Clustered Sovereign Defaults: Online Appendix

A Estimation Equations

A.1 State-Space Form: The Basic Version

Measurement Equation

$$\Delta y_t = W + V \cdot \theta_t$$

where,

$$\Delta y_t = \left[\Delta y_t^1, \cdot, \Delta y_t^c, \cdot, \Delta y_t^{nc}\right]^{\mathrm{T}}$$

$$W = \left[\ln(g_{ss}^1) + \alpha_X^1 \ln(g_{ss}^w), \cdot, \ln(g_{ss}^c) + \alpha_X^c \ln(g_{ss}^w), \cdot, \ln(g_{ss}^{nc}) + \alpha_X^{nc} \ln(g_{ss}^w)\right]^{\mathrm{T}}$$

$$V = \begin{bmatrix} \alpha_z^1 & -\alpha_z^1 & \alpha_X^1 & 1 & -1 & 1 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \alpha_z^c & -\alpha_z^c & \alpha_X^c & 0 & 0 & 0 & \cdot & 1 & -1 & 1 & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \alpha_z^{nc} & -\alpha_z^{nc} & \alpha_X^{nc} & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 1 & -1 & 1 \end{bmatrix}$$

and

$$\theta_t = \Big[\ z_t^w \quad z_{t-1}^w \quad \ln(g_t^w/g_{ss}^w) \quad z_t^1 \quad z_{t-1}^1 \quad \ln(g_t^1/g_{ss}^1) \quad \cdot \quad z_t^c \quad z_{t-1}^c \quad \ln(g_t^c/g_{ss}^c) \quad \cdot$$
$$\cdot \quad z_t^{nc} \quad z_{t-1}^{nc} \quad \ln(g_t^{nc}/g_{ss}^{nc})\ \Big]^{\mathrm{T}}$$

The dimension of Δy_t is $(nc \times 1)$. W is also $(nc \times 1)$ and it is time invariant. V is $(nc \times (3 * nc + 3))$ and it is time invariant as well. The state variable vector, θ_t, is $((3 * nc + 3) \times 1)$.

Transition Equation

The evolution of state vector (transition equation) can be represented as:

$$\theta_t = K \cdot \theta_{t-1} + \lambda_t$$

where $\lambda_t = \left[\epsilon_{z,t}^w, 0, \epsilon_{g,t}^w, \epsilon_{z,t}^1, 0, \epsilon_{g,t}^1, \cdot, \epsilon_{z,t}^c, 0, \epsilon_{g,t}^c, \cdot, \epsilon_{z,t}^{nc}, 0, \epsilon_{g,t}^{nc}\right]^{\mathrm{T}}$, $\epsilon_z^w \sim N(0, (\sigma_z^w)^2)$, $\epsilon_g^w \sim N(0, (\sigma_g^w)^2)$, $\epsilon_z^c \sim N(0, (\sigma_z^c)^2)$, $\epsilon_g^c \sim N(0, (\sigma_g^c)^2)$ and

$$K = \begin{bmatrix} \rho_z^w & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ 0 & 0 & \rho_g^w & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ 0 & 0 & 0 & \rho_z^1 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & \rho_g^1 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdot & \rho_z^c & 0 & 0 & \cdot & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 1 & 0 & 0 & \cdot & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & \rho_g^c & \cdot & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & \rho_z^{nc} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & \cdot & 0 & 0 & \rho_g^{nc} \end{bmatrix}$$

Posteriors

Given that all the prior distributions are assumed to be uniform, the posterior distributions show that they differ significantly from the prior distributions. Table OA1 in the appendix shows the means and standard deviations of all the estimated parameters. Among all the parameters related to a persistent level of shocks, the persistence of global shock to the transitory component of output is most precisely estimated. This precision is evident from the standard deviation of ρ_z^w reported to be 0.04 in Table OA1. Some of the parameters related to the persistence level are not very precisely estimated. Table OA1 shows that the posterior distribution of the standard deviations is precisely estimated for all the countries. Though mean α values are positive for most of the countries, as shown in columns 7 and 8 of Table OA1, and the distributions of these α values are also precise, it is difficult to say whether the α values differ significantly from 0 for some of the countries.

A.2 State-Space Form: The Full Version

The mechanism works through labor demand and the working-capital constraint. Through this channel, changes in real interest rate affect equilibrium quantity of labor. Since output is assumed to be produced using labor, output is also affected by interest rate changes.

