Selective Sovereign Defaults

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Abstract

Governments issue debt using a variety of financial instruments. Different instruments appeal to different investors and introduce the possibility of selective defaults. In this paper we investigate how currency denomination influences default risk and economic dynamics around default. First, we show that defaults on local-currency bonds are associated with a sharp contraction of domestic credit, while defaults on foreign-currency bonds are associated with a sharp contraction of imports. Next, we develop a general equilibrium model with endogenous default risk that replicates the economic dynamics observed in the data. Within this framework, we study the optimal borrowing and default decisions of a government that issues local- and foreign-currency bonds and defaults selectively on them. Finally, we study the welfare implications of selective defaults. We show that selective defaults increase welfare, despite reducing governments’ borrowing ability and increasing the risk of defaults.

JEL classification: F34, F41, H63.
Keywords: Sovereign Defaults, Selective Defaults, Domestic Debt, External Debt, Real Exchange Rate, Debt Crises.

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1 Introduction

Governments issue debt using a variety of financial instruments. Different instruments appeal to different investors and introduce the possibility of selective defaults. In this paper, we focus on debt’s currency denomination and study how it influences the default decision of the government.

First, we document four key empirical regularities: (i) Selective sovereign defaults are frequent. Since 1980, about 67% of the default episodes have selectively involved either foreign-currency bonds or domestic-currency bonds. (ii) While output dynamics are similar around episodes of selective and non-selective defaults, credit and imports dynamics are not. (iii) Credit contracts sharply around defaults on domestic-currency bonds, while it remains broadly stable around defaults on foreign-currency debt. (iv) The opposite is true for imports: they contract more around defaults on foreign-currency bonds. Based on these empirical regularities, we construct a dynamic stochastic general equilibrium model with endogenous default risk a la Eaton and Gersovitz (1981) that rationalizes the empirical findings.

The theoretical model extends the work of Mendoza and Yue (2012) to include domestic credit and two types of government bonds: tradable-denominated bonds and nontradable-denominated bonds that are used as proxies for foreign-currency and domestic-currency bonds as in Gumus (2013) and Asonuma (2016). The model is composed of six sectors: a benevolent government, households, domestic investors (bankers), intermediate goods producers, final good producers, and foreign investors. Households are hand-to-mouth agents who own firms and supply labor to the domestic intermediate good producer. The benevolent government issues debt using tradable and nontradable-denominated bonds 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. Financing costs of working capital crucially depend on the borrowing and default decisions of the government. When the government defaults, the financing costs increase. We calibrate the model to South America and we show that the model replicates the four regularities outlined above and generates default and borrowing patterns that are consistent with those observed in the data.

The paper makes two main contributions: First, we document a number of stylized facts
about selective defaults and we propose a theoretical model of selective defaults that replicates them. Second, we quantitatively evaluate the welfare implications of selective defaults. We show that selective defaults reduce government borrowing ability and increase the default risk, but they also improve the overall welfare of the economy.

Theoretical sovereign default models typically assume that governments issue debt using only one instrument and that investors are foreign. While these assumptions make sovereign default models much more tractable, they also rule out debt composition as a factor explaining sovereign default patterns. Mallucci (2015) and Perez (2015) propose two theoretical models of sovereign defaults that introduce heterogeneity in the government debt structure allowing for the simultaneous presence of both domestic and foreign investors. Both papers find that the composition of the investor base is relevant in determining default risk and government borrowing decisions. This paper goes one step further, introducing a second source of heterogeneity: currency denomination. Governments can issue both tradable-denominated bonds and nontradable-denominated bonds, which are used as proxies for foreign- and local-currency debt.

Currency denomination complicates government debt management. Governments not only need to choose how much to borrow in every period and whether to default or not, they also need to choose how much to borrow in each currency and whether to default or not on each of the two components of debt. The quantitative model of sovereign presented in this paper, which is calibrated to South America, delivers an interesting result. In equilibrium, local-currency bonds are typically held by domestic investors, while foreign-currency bonds are typically held by foreign investors. Hence, a key trade off emerges. On the one hand, governments may want to issue domestic-currency bonds, thereby promoting domestic credit and the expansion of domestic investors’ balance sheet. On the other hand, governments may want to issue foreign-currency bonds, thereby facilitating foreign credit and receiving a transfer from abroad. In equilibrium, the government’s borrowing decision ensures that domestic investors supply adequate credit to firms, while preserving access to foreign intermediates.

Turning to the defaults dynamics, we find that government default decisions is determined by two factors: the economic cycle and the relative size of local- and foreign-currency debt. Defaults are more likely to affect the component of debt that is relatively more abundant and are more likely to happen when productivity is low. The model also replicates and explains output, credit, and imports patterns around defaults. Local-currency debt is held primarily by domestic investors who supply credit to the private sector, while foreign-currency debt is held primarily by foreign investors who determine the financing cost for the purchase of
foreign intermediates. As such, defaults on nontradable-denominated debt hurt domestic credit, while defaults on foreign-currency bonds reduce access to foreign intermediates and hamper intermediate imports.

The quantitative nature of the model enables me to evaluate the welfare implications of selective defaults. We compare the baseline model economy with an identical economy in which the government can only default non-selectively. We find that selective defaults increase the default risk, reduce government borrowing ability, but improve the welfare of the economy by roughly 0.4% in permanent units of consumption. Both domestic workers and domestic investors benefit from the existence of selective defaults.

The literature on selective sovereign defaults is quite small. Earlier works, such as Reinhart and Rogoff (2008) and Sturzenegger and Zettelmeyer (2008), survey default episodes and note that selective defaults happen frequently. More recent papers, such as Kohlscheen (2009) and Van Rijckeghem and Weder di Mauro (2004), try to single out determinants explaining selective default patterns, focusing in particular on political economy factors. The paper of Erce (2012), which is closest to our work, develops a stylized model of sovereign defaults with both domestic and foreign investors that highlights three main macroeconomic factors explaining selective defaults pattern—the origin of the liquidity pressure, the ex ante strength of the domestic banking system, and the importance of foreign financing for private firms—and he tests them in a sample of emerging economies. Our paper shares some key similarities with the work of Erce (2012). In particular, we also outline the importance of the domestic banking sector and foreign credit to determine default costs and therefore default incentives. Our paper, however, departs from Erce (2012) in that it does not only account for differences in investors’ residence, but it also account for differences in the denomination of government debt. Additionally, the spirit of this paper is also different. While Erce (2012) aims to uncover the determinants of selective default patterns, our paper aims to propose a quantitative model of sovereign defaults that replicates the evolution of South American economies around default episodes.

Our paper is also related to the literature about local-currency debt, inflation and default risk started by Calvo (1988). Works in this area show that government may default on local-currency debt through inflation. Recent papers such as Du and Schreger (2016), Engel and Park (2016), and Perez and Ottonello (2016) have outlined the importance of monetary policy credibility to determine returns in the sovereign debt market as well as default incentives for the government. This literature mainly concentrates on a key trade off. One the one hand governments prefer to issue debt in local-currency debt, as the exchange rate reduces
borrowing costs in bad times. On the other hand, borrowing in local currency quickly becomes expensive as investors are wary that governments may inflate local-currency debt away. Our paper differs in that it proposes an alternative trade off to explain government borrowing patterns. We show that local-currency bonds and domestic currency bonds appeal to different classes of investors. On the one hand, local-currency bonds appeal to domestic investors and provide liquidity to the domestic credit market. On the other hand, the government wants to issue foreign-currency bonds to attract resources from abroad and reduce the cost of foreign intermediates.

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 quantitatively evaluates the economic implication of a policy that eliminates selective defaults. Section 8 concludes the paper.

2 Stylized Facts

The academic 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 domestic financial sector. Domestic banks typically hold a large share of government debt. Following a sovereign default, domestic banks suffer a loss which induces a contraction of the domestic credit supply.

In this section we analyze a database that contains data for 57 default episodes in 41 countries between 1980 and 2010. we show that, while output dynamics around defaults are similar regardless of the currency denomination of bonds involved, the channels explaining output contraction are different. On the one hand, the trade channel explains output contraction in the aftermath of defaults on foreign-currency debt. On the other hand, the credit channel...
explains the output contraction in the aftermath of defaults on local-currency debt.\footnote{Table 11 lists data sources.}

\section*{2.1 Default Frequency}

Following Reinhart and Rogoff (2008), Kohlscheen (2009), and Sturzenegger and Zettelmeyer (2008), we adopt Standard and Poor’s methodology to identify sovereign defaults. A country is considered in default when it either misses a payment or restructure its debt. We identify 57 default episodes between 1980 and 2010 and we classify them in three categories: local-currency defaults, foreign-currency default, and non-selective defaults.\footnote{The complete list of sovereign default episodes including their classification can be found in Table 10 in the Appendix.}

\begin{table}[h]
\centering
\begin{tabular}{lccc}
\hline
\textbf{Time} & \textbf{Local Currency} & \textbf{Foreign Currency} & \textbf{Non-selective} \\
\hline
Obs. & 18 & 20 & 19 \\
Pct. of Total & 32\% & 35\% & 33\% \\
\hline
\end{tabular}
\caption{Incidence of Sovereign Defaults}
\end{table}

Table 1 displays the incidence of sovereign default episodes. Episodes are grouped according to the three categories of local-currency defaults, foreign-currency defaults and non-selective defaults. The time window considered is between 1980 and 2010.

Table 1 reports the incidence of each of the three types of default. Selective defaults are frequent. More than half of the sovereign default episodes are selective and only involve either local- or foreign-currency debt.

\section*{Output Dynamics}

Table 2 displays the average evolution of output around episodes of local-currency, foreign-currency, and non-selective defaults. Regardless of the default type, output contracts markedly in the year of the default and remains below the pre-default level in the following years as
Table 2. Output Dynamics around Default

<table>
<thead>
<tr>
<th>Time</th>
<th>Local (1)</th>
<th>Foreign (2)</th>
<th>Non-Sel. (3)</th>
<th>Local=Foreign (4)</th>
<th>Local=Non-Sel. (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-3</td>
<td>0.16</td>
<td>-10.68</td>
<td>-2.84**</td>
<td>0.50</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>(0.11)</td>
<td>(1.46)</td>
<td>(2.04)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-2</td>
<td>0.59</td>
<td>-4.92</td>
<td>1.39</td>
<td>-1.17</td>
<td>0.59</td>
</tr>
<tr>
<td></td>
<td>(0.74)</td>
<td>(0.95)</td>
<td>(1.32)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>t</td>
<td>-3.98*</td>
<td>-1.21*</td>
<td>-4.43**</td>
<td>-1.10</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(1.89)</td>
<td>(1.68)</td>
<td>(1.98)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t+1</td>
<td>-6.10</td>
<td>-4.91***</td>
<td>-2.72</td>
<td>-0.29</td>
<td>0.19</td>
</tr>
<tr>
<td></td>
<td>(1.47)</td>
<td>(3.13)</td>
<td>(0.43)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t+2</td>
<td>-4.58</td>
<td>-4.29**</td>
<td>-4.89</td>
<td>-0.04</td>
<td>-0.65</td>
</tr>
<tr>
<td></td>
<td>(0.99)</td>
<td>(2.38)</td>
<td>(0.17)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t+3</td>
<td>-1.05</td>
<td>-4.02*</td>
<td>-0.83</td>
<td>0.44</td>
<td>-1.74*</td>
</tr>
<tr>
<td></td>
<td>(0.19)</td>
<td>(1.78)</td>
<td>(0.79)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 describes the average evolution of output in the three years before a default episode and in the three years afterwards. Columns (1), (2) and (3) report the average percentage deviation of the output from its value in t-1 in each of the three default categories. Parentheses report the t-test against the hypothesis that the percentage change from t-1 is equal to zero. Column (4) contains the t-statistics for the difference in means between local and foreign default while column (5) contains local and non-selective defaults for the difference in means between local and non-selective defaults. * Indicates a significance at the 10% confidence level. ** Indicates significance at the 5% confidence level. *** Indicates significance at the 1% confidence level.

well. T-tests in column (4) and column (5) confirm that output patterns around defaults are statistically equal regardless of the currency denomination of bonds involved.

