda_c^{\frac{1}{\mu_c}} \left(c^{b,T}\right)^{\frac{\mu_c - 1}{\mu_c}}\right]^{\frac{\mu_c}{\mu_c - 1}}. \tag{29}$$

The representative banker chooses asset holdings b', and loan supply l to maximize its consumption under the constraint imposed by equations (27) and (28). The recursive problem of the banker is

$$W(z, b) = \max_{c^{b,NT}, c^{b,T}, b', l} C^b + \beta EW'\left(z', b'|z\right) - \mu\left[l - b\left(1 - def^H - def\right) - \Gamma\right],$$

international bond markets. This is in line with the evidence regarding the in Arslap and Tsuda (2014).

[9]The term Γ is analogous to the exogenous capital flow term ξ introduced in Mendoza and Yue (2012). In their work the exogenous capital flow is introduced to account for international capital flows that are independent of government borrowing and default decisions. In this set up Γ accounts for flows that domestic investor receive irrespective of the borrowing and default decisions of the government. In the calibration exercise Γ is chosen to match the contraction of credit observed around default.

[10]It is assumed domestic consumption bias λ and the elasticity of substitution between tradable and nontradable goods μ_c is the same for bankers and workers.

subject to:

$$PC^b + qb'\left(1 - def'^H - def'\right) = \left(1 + r^L\right) l. \tag{30}$$

The maximization problem of the banker is solved using a standard two-stage budgeting approach. In the first stage the banker chooses the demand for government bonds b', the loan supply l, and consumption C^b. In the second stage the banker allocates consumption between tradable and nontradable goods to minimize consumption costs.

The first-order conditions associated with the first-stage maximization problem are

$$C^b : \; \lambda = \frac{1}{P}; \tag{31}$$

$$l : \; \left(1 + r^l\right) - \mu = 1; \tag{32}$$

$$b : \; -q\lambda + \beta E\left[W'_{b'}\right] = 0; \tag{33}$$

$$\mu : \; \mu\left[l - b^{b,NT}\left(1 - def^{NT} - def\right) - \Gamma\right] = 0 \tag{34}$$

The envelope conditions reads

$$W_b = \left(1 - def^H - def\right)\mu, \tag{35}$$

Combining equations (33), (34), and (35), and defining the real exchange rate as $S \equiv 1/P$, we obtain the domestic bankers' asset pricing equations for government bonds:

$$b : \; q = \beta E\left[\frac{S'}{S}\left(1 - def'^H - def'\right)\left(1 + r'^L\right)\right]. \tag{36}$$

Three factors determine the price of domestic bonds: default risk, the interest rate on private-sector loans, and expected changes in the real exchange rate S'/S. When default risk is high, the price of government bonds declines as investors need to be compensated for credit risk. Holding default risk constant, higher interest rates r^L are, instead, associated with low government yields as they induce bankers to purchase more government bonds and increase the provision of credit. Finally, the price of government bonds increases when the real exchange rate is expected to appreciate.[11] The government issues bonds that are denominated in units of tradable. When the real exchange rate appreciates, the price of

[11]The exchange rate is expected to appreciate when S' increases.

nontradable goods declines relative to the price of tradable goods. Hence, domestic investors benefit from holding government bonds that are denominated in units of tradables.

The allocation of consumption between tradable and nontradables is determined in the second stage of the maximization problem. The first-order conditions associated with the second stage are

$$c^{b,NT} : c^{b,NT} = (1-\lambda_c)\left(\frac{p^{NT}}{P}\right)^{-\mu_c} C^b; \tag{37}$$

$$c^{b,T} : c^{b,T} = \lambda_c \left(\frac{1}{P}\right)^{-\mu_c} C^b.$$

The composition of the consumption bundle depends on the bias λ, on the elasticity of substitution $-\mu_c$, and on the relative prices of tradable and nontradable goods.

3.5 Foreign Investors

Foreign investors are risk neutral agents with deep pockets. They have access to three different investment opportunities. First, risk-free asset that pays the risk-free interest rate r^f. Second, risky international government bonds. Third, working capital for the purchase of foreign intermediates at the rate r^*. Let def^F, be a dummy variable that is equal to one when the government defaults on foreign debt, the asset pricing equation for government bonds held abroad is:

$$q^* = E\left[\frac{(1 - def'^F - def')}{(1+r^f)}\right]; \tag{38}$$

Following Mendoza and Yue (2012) we assume that the government diverts private payments to external investors in case of default. Hence, the no-arbitrage condition between sovereign lending and working capital loans implies that:

$$1 + r^* = \frac{1}{q^*}\,. \tag{39}$$

Equation (39) establishes a tight correspondence between interest rates on international loans and sovereign yields. When sovereign yields are high, returns on international loans are also high. Mendoza and Yue (2012) show that this relation is true in the data.[12]

[12] According to Mendoza and Yue (2012), the median correlation between sovereign interest rates and private interest rates is 0.7. Arteta and Hale (2008) and Reinhart (2010) also show that sovereign defaults

3.6 Private Sector Equilibrium

The private sector equilibrium is a set of prices $\{w, r^L, p^{NT}, P\}$ and quantities $\{m, m^*, M, N, l, C^h, c^{h,NT}, c^{h,NT}, C^b, c^{b,NT}, c^{b,NT}, \pi^{NT}, \pi^T\}$, that given the states of the economy $\{b, b^*, z\}$, the government debt policies $\{b'b'^*\}$, the default policies $\{def^H, def^F, def\}$, debt prices $\{q, q^*\}$, and the foreign intra-temporal interest rate r^*, solve the following set of equations:

$$\alpha_m z M^{\alpha_m - \mu} (1-\lambda)(m^*)^{\mu-1} = \left[(1-\theta)\left(p^{NT}\right)^{\frac{\nu}{\nu-1}} + \theta\left(p^{NT}\right)^{\frac{\nu}{\nu-1}}\left(1+r^L\right)\right]^{\frac{\nu-1}{\nu}}; \tag{40}$$

$$\alpha_m z M^{\alpha_m - \mu} \lambda (m)^{\mu-1} = \left[(1-\theta)\left(p^{NT}\right)^{\frac{\nu}{\nu-1}} + \theta(\left(p^{NT}\right)^{\frac{\nu}{\nu-1}}\left(1+r^L\right)\right]^{\frac{\nu-1}{\nu}}; \tag{41}$$

$$M = \left[(1-\lambda)(m^*)^{\mu} + \lambda (m)^{\mu}\right]^{\frac{1}{\mu}}; \tag{42}$$

$$-\frac{U_N(c,N)}{U_c(c,N)} = \frac{w}{P}; \tag{43}$$

$$w = p_j^{NT} A \gamma (N_j)^{\gamma-1}; \tag{44}$$

$$PC^h + T = wN + \pi^T + \pi^{NT}; \tag{45}$$

$$c^{h,NT} = (1-\lambda_c)\left(\frac{p^{NT}}{P}\right)^{-\mu_c} C^h; \tag{46}$$

$$c^{h,T} = \lambda_c \left(\frac{1}{P}\right)^{-\mu_c} C^h; \tag{47}$$

$$PC^h = p^{NT} c^{h,NT} + c^{h,T}; \tag{48}$$

$$\pi^T = zM^{\alpha_m} - P(r^L)m - P(r^*)m^*; \tag{49}$$

have an adverse effect on private access to foreign credit.