In the full version, the output of country c at given time t (omitted from the equation for convenience) is given as:

$$Y^c = A^c (L^c)^{\alpha_L^c}$$

where $A^c = e^{z^c+\alpha_z^c z^w} X^c (X^w)^{\alpha_X^c}$ represents technology level.[22]

The technology, A^c, in full version is exactly the same as the output in basic version. Thus, the technology grows with shocks around a trend. The labor, as we know from our macro models as well as the data, is stationary. Even though labor is stationary, it fluctuates along with fluctuations in technology. Thus, labor here is assumed to be dependent on detrended level of technology which make it stationary but at the same time responsive to technology shocks.

Additionally, I assume that labor is inversely proportional to the world interest rate, which can occur because production is costly and firms in emerging markets tend to borrow in order to produce. When the interest rates rise, the borrowing cost increases, which causes a decrease in labor demand as well as the output. This relationship between labor and interest rate is microfounded at a later stage, when I discuss the model.

The two assumptions together give: $L_t^c = \kappa \tilde{A}_t^c/((1+r_t^*)^\eta)$, where κ is a constant and $\tilde{A}$ is the detrended level of technology.[23] The output can, therefore, be rewritten as:

$$Y^c = e^{z^c+\alpha_z^c z^w} X^c (X^w)^{\alpha_X^c} (\kappa e^{z^c+\alpha_z^c z^w} g^c (g^w)^{\alpha_X^c}/(1+r^*))^{\alpha_L^c}$$

Measurement Equation

$$\Delta y_t = W_t + V \cdot \theta_t$$

where,

$$\Delta y_t = \left[\Delta y_t^1, \cdot, \Delta y_t^c, \cdot, \Delta y_t^{nc}\right]^{\mathrm{T}}$$

$$\begin{aligned} W_t = \big[&\ln(g_{ss}^1) + \alpha_X^1 \ln(g_{ss}^w) - (\psi^1 - 1)\eta^1 \Delta r_t^*, \cdot, \ln(g_{ss}^c) + \alpha_X^c \ln(g_{ss}^w) - (\psi^c - 1)\eta^c \Delta r_t^*, \cdot \\ &, \ln(g_{ss}^{nc}) + \alpha_X^{nc} \ln(g_{ss}^w) - (\psi^{nc} - 1)\eta^{nc} \Delta r_t^*\big]^{\mathrm{T}} \end{aligned}$$

$$\begin{aligned} \theta_t = \big[&z_t^w, z_{t-1}^w, \ln(g_t^w/g_{ss}^w), \ln(g_{t-1}^w/g_{ss}^w), z_t^1, z_{t-1}^1, \ln(g_t^1/g_{ss}^1), \ln(g_{t-1}^1/g_{ss}^1), \cdot, z_t^c, z_{t-1}^c, \\ &\ln(g_t^c/g_{ss}^c), \ln(g_{t-1}^c/g_{ss}^c), \cdot, z_t^{nc}, z_{t-1}^{nc}, \ln(g_t^{nc}/g_{ss}^{nc}), \ln(g_{t-1}^{nc}/g_{ss}^{nc})\big]^{\mathrm{T}} \end{aligned}$$

[22] I call A_t^c as technology level and the corresponding shocks are shocks to technology but in reality, these shocks can be demand shocks or some other shocks. The purpose of the equation is to capture the shocks to output and in the full version, it is convenient to call the shocks as technology shocks.

[23] This functional form of labor is equivalent to $L_t^c = \kappa(\tilde{A}_t^c)^\mu/((1+r_t^*)^\eta)$ since it can be written as $L_t^c = (\kappa_1(\tilde{A}_t^c)/((1+r_t^*)^{\eta/\mu}))^\mu$. Once I substitue this in the output function, any scale effect of μ can be taken into account by a different value of α_L^c.

and

$$V = \begin{bmatrix} \psi^1\alpha_z^1 & \cdot & \psi^c\alpha_z^c & \cdot & \psi^{nc}\alpha_z^{nc} \\ -\psi^1\alpha_z^1 & \cdot & -\psi^c\alpha_z^c & \cdot & -\psi^{nc}\alpha_z^{nc} \\ \psi^1\alpha_X^1 & \cdot & \psi^c\alpha_X^c & \cdot & \psi^{nc}\alpha_X^{nc} \\ -(\psi^1-1)\alpha_X^1 & \cdot & -(\psi^c-1)\alpha_X^c & \cdot & -(\psi^{nc}-1)\alpha_X^{nc} \\ \psi^1 & \cdot & 0 & \cdot & 0 \\ -\psi^1 & \cdot & 0 & \cdot & 0 \\ \psi^1 & \cdot & 0 & \cdot & 0 \\ -(\psi^1-1) & \cdot & 0 & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & \psi^c & \cdot & 0 \\ 0 & \cdot & -\psi^c & \cdot & 0 \\ 0 & \cdot & \psi^c & \cdot & 0 \\ 0 & \cdot & -(\psi^c-1) & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & \cdot & 0 & \cdot & \psi^{nc} \\ 0 & \cdot & 0 & \cdot & -\psi^{nc} \\ 0 & \cdot & 0 & \cdot & \psi^{nc} \\ 0 & \cdot & 0 & \cdot & -(\psi^{nc}-1) \end{bmatrix}^T$$