Trade Dynamics

Table 3 describes the evolution of imports around sovereign default episodes. Imports decline more than 19% in the two years following a foreign-currency default (column 2), while they remain little changed after a default on local-currency debt (column 1). Imports decline is
Table 3. Import Dynamics around Default

<table>
<thead>
<tr>
<th>Time</th>
<th>Local (1)</th>
<th>Foreign (2)</th>
<th>Non-selective (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>t-3</td>
<td>-5.95**</td>
<td>-12.10</td>
<td>-7.61</td>
</tr>
<tr>
<td></td>
<td>(2.02)</td>
<td>(1.49)</td>
<td>(0.10)</td>
</tr>
<tr>
<td>t-2</td>
<td>-1.69</td>
<td>-1.22</td>
<td>-1.83</td>
</tr>
<tr>
<td></td>
<td>(0.62)</td>
<td>(0.26)</td>
<td>(0.37)</td>
</tr>
<tr>
<td>t-1</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
<tr>
<td>t</td>
<td>-5.09</td>
<td>-1.98</td>
<td>-12.36**</td>
</tr>
<tr>
<td></td>
<td>(0.99)</td>
<td>(0.52)</td>
<td>(2.23)</td>
</tr>
<tr>
<td>t+1</td>
<td>10.12</td>
<td>-19.74***</td>
<td>-3.92*</td>
</tr>
<tr>
<td></td>
<td>(1.08)</td>
<td>(4.41)</td>
<td>(0.43)</td>
</tr>
<tr>
<td>t+2</td>
<td>14.93**</td>
<td>-15.37**</td>
<td>6.91</td>
</tr>
<tr>
<td></td>
<td>(2.16)</td>
<td>(2.58)</td>
<td>(0.66)</td>
</tr>
<tr>
<td>t+3</td>
<td>22.62***</td>
<td>-4.89</td>
<td>21.43*</td>
</tr>
<tr>
<td></td>
<td>(3.50)</td>
<td>(0.51)</td>
<td>(1.61)</td>
</tr>
</tbody>
</table>

Table 3 describes the average evolution of imports in the three years before a default episode and in the three years afterward. Columns (1), (2) and (3) report the average percentage change of imports from their level in t-1. The parentheses contain t-tests for the means against the alternative null hypothesis that the average percentage change is zero. * Indicates a significance at the 10% confidence level. ** Indicates significance at the 5% confidence level. *** Indicates significance at the 1% confidence level.

Also sizable around non-selective default episodes (column 3). Altogether these findings show that the trade channel is mainly at work when sovereign defaults involve foreign-currency debt.

Results are confirmed when the trade balance is employed as a measure for trade dynamics and by the results of a regression presented in Appendix A.3 that controls for a number of variables such as inflation and the nominal exchange rate.
Table 4. Credit Dynamics around Default

<table>
<thead>
<tr>
<th>Time</th>
<th>Local</th>
<th>Foreign</th>
<th>Non-Selective</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>t-3</td>
<td>-9.07***</td>
<td>-17.08*</td>
<td>5.12</td>
</tr>
<tr>
<td></td>
<td>(2.33)</td>
<td>(1.64)</td>
<td>(0.53)</td>
</tr>
<tr>
<td>t-2</td>
<td>-5.25</td>
<td>1.82</td>
<td>7.45</td>
</tr>
<tr>
<td></td>
<td>(1.24)</td>
<td>(0.14)</td>
<td>(1.41)</td>
</tr>
<tr>
<td>t-1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>t</td>
<td>6.20</td>
<td>-4.23</td>
<td>-12.89**</td>
</tr>
<tr>
<td></td>
<td>(0.64)</td>
<td>(0.77)</td>
<td>(2.28)</td>
</tr>
<tr>
<td>t+1</td>
<td>-22.34***</td>
<td>-2.26</td>
<td>-15.22*</td>
</tr>
<tr>
<td></td>
<td>(3.01)</td>
<td>(0.24)</td>
<td>(1.82)</td>
</tr>
<tr>
<td>t+2</td>
<td>-9.85</td>
<td>-2.69</td>
<td>-8.09</td>
</tr>
<tr>
<td></td>
<td>(1.25)</td>
<td>(0.29)</td>
<td>(0.86)</td>
</tr>
<tr>
<td>t+3</td>
<td>7.22</td>
<td>-1.15</td>
<td>-6.31</td>
</tr>
<tr>
<td></td>
<td>(0.58)</td>
<td>(0.09)</td>
<td>(0.60)</td>
</tr>
</tbody>
</table>

Table 4 describes the evolution of credit in the three years before a default episode and in the three years afterwards. Columns (1), (2) and (3) report the average percentage change of credit from its level in t-1. The parentheses contain t-tests for the means against the alternative the null hypothesis that the average percentage change is zero. * Indicates a significance at the 10% confidence level. ** Indicates significance at the 5% confidence level. *** Indicates significance at the 1% confidence level.

Credit Dynamics

Table 4 describes the evolution of credit supply to the private sector around sovereign defaults. Credit falls more than 20% in the two years after a local-currency default (column 1) and more than 15% in the two years after a non-selective default (column 3). The credit channel is instead very weak around foreign-currency defaults (column 2). Results are confirmed by the regression analysis presented in Appendix A.3 which controls for a number of variables such as inflation and the nominal exchange rate.\(^3\)

\(^3\)Similar results are also obtained when deviations from long-run trends are used to evaluate changes in credit supply patterns.
3 Model

The model extends the work of Mendoza and Yue (2012) along four dimensions. First, it introduces nontradable goods and therefore. Second, it introduces a role for the domestic credit market. Third, it allows the government to issue debt using two instruments: bonds denominated in units of tradables and bonds denominated in units of non-tradables. Finally, the model introduces the option for the government to default selectively on the two types of bonds.

The economy is composed of six sectors: households, bankers, tradable producers, nontradable producers, external investors and the government. As it is standard in the literature, the government is altruistic and takes the default and borrowing decisions to maximize the welfare of the domestic agent. Additionally, the government also allocates debt optimally between domestic and foreign agents to maximize the welfare of the economy.

3.1 Nontradable Producers

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

$$\max_{N_j} p_j^{NT} y_j^{NT} - w N_j^{NT};$$  \hspace{1cm} (1)

$$y_j^{NT} = (N_j)^{\gamma}. \hspace{1cm} (2)$$

The first order condition associated with the maximization problem of nontradable producers is:
\[ N_j : w = p_j^{NT} A \gamma (N_j)^{\gamma - 1}. \]  

The marginal product of labor equals real wages.

### 3.2 Tradable Producers

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

\[ y^T = z M^{\alpha_m} (N)^{\alpha_n}, \]  

where \( z \) is an aggregate productivity shock and \( M \) is the bundle of domestic and foreign intermediates.

The bundle \( M \) is defined by a standard CES Armington aggregator:

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

\( m^{NT} \) and \( m^* \) are the Dixit-Stiglitz aggregators that combine the continuum of differentiated domestic goods \( m^{NT}_j \) and imported goods \( m^*_j \), respectively:

\[ m^{NT} \equiv \left[ \int_0^1 (m^{NT}_j)^\nu \, dj \right]^{\frac{1}{\nu}}; \quad m^* \equiv \left[ \int_0^1 (m^*_j)^\nu \, di \right]^{\frac{1}{\nu}}. \]  

Domestic inputs are nontradable goods, that are purchased at market price \( p_j^{NT} \). Foreign inputs are tradable goods, that are purchased at price \( p_i^T \).

Following Mendoza and Yue (2012) it is assumed that a subset \( \Theta^* \) 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 \( \Theta \) of domestic input varieties in the interval \( 0 < \theta < 1 \) also needs to be paid in advance. As a result tradable producers are subject to two pay-in-advance conditions driving the demand.
for working capital:
\[
\frac{\kappa}{1 + r_L} \geq \int_0^\theta p_j^{NT} m_j^{NT} dj; \quad \frac{\kappa^*}{1 + r^*} \geq \int_0^{\theta^*} p_i^T m_i^* di. \tag{7}
\]

Working capital loans \( \kappa \) and \( \kappa^* \) 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 \( \kappa \) and \( \kappa^* \) so that the working capital constraints hold with equality. Tradable producers take prices as given. The maximization problem of tradable producers is

\[
\max_{m_j^{NT}, m_i^*} z(M)^{\alpha_m} (N)^{\alpha_n} - \int_0^1 p_j^{NT} m_j^{NT} dj - r_L \int_0^\theta p_j^{NT} m_j^{NT} dj - \int_0^1 p_i^T m_i^* di - r^* \int_0^{\theta^*} p_i^T m_i^* di - wN \tag{8}
\]

The price of domestic inputs \( p^{NT} \) is the CES index \( \int_0^1 (p_j^{NT})^{\frac{\nu}{\nu - 1}} dj \). Analogously the price of foreign inputs \( p^T \) is the CES index \( \int_0^1 (p_i^T)^{\frac{\nu}{\nu - 1}} di \). As some of the domestic goods carry the cost of working capital, the price index of domestic intermediates is

\[
P(r_L) = \left[ \int_0^1 (p_j^{NT})^{\frac{\nu}{\nu - 1}} dj + \int_0^\theta (p_j^{NT} (1 + r_L))^{\frac{\nu}{\nu - 1}} dj \right]^{\frac{\nu - 1}{\nu}}. \tag{9}
\]

Similarly, the price index of foreign intermediates is

\[
P(r^*) = \left[ \int_0^1 (p_i^T)^{\frac{\nu}{\nu - 1}} di + \int_0^{\theta^*} (p_i^T (1 + r^*))^{\frac{\nu}{\nu - 1}} di \right]^{\frac{\nu - 1}{\nu}}. \tag{10}
\]

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

\[
\max_{m^{NT}, m^*} zM^{\alpha_m} (N)^{\alpha_n} - P(r_L) m^{NT} - P(r^*) m^*. \tag{11}
\]

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

$$m^*: P(r^*) = \alpha_m z M^{\alpha_m - \mu} (N)^{\alpha_n} (1 - \lambda) (m^*)^{\mu - 1}; \quad (12)$$

$$m^{NT}: P(r_L) = \alpha_m z M^{\alpha_m - \mu} (N)^{\alpha_n} \lambda (m^{NT})^{\mu - 1}. \quad (13)$$