$$\pi^{NT} = p^{NT} (N)^{\gamma} - wN; \tag{50}$$

$$PC^b + \left(1 - def^H - def\right) [qb' - b] = \left(1 + r^L\right) l + \Gamma; \tag{51}$$

$$c^{b,NT} = (1 - \lambda_c) \left(\frac{p^{NT}}{P}\right)^{-\mu_c} C^b; \tag{52}$$

$$c^{b,T} = \lambda_c \left(\frac{1}{P}\right)^{-\mu_c} C^b; \tag{53}$$

$$PC^b = p^{NT} c^{b,NT} + c^{b,T}; \tag{54}$$

$$l \leq b \left(1 - def^H - def\right) + \Gamma; \tag{55}$$

$$\frac{l}{1 + r^L} \geq \theta p^{NT} m; \tag{56}$$

3.7 Government

The government seeks to maximize the welfare of the households choosing the optimal domestic and foreign debt policy $\{b', b'^*\}$, and the optimal default strategy $\{def^H, def^F, def\}$ under the constraints imposed by the conditions that define the private-sector equilibrium and its own budget constraint:

$$T + qb' + q^* b'^* = b + b^*. \tag{57}$$

Full Market Access

If the government has access to both domestic and foreign financial markets the optimal debt policy solves:

$$G^{nd}(b, b^*) = \max_{b', b'^*,} U(c, N) + \beta E\left[G'^{nd}(z', b', b'^*)\right],$$

subject to

$$q = \beta E\left[\frac{S'}{S}\left(1 - def'^{H} - def'\right)\left(1 + r'^{L}\right)\right]; \tag{58}$$

$$q^{*} = E\left[\frac{\left(1 - def'^{F} - def'\right)}{\left(1 + r^{f}\right)}\right]; \tag{59}$$

Equations (40)-(57).

Foreign Market Access

Let λ_H be the exogenous probability that a government is readmitted to the domestic financial market after a domestic default. The optimal debt policy of the government that has no access to the domestic bond market is

$$G^{dd}\left(z, 0, b^{*}\right) = \max_{b'^{*}} U(c, N) + \left(1 - \lambda_H\right)\beta E\left[G'^{dd}\left(z', b', b'^{*}\right)\right] + \lambda_H \beta E\left[G'^{nd}\left(z', b', b'^{*}\right)\right],$$

subject to

$$q^{*} = E\left[\frac{\left(1 - def'^{F} - def'\right)}{\left(1 + r^{f}\right)}\right]; \tag{60}$$

Equations (40)-(57).

Domestic Market Access

Let λ_F be the exogenous probability that a government is readmitted to the foreign financial market after an external default. The optimal debt policy of the government that has no access to the foreign bond market is

$$G^{df}\left(z, b, 0, \right) = \max_{b'} U(c, N) + \left(1 - \lambda_F\right)\beta E\left[G^{df}\left(z', b', b'^{*}\right)\right] + \lambda_F \beta E\left[G^{nd}\left(z', b', b'^{*}\right)\right],$$

subject to

$$q = \beta E\left[\frac{S'}{S}\left(1 - def'^{H} - def'\right)\left(1 + r'^{L}\right)\right]; \tag{61}$$

Equations (40)-(57).

No Market Access

The welfare of the government that has no access to either the domestic or the foreign bond market is

$$G^{d}(z,0,0)=U(c,N)+\lambda_{H}\lambda_{T}\beta E\left[G^{nd}(z',0,0)\right]+\lambda_{H}(1-\lambda_{F})\beta E\left[G^{df}(z',b',0)\right]$$
$$+(1-\lambda_{H})\lambda_{F}\beta E\left[G^{dd}(z',0,b'^{*})\right]+(1-\lambda_{H})(1-\lambda_{F})\beta G^{d}\left[V(z',0,0)\right].$$

subject to

equations (40)-(57).

Optimal Default Decision

Three types of default are possible. The government can either default on the entire stock of government debt or it can selectively default on either domestic or foreign debt. The optimal default decision maximizes the welfare of the economy:

$$def^{H}=\begin{cases}1 & G^{dd}\geq G^{nd}\,\&G^{dd}\geq G^{df}\,\&G^{dd}\geq G^{d}\\ 0 & \text{else}\end{cases}\quad def^{F}=\begin{cases}1 & G^{df}\geq G^{nd}\,\&G^{df}\geq G^{dd}\,\&G^{df}\geq G^{d}\\ 0 & \text{else}\end{cases}.$$

and

$$def=\begin{cases}1 & G^{d}\geq G^{d}\ \&\ G^{d}\geq G^{dn}\ \&\ G^{dt}\geq G^{dt}\\ 0 & \text{else}\end{cases}.$$

4 Equilibrium

We define the recursive Markovian equilibrium in three steps. First we formally define the private-sector equilibrium given the government policy already introduced in section 3.6. In the second step we define the optimal government policies. Finally, we characterize the recursive Markovian equilibrium.

Private Sector Equilibrium: The private-sector equilibrium is a set of prices $\{w, r^{L}$, $p^{NT}, p^{NT}\}$ and quantities $\{m, m^{*}, M, N, l, C^{h}, c^{h,T}, c^{h,NT}, C^{b}, c^{b,T}, c^{b,NT}\}$ that solve the system of equations (40)-(56), given the outstanding debt levels $\{b, b^*\}$, debt policies $\{b', b'^*\}$, default policies $\{def^{NT}, def^H, def^F\}$, debt prices $\{q, q^*\}$, and foreign interest rate r^*.

Optimal Government Policy: The optimal government policy is a set of borrowing rules $\{b', b'^*\}$, and the default decisions $\left\{def, def^H, and def^F\right\}$ that maximize the welfare of the economy given the private sector equilibrium, the asset pricing equation (38) of foreign investors, and the arbitrage equation (39).

Recursive Markovian Equilibrium: A recursive Markovian equilibrium is a set of government borrowing rules $\{b', b'^*\}$, and default rules $\{def, def^H, def^F\}$ with associated consumption, credit, and production plans $\{C^b, c^{b,NT}, c^{b,NT} l, m, m^*, M, N\}$ equilibrium prices $\{ w, r^L, p^{NT}\}$; and asset pricing equations $\{q, q^*\}$ for sovereign bonds such that:

- Consumption, credit, and production plans solve the maximization problems of producers, households, and bankers given the optimal government debt policies, default policies, sovereign debt prices, and the foreign intra-temporal interest rate r^*.
- Government borrowing decisions and default rules solve the government decision problem, given the private sector equilibrium.
- Foreign investors' asset pricing equations for government bonds satisfy equation (38).
- The interest rate on foreign intra-temporal loans r^* is determined by arbitrage according to equation (39).
- Credit, labor and non-tradable goods markets clear at prices $\{w, r^L, p^{NT}\}$.
- The taxation rule T satisfies the government budget constraint (57).