The dimension of Δy_t is $(nc \times 1)$ (where nc is the total number of countries). W_t is not time invariant now as it depends on changes in world interest rate. The dimension of W_t is also $(nc \times 1)$. V is $(nc \times (4 * nc + 4))$ and it is still time invariant as before. The state variable θ_t is $((4 * nc + 4) \times 1)$.

Transition Equation

The evolution of state vector (transition equation) is represented as:

$$\theta_t = K \cdot \theta_{t-1} + \lambda_t$$

where

$$K = \begin{bmatrix} \rho_z^w & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & \rho_g^w & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & \rho_z^w & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \rho_g^w & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & \rho_z^w & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 1 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & \rho_g^w & 0 & \cdot & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 1 & 0 & \cdot & 0 & 0 & 0 & 0 \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & \rho_z^w & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & \rho_g^w & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 0 & 0 & \cdot & 0 & 0 & 1 & 0\cdot \end{bmatrix}$$

and $\lambda_t = [\epsilon^w_{z,t}, 0, \epsilon^w_{g,t}, 0, \epsilon^1_{z,t}, 0, \epsilon^1_{g,t}, 0, \cdot, \epsilon^c_{z,t}, 0, \epsilon^c_{g,t}, 0, \cdot, \epsilon^{nc}_{z,t}, 0, \epsilon^{nc}_{g,t}, 0]^{\mathrm{T}}$, $\epsilon^w_z \sim N(0, (\sigma^w_z)^2)$, $\epsilon^w_g \sim N(0, (\sigma^w_g)^2)$, $\epsilon^c_z \sim N(0, (\sigma^c_z)^2)$ and $\epsilon^c_g \sim N(0, (\sigma^c_g)^2)$.

Posteriors

Table OA2 shows that the persistence parameters are much more precisely estimated in the full model than in the basic model. Small standard deviations for α values show that α is more precisely estimated than in the basic version, and the table also shows that α values are statistically different from 0 for many countries. Standard deviation values for ψ^c and η^c show that those values are also precisely estimated. The standard deviations are much smaller for ψ^c than for η^c.

B Empirical Analysis

The Kalman smoothed time series of shocks—country-specific shocks for every country and global shocks—obtained from the estimation part are used to perform some preliminary tests. Moreover, using a regression framework, I ask whether countries faced different shocks during clustered defaults vis-à-vis idiosyncratic defaults.

I start by examining the transitory and permanent shocks around idiosyncratic and clustered default episodes.[24] I then decompose these shocks into their global and country-specific components to investigate their individual contributions to idiosyncratic and clustered default events. In the next step, I perform a regression analysis to uncover whether global shocks play a substantial role in explaining clustered defaults. I begin with a logistic regression exercise and predict the probability of default events. I then test whether including global shocks as an explanatory variable increases the predicted probability of the default events.

In order to utilize the data on defaults by 92 countries and 146 default events from 1975 to 2014, I perform the Bayesian estimation on biggest possible subset of countries. I impose the condition that countries must have a continuous time series of output starting no later than 1960. This along with data availability of other regressors leaves 49 countries and 87 default episodes to analyze. To check robustness, and to work on an even larger set of countries, I also perform HP-filtering on the output data which requires output from 1975 and not 1960. This results in 58 countries and 99 defaults episodes to be analyzed.

B.1 Data

In the empirical section, the paper uses the Kalman-smoothed time series of output shocks, which comes from the estimation section. The paper also uses some data on defaulting countries and some global variables to evaluate their explanatory power for the default decision of the country.