In the second stage, tradable producers determine the optimal demand for domestic and foreign varieties $m^{NT}_j$ and $m^*_i$, to minimize costs, taking $m^{NT}$ and $m^*$ as given. First order conditions associated with the second stage are

$$m^{NT}_j: m^{NT}_j = \begin{cases} \left( \frac{p^{NT}}{P(r_L)} \right)^{-\frac{1}{1-\nu}} m^{NT} & j \in [\theta, 1] \\ \left( \frac{(1+r_L)p^{NT}}{P(r_L)} \right)^{-\frac{1}{1-\nu}} m^{NT} & j \in [0, \theta]; \end{cases} \quad (14)$$

and

$$m^*_i: m^*_i = \begin{cases} \left( \frac{p^T}{P(r^*)} \right)^{-\frac{1}{1-\nu}} m^* & i \in [\theta^*, 1] \\ \left( \frac{(1+r^*)p^T}{P(r^*)} \right)^{-\frac{1}{1-\nu}} m^* & i \in [0, \theta^*]. \end{cases} \quad (15)$$

As nontradable producers are not subject to productivity shocks, the price index $p^{NT}_j$ of domestic inputs is the same across varieties and equation (9) simplifies to

$$P(r_L) = \left[ (1 - \theta) \left( p^{NT} \right)^{\frac{\nu}{\nu - 1}} + \theta \left( p^{NT} \right)^{\frac{\nu}{\nu - 1}} (1 + r_L) \right]^{\frac{\nu - 1}{\nu}}. \quad (16)$$

Similarly, the price of foreign inputs $p^T_i$ is the same across varieties and can be normalized to one. The price index for foreign intermediates becomes:

$$P(r^*) = \left[ (1 - \theta^*) + \theta^* (1 + r^*)^{\frac{\nu}{\nu - 1}} \right]^{\frac{\nu - 1}{\nu}}. \quad (17)$$

### 3.3 Households

Households are hand-to-mouth agents. They own firms and supply labor to tradable and nontradable producers. Households consume both tradable and nontradable goods and seek to maximize their intra-temporal utility $U(C^h, N)$ when choosing tradable consumption $c^{h,T}$, nontradable consumption $c^{h,NT}$ and labor supply $N$. Households also pay lump-sum taxes
Let \( C^h \) be the Armington aggregator for consumption and let \( P \) be the corresponding price index:

\[
C^h \equiv \left[ (1 - \lambda) \pi \left( c^{h,NT} \right)^{\frac{\mu_c - 1}{\mu_c}} + \lambda \mu_c \left( c^{h,T} \right)^{\frac{\mu_c - 1}{\mu_c}} \right]^{\frac{\mu_c}{\mu_c - 1}}; \quad (18)
\]

\[
P = \left[ (1 - \lambda) \left( p^{NT} \right)^{1 - \mu_c} + \lambda \right]^{\frac{1}{1 - \mu_c}}. \quad (19)
\]

Where parameters \( \lambda \) and \( \mu_c \) determine the bias toward tradable consumption and the elasticity of substitution between tradable and nontradable goods.

The maximization problem of the household is

\[
V(z, b^{h,NT}, b^{h,T}, b^{s,NT}, b^{s,T}) = \max_{c^{h,T}, c^{h,NT}, N} U(C^h, N) + \beta V(z', b^{h,NT'}, b^{h,T'}, b^{s,NT'}, b^{s,T'}), \quad (20)
\]

subject to:

\[
PC^h + T = wN + \pi^T + \pi^{NT}. \quad (21)
\]

Where the terms \( \pi^T \) and \( \pi^{NT} \) denote respectively profits of tradable and nontradable producers. The maximization problem of the household is solved using a standard two-stage budgeting approach. First, households choose aggregate consumption \( C^h \) and labor \( N \) to maximize their utility. The first-order condition that determines labor supply is

\[
N : -\frac{U_N(c, N)}{U_c(c, N)} = \frac{w}{P}. \quad (22)
\]

Second, households choose the optimal composition of the consumption basket \( c^{h,T} \) and \( c^{h,NT} \) to minimize costs. The first-order conditions associated with the second stage are the following:

\[
c^{h,NT} : \quad c^{h,NT} = (1 - \lambda_c) \left( \frac{p^{NT}}{PC} \right)^{-\mu_c} C^h; \quad (23)
\]

\[
c^{h,T} : \quad c^{h,T} = \lambda_c \left( \frac{1}{PC} \right)^{-\mu_c} C^h. \quad (24)
\]

### 3.4 Bankers

The representative banker is risk neutral. It has access to the market of government bonds, it supplies credit to tradable producers, and it consumes both tradable and nontradable goods.
goods. Each period is composed of two interim times—morning and afternoon—that can be analyzed separately.

In the morning, bankers receive payments from maturing bonds and supply loans \( l \) to tradable good producers. There are two types of government bonds in the economy: bonds \( b^{NT} \) that are denominated in units of nontradables and bonds \( b^T \) that are denominated in units of tradables. The resource constraint of the banker in the morning is

\[
l \leq p^{NT} b^{b,NT} (1 - def^{NT} - def) 1_{NT} + b^{b,T} (1 - def^T - def) 1_T + \Gamma. \tag{25}
\]

\( 1_{NT} \) and \( 1_T \) are two indicators tracking how debt is allocated between domestic and foreign investors. When domestic banks purchase non-tradable-denominated bonds, \( 1_{NT} \) is equal to one. Similarly, when domestic bankers purchase tradable-denominated debt, \( 1_T \) is equal to one. \( def^{NT} \), \( def^T \), and \( def \) are also three indicators, and they are associated with the default decision of the government. \( def^{NT} \) is equal to one when the government defaults on bonds denominated in units of nontradables; \( def^T \) is equal to one when defaults target tradable-denominated bonds; \( def \) is equal to one when defaults are non-selective. Finally, \( \Gamma \) is a time-invariant exogenous endowment that bankers receive in every period irrespective of the borrowing and default decisions of the government.\(^4\) Parameter \( \Gamma \) ensures the credit supply remains positive even when the government debt market is shut. In the calibration exercise \( \Gamma \) is chosen to match the contraction of credit observed around default.

Equation (25) highlights the mechanism explaining output contraction around defaults when domestic investors hold government debt. Upon default, bankers ability to supply credit to the economy is diminished. As domestic credit becomes more scarce, tradable producers reduce their demand for domestic intermediates. Ultimately, both tradable and nontradable production shrinks.

In the afternoon bankers receive interest rate payments \( r^L L \) from tradable producers, purchases government bonds and consume. The budget constraint of the bankers in the afternoon is

\[
P C^b + p^{NT} q^{b,NT} b^{b,NT} (1 - def^{NT} - def^T) 1_{NT} + q^{b,T} b^{b,T} (1 - def^T - def^T) 1_T' = r^L l, \tag{26}
\]

\(^4\)The term \( \Gamma \) is analogous to the exogenous capital flow term \( \xi \) 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 \( \Gamma \) accounts for liquidity flows that domestic investor receive irrespective of the borrowing and default decisions of the government.
where $C^b$ is the Armington aggregator for tradable and nontradable consumption:

$$C^b \equiv \left[ (1 - \lambda_c) \frac{1}{\mu_c} \left( e^{b,NT} \right)^{\frac{\mu_c - 1}{\mu_c}} + \lambda_c \mu_c \left( e^{b,T} \right)^{\frac{\mu_c - 1}{\mu_c}} \right]. \quad (27)$$

The representative banker chooses asset holdings $b^{b,NT}$ and $b^{b,T}$, and loan supply $l$ to maximize its consumption under the constraint imposed by equations (25) and (26). The recursive problem of the banker reads:

$$W(z, b^{b,NT}, b^{b,T}, b^{*,NT}, b^{*,T}, 1_{NT}, 1_T) = \max_{c^{b,NT}, c^{b,T}, b^{b,NT}', b^{b,T}', l} C^b$$

$$- \mu \left[ l - p^{NT} b^{b,NT} (1 - d e^{f^{NT}} - d e f^{NT}) 1_{NT} - b^{b,T} (1 - d e f^{T} - d e f^{T}) 1_T - \Gamma \right]$$

$$+ \beta \left[ E W'(z', b^{b,NT}', b^{b,T}', b^{*,NT}', b^{*,T}', 1_{NT}', 1_T') | z \right],$$

subject to:

$$P C^b + p^{NT} q^{b,NT} b^{b,NT} (1 - d e f^{NT} - d e f) 1_{NT} + q^{b,T} b^{b,T} (1 - d e f^{T} - d e f) 1_T = r^b l. \quad (28)$$

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 $b^{b,NT}$ and $b^{b,T}$, 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

$$C^B : \lambda = \frac{1}{P}; \quad (29)$$

$$l : r^l - \mu = 1; \quad (30)$$

$$b^{b,T} : -q^{b,T} (1 - d e f^{T} - d e f) - \beta E \left[ \frac{P}{P'} W'_{y^{b,T}} \right] = 0; \quad (31)$$

$$b^{b,NT} : -q^{b,NT} (1 - d e f^{NT} - d e f) - \beta E \left[ \frac{P}{P'} q^{NT}_{y^{b,NT}} W'_{y^{b,NT}} \right] = 0; \quad (32)$$

\(^5\)It is assumed that bankers and household share the same bias in domestic consumption $\lambda$ and the same elasticity of substitution $\mu_c$ between tradable and nontradable goods. These assumptions ensure that the price index $P$ is identical for bankers and households.
\[
\mu : \mu \left[ l - p^{NT} b^{b,NT} (1 - def^{NT} - de f) \mathbb{1}_{NT} - b^{b,T} (1 - def^T - de f) \mathbb{1}_{T} - \Gamma \right] = 0 \quad (33)
\]

The two envelope conditions read
\[
W_{b,T} = (1 - def^T - de f) (1 + \mu), \quad (34)
\]
\[
W_{b,NT} = (1 - def^{NT} - de f) (1 + \mu). \quad (35)
\]

Combining equations (31), (32), (34), and (34) I obtain the domestic bankers’ asset pricing equations for government bonds:

\[
b^{b,T} : q^{b,T} = \beta E \left[ \frac{S}{S'} (1 - de f^T - de f') (1 + r'^L) | T = 1 \right]; \quad (36)
\]
\[
b^{b,NT} : q^{b,NT} = \beta E \left[ \frac{S p^{NT}}{S' p^{NT}} (1 - def^{NT} - de f') (1 + r'^L) | NT = 1 \right]. \quad (37)
\]

\(S\) is the real exchange rate that, by construction, is equal to the price index \(P\).

Three factors determine the price of tradable-denominated bonds in equation (36): the default risk \((def' + def^T)\), the interest rate on loans \(r'^L\), and changes in the real exchange rate \(S/S'\). As the default risk rises, investors demand higher yields. High interest rates on private loans instead demand lower yields due to the complementarity between credit supply and government debt. Ceteris paribus, high interest rates induce bankers to purchase more government bonds and expand credit supply, thus bidding up the price of government bonds. Finally, the real exchange rates also matters in determining the price of government bonds. When the real exchange rate appreciates, domestic prices also increase. Hence, domestic investors demand higher yields as compensation for higher prices in the economy.