5 Calibration

Table 3. Calibration

Calibrated Parameter		Value	Source/Target Statistics Argentina
Nontrad. goods TFP coefficient	A	0.67	Mano and Castillo (2015)
Intermediates share in trad. production	α_m	0.46	OECD Input/Output Tables
Labor share in NT production	γ	0.70	Standard
Re-entry probability domestic mkt.	λ_H	0.10	Gelos et al. (2011)
Re-entry probability foreign mkt.	λ_F	0.083	Gelos et al. (2011)
Armington weight on dom. intermediates	λ	0.62	Mendoza and Yue (2012)
CES weight on tradables consumption	λ_c	0.44	Neumeyer and Rozada (2003)
Armington curvature parameter	μ	0.65	Mendoza and Yue (2012)
CES curvature	μ_c	0.38	Neumeyer and Rozada (2003)
Dixit-Stiglitz aggregator for int.	ν	0.59	Mendoza and Yue (2012)
Autocorrelation of TFP shocks	ρ	0.945	Arellano (2008)
Variance of TFP shocks	σ_z	0.025	Arellano (2008)
Coefficient of relative risk aversion	σ	2	Standard RBC
Curvature Parameter Labor supply	ω	1.455	Standard Frisch Elast.
Risk-free rate	r^f	0.01	Standard RBC
Discount factor	β	0.9	Frequency of NS defaults
Bankers endowment	Γ	0.026	Credit drop upon NS def.
Domestic working capital parameter	θ	0.11	Work. Cap. loans to GDP
Foreign working capital parameter	θ^*	0.15	Foreign Work. Cap. to GDP

Table 3 reports parameter values that are used for the calibration of the model and the associated target statistics.

Table 3 presents parameter values used in the numerical exercise and the corresponding target statistics. The calibration aims to replicate the quarterly evolution of the Argentinean economy between 1980 and 2005. Parameters above the line are calibrated independently either targeting moments from the data or choosing values that are standard in the literature. Parameters below the line are jointly determined using the method of moments to match the default frequency and domestic investors' exposure to sovereign debt. Data sources for the target statistics are listed in the last column.

The TFP coefficient A for intermediate goods is set equal to 0.67. This value corresponds to the weighted average of the nontradables-to-tradables productivity ratio for Argentina found in Mano and Castillo (2015). The share of intermediate goods in tradable production α_m is set equal to 0.46 to replicate the weighted average of the intermediate goods-to-gross production ratios between 1995 and 2005, which are available on the OECD website. The labor share of nontradable production γ takes the standard value of 0.7. Reentry probabilities λ_H and λ_F are chosen to reproduce the average exclusion times in Argentina as reported in Gelos et al. (2011).

The calibration of parameters λ, μ, and ν that define the production function for tradable goods is more involved. λ and μ are estimated running a non-linear regression based on the relation between prices and quantities obtained dividing equation (26) by equation (25). Data for relative prices and quantities of domestic and foreign intermediates are not available for Argentina. Hence, following the example of Mendoza and Yue (2012), estimates for parameters λ and μ are computed using Mexican data. The calibration of ν is also challenging as it requires input and output data at the industry level. In this paper we set ν equal to 0.59, as in Mendoza and Yue (2012) which is consistent with the elasticity across varieties found by Gopinath and Neiman (2011) for Argentina.

Parameters λ_c and μ_c, that define the CES aggregator for consumption, are taken from Neumeyer and Rozada (2003). The elasticity of substitution between tradables and non tradables is pretty low and equal to 0.38. Consumers also display a modest bias towards the consumption of nontradables as λ_c is equal to 0.44.

Productivity z follows a standard AR(1) process: $\log z_t = \rho \log z_{t-1} + \epsilon_t$, where ϵ_t is a normally distributed productivity shock with variance σ_z. The autocorrelation parameter ρ and the variance of the TFP shocks σ_z are calibrated as in Arellano (2008) to match the quarterly evolution of productivity in Argentina.

The utility function of households is a standard GHH function:

$$U(C^h, N) = \frac{\left(C^h - \frac{1}{\omega} N^\omega\right)^{1-\sigma}}{1-\sigma}. \tag{62}$$

Parameters σ and ω are set equal to 2 and 1.455, as is standard in the literature. The risk-free rate r^f is also standard and equal to 0.01.

The remaining four parameters β, θ, θ^*, and Γ are calibrated using the simulated method of moments. Parameter β is set equal to 0.9 to replicate the incidence of non-selective defaults between 1980 and 2010. There were two nonselective default episodes in Argentina: on in

1981 and one in 2001. The default incidence is therefore 1.6%. Γ is set equal to 0.026 to match the 26% credit contraction recorded on average after the two defaults of 1981 and 2001. Finally, parameters θ and θ^* are set equal to 0.11 and 0.15 respectively to match the average working capital loans from the banking sector to the private sector and the working capital for foreign intermediates. Following Schmitt-Grohe and Uribe (2007) we proxy domestic working capital with the fraction of M1 held by firms. As a proxy for foreign working capital we use instead the fraction of M1 held by firms in foreign currency.[13]

6 Quantitative Analysis

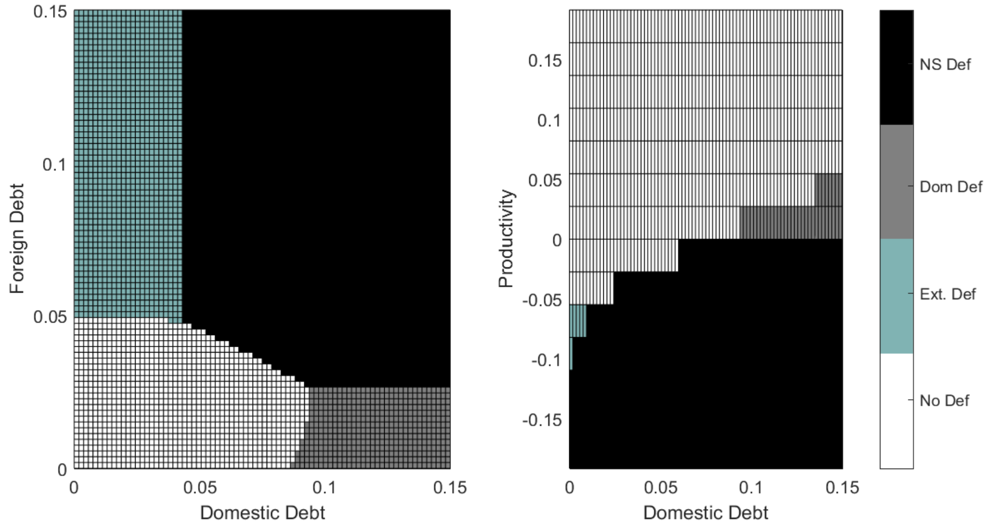
6.1 Optimal Default Policy

Under what circumstances do governments default? When are selective defaults preferred to nonselective ones? Figure 1 provides an answer these questions. Panel A plots the default set as a function of domestic debt (x-axis) and foreign debt (y-axis) for a given productivity level $\hat{z}$. Default decisions depend on the source of the liquidity pressure. When foreign liabilities are large and domestic ones are low, the government defaults on foreign bonds. When domestic liabilities are large and foreign debt is low, the government default on domestic bonds. Finally, when both the domestic and foreign liabilities are large, the government defaults non-selectively on the entire stock of debt.