For the empirical analysis, to capture the output shocks, I use the Kalman-smoothed time series of country-specific and global components of the output process for every country. This time series comes directly from the estimation section, and it 49 defaulting countries and 87 defaults for the period of 1975-2014. I test the robustness of the results by using HP-filtered components of GDP, which provide a larger set of countries.[25] This expanded set of countries also covers the sovereign defaults between 1975 and 2014. The data on these default episodes come from Uribe and Schmitt-Grohé (2017). As summarized in Table OA3,

[24]The time series of all the four components of output that we use has a nice property. Since the only observable in the estimation is the output growth of countries, the estimation process is completely independent of the default data. Additionally, adding developed countries that have never defaulted to the estimation process ensures that the estimated global shocks are not contaminated by the presence of default events. Thus, adding these additional developed countries eliminates the reverse causality problem. A negative shock to some global component of output will not be a result of the output decline of a set of countries in response to default.

[25]The global shocks are proxied by using HP-filtered cycle and trend components of GDP for the US.

this dataset contains a set of 92 countries that chose to default 146 times between 1975 and 2014. The greatest share of these defaults comes from two regions: (1) Africa and the Middle East, where 42 countries led to 65 defaults, and (2) Latin America and the Caribbean, where 28 countries defaulted a total of 51 times. The dataset contains not only the years of default but also the number of years[26] subsequent to the default episode during which the countries remained in default status.[27] Additionally, the paper uses country-specific data on the total external debt to GDP ratio of countries. I use the data on net foreign assets of the borrowers as a fraction of GDP from the full version of Lane and Milesi-Ferretti (2007) to proxy for total external-debt to GDP ratio. Another proxy that I use is the data on government debt as a fraction of GDP from Abbas et al. (2010). Finally, spot crude oil price data, another global variable, are also retrieved from FRED. I adjust the oil price for inflation using consumer price index data for all urban consumers, also retrieved from FRED.

B.2 Global and Country-specific Shocks around Default Episodes

I use aggregate transitory and permanent shocks, along with their global and country-specific components, around different default episodes. In this manner, I aim to distinguish whether a representative clustered default episode faced different shocks, in terms of nature and severity, than a representative idiosyncratic default episode. I use the median values of shocks across default episodes, clustered or idiosyncratic or both type, to obtain the representative default of respective category. The results remain robust to using mean values.

The basic version of the output process of a country, c, has already been given as:

$$Y_t^c = e^{z_t^c + \alpha_z^c z_t^w} \cdot X_t^c (X_t^w)^{\alpha_X^c}$$

[26]The data contain start and end dates of default. For example, Peru had one default with a start date of 1978 and an end date of 1978, and Argentina had a default with a start date of 1982 and an end date of 1993. I use the date of start of default as the default date and calculate the number of years that the country remained in default for every default episode. The number of years for the Peruvian default of 1978, for example, is calculated as 1, and the number of years for the Argentinean default of 1982 is calculated as 12.

[27]The definition of a country in default status is as follows, from Uribe and Schmitt-Grohé (2017), who in turn follow Standard and Poor's specification: *Standard and Poor's defines default as the failure to meet a principal or interest payment on the due date (or within a specified grace period) contained in the original terms of a debt issue (Beers and Chambers, 2006). This definition includes not only situations in which the sovereign simply refuses to pay interest or principal, but also situations in which it forces an exchange of old debt for new debt with less-favorable terms than the original issue or it converts debt into a different currency of less than equivalent face value. A country is considered to have emerged from default when it resumes payments of interest and principal including arrears. In cases of debt renegotiation and restructuring, the country is assumed to rejoin the markets when the rating agency concludes that no further near-term resolution of creditors' claims is likely.*

Using this output specification in a multicountry setting, the Bayesian estimation provided the parameters that govern global shock processes—z^w, $\ln(g^w)$—and country-specific shock processes—z^c, $\log(g^c/g^c_{ss})$. The estimation also provides the parameter through which global shocks affect the output of country c: α^c_z and α^c_X. Thus, I construct the aggregate transitory and permanent shocks—$z^c + \alpha^c_z z^w$, $\ln(g^c/g^c_{ss}) + \alpha^c_X \ln(g^w)$—for the output of every country. I then decompose these aggregate transitory and permanent shocks into global and country-specific components to study their movements near the default episodes.

The first row of Figure OA5 shows median values for the aggregate transitory component of the GDP and growth in the aggregate permanent component of the GDP near default episodes. The three lines in each figure show median values across all default episodes, across clustered default episodes and across idiosyncratic default episodes. The figure suggests that during clustered defaults, even though the countries were doing much better 1 year before the crisis and 2 years before the crisis, they underwent a steep reduction in output as they approached the year of default. This drop is much more severe in the case of the transitory component of the GDP. For idiosyncratic defaults, half of the time, the countries were doing poorly even 2 years before the default, and they gradually did worse as they approached the default year. The next two rows decompose the permanent and transitory shocks into global and idiosyncratic components.