The first order conditions associated with the second-stage maximization problem of bankers determine investors consumption is

\[
c^{b,NT} : c^{b,NT} = (1 - \lambda) \left( \frac{p^{NT}}{P^c} \right)^{-\mu_c} C^b; \quad (38)
\]
\[
c^{b,T} : c^{b,T} = \lambda \left( \frac{1}{P^c} \right)^{-\mu_c} C^b. \quad (39)
\]

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The consumption of nontradables (tradables) depends on the bias $\lambda$ toward tradable consumption, on the elasticity of substitution $\frac{1}{\eta}$, and on the relative prices of tradables and nontradables.

### 3.5 Foreign Investors

Foreign investors are risk neutral agents with deep pockets. They have access to three different inter-temporal investment opportunities. The first investment opportunity is a risk-free asset that pays the risk-free interest rate $r^f$ in every possible contingency. The other two investment opportunities are the two risky government bonds. Bond prices are determined by arbitrage:

$$q^{*,T} = E \left[ \frac{(1 - df^T - def^f)}{(1 + rf)} | 1_T' = 0 \right]; \quad (39)$$

and

$$q^{*,NT} = E \left[ \frac{p^{NT} (1 - df^{NT} - def^f)}{p^{NT} (1 + rf)} | 1_{NT}' = 0 \right]. \quad (40)$$

The prices of tradable and non tradable bonds are pinned down by the default risk and by the relative prices of tradable and non tradable goods.

Foreign investors also supply credit to finance the working capital constraint for the purchase of foreign intermediates. Following Mendoza and Yue (2012) we assume that the government diverts private payments to external investors in case of default.\(^6\) Hence, the no-arbitrage condition between sovereign lending and working capital loans implies that:

$$1 + r^* = \frac{1}{(1 - 1_T) q^{*,T} + (1 - 1_{NT}) q^{*,NT} - (1 - 1_T) (1 - 1_{NT}) q^{*,NT}}. \quad (41)$$

Equation (41) establishes a tight correspondence between interest rates on international loans and sovereign yields. This relation is consistent with the empirics. 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 have an adverse effect on private access to foreign credit.

\(^6\) It is also assumed that domestic and foreign credit markets are segmented and therefore foreign investors cannot supply credit to domestic firms.
3.6 Optimal Allocation

Domestic and foreign investors price bonds according to equations (36),(37), (39), and (40). Bonds are allocated to the investor that bids the highest price for that type of bond:

\[ 1'_{NT} = \begin{cases} 1 \text{ if } q^{b,NT} \geq q^{*,NT} \\ 0 \text{ otherwise} \end{cases}; \quad 1'_{T} = \begin{cases} 1 \text{ if } q^{b,T} \geq q^{*,T} \\ 0 \text{ otherwise}. \end{cases} \] (42)

The resulting allocation pattern is consistent with the existence of an efficient secondary market that allocates bonds to investors that value them the most regardless of the allocation on the primary market.

3.7 Private Sector Equilibrium

Given the outstanding debt levels \{b^{b,NT}, b^{b,T}, b^{*,NT}, b^{*,T}\}, debt policies \{b^{b,NT}, b^{b,T}\}, fiscal policies \{T\}, default policies \{def^{NT}, def^{T}\}, debt prices \{q^{b,NT}, q^{b,T}, q^{*,NT}, q^{*,T}\}, and the foreign intra-temporal interest rate \( r^{*} \), the private sector equilibrium is a set of prices \( \{w, r^{L}, p^{NT}, P\} \) and quantities \( \{m^{NT}, m^{*}, M, l, C^{h,NT}, C^{h,T}, e^{b,NT}, e^{b,T}, \pi^{NT}, \pi^{T}\} \) that solve the following non-linear system of equations:

\[ \alpha_m z M^{\alpha_m - \mu} (N)^{\alpha_n} (1 - \lambda) (m^{*})^{\mu - 1} = \left[ (1 - \theta) (p^{NT})^{\frac{\nu}{\nu - 1}} + \theta (p^{NT})^{\frac{\tau}{\tau - 1}} (1 + r^{L}) \right]^{\frac{\nu - 1}{\nu}}; \] (43)

\[ \alpha_m z M^{\alpha_m - \mu} (N)^{\alpha_n} \lambda (m^{NT})^{\mu - 1} = \left[ (1 - \theta) (p^{NT})^{\frac{\nu}{\nu - 1}} + \theta ((p^{NT})^{\frac{\tau}{\tau - 1}} (1 + r^{L}) \right]^{\frac{\nu - 1}{\nu}}; \] (44)

\[ w = \alpha_n z M^{\alpha_n} (N)^{\alpha_n - 1}; \] (45)

\[ M = \left[ (1 - \lambda) (m^{*})^{\mu} + \lambda (m^{NT})^{\mu} \right]^{\frac{1}{\mu}}; \] (46)

\[ - \frac{U_N (c, N)}{U_c (c, N)} = w; \] (47)
\[ w = p_j^{NT} A_\gamma (N_j)^{\gamma - 1}; \]  

(48)  

\[ PC^h + T = w N + \pi^T + \pi^{NT}; \]  

(49)  

\[ \pi^T = z M^a m^{NT} - P(r^L) m^{NT} - P(r^*) m^*; \]  

(50)  

\[ \pi^{NT} = p^{NT} (N)^\gamma - w N; \]  

(51)  

\[ c_{h,NT} = (1 - \lambda_c) \left( \frac{p^{NT}}{P} \right)^{-\mu_c} C^h; \]  

(52)  

\[ c_{h,T} = \lambda_c \left( \frac{1}{P} \right)^{-\mu_c} C^h; \]  

(53)  

\[ PC^h = p^{NT} c_{h,NT} + c_{h,T}; \]  

(54)  

\[ PC^b = r^L l + \Gamma + p^{NT} b^{h,NT} (1 - de f^{NT} - de f') 1_{NT} + b^{h,T} (1 - de f^T - de f') 1_T - p^{NT} q^{b,NT} b^{h,NT} (1 - de f^{NT} - de f') 1'_{NT} - q^{b,T} b^{h,T} (1 - de f^T - de f') 1'_T; \]  

(55)  

\[ C^h \equiv [(1 - \lambda_c) (c_{h,NT})^{\mu_c} + \lambda (c_{h,T})^{\mu_c}] \frac{1}{\mu_c}; \]  

(56)  

\[ c_{h,NT} = (1 - \lambda_c) \left( \frac{p^{NT}}{P} \right)^{-\mu_c} C^h; \]  

(57)  

\[ c_{h,T} = \lambda_c \left( \frac{1}{P} \right)^{-\mu_c} C^h; \]  

(58)  

\[ PC^b = p^{NT} c_{h,NT} + c_{h,T}; \]  

(59)  

\[ l = P b^{h,NT} (1 - de f^{NT} - de f') 1_{NT} + b^{h,T} (1 - de f^T - de f') 1_T + \Gamma; \]  

(60)  

\[ \frac{l}{1 + r^L} = \theta p^{NT} m^{NT}. \]  

(61)
And the optimal allocation decisions $1'_{NT}$ and $1'_{T}$ are consistent with the rules defined in equation (42).

### 3.8 Government

The government seeks to maximize the welfare of the economy by choosing the optimal debt policy $\{b^{NT}, b^{h,T}, b^{*,NT}, b^{*,T}\}$ and the optimal default strategy $\{def^{NT}, def^{T}, def\}$ under the constraints imposed by the conditions defining the private-sector equilibrium. The budget constraint of the government is

$$T + 1_{NT} \left(p^{NT} q^{h,NT} b^{h,NT} - p^{NT} b^{h,NT}\right) + (1 - 1_{NT}) \left(p^{NT} q^{*,NT} b^{*,T} - p^{NT} b^{*,NT}\right) + 1_{T} \left(q^{h,T} b^{h,T} - b^{h,T}\right) + (1 - 1_{T}) \left(q^{*,T} b^{*,T} - b^{*,NT}\right) = 0.$$ (62)

Let $\psi$ denote the Pareto weight that the government assigns to workers. In the non-default scenario, the maximization problem of the government is

$$G^{nd} \left(b^{NT}, b^{T}, 1_{NT}, 1_{T}\right) = \max_{b^{NT}, b^{h,T}, c^{T}, C^{b}} G^{nd},$$ subject to

$$G^{nd} = \psi U(c, N) + (1 - \psi) C^{b} + \beta E \left[G^{nd} \left(z', b^{NT}', b^{T}', 1_{NT}', 1_{T}'\right)\right];$$ (63)

$$q^{NT} = 1'_{NT} q^{h,NT} + (1 - 1'_{NT}) q^{*,NT};$$ (64)

$$q^{T} = 1'_{b,T} q^{h,T} + (1 - 1'_{T}) q^{*,T}. $$ (65)

Equations (43)-(62).

Let $\lambda_{NT}$ be the exogenous probability that a government is readmitted to the market for nontradable-denominated bonds after a default. The maximization problem of the government that chooses to default on nontradable-denominated debt is

$$G^{dn} \left(z, 0, b^{T}, 1_{NT}\right) = \max_{y^{T}, c^{h,T}, C^{b}} G^{dn},$$
subject to
\[ G^{dn} = \psi U(c, N) + (1 - \psi) C^b + (1 - \lambda_{NT}) \beta E \left[ G'^{nd} \left( z', 0, b^T, 1'_{NT} \right) \right] \]
\[ + \lambda_{NT} \beta E \left[ G'^{nd} \left( z', 0, b^T, 1'_{NT}, 1'_{T} \right) \right]. \]  
(66)

\[ q^T = 1'_{T} q^{b,T} + (1 - 1'_{T}) q^{*,T}. \]  
(67)

Equations (43)-(62).

Let \( \lambda_T \) be the exogenous probability that a government is readmitted to the market for tradable-denominated bonds after a default. The maximization problem of the government that chooses to default on tradable-denominated debt is:
\[ G^{dt} (z, b^{NT}, 0, 1_{T}) = \max_{c^{h,T}, C^b} G^{dt}, \]
subject to
\[ G^{dt} = \psi U(c, N) + (1 - \psi) C^b + (1 - \lambda_{T}) \beta E \left[ G^{dt} \left( z', b'^{NT}, 0, 1'_{T} \right) \right] \]
\[ + \lambda_{T} \beta E \left[ G^{nd} \left( z', b'^{NT}, 0, 1'_{T}, 1'_{NT} \right) \right]. \]  
(68)

\[ q^{NT} = 1'_{NT} q^{b,NT} + (1 - 1'_{NT}) q^{*,NT}. \]  
(69)

Equations (43)-(62).

Finally, the maximization problem of the government that chooses to default non-selectively on both tradable and nontradable-denominated debt is
\[ G^{d} (z, 0, 0, 1_{NT}, 1_{T}) = \max_{c^{h,T}, C^b} \psi U(c, N) + (1 - \psi) C^b + \lambda_{NT} \lambda_T \beta E \left[ G'^{nd} \left( z', b'^{NT}, b^T, 1'_{NT}, 1'_{T} \right) \right] \]
\[ + \lambda_{NT} (1 - \lambda_{T}) \beta E \left[ G'^{dt} \left( z', b'^{NT}, 0, 1'_{NT}, 1'_{T} \right) \right] \]
\[ + (1 - \lambda_{NT}) \lambda_T \beta E \left[ G'^{dn} \left( z', 0, b^T, 1'_{NT}, 1'_{T} \right) \right] + (1 - \lambda_{NT}) (1 - \lambda_{T}) \beta G^{d} \left[ V (z', 0, 0, 1'_{NT}, 1'_{T}) \right]. \]
subject to
equations (43)-(62).