Productivity also matters to determine default risk. Panel B plots the default set as a function of domestic debt (x-axis) and productivity (y-axis). As productivity increases, the default set shrinks suggesting that defaults typically happen in bad times. Panel B also shows that there is a pecking order in the way government defaults. When recessions are moderate, governments default selectively on either domestic or foreign debt depending on which one is larger. This is why the gray and cyan-shaded are lie above the black area in Panel B. When instead, recessions are severe the government operates nonselective defaults.

[13] We could only find information on the foreign-currency component of the M1 for Mexico. Hence, in the calibration exercise we assume that the ratio between foreign-currency M1 and domestic-currency M1 is the same in Argentina and in Mexico.

Figure 1. Default Sets



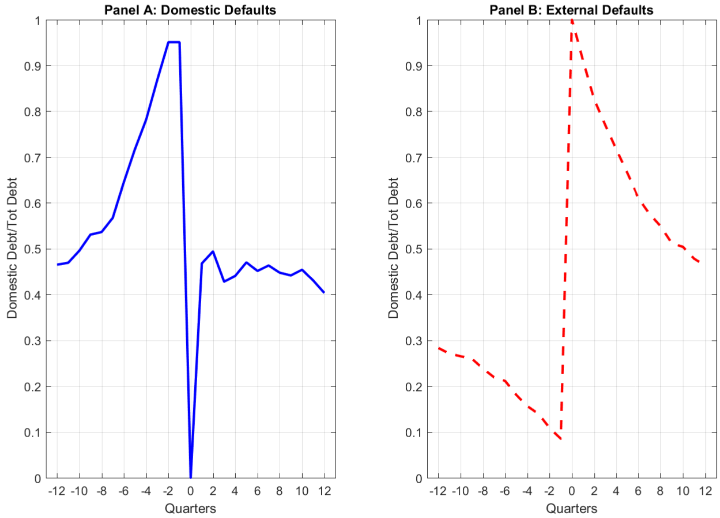
Panel A plots the default set as a function of foreign debt (horizontal axis) and domestic debt (vertical axis) holding productivity constant. The black shaded area corresponds to the area of non-selective defaults. The gray shaded area is the area of selective defaults on domestic debt. The area in cyan is the area of selective default on external debt. Panel b draws the default set as a function of domestic debt (horizontal axis) and productivity (vertical axis), holding foreign debt constant. The selective and non-selective default areas are color coded as in Panel A.

6.2 Debt Composition and the Real Exchange Rate

Default patterns are explained by the source of the liquidity pressure and therefore by debt composition. Figure 2 compares the evolution of debt composition around domestic and external defaults. Two regularities are worth mentioning. First, the domestic component of government debt is the largest component of government debt before domestic defaults, while the opposite is true before external defaults. Second, the share of domestic debt tends to increases in the wake of domestic defaults, while it declines before external defaults.

The real exchange rate explains the evolution of debt composition over the cycle. Government debt is issued in units of tradables. Hence domestic investors, unlike foreign ones, are exposed to currency risk. When the domestic currency appreciates, the price of nontradables declines relative to the price of tradables and the value to domestic investors of holding tradable-

Figure 2. Government Debt Composition

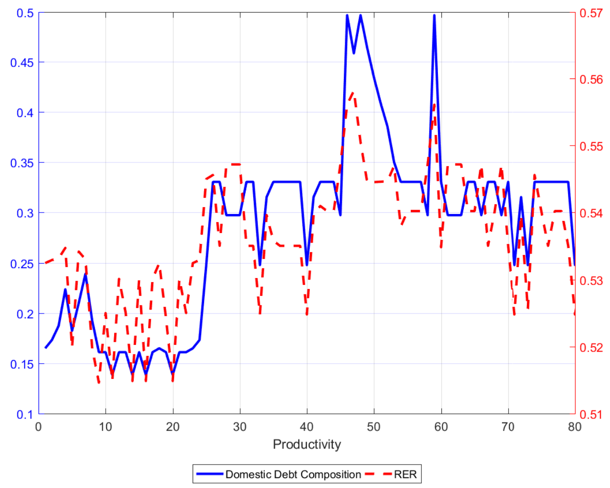


Panel A plots the average evolution of the domestic-to-total debt ratio in the 24 quarters around a domestic default episode. Panel B plots the average evolution of the domestic-to-total debt ratio in the 24 quarters around an external default episode.

denominated bonds increases. Thus, the domestic component of government debt increases. Conversely, a depreciation of the real exchange rate generates a decrease of the domestic share of government debt. Figure 3 plots the average evolution of the real exchange rate and the domestic share of government debt over a twenty-year long cycle highlighting the positive correlation between the real exchange rate and the domestic share of government debt. This results is confirmed in the data as we show in Section 6.3.

Throughout the paper it is assumed that both domestic and foreign debt are issued in units of tradables This assumption works well for Argentina, where most of the debt is issued in dollar, but is less accurate for other countries. An inspection of our database actually suggests that most countries tend to issue domestic-law debt in local currency and foreign-law debt in dollars. To address this issue we checked how different our results are when the government issues foreign debt in units of tradables and domestic debt in units of nontradables. We find that the two models deliver similar results as default patterns and dynamics around default remain similar. The main difference is quantitative. The government tends to issue less

Figure 3. Debt Composition and Real Exchange Rate



The figure plots the evolution of the domestic-to-total debt ratio (blue line) and the real exchange rate (red line) over a twenty-year long cycle.

domestic debt in the alternative scenario with nontradable-denominated domestic debt.[14]

6.3 Cyclical co-movements in the baseline calibration

Table 4 compares key moments in the data (column 1) with the corresponding moments in the simulated model economy (column 2). The model predicts an average debt-to-GDP level that is smaller than in the data.[15] However, the model matches fairly well debt composition and captures about 45% of the mean spread.[16]

Turning to the second moments, the correlation between spreads and GDP is negative both in the data and in the model. This finding is consistent with the intuition that default

[14]When the economy is hit by a negative productivity shock, the real exchange rate depreciates. Hence, in the alternative specification, domestic bonds pay less in bad times. In equilibrium, the government issues less domestic debt at a higher price.