Figure OA5 further suggests that the large negative transitory shock that many borrowers observe during clustered default episodes is driven mainly by the global shock to the transitory component of output rather than by idiosyncratic shock. In contrast, the permanent shock, which is slightly more pronounced in the clustered default episodes, comes mainly from country-specific shocks.

Another point to note in Figure OA5 is that the decline in the transitory component of the GDP is much more severe than the actual magnitude of the transitory component, even in the year of default. Growth in the permanent component, on the other hand, is negatively affected for most of the defaulters.

The results for permanent and transitory shocks presented in Figure OA5 remain robust to HP-filtering the output series of individual countries to obtain the cycle and the trend growth. [28]

The last global variable I review is the world real interest rate. Since the period 1981-1983 is a period of higher-than-usual interest rates as well as a period of clustered defaults, Figure OA6 shows that the clustered defaults were accompanied by higher risk-free interest

[28] Since the HP filter cannot provide a global shock from country outputs, we use cyclical and trend shocks to world output as a proxy for global shock. For idiosyncratic shock, we use cyclical and trend components for every country individually.

rates, while idiosyncratic defaults occurred at a median risk free rate of approximately 4%.

B.3 Empirical Specifications

A preliminary observation of country-specific and global shocks shows that countries involved in clustered defaults faced negative global transitory shocks to output as well as a hike in the world interest rate. In this subsection, I incorporate country-specific and global shocks into a regression framework to address the problem in a formal setting. I predict the probability of default for all the observed default events using two specifications: one with only country-specific explanatory variables and the other with both country-specific and global explanatory variables. Predicting the default probability of default events and comparing them across the two specifications informs us about the marginal role played by global variables in influencing sovereign defaults. The empirical exercise shows that clustered default episodes can be explained significantly better when the specification includes global variables. Idiosyncratic defaults, on the other hand, are not influenced by the presence of global variables in the specification, and the predicted probability of default remains the same across both specifications.

Since the canonical work on sovereign default attributes defaults to the high indebtedness of the borrower or to the negative output shock to the borrowing countries, it is natural to assume the same for idiosyncratic defaults. Clustered defaults, however, due to the nature of being concentrated around a small window, suggest a role of worsening global fundamentals. Thus, I test whether global shocks play a different role in clustered defaults than in idiosyncratic defaults. Since the default decision is a 0/1 variable, I use a logistic regression framework, similar to that of Kaminsky and Vega-Garcia (2016), to explain default decisions.

The logistic regression framework attributes the default status of a country to a set of factors including negative output shocks to countries. Negative output shocks to a borrowing country might keep the borrowing country in default status. This suggestion gives rise to a probable reverse causality concern. Not only low output in the country might lead the borrower to default and to remain in default status for a long time, but also, a default in the borrowing country might cause its output to remain low for the foreseeable future.[29] Thus, to get ride of reverse causality issue, it is reasonable to eliminate data for the borrower for a few years after the country's default. I remove data subsequent to a default for all years in which the borrower remains in default status and has difficulty accessing world financial

[29]The output can remain low after default for several reasons: reduced borrowing due to restricted access to financial markets, trade restrictions, increased unemployment due to postdefault devaluation policies , etc.

markets.[30]

The two regression specifications are as follows:

Specification 1:

$$D_{c,t} = \beta X_{c,t} + \mu_c + e_{c,t}$$

Specification 2:

$$D_{c,t} = \beta X_{c,t} + \gamma X_{w,t} + \mu_c + e_{c,t}$$

In both specifications, the default dummy, $D_{c,t}$, is the dependent variable. It takes a value of 1 in the year the country defaulted or is in default status and 0 otherwise. Since I remove data points in which the country is in default status after the country has defaulted because of reverse causality concerns, I have $D_{c,t} = 1$ only in the period of default. Both specifications include country fixed effects to account for unobserved country-specific differences. In terms of explanatory variables, both specifications have country-specific variables, $X_{c,t}$. Only the second specification has global variables, $X_{w,t}$, which is the difference between two specifications.

As most of the literature emphasizes, output shocks to borrowers are one of the most important criteria that explain sovereign defaults. To capture these output shocks, I use the same components of output that I obtained from the estimation exercise: country-specific and global shocks to transitory and permanent components of output.

In addition to the transitory and permanent components of country-specific output shocks, the next country-specific explanatory variable used here is the borrower's net foreign asset position as a percentage of GDP.[31] This ratio of net foreign assets to GDP measures the indebtedness of the borrower. For global explanatory variables, the first one that I use is real interest at the disposal of investors. I construct the data on the world real interest rates by using the rate on