The optimal default policy is taken comparing the welfare of the economy in the four scenarios above. The decision rules for selective defaults are

\[
def^{NT} = \begin{cases} 
1 & G^{dn} \geq G^{nd} \& G^{dt} \geq G^{dn} \& G^{dt} \geq G^{d} \\
0 & \text{else}
\end{cases}
\]

\[
def^{T} = \begin{cases} 
1 & G^{dt} \geq G^{nd} \& G^{dt} \geq G^{dn} \& G^{dt} \geq G^{d} \\
0 & \text{else}
\end{cases}
\]

The decision rule for non-selective defaults is:

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

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 3.7. 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 \(\{m^{NT}, m^*, M, l, c^h,T, c^{h,NT}, c^b, c^{b,T}, c^{b,NT}\}\) that solve the system of equations (43)-(61), given the outstanding debt levels \(\{b^{b,NT}, b^{b,T}, b^{*,NT}, b^{*,T}\}\), debt policies \(\{b^{b,NT}, b^{b,T}, b^{*,NT}, b^{*,T}\}\), fiscal polices \(\{T\}\), default policies \(\{def^{NT}, def^{T}, def\}\), debt prices \(\{q^{b,T}, q^{b,T}, q^{*,NT}, q^{*,T}\}\), and foreign interest rate \(r^*\). Moreover, government bond allocations \(1^{NT}\) and \(1^{T}\) are consistent with the allocation rule (42).

Optimal Government Policy: The optimal government policy is defined by the government borrowing rules \(\{b^{b,NT}, b^{b,T}, b^{*,NT}, b^{*,T}\}\) and the default decisions \(def^{NT}, def^{T}, def\) that maximize the welfare of the economy given the private sector equilibrium.
conditions, and given the asset pricing equations (36), (37), (39), and (40).

**Recursive Markovian Equilibrium:** A recursive Markovian equilibrium is a set of government borrowing rules $\{b^h_{NT}, b^h_T, b^*,_{NT}, b^*,T\}$; allocations and default rules $\{1_{NT}, 1_T, def^NT, def^T, def\}$ with associated consumption, credit and production plans $\{C^b, C^b_{NT}, c^b_{NT}, m^NT, m^*, M, N\}$; equilibrium prices $\{w, r^L, p^NT\}$; and asset pricing equations $\{q^{hT}, q^{hT}, q^*,_{NT}, q^*,T\}$ for sovereign bonds such that:

- The consumption, credit, and production plans solve the maximization problems of the representative nontradable and tradable producers, households, and bankers given the optimal government debt policies, default policies, sovereign debt prices, and the foreign intra-temporal interest rate $r^*$.

- The government borrowing decisions and default rules solve the government decision problem, given the equilibrium conditions for consumption, credit and production.

- Bonds allocations across investors are consistent with the rule (42).

- The asset pricing equations for government debt satisfy equations (36), (37), (40), and (39).

- The interest rate on foreign intra-temporal loans $r^*$ is determined by arbitrage according to equation (41).

- The credit market, the labor market and the market for nontradable goods clear at prices $\{w, r^L, p^NT\}$.

- The taxation rule $T$ satisfies the government budget constraint (62).
## 5 Calibration

Table 5. Calibration

<table>
<thead>
<tr>
<th>Calibrated Parameter</th>
<th>Value</th>
<th>Argentina Source/Target Statistics</th>
<th>Brazil Source/Target Statistics</th>
<th>Mexico Source/Target Statistics</th>
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<tr>
<td>Intermediates share in trad. production αm</td>
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<td>OECD Input/Output Tables</td>
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<td>Gelos et al. (2011)</td>
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<td>Gelos et al. (2011)</td>
<td>Gelos et al. (2011)</td>
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<td>Armington weight on dom. intermediates λ</td>
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<td>Regression Estimates</td>
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<td>Armington curvature parameter μ</td>
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<td>Regression Estimates</td>
<td>Regression Estimates</td>
<td>Regression Estimates</td>
</tr>
<tr>
<td>Coefficient of relative risk aversion σ</td>
<td>2</td>
<td>Standard RBC</td>
<td>Standard RBC</td>
<td>Standard RBC</td>
</tr>
<tr>
<td>Pareto weights ψ</td>
<td>0.5</td>
<td>Equal weights</td>
<td>Equal weights</td>
<td>Equal weights</td>
</tr>
<tr>
<td>Risk-free rate r_f</td>
<td>0.01</td>
<td>Standard RBC</td>
<td>Standard RBC</td>
<td>Standard RBC</td>
</tr>
<tr>
<td>Discount factor β</td>
<td>0.8</td>
<td>Standard RBC</td>
<td>Standard RBC</td>
<td>Standard RBC</td>
</tr>
<tr>
<td>Exogenous endowment Γ</td>
<td>0.042</td>
<td>Credit drop upon NT def.</td>
<td>Credit drop upon NT def.</td>
<td>Credit drop upon NT def</td>
</tr>
<tr>
<td>Domestic working capital parameter θ</td>
<td>0.08</td>
<td>Work. Cap. loans to GDP</td>
<td>Work. Cap. loans to GDP</td>
<td>Work. Cap. loans to GDP</td>
</tr>
<tr>
<td>Foreign working capital parameter θ*</td>
<td>0.27</td>
<td>Foreign Work. Cap. to GDP</td>
<td>Foreign Work. Cap. to GDP</td>
<td>Foreign Work. Cap. to GDP</td>
</tr>
</tbody>
</table>

Table 5 reports parameter values that are used for the calibration of the model and the associated target statistics.
Venezuela is the only country to have experienced local-currency defaults, foreign-currency defaults and non-selective defaults since 1980. However, data for Venezuela are scarce and incomplete making it hard to use this country as a target for the calibration. Hence, the model is calibrated using key moments of a synthetic economy, which is obtained as the weighted average of the three largest Latin American economies: Argentina, Brazil, and Mexico between 1980 and 2005.\textsuperscript{7} Argentina and Brazil experienced three episodes of non-selective defaults in total and two episodes of local-currency defaults. Mexico experienced one episode of foreign-currency default.

The TFP coefficient $A$ for intermediate goods is set equal to 0.91. This value corresponds to the weighted average of the nontradables-to-tradables productivity ratio for Argentina, Brazil, and Mexico. Data are taken from Mano and Castillo (2015). The share of intermediate goods in tradable production $\alpha_m$ is set equal to 0.46. This value corresponds to 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 $\gamma$ takes the standard value of 0.7. Exclusion times $\lambda_{NT}$ and $\lambda_T$ are chosen to reproduce the average exclusion times observed in the data. Mexico was excluded from financial markets for three years after defaulting selectively on its foreign-currency debt. Argentina and Brazil were excluded, respectively, for three and two years after defaulting on domestic currency debt.

The calibration of production parameters $\lambda$, $\mu$, and $\nu$ is slightly more involved. $\lambda$ and $\mu$ are estimated running a non-linear regression based on the relation between prices and quantities obtained by dividing equation (24) by equation (23). Data for relative prices and quantities of domestic and foreign intermediates employed in production are obtained from national sources for both Brazil and Mexico.\textsuperscript{8} Unfortunately data for the relative price of domestic and foreign intermediates are not available for Argentina. Hence, following Mendoza and Yue (2012), estimates for parameters $\lambda$ and $\mu$ for Argentina are set equal to estimates for Mexico. Of note, the estimated curvature parameter $\mu$ implies an elasticity of substitution of 4 and the value of $\lambda$ implies a small bias toward home inputs. The value $\nu$ determines the elasticity across different varieties of domestic and foreign inputs. It is very challenging to calibrate this parameter as it requires input and output data at the industry level. In this paper we set $\nu$ equal to 0.59, as in Mendoza and Yue (2012) which is consistent with the

\textsuperscript{7}Weights are assigned to reflect the average relative size of each economy in the period between 1980 and 2015

\textsuperscript{8}For Brazil CNI is the source for data for the relative price of domestic and foreign intermediate. WITS is the data source for intermediate imports and OECD input and output tables are the sources for domestic intermediate production. For Mexico data sources are the same as in Mendoza and Yue (2012).
elasticity across varieties found by Gopinath and Neiman (2011) for Argentina.

Turning to the CES function for tradable and nontradable consumption, parameters $\lambda_c$ and $\mu_c$ are taken from the literature. Estimates for Argentina are taken from Neumeyer and Rozada (2003), estimates for Brazil come from Alves et al. (2003), and estimates for Mexico are taken from Kehoe and Ruhl (2009). The elasticity of substitution between tradables and nontradables is quite low: 0.42. Consumers also display a modest home bias in consumption $\lambda_c$.

The variance parameter for the TFP shocks $\sigma_z$ and the autocorrelation of the productivity process $\rho$ are the weighted average of the corresponding parameters for Argentina, Brazil, and Mexico. Parameters for Argentina are taken from Arellano (2008), parameters for Brazil are taken from Arellano and Ramanarayanan (2012), and parameters for Mexico are taken from Cuadra et al. (2010).

The utility function of households is a standard CRRA:

$$U(C^h, N) = \frac{(C^h - \frac{1}{\sigma} N^\omega)^{1-\sigma}}{1-\sigma}. \quad (70)$$

Parameters $\sigma$ and $\omega$ 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 Pareto weight $\psi$ is chosen arbitrarily to be equal to 0.5 implying that the government assigns the same weight to the welfare of the households and the welfare of the bankers. In the sensitivity analysis section, we show how a set of key moments changes when we modify our assumption about $\psi$.

The remaining four parameters $\beta$, $\theta$, $\theta^*$, and $\Gamma$ are calibrated using the simulated method of moments. Parameter $\beta$ is set equal to 0.8 to replicate the incidence of non-selective defaults. There were three non-selective default episodes since 1980 in the targeted countries: two in Argentina (1981 and 2001), and one in Brazil (1983), implying a quarterly default incidence of 1.4% in Argentina, 0.7% in Brazil and 0% in Mexico. The weighted average of the default incidence is therefore 0.61%. $\Gamma$ is set equal to 0.042 to reproduce average credit contraction following a non-selective default. Finally, parameters $\theta$ and $\theta^*$ are set equal to 0.08 and 0.27 to target the average working capital loans from the banking sector to the private sector and the working capital for foreign intermediates.\(^9\)

\(^9\)Data for working capital loans to the private sector are only available for Brazil. Working capital loans for Argentina and Mexico are estimated assuming that the average ratio of working capital loans to total loans to the private sector is the same in these two countries as in Brazil. Working capital loans is computed following Schmitt-Grohe and Uribe (2007). Schmitt-Grohe and Uribe (2007) proxy working capital as the
6 Quantitative Analysis

6.1 Equilibrium Allocation

A number of forces determine bond prices and therefore the equilibrium allocation of government debt between domestic and foreign investors. First, default incentives are different when government bonds are held by domestic or foreign investors, irrespective of their denomination. When domestic investors hold government bonds, altruistic governments are less inclined to default as they internalize investors' losses. Second, the discount rate is different for domestic and foreign investors. Domestic investors discount the future more than foreign ones and are inclined to bid lower prices. Third, domestic investors, unlike foreign ones, employ the liquidity of maturing bonds to produce loans that pay them an interest rate \( r^L \). Finally, denomination also matters. Nontradable-denominated bonds appeal to domestic investors, as they protect them against fluctuations of the price index \( P \). Tradable-denominated bonds instead remove the exchange risk for foreign investors.