[15]GDP is defined as final production in the economy: $gdp = y^T + y^{NT} - m - m^*$

[16]Spreads for are computed using the J.P. Morgan Emerging bond Index (EMBI), which measures yields for sovereign bonds issued in foreign currency.

Table 4. Simulations

Panel A: Non Targeted Moments

Moments	Data (1)	Model (2)
Mean Debt/GDP ratio	46.7%	11.5%
Mean Domestic/Total Debt ratio	67%	71%
$EMBISpread$	684	320
$Spread^H$	-	570
$\rho(spread, gdp)$	-0.62	-0.35
$\rho(spread, C)$	-0.61	-0.28
$\rho(spread, C^h)$	-	-0.27
$\rho(spread, C^b)$	-	0.36
$\rho(spread, m)$	-0.03	-0.04
$\rho(spread, m^*)$	-0.67	-0.64
$\rho(gdp, nx)$	0.47	0.11
$\rho(RER, Dom/Tot.\ Debt)$	0.46	0.54

Panel B: Targeted Moments

Moments	Data	Model
Non-selective Default Incidence	1.6%	1.2%
Credit Drop Domestic-law Default	−31%	−31%
Working Capital to GDP	0.088	0.073
Foreign working capital/GDP ratio	0.007	0.009

The first column contains moments from the data while the second and third columns report average moments that are obtained simulating the model 100 times for 10,000 periods.

risk is higher when productivity is low. Interestingly, the correlation between spreads and consumption has a different sign for domestic households and bankers. As spreads increase, governments' ability to roll over debt diminishes. Governments are therefore forced to increase taxes, which depress household consumption. Bankers, instead, consume more when spreads are high, as government bond purchases become cheaper. The model also reproduces the procyclicality of the financial account nx which is typical of emerging markets. When production is low, spreads are high, implying that the government borrows less when it needs it the most. Finally, the positive correlation between the real exchange rate and the domestic share of government debt observed is consistent with the dynamics highlighted in Section 6.2.

Panel B compares data and simulation results for those moments that were targeted in the simulation exercise. The model tracks closely the incidence of non-selective defaults. The default probability is 1.6% in the data and 1.2% percent in the model. The model also reproduces well credit dynamics around default. Credit to the private sector contracted on average 31% in Argentina in the 12 months following the 1981 and the 2001 defaults. The model generates an average contraction of 29% around default. Average domestic and foreign working capital levels are also similar in the model and in the data.

6.4 Dynamics around Defaults

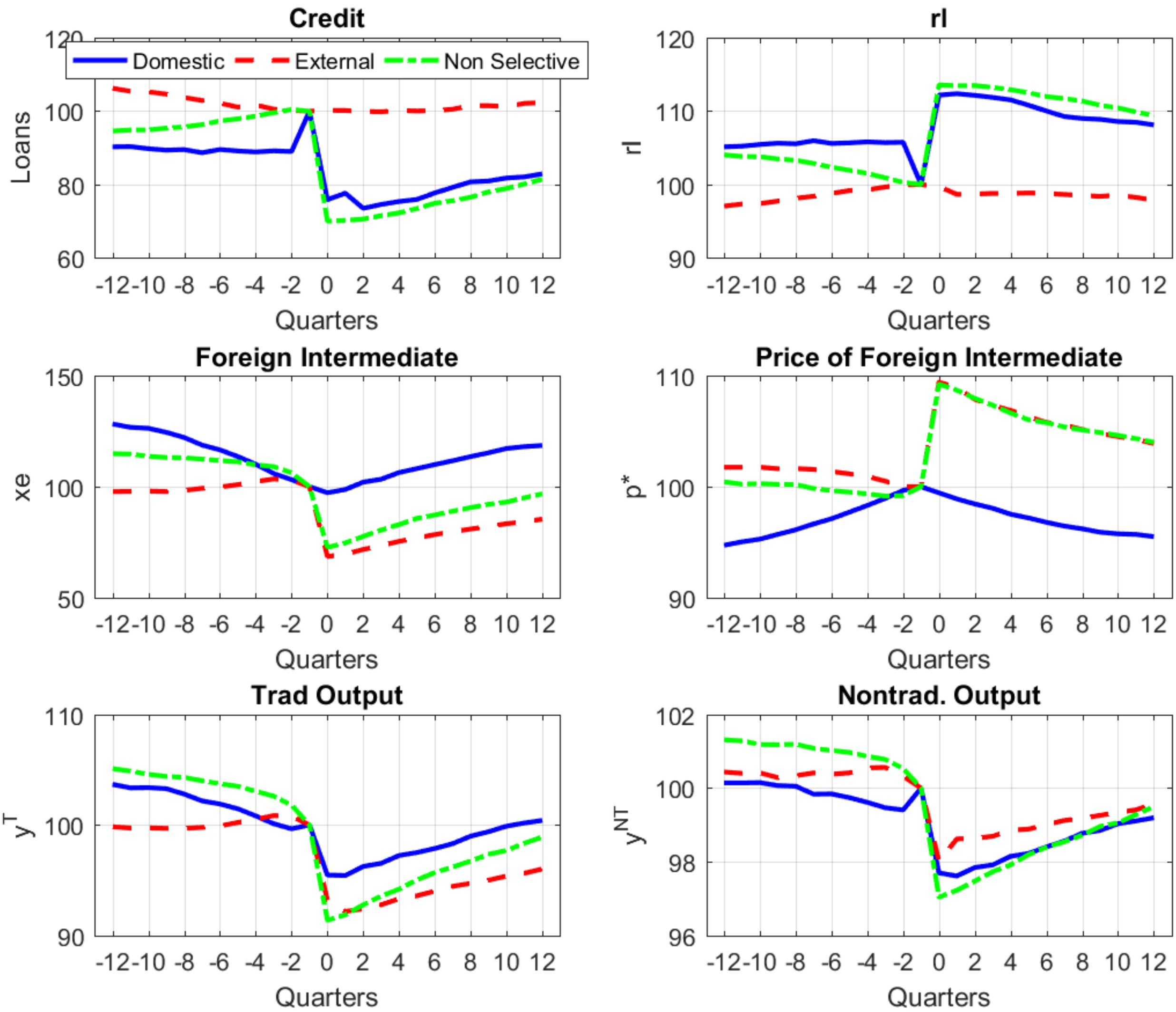
A key trade off explains government incentives to default. Either the government defaults on domestic debt, thereby hurting domestic investors and disrupting domestic credit, or it defaults on foreign debt, thereby restricting private-sector access to foreign intermediates. Figure 4 compares simulated dynamics for credit, intermediate imports, and output around selective and non-selective defaults. Domestic defaults are associated with a sharper contraction of credit and an increase of interest rates, while foreign intermediates are little affected. External defaults, instead, are associated with a sharp decline of intermediated imports, an increase of intermediates' prices, and little action in the credit market. These dynamics are consistent with the results presented in Section 2.3 about the effects of sovereign defaults.