Panel A in Figure 1 plots tradable-denominated debt allocation between domestic and foreign investors as a function of productivity and outstanding tradable debt levels. We find that tradable-denominated bonds are purchased by foreign investors when productivity is high (white area) and by domestic investors when productivity is low (blue area). Nontradable-denominated bonds are instead always purchased by domestic investors. Default risk explains allocation patterns for tradable-denominated debt. When productivity is high, the risk of default is small regardless of the identity of the lender. Foreign investors end up purchasing government bonds as they have a lower discount rate than domestic investors and because tradable-denominated debt does not shield domestic investors from fluctuations of the price index \( P \). When productivity is low, however, the probability of default increases and the identity of the lender matters to determine the default risk. Government incentives to default are higher when domestic investors purchase government debt. Foreign investors internalize this and bid lower prices than domestic investors. The allocation pattern for nontradable-denominated debt is explained real exchange rate dynamics. Tradable-denominated bonds protect domestic investors against fluctuations of the real exchange rate, while they expose foreign investors to real exchange rate risk. As such, they are more valuable to domestic
Panel A plots tradable-denominated debt allocation between domestic and foreign investors as a function of productivity and outstanding tradable debt levels. The blue area highlights those states in which debt is allocated to the domestic investor, while the white area highlights those states in which debt is allocated to foreign investors. Panel B plots government total borrowings \( p^{NT} q^{NT} b^{NT} (1 - df^{NT}) + q^T b^T (1 - df^T) \) as a function of productivity. The red line describes total borrowings when tradable-denominated bonds are purchased by the domestic investor. The green line describes the total borrowings when tradable-denominated debt is purchased by the domestic investor. The blue line describes the equilibrium allocation.

6.2 Optimal Default Policy

Under what circumstances do governments decide to default? When are selective defaults preferred to non-selective ones? Figure 2 provides an answer to these questions. Panel A plots the default set as a function of tradable-denominated bonds (x-axis) and nontradable-denominated bonds (y-axis) holding constant the productivity level \( z \). When both tradable and nontradable-denominated debt are small, then the government prefers not to default. On the contrary, when both types of debt are large, the government operates non-selective
Panel A plots the default set as a function of tradable-denominated debt (horizontal axis) and nontradable-denominated 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 involving nontradable-denominated debt only. The area in cyan is the area of selective default involving tradable-denominated debt only. Panel B draws the default set as a function of tradable-denominated debt (horizontal axis) and productivity (vertical axis), holding nontradable debt constant. The selective and non-selective default areas are color coded as in Panel A.

defaults. Selective defaults finally happen when either local- or foreign-currency is relatively large. In particular, selective defaults on tradable-denominated debt happen when that debt is relatively large, while selective defaults on nontradable-denominated debt (cyan area) happen when that debt is relatively large.

Productivity also matters in determining default risk. Panel B plots the default set as a function of tradable-denominated debt (x-axis) and productivity (y-axis), holding nontradable debt levels constant. As productivity increases, larger quantities of debt become sustainable and the default set shrinks.
6.3 Cyclical co-movements in the Baseline calibration

Table 6. Simulations

<table>
<thead>
<tr>
<th>Panel A: Non Targeted Moments</th>
<th>Data (1)</th>
<th>Model (2)</th>
<th>No Sel. Def. (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Debt/GDP ratio</td>
<td>38.5%</td>
<td>6.7%</td>
<td>11.8%</td>
</tr>
<tr>
<td>Mean Nontradable/Total Debt ratio</td>
<td>50.4%</td>
<td>51.4%</td>
<td>49.5%</td>
</tr>
<tr>
<td>EMBISpread^T</td>
<td>661</td>
<td>198</td>
<td>66</td>
</tr>
<tr>
<td>Spread^{NT}</td>
<td></td>
<td>1013</td>
<td>933</td>
</tr>
<tr>
<td>(\rho(spread^T, gdp))</td>
<td>-0.49</td>
<td>-0.26</td>
<td>-0.30</td>
</tr>
<tr>
<td>(\rho(spread^T, C))</td>
<td>-0.31</td>
<td>-0.20</td>
<td>-0.20</td>
</tr>
<tr>
<td>(\rho(spread^T, C^b))</td>
<td>-</td>
<td>-0.25</td>
<td>-0.28</td>
</tr>
<tr>
<td>(\rho(spread^T, C^b))</td>
<td>-</td>
<td>0.27</td>
<td>0.47</td>
</tr>
<tr>
<td>(\rho(spread^T, m^{NT}))</td>
<td>-0.03</td>
<td>-0.03</td>
<td>-0.27</td>
</tr>
<tr>
<td>(\rho(spread^T, m^*))</td>
<td>-0.67</td>
<td>-0.54</td>
<td>-0.37</td>
</tr>
<tr>
<td>(\rho(spread^{NT}, gdp))</td>
<td></td>
<td>-0.38</td>
<td>-0.30</td>
</tr>
<tr>
<td>(\rho(spread^{NT}, C))</td>
<td></td>
<td>-0.25</td>
<td>-0.20</td>
</tr>
<tr>
<td>(\rho(spread^{NT}, C^b))</td>
<td></td>
<td>-0.34</td>
<td>-0.26</td>
</tr>
<tr>
<td>(\rho(spread^{NT}, C^b))</td>
<td></td>
<td>0.61</td>
<td>0.48</td>
</tr>
<tr>
<td>(\rho(spread^{NT}, m^{NT}))</td>
<td></td>
<td>-0.48</td>
<td>-0.28</td>
</tr>
<tr>
<td>(\rho(spread^{NT}, m^*))</td>
<td></td>
<td>-0.18</td>
<td>-0.37</td>
</tr>
<tr>
<td>(\rho(gdp, nx))</td>
<td>0.32</td>
<td>0.20</td>
<td>0.25</td>
</tr>
<tr>
<td>(\rho(gdp, NT debt/Tot. Debt))</td>
<td>-0.21</td>
<td>-0.37</td>
<td>-0.54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Panel B: Targeted Moments</th>
<th>Data (1)</th>
<th>Model (2)</th>
<th>No Sel. Def. (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default Incidence NS</td>
<td>0.62%</td>
<td>0.56%</td>
<td>0.69%</td>
</tr>
<tr>
<td>Credit Drop NT Default</td>
<td>-33%</td>
<td>-27%</td>
<td>-</td>
</tr>
<tr>
<td>Working Capital to GDP</td>
<td>0.097</td>
<td>0.065</td>
<td>0.074</td>
</tr>
<tr>
<td>Foreign working capital/GDP</td>
<td>0.006</td>
<td>0.002</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Table 6 reports moments obtained from model simulations. The first column contains moments from the data while the second and third columns report moments obtained simulating the economy with and without selective defaults. Moments are obtained simulating the model 100 times for 10,000 periods and averaging across the simulations.

Table 6 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.\(^{10}\) This limitation is widespread within quantitative models of sovereign defaults with one-period maturity debt. The model instead pretty well matches

\[^{10}\text{GDP is defined as final production in the economy: } gdp = y^T + y^{NT} - m^{NT} - m^*\]
the average debt composition. Government debt is almost evenly split between tradable- and nontradable-denominated debt. The model captures about 30% of the spread level in the tradable-denominated bonds market.\textsuperscript{11} Data for sovereign yields of local-currency bonds are only available from 2007 onward and only for Brazil and Mexico. This limited sample shows that yields of local-currency bonds are significantly higher than yields of foreign-currency bonds.\textsuperscript{12} This pattern is confirmed by the model that predicts higher spreads for nontradable-denominated bonds.

Turning to the second moments, the correlation between spreads and GDP is negative for both tradable- and nontradable-denominated debt. This finding is consistent with the intuition that default 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. Of note, as domestic bankers mainly purchase nontradable-denominated debt, the correlation between spreads of nontradable-denominated debt and bankers’ consumption is stronger than the one between tradable-denominated debt and bankers’ consumption. The model also reproduces the procyclicality of the financial account $\Delta x$ 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 negative correlation between GDP and the nontradable share of government debt is consistent with the equilibrium allocation of government bonds between domestic and foreign investors. As productivity increases, default risk falls and foreign investors begin purchasing tradable-denominated bonds.

Panel B compares data and simulation results for those moments that were the target of the simulation exercise. The incidence of non-selective defaults is tracked very closely by the model. Default probability is 0.56% in the model and 0.62% in the data. The model also closely matches credit contraction dynamics around defaults on nontradable-denominated debt. According to the model, credit contracts roughly 27%, which is close to the 33% observed in the data. The model also delivers domestic and foreign working capital levels that are of same order of magnitude as those observed in the data.

\textsuperscript{11}Spreads for tradable-denominated debt are computed using the J.P. Morgan Emerging Bond Index (EMBI), which measures yields for sovereign bonds issued in foreign currency.

\textsuperscript{12}On average Mexican and Brazilian sovereign yields on local-currency bonds are about 700 b.p. higher than the corresponding foreign-currency bonds spreads.
6.4 Dynamics around Defaults

Defaults happen when a sequence of positive productivity shocks is interrupted by a sudden productivity drop. As shown in Section 6.1, for high enough productivity levels, nontradable-denominated debt is allocated to domestic investors while tradable-denominated debt is allocated to foreign investors. As such, defaults typically happen when domestic investors hold maturing nontradable-denominated bonds, while foreign investors hold maturing tradable-denominated bonds. It follows that the government faces a key trade off: Either it defaults on nontradable-denominated debt, thereby hurting domestic investors and disrupting domestic credit, or it defaults on tradable-denominated debt, thereby restricting private-sector access to foreign intermediates.

Table 7. Simulations around Defaults

<table>
<thead>
<tr>
<th>Moments</th>
<th>Data (1)</th>
<th>Model (2)</th>
<th>No Sel. Def. (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavior around NT defaults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default Incidence</td>
<td>0.80%</td>
<td>1.64%</td>
<td>-</td>
</tr>
<tr>
<td>Mean GDP loss</td>
<td>−7.46%</td>
<td>−5.13%</td>
<td>-</td>
</tr>
<tr>
<td>Mean Credit contraction</td>
<td>−33.12%</td>
<td>−27.72%</td>
<td>-</td>
</tr>
<tr>
<td>Mean Foreign Int. contraction</td>
<td>2.52%</td>
<td>−3.72%</td>
<td>-</td>
</tr>
<tr>
<td>Behavior around T defaults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default Incidence</td>
<td>0.53%</td>
<td>0.75%</td>
<td>-</td>
</tr>
<tr>
<td>Mean GDP loss</td>
<td>−3.13%</td>
<td>−5.56%</td>
<td>-</td>
</tr>
<tr>
<td>Mean Credit contraction</td>
<td>2.84%</td>
<td>−8.89%</td>
<td>-</td>
</tr>
<tr>
<td>Mean Foreign Int. contraction</td>
<td>−32.38%</td>
<td>−30.56%</td>
<td>-</td>
</tr>
<tr>
<td>Behavior around NS defaults</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Default Incidence</td>
<td>0.62%</td>
<td>0.56%</td>
<td>0.69%</td>
</tr>
<tr>
<td>Mean GDP loss</td>
<td>−4.52%</td>
<td>−6.93%</td>
<td>−8.42%</td>
</tr>
<tr>
<td>Mean Credit contraction</td>
<td>−33.02%</td>
<td>−25.81%</td>
<td>−31.47%</td>
</tr>
<tr>
<td>Mean Foreign Int. contraction</td>
<td>−26.31%</td>
<td>−24.49%</td>
<td>−27.70%</td>
</tr>
</tbody>
</table>

Table 7 reports moments obtained from model simulation. The first column contains moment from the data, while the second and third columns report moments obtained by simulating the model economy 100 times for 10,000 periods and averaging across the simulations. 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.

Figure 3 compares simulated dynamics for credit, intermediate imports, and output around selective and non-selective default episodes. Defaults on nontradable-denominated debt are

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13 In our simulation 85.6% of defaults happen when domestic investors hold nontradable-denominated debt, while foreign investors hold tradable denominated debt.
The figure plots the average evolution of quantities and prices in the credit market and in the market of foreign intermediates around defaults on nontradable-denominated debt (blue line), tradable-denominated debt (red line), and non-selective defaults (green line). The bottom two panels also plot the evolution of tradable output and nontradable output around defaults.

associated with credit crunches, with credit supply falling roughly 24% and the interest rate on loans increasing sharply. Foreign intermediates are, instead, little affected as they only decline roughly 2% below the pre-crisis levels. Dynamics are different around selective defaults involving tradable-denominated bonds. The price of foreign intermediates increases and private sector purchases of foreign intermediates decline roughly 30%. The credit market, instead, is little affected with credit declining only marginally in the first few quarters after
default and quickly recovering afterwards.

 Tradable and nontradable output are affected in a similar fashion by defaults, regardless of the nature of the default episode. Domestic and foreign intermediates are imperfect substitutes for the production of tradable output; hence, when either of the two markets is disrupted also the other is affected. Table 7 compares simulated moments with actual moments in the data. The mode closely replicates output, credit, and foreign intermediates dynamics.

6.5 Sensitivity Analysis
In this section we evaluate how a set of key moments reacts to changes in the values of the parameters. In particular, we concentrate on parameters: \( A, \Gamma, \theta, \) and \( \theta^* \). Results are summarized in Table 8.
Table 8. Sensitivity Analysis

<table>
<thead>
<tr>
<th></th>
<th>Debt GDP</th>
<th>NT Debt</th>
<th>Default Rate</th>
<th>% GDP loss</th>
<th>% Credit loss</th>
<th>% Foreign Intern. loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>38.5%</td>
<td>0.50</td>
<td>0.62%</td>
<td>0.53%</td>
<td>0.80%</td>
<td>-4.52% -3.13% -7.46% -33.02% 2.84% -33.12% -26.31% -32.38% 2.52%</td>
</tr>
<tr>
<td>Benchmark</td>
<td>3.7%</td>
<td>0.51</td>
<td>0.56%</td>
<td>0.75%</td>
<td>1.64%</td>
<td>-6.93% -5.56% -5.13% -25.81% -8.89% -27.72% -24.49% -30.56% -3.72%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$A = 0.8$</td>
<td>2.3%</td>
<td>0.60</td>
<td>0.92%</td>
<td>0.27%</td>
<td>1.65%</td>
<td>-6.00% -7.65% -5.09% -18.91% -19.07% -17.05 -21.597% -25.97% -6.99%</td>
</tr>
<tr>
<td>$A = 1$</td>
<td>9.6%</td>
<td>0.42</td>
<td>0.05%</td>
<td>0.38%</td>
<td>0.38%</td>
<td>-6.29% -5.58% -5.77% -22.43% -2.08% -25.42% -20.86% -31.73% -7.31%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta = 0.78$</td>
<td>2.7%</td>
<td>0.53</td>
<td>1.32%</td>
<td>3.39%</td>
<td>-</td>
<td>-5.67% -5.52% -3.83% -24.97% -1.99% -21.25 -16.62% -30.90% -2.07%</td>
</tr>
<tr>
<td>$\beta = 0.82$</td>
<td>10.1%</td>
<td>0.49</td>
<td>0.38%</td>
<td>0.02%</td>
<td>-</td>
<td>-7.03% -5.86% -29.47% -0.21% -19.55% -32.78% -</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Gamma = 0.040$</td>
<td>6.9%</td>
<td>0.50</td>
<td>0.61%</td>
<td>0.71%</td>
<td>1.16%</td>
<td>-7.33% -6.62% -5.22% -27.82% -10.15% -28.54% -24.95% -30.26% -3.75%</td>
</tr>
<tr>
<td>$\Gamma = 0.044$</td>
<td>4.7%</td>
<td>0.54</td>
<td>1.25%</td>
<td>0.26%</td>
<td>2.95%</td>
<td>-6.79% -5.83% -3.44% -25.08% -3.42% -23.60% -23.47% -30.98% -4.66%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta = 0.06$</td>
<td>5.6%</td>
<td>0.49</td>
<td>0.93%</td>
<td>0.64%</td>
<td>2.15%</td>
<td>-7.34% -5.42% -4.78% -29.23% -5.73% -26.04% -20.36% -26.70% -3.52%</td>
</tr>
<tr>
<td>$\theta = 0.10$</td>
<td>5.1%</td>
<td>0.50</td>
<td>1.11%</td>
<td>0.76%</td>
<td>2.84%</td>
<td>-6.99% -6.37% -4.52% -26.80% -8.55% -25.94% -25.78% -33.31% -2.00%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\theta^* = 0.25$</td>
<td>3.6%</td>
<td>0.60</td>
<td>0.66%</td>
<td>1.65%</td>
<td>2.67%</td>
<td>-6.33% -6.48% -4.72% -23.77% -2.81% -24.19% -19.72% -31.94% -4.25%</td>
</tr>
<tr>
<td>$\theta^* = 0.30$</td>
<td>10.1%</td>
<td>0.53</td>
<td>0.25%</td>
<td>-</td>
<td>0.31%</td>
<td>-7.70% -6.32% -4.96% -30.23% -1.48% -25.12% -22.24% -31.75% -5.47%</td>
</tr>
</tbody>
</table>

Table 8 compares key moments obtained by simulating the model economy for a number of different parameters. Moments are obtained by simulating the model 100 times over 10,000 periods and averaging across simulations.
Parameter $A$ is the TFP coefficient for nontradable production. The lower the value of $A$, the smaller the production of nontradable goods. Parameter $A$ contributes to determine the effective costs of defaults. When the government defaults selectively on tradable-denominated debt, tradable producers substitute foreign intermediates with domestic ones. The cost of domestic intermediates depends on the productivity of the nontradable sector. When productivity parameter $A$ is low, domestic intermediates are scarce and expensive, and the output cost of a default is large. On net, the default incidence of selective defaults on nontradable-denominated debt falls when $A$ is low.

Parameter $\Gamma$ is the exogenous endowment that bankers receive in every period. Credit contraction around defaults depends crucially on $\Gamma$, as highlighted by equation 25. Large values of $\Gamma$ are associated with a small contraction of the credit supply. Hence, when $\Gamma$ is low, governments’ incentive to default is small and larger quantities of debt are sustained in equilibrium.

Parameters $\theta$ and $\theta^*$ determine the working capital needs for domestic and foreign intermediates. When $\theta$ ($\theta^*$) is large, final good producers need to pay a large fraction of the domestic (foreign) inputs in advance, making the default option less appealing. Indeed, large values of $\theta$ and $\theta^*$ are associated with a lower risk of default.

7 Selective Defaults: Welfare Implications

Do selective defaults improve welfare? This question is not trivial. On the one hand, selective defaults introduce the option for governments to default on a fraction of their debt, thereby improving government debt management. On the other hand, selective defaults worsen the commitment problem of the government and therefore increase government financing costs. In this section we quantitatively evaluate the welfare implications of selective defaults. We compare the baseline model economy with an economy in which only non-selective defaults are possible. We find that selective defaults reduce government borrowing ability and increase default risk, while at the same time increasing the welfare of the economy by roughly 0.4%. Both bankers and households benefit from the existence of selective defaults.
7.1 Government Debt Management and Economic Dynamics with No Selective Defaults

Columns (2) and (3) in Table 7 compare the evolution of the economy around defaults with and without the selective default option. Defaults are far less frequent when selective defaults are ruled out, but they also become more disruptive as they involve larger quantities of debt. GDP contracts on average more than 8% upon default when selective defaults are not allowed, while it only contracts roughly 6.5% when selective defaults are allowed.

7.2 Welfare Analysis

Table 9 reports welfare gains achieved by households and bankers when selective defaults are ruled out. Let $V(C^h, N)$ and $W(C^b)$ be the value functions of households and bankers, respectively, and let $V^{nso}(C^h, N)$ and $W^{nso}(C^b)$ be the corresponding value functions when
Table 9. Welfare Gains of Eliminating Selective Defaults

<table>
<thead>
<tr>
<th></th>
<th>Households</th>
<th></th>
<th>Bankers</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\Delta_{h,c}$</td>
<td>$\Delta_{h,N}$</td>
<td>$\Delta_{h}$</td>
<td>$\Delta_{b}$</td>
</tr>
<tr>
<td>Baseline:</td>
<td>0.14%</td>
<td>-0.43%</td>
<td>-0.29%</td>
<td>-4.09%</td>
</tr>
<tr>
<td>Sensitivity Analysis</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\psi = 0.3$</td>
<td>0.06%</td>
<td>-0.08%</td>
<td>-0.02%</td>
<td>-0.99%</td>
</tr>
<tr>
<td>$\psi = 0.7$</td>
<td>0.21%</td>
<td>-0.41%</td>
<td>-0.20%</td>
<td>-2.84%</td>
</tr>
</tbody>
</table>

The table reports the welfare gains obtained eliminating selective defaults. Welfare gains are computed according to equations (71), (72), and (73) as a percentage of the permanent units of consumption.

Selective defaults are not possible. Welfare gains $\Delta_h$ and $\Delta_b$ in permanent units of consumption are defined as follows:

$$ V(C^h(1 + \Delta_h), N) = V^{nso}(C^{h,nso}, N^{nso}) ; $$  \hspace{1cm} (71)

$$ W(C^b(1 + \Delta_h)) = W^{nso}(C^{b,nso}) . $$  \hspace{1cm} (72)

Households’ welfare gains $\Delta_h$ can be further decomposed to isolate the consumption contribution $\Delta_{h,c}$ and the labor contribution $\Delta_{h,N}$ to the overall welfare gain:

$$ V^{nso}(C^{h,nso}, N^{nso}) = V(C^h(1 + \Delta_{h,c}), N^{nso}) + V(C^{h,nso}(1 + \Delta_{h,N}), N) ; $$  \hspace{1cm} (73)

The elimination of selective defaults is detrimental to both households and bankers. On the one hand, households enjoy higher consumption in the absence of selective defaults, as the government can issue more bonds and attract resources from abroad. This channel explains the positive sign of the term $\Delta_{h,c}$ in Table 9. On the other hand, as output increases, households need to supply more labor to the economy which reduces their welfare. This channel explains the negative sign of the term $\Delta_{h,N}$. On net, the overall effect on households’ welfare is negative with welfare declining 0.29% in permanent units of consumption. Bankers are also worse off when selective defaults are ruled out as they benefit from the high yields...
that are associated with the higher default risk. Hence, the welfare of bankers declines more than 4% in permanents units of consumption.