Credit imports and output dynamics reported in Figure 4 are consistent with the stylized facts presented in Section 2.2 and quantitatively replicate the dynamics observed in Argentina as shown in Table 5. Argentina defaulted non-selectively in 1982 and 2001. Following these defaults credit, intermediate imports, and GDP contracted on average 31%, 40% and 6.7% respectively.[17]. Our model predicts a credit contraction of 31%, an intermediate import contraction of 28% and an output contraction of 5.5%.

Argentina also defaulted selectively on domestic bonds in 1989. The model replicates closely credit contraction around this domestic default episode, while it slightly underestimates output contraction. Unfortunately, data for Argentinean intermediate imports are not available before 1994. Thus, a direct comparison between the model and the data for this variable is not possible.

[17]Data for intermediate imports are not available before 1994. So the reported figure for intermediate imports refer to the 2001 episode only

Figure 4. Dynamics around default episodes



The figure plots the average evolution of quantities and prices in the credit market and in the market of foreign intermediates around defaults on domestic-law debt (blue line), foreign-law (red line), and non-selective defaults (green line). The bottom two panels also plot the evolution of tradable and nontradable output around defaults.

Table 5. Simulations around Defaults

Moments	Data (1)	Model (2)
Behavior around non-selective defaults		
Default incidence	1.6%	1.2%
Credit contraction	−31%	−31%
Import contraction	−40%	−28%
GDP loss	−6.7%	−5.5%
Behavior around Domestic Defaults		
Default incidence	0.83%	0.62%
Credit contraction	−25%	−28%
Import contraction	-	−2.2%
GDP loss	−6.5	−3.6%
Behavior around Foreign defaults		
Default incidence	0%	0.8%
Credit contraction		−0.8%
Import contraction		−33%
GDP loss		−4.4%

The first column contains data moments, while the second and third columns report moments obtained simulating the model economy 100 times for 10,000 periods. The second column reports moments for an economy characterized by the existence of selective defaults. The third column reports moments for an economy in which selective defaults are not allowed.

6.5 Sensitivity Analysis

In this section we evaluate how a set of key moments react to changes in the values of the parameters that define the model economy. Results are summarized in Table 6.

Parameter β is the discount factor of domestic households. When β increases, households become more patient and their desire to borrow declines. Hence, debt to GDP ratios decline and so does default risk. Interestingly, output, credit, and imports dynamics around default are not very sensitive to changes in β. This is due to two off-setting forces. On the one side, higher levels of β are associated with a decline of default risk. Hence defaults, when they happen, are associated with sharper productivity drops. On the other side, when β increases government debt is lower, reducing the impact of a default on the economy.

Γ is the exogenous endowment that bankers receive in every period. This is the parameter that regulates domestic investors' exposure to government debt. When Γ is low the probability of external default increases sharply, while the probability of a domestic default declines. The intuition for this result is straightforward. As Γ declines, domestic investors become more exposed towards government debt. Hence, government incentives to default on domestic debt are lower as the consequences of a default are more severe as outlined by the sharp contraction of credit (-43%) and output (-5.5%). If one understands Γ as banks'capital, the result above can be read as implying that where banks are insufficiently capitalized defaults are more likely to occur on foreign-law debt.

Parameter A determines the productivity of the nontradable sector relative to the tradable sector. The lower the value of A, the lower the productivity of the nontradable sector. When the government defaults selectively on foreign debt, tradable producers may substitute foreign intermediates with domestic ones. Hence, government incentives to default on foreign debt should be greater when A is high as domestic inputs are more abundant.

Parameter λ determines the home bias in the production of tradables. The higher λ, the smaller the share of external intermediates in the production of tradables and therefore the lower intermediate imports. We find that when λ is small, the incidence of domestic defaults increases. This result confirms one of the empirical regularity documented in Section 2.4. Domestic defaults are more likely when imports are depressed.

Finally, parameters θ and θ^* determine the size of the domestic and the external working capital. When θ (θ^*) is large, a large fraction of domestic (foreign) intermediates needs to be paid in advance, making final good production more dependent on domestic (foreign) credit. We find that, when θ increases the risk of a domestic default decreases. This result confirms one of the empirical regularities documented in Section 2.4. An increase in θ^*, instead, reduces the risk of an external defaults.

Table 6. Sensitivity Analysis

	$\frac{Debt}{GDP}$	$\frac{NT\ Debt}{Tot.\ Debt}$	Default Rate			% GDP loss			% Credit loss			% Foreign Interm. loss		
			NS	T	NT	NS	T	NT	NS	T	NT	NS	T	NT
Data	46.7%	0.67	1.6%	0.0%	0.83%	−6.7%	–	−6.5%	−31%	–	−25%	−40%	–	–
benchmark	11.5%	0.71	1.2%	0.8%	0.62%	−6.2%	−5.7%	−4.7%	−29%	−0.33%	−28%	−30%	−30%	−4%
Discount Rate. benchmark value: $\beta = 0.80$														
$\beta = 0.88$	12.7%	0.68	0.58%	3.41%	2.1%	−5.7%	−5.1%	−4.0%	−33%	−0.71%	−33%	−33%	−37%	−5%
$\beta = 0.92$	11.0%	0.72	0.83%	0.37%	0.2%	−4.2%	−4.7%	−4.1%	−33%	−0.34%	−34%	−26%	−36%	−4.1%
Exogenous Wealth. benchmark value: $\Gamma = 0.026$														
$\Gamma = 0.015$	10.7%	0.67	0%	2.2%	0.6%	–	−6.0%	−5.5%	–	−6.4%	−43%	−%	−28%	−7.4%
$\Gamma = 0.035$	11.7%	0.69	0.31%	0.35%	1.7%	−5.8%	−4.3%	−4.1%	−30%	−2.6%	−30%	−34%	−35%	−6.5%
Nontrad. goods TFP coefficient: $A = 0.67$														
$A = 0.60$	12.3%	0.71	0.45%	0.14%	1.2%	−5.6%	−5.6%	−3.9%	−31%	−3.9%	−31%	−33%	−38%	−11%
$A = 0.74$	11.3%	0.68	0.16%	2.47%	0.2%	−5.6%	−2.9%	−3.4%	−33%	−1.5%	−40%	−29%	−31%	−3.2%
Home bias in production: $\lambda = 0.57$														
$\lambda = 0.52$	15.8%	0.85	0.01%	0.12%	−%	−7.9%	−6.1%	–	−33%	−26%	–	−37%	−38%	–
$\lambda = 0.62$	11.3%	0.71	1.2%	0.8%	0.6%	−4.4%	−4.0%	−3.5%	−31%	−0.72%	−32%	−28%	−32%	−2.6%
Domestic W-K constraint. benchmark value: $\theta = 0.11$														
$\theta = 0.06$	10.1%	0.69	0.96%	1.07%	0.80%	−4.1%	−3.5%	−3.7%	−30%	0.8%	−30%	−26%	−32%	−3.2%
$\theta = 0.16$	12.1%	0.61	–	0.22%	–	–	−3.2%	–	–	−2.3%	–	−%	−30%	–
Foreign W-K constraint. benchmark value: $\theta^* = 0.15$														
$\theta^* = 0.1$	10.6%	0.77	0.4%	0.9%	2.5%	−5.6%	−4.0%	−3.4%	−34%	0.8%	−33%	−25%	−28%	−3%
$\theta^* = 0.2$	13.7%	0.70	–	0.11	–	–	−5.6%	–	–	−0.7%	–	–	−46%	–

Table 6 compares key moments obtained simulating the model economy 100 times over 10,000 periods for a number of different parameters.