Finally, we also compute the overall welfare gain for the economy $\Delta_t$ as the weighted average of bankers and household welfare gains. Weights are set equal to the share of each agents’ consumption in total consumption. The elimination of selective defaults reduces welfare by 0.43%. Admittedly, overall total losses can be quantitatively very different when different weights are used to aggregate workers and investors’ welfare. The last two rows of Table 9 report how welfare measures change when the Pareto weight $\psi$ changes. Total welfare loss increases to $-3.1\%$ when Pareto weight $\psi$ is set equal to 0.7, while it declines to 5% when $\psi$ is set equal to 0.3. Still as long as the elimination of selective defaults reduces the welfare of both bankers and households, the overall effect of such policy is unambiguously negative.

8 Conclusion

While the sovereign default literature assumes that government debt is issued using only one type of asset, governments typically use a variety of financial instruments to issue government debt, introducing the possibility of selective defaults. In this paper we concentrate on the currency denomination of government bonds and show that: (i) Selective defaults are frequent. (ii) Credit and imports dynamics are different around different types of default. Credit contracts sharply following a default on local-currency debt, while imports are largely unaffected. (iii) The opposite is true around defaults on foreign-currency debt. Based on these empirical regularities, we construct a theoretical model with endogenous default risk à la Eaton and Gersovitz (1981) characterized by the existence of both tradable-denominated and nontradable-denominated debt, which are used as proxies for foreign- and domestic-currency debt. We calibrate the model to South America and show that it closely reproduces the evolution of the economy as it is observed in the data.

This paper also investigates the welfare implications of policies that eliminate selective defaults. We find that such policies would reduce the default risk and increase the borrowing ability of the government, but they would also reduce the welfare of the economy.
References


Bofondi, Marcello, Luisa Carpinelli, and Enrico Sette, “Credit Supply during a Sovereign Debt Crisis,” Temi di discussione (Economic working papers) 909, Bank of Italy, Economic Research and International Relations Area April 2013.


## A Tables and Graphs

### A.1 Default Episodes

Table 10 reports the list of default episodes observed between 1980 and 2005. Following Reinhart and Rogoff (2008), Kohlscheen (2009), and Sturzenegger and Zettelmeyer (2008) we adopt Standard and Poor’s classification of defaults. A country is considered in default whenever it misses a payment or it restructure debt. The last column highlights data availability for each of the variables considered: Output Y, Trade balance to GDP ratio TB/Y, credit L, and imports I.

<table>
<thead>
<tr>
<th>Country</th>
<th>LC Default</th>
<th>FC Default</th>
<th>NS Default</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belize</td>
<td>2005</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>1981</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Dominica</td>
<td>2003</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Egypt</td>
<td>1984</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Grenada</td>
<td>2004</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Guatemala</td>
<td>1989</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Indonesia</td>
<td>1997</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Iraq</td>
<td>1986</td>
<td>Y</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Jamaica</td>
<td>1985</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Kuwait</td>
<td>1990</td>
<td>TB/Y, I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liberia</td>
<td>1989</td>
<td>Y</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Macedonia</td>
<td>1992</td>
<td>Y</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>1982</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Mongolia</td>
<td>1999</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Myanmar</td>
<td>1987</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Pakistan</td>
<td>1998</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Philippines</td>
<td>1982</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>1998</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Salomon Islands</td>
<td>1996</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Thailand</td>
<td>1998</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>+ Turkey</td>
<td>1999</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Ukraine</td>
<td>1998</td>
<td>Y, TB/Y, L</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Vietnam</td>
<td>1985</td>
<td>Y</td>
<td>TB/Y, I</td>
<td></td>
</tr>
</tbody>
</table>

Table 10 reports the list of default episodes observed between 1980 and 2005. Following Reinhart and Rogoff (2008), Kohlscheen (2009), and Sturzenegger and Zettelmeyer (2008) we adopt Standard and Poor’s classification of defaults. A country is considered in default whenever it misses a payment or it restructure debt. The last column highlights data availability for each of the variables considered: Output Y, Trade balance to GDP ratio TB/Y, credit L, and imports I.
## A.2 Data Sources

Table 11. Data Sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>Y Real GDP in local currency</td>
<td>IMF IFS &amp; World bank WDI</td>
</tr>
<tr>
<td>Trade Balance</td>
<td>TB/Y Current account in dollars divided by nominal GDP in $</td>
<td>IMF IFS</td>
</tr>
<tr>
<td>Credit</td>
<td>L Outstanding credit to the private sectors in $</td>
<td>World bank WDI</td>
</tr>
</tbody>
</table>

Table 11 reports the list of sources for the variables analyzed in the stylized fact sector.
A.3 Imports and Credit Dynamics: robustness analysis

Table 12: Imports and Credit dynamics around Default

<table>
<thead>
<tr>
<th></th>
<th>∆ Imports (1)</th>
<th>∆ Imports (2)</th>
<th>∆ Imports (3)</th>
<th>∆ Credit (4)</th>
<th>∆ Credit (5)</th>
<th>∆ Credit (6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Def^ext_i,t−1</td>
<td>-0.290**</td>
<td>-0.181**</td>
<td>-0.183***</td>
<td>0.021</td>
<td>0.098</td>
<td>0.109</td>
</tr>
<tr>
<td></td>
<td>(0.101)</td>
<td>(0.079)</td>
<td>(0.078)</td>
<td>(0.128)</td>
<td>(0.124)</td>
<td>(0.120)</td>
</tr>
<tr>
<td>Def^dom_i,t−1</td>
<td>-0.049</td>
<td>-0.032</td>
<td>0.045</td>
<td>-0.363***</td>
<td>-0.344***</td>
<td>-0.340***</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.046)</td>
<td>(0.045)</td>
<td>(0.702)</td>
<td>(0.068)</td>
<td>(0.066)</td>
</tr>
<tr>
<td>Def^ns_i,t−1</td>
<td>0.061</td>
<td>0.081*</td>
<td>0.090**</td>
<td>-0.167**</td>
<td>-0.179**</td>
<td>0.156**</td>
</tr>
<tr>
<td></td>
<td>(0.059)</td>
<td>(0.045)</td>
<td>(0.045)</td>
<td>(0.073)</td>
<td>(0.071)</td>
<td>(0.070)</td>
</tr>
</tbody>
</table>

Control Var. Yes Yes Yes Yes Yes Yes
Time FE No Yes Yes No Yes Yes
County FE No No Yes No No Yes

Table 12 reports results obtained from regression 74. Columns (1) to (3) contain regression results that are obtained using changes in log imports as the outcome variable. Columns (4) to (6) contain regression coefficient that are obtained using changes in log credit as the outcome variable. Standard errors are reported in brackets. * indicates significance at the 10% confidence level. ** indicates significance at the 5% confidence level.

Imports and credit dynamics presented in Section 2 are confirmed after controlling for a number of key economic variables. Inspired by the work of Gennaioli et al. (2014), we run the following regression:

\[ \Delta_i y = \gamma_0 + \gamma_1 De^f_{i,t-1} + \gamma_2 De^d_{i,t-1} + \gamma_3 De^n_{i,t-1} + \gamma_4 X_{i,t-1} + \mu_t + \epsilon_{i,t}. \]  

(74)

Let \( y \) be the outcome variable that is either imports or credit depending on the specification and let \( \Delta_i y \) be the change in the outcome variable between time \( t \) and time \( t - 1 \) in country \( i \).\(^{14}\) \( De^f_{i,t-1}, De^d_{i,t-1}, \) and \( De^n_{i,t-1} \) are three dummies that are equal to one when a country defaults on foreign-currency debt, on local-currency debt, and non-selectively, respectively. \( X_{i,t-1} \) is a vector of country-level variables that may affect the evolution of the outcome variable. The vector includes: GDP levels, credit levels, unemployment growth, changes in the exchange rate, inflation rate, a rating for the economic risk, a rating for the political

\(^{14}\)Both outcome variables are measured in logs and are collected at yearly frequency.
risk, and a rating for the financial risk of each country in the sample. Finally $\mu_t$ is a set of time fixed effects that controls for aggregate trends.

Results are summarized in Table 12 and confirm that the trade channel is more active around defaults on foreign-currency debt, while the credit channel is more active when defaults affect domestic currency debt. Coefficients $\gamma_1$, $\gamma_2$, and $\gamma_3$ capture the average effect of domestic, external, and non-selective defaults on the growth rate of imports and credit and they are the main focus of the analysis. Columns (1) to (3) present results for the growth rate of imports in the year following a sovereign default episode. In each of the three specifications, we find that foreign and non-selective defaults significantly reduce import growth. Domestic defaults have no effect on imports dynamics. Columns (3) to (6) present similar results for credit dynamics. Credit growth contracts around domestic and non-selective defaults, while it remains broadly unchanged in the aftermath of a default on foreign-currency debt.
B “Non-standard” Selective Defaults

The figure reports dynamics for six key variables around episodes of “non-standard” selective defaults on tradable-denominated debt.

Domestic investors typically hold nontradable-denominated debt in proximity of a default while foreign investors typically hold tradable-denominated debt as outlined in Section 6.4. There are, however, a few cases in which domestic investors hold both types of bonds. This scenario happens 14.4% of the time in our simulations. These “non-standard” default episodes share three common patterns: First, productivity drops before these episodes but less so than in the proximity of “standard” default episodes. Second, debt allocation changes just before default. Third, domestic investors hold both types of assets at the time of default.
Defaults are always triggered by a productivity drop. However, when the productivity drop is not too large, it may be optimal for the government to allocate both types of debt to domestic investors, thereby reducing the default risk and maximizing its borrowings ability. This is the commitment channel highlighted in Section 6.1, and it explains dynamics around non-standard defaults. Just before “non-standard” default episodes, governments are hit by a negative productivity shock and reallocate tradable-denominated debt from foreign to domestic investors. In the following periods, either productivity improves and the default is avoided or it worsens, leading to a default. This pattern is consistent with the observed regularity with which the domestic share of government debt holdings increases around defaults. Figure 5 plots credit, import and output dynamics around such default episodes. Purchases of foreign intermediates drop as early as one period before the actual default as tradable-denominated debt is purchased by domestic investors. Domestic intermediates instead discretely increase one period before the default, as resources are diverted from foreign to domestic investors, before plunging during the default.
C 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:

- Make an assumption about the optimal debt allocations $1'_{T}$ and $1'_{NT}$
- In the final period:
  - Discretize the productivity shock $z$ using a quadrature method, as in Tauchen and Hussey (1991).
  - Set up the vector $\Omega = \{1_T \times 1_{NT} \times z \times b^T \times b^{NT}\}$ defining the state space
  - Solve the system of equations (43)-(61) on the vector $\Omega$ in the default scenarios and in the nondefault scenarios.
  - Compute value function of bankers and households
- In every other periods:
  - Set up the grid $\Omega = \{1_T \times 1_{NT} \times z \times b^T \times b^{NT}\} \times \{b'^{T} \times b'^{NT}\}$ defining the state and choice space.
  - Solve the system of equations (43)-(61) on the grid $\Omega$ 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 $1e^{-6}$.
- Compare equilibrium value functions in each of the four default scenarios and determine the optimal allocation choice.