7 Conclusion

Governments typically use a variety of financial instruments to issue government debt, introducing the possibility of selective defaults. Using a new database that separates defaults according to the legal jurisdiction of the defaulted instruments, we show that selective defaults are the norm. Additionally, we show that imports and credit dynamics are radically different around domestic, external, and nonselective defaults. Based on this regularities, we construct a theoretical model with endogenous default risk á la Eaton and Gersovitz (1981) that allows for selective defaults and we calibrate the model to Argentina. We show that the model replicates the evolution of the Argentinean economy closely and highlights a key trade off that explains selective default patterns: Either the government defaults on domestic debt, thereby hurting domestic investors and disrupting domestic credit, or it defaults on foreign debt, thereby restricting private-sector access to foreign intermediates.

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A Tables and Graphs

A.1 Default Episodes

Table 7. Default Episodes and Data Availability

Country	Domestic Default	Foreign Default
Angola	1992, 2003, 2008	
Antigua-Barbuda	1998, 2008	
Argentina	1982, 1989, 2001, 2002	1982, 1985, 1988, 2001
Belize		2006, 2012
Bolivia	1982	1980, 1988
Brazil	1986, 1990	1982, 1983, 1984, 1986, 1989
Cameroon	2004	1985
Chile		1983, 1984, 1986, 1990
Costa Rica		1981, 1984, 1986
Cote d'Ivoire	2010	1983, 2000
Croatia	1992	1992
Cyprus	2013	
Dominica	2003	2003
Dominican Rep.	2004	1982, 1987, 2004
Ecuador	1999	1982, 1983, 1984, 1986, 1999, 2008
Egypt		1984
El Salvador	1981	
Gabon	1999	
Ghana	1979, 1982	
Greece	2011	2011
Grenada	2004, 2013	2004
Guatemala		1989
Honduras		1981, 1990
Indonesia		1997
Iraq		1986
Jamaica	2010, 2013	1980, 1983, 1984, 1986, 1990
Jordan		1989
Kuwait	1990	
Liberia	1989	1980
Macedonia		1992
Madagascar	2002	1981, 1982, 1985, 1987
Mexico	1982	1982, 1984, 1986, 1987, 1988
Moldova		2001, 2002
Mongolia	1997	2003
Morocco		1983, 1985, 1989
Mozambique	1980	
Myanmar	1984, 1987	
Nicaragua	2003, 2008	1981, 1982, 1983, 1985
Nigeria	2004	1982, 1983, 1986, 1987, 1988, 1989
Pakistan	1998	1998, 1999
Panama	1988	1984, 1987
Paraguay	2002	1986
Peru	1979, 1985	1979, 1983, 1984
Philippines		1983, 1986, 1988, 1990
Poland		1981, 1982, 1983, 1986, 1988, 1989
Romania		1981, 1983, 1986
Russia	1998	1991, 1998, 1999
Rwanda	1995	
Serbia		1992
Sierra Leone	1997, 2005	
Solomon Islands	1995	
South Africa		1985, 1989, 1992
Sri Lanka	1996	
St. Kitts and Nevis	2012	2011
Sudan	1991	
Suriname	1998, 2009	
Trinidad & Tobago		1988
Turkey	1999	1981
Ukraine	1998	1998, 1999, 2000
Uruguay	2003	1983, 1985, 1987, 1989, 2003
Venezuela	1998, 2002	1983, 1986, 1989
Vietnam		1982
Zimbabwe	2001,2010	

Table 7 reports the list of default episodes observed between 1980 and 2005. External defaults are as reported by Cruces and Trebesch (2013) and Asonuma and Trebesch (2016).

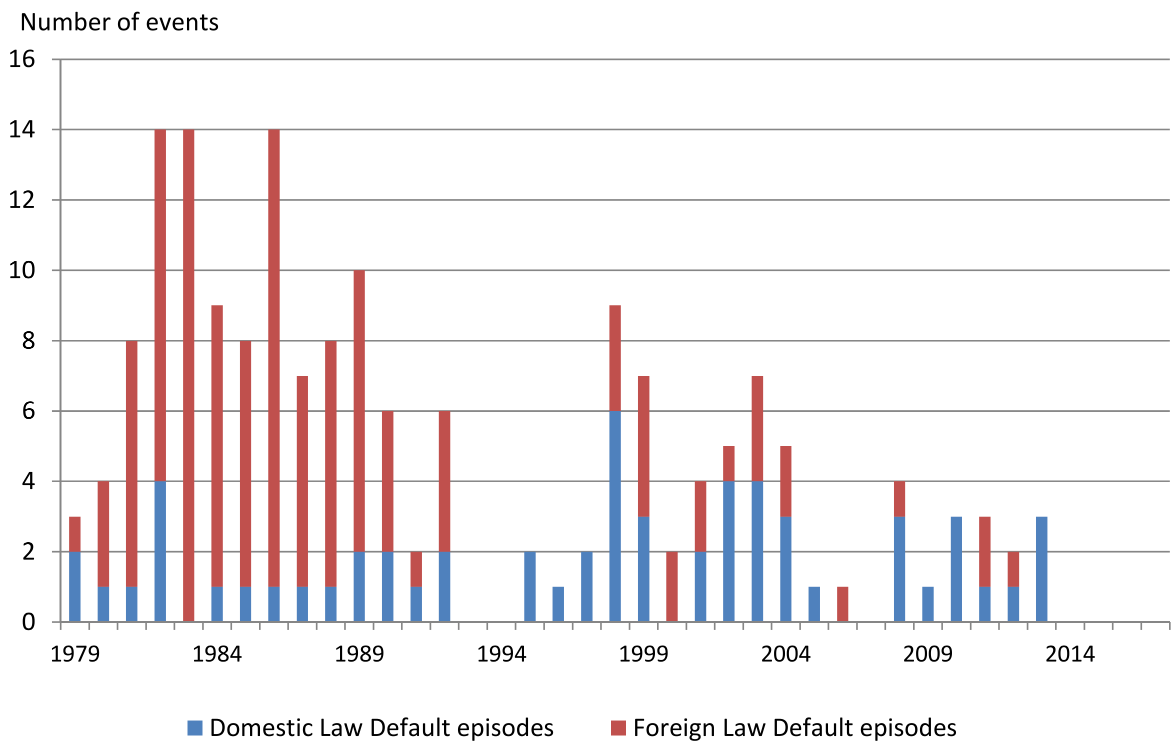
A.2 Data Sources

Table 8. Data Sources

Variable		Description	Source
Output growth	g	Real GDP growth	IMF International Financial Statistics
Output	Y	Nominal output in $	IMF International Financial Statistics
Imports	I	Imports in $	IMF International Financial Statistics
Credit	L	Outstanding bank credit to the private sector in $	IMF International Financial Statistics

Table 8 reports the list of sources for the variables used in the empirical analysis.

Figure 5. Domestic- and Foreign-Law Defaults Overtime



A.3 Event Analysis

Table 9. Selective and Non-Selective Defaults: Event Analysis

	(1) Growth	(2) Imports	(3) Credit
Three years before Domestic Law default	0.015	0.013	-0.069
	(0.026)	(0.028)	(0.077)
Two years before Domestic Law default	0.010	0.024	-0.070
	(0.023)	(0.032)	(0.078)
One year before Domestic Law default	-0.006	0.013	-0.164***
	(0.047)	(0.031)	(0.033)
Domestic Law default	-0.046	-0.017	-0.178***
	(0.031)	(0.032)	(0.029)
One year after a Domestic Law default	-0.093**	-0.005	-0.156***
	(0.036)	(0.041)	(0.039)
Two years after a Domestic Law default	-0.017	-0.027	-0.178***
	(0.027)	(0.032)	(0.033)
Three years after a Domestic Law default	-0.015	-0.037	-0.184***
	(0.032)	(0.032)	(0.030)
Three years before Foreign Law default	-0.008	-0.032	0.038
	(0.024)	(0.025)	(0.032)
Two years before Foreign Law default	-0.091***	-0.035	0.016
	(0.034)	(0.023)	(0.033)
One year before Foreign Law default	-0.067***	-0.043*	0.027
	(0.019)	(0.022)	(0.031)
Foreign Law default	-0.106***	-0.074***	0.011
	(0.026)	(0.022)	(0.033)
One year after a Foreign Law default	-0.044**	-0.079***	-0.039
	(0.021)	(0.023)	(0.027)
Two years after a Foreign Law default	0.039**	-0.073***	-0.076***
	(0.019)	(0.023)	(0.025)
Three years after a Foreign Law default	0.028	-0.063***	-0.065**
	(0.022)	(0.021)	(0.028)
Three years before Non-Selective Default	-0.060	-0.071	0.046
	(0.056)	(0.061)	(0.115)
Two years before Non-Selective Default	0.005	-0.103*	0.076

	(0.044)	(0.059)	(0.116)
One year before Non-Selective Default	-0.021	-0.086	0.192*
	(0.068)	(0.057)	(0.108)
Non-Selective Default	-0.159***	-0.146***	0.001
	(0.050)	(0.042)	(0.090)
One year after Non-Selective Default	-0.015	-0.045	0.078
	(0.112)	(0.066)	(0.067)
Two years after Non-Selective Default	0.053	-0.014	0.204**
	(0.059)	(0.066)	(0.088)
Three years after Non-Selective Default	0.071	0.001	0.207**
	(0.048)	(0.055)	(0.097)
Observations	1876	1847	1824

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$*** $p < 0.01$.

Credit and imports are measured as percentage of GDP. Growth is measured in per capita terms.

A.4 Effect of Domestic and Foreign Law Defaults

Table 10. Effect of Selective and Non-Selective Law Defaults

	(1) Growth	(2) Growth	(3) Growth	(4) Credit	(5) Credit	(6) Credit	(7) Imports	(8) Imports	(9) Imports
Domestic Law default	-0.041	-0.046*	-0.044*	-2.507***	-2.002**	-1.191*	-0.024	-0.027	-0.029
	(0.027)	(0.023)	(0.025)	(0.666)	(0.991)	(0.706)	(0.017)	(0.019)	(0.020)
Foreign Law default	-0.100***	-0.079***	-0.076***	-3.896***	-2.523	-1.237	-0.041***	-0.030***	-0.014**
	(0.024)	(0.021)	(0.019)	(1.490)	(1.613)	(1.448)	(0.007)	(0.007)	(0.007)
Non-selective default	-0.161***	-0.145***	-0.135**	-7.214**	-6.155*	-2.537	-0.058***	-0.051***	-0.016
	(0.052)	(0.048)	(0.054)	(2.981)	(3.266)	(3.655)	(0.011)	(0.011)	(0.011)
GDP pc growth						22.135***			0.189***
						(3.052)			(0.025)
Lagged credit			-0.012			4.454***			0.001
			(0.014)			(1.557)			(0.006)
Lagged imports			0.048**			2.983***			0.027**
			(0.019)			(1.103)			(0.011)
Lagged inflation			-0.000			-0.000			-0.000***
			(0.000)			(0.001)			(0.000)
Lagged US rate			0.005			0.645***			0.005***
			(0.004)			(0.146)			(0.001)

GDP pc			-0.000***			0.000***			-0.000
			(0.000)			(0.000)			(0.000)
Lagged exchange rate			0.000***			0.000***			0.000*
			(0.000)			(0.000)			(0.000)
Observations	2181	2181	1969	2079	2079	1961	2124	2124	1965
Country Fixed-Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Time Fixed-Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes

Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B Solution Algorithm

Following Hatchondo et al. (2010) equilibria are found by iterating the finite model backward until convergence. In the terminal period, it is assumed that financial markets are closed, as there is no need to transfer resources across time:

- In the final period:
  - Discretize the productivity shock z using a quadrature method, as in Tauchen and Hussey (1991).
  - Set up the vector $\Omega = \left\{_T \times \times z \times b^T \times b^{NT}\right\}$ defining the state space
  - Solve the system of equations (40)-(56) on the vector Ω in the default scenarios and in the nondefault scenarios.
  - Compute value function of bankers and households
- In every other periods:
  - Set up the grid $\Omega = \left\{_T \times \times z \times b^T \times b^{NT}\right\} \times \left\{b'^T \times b^{NT}\right\}$ defining the state and choice space.
  - Solve the system of equations (40)-(56) on the gird Ω in the default scenarios and in the nondefault scenarios.
  - Determine the policy functions for b'^T and b'^{NT}.
  - Update value functions V^{nd}, V^{dd}, V^{fd}, V^d, W^{nd}, W^{dd}, W^{fd}, and W^d.
  - Determine the optimal default decision by comparing value functions and update government debt prices q^{NT} and q^T accordingly.
  - Repeat until value functions and debt prices converge. Tolerance values are set to $1e^{-6}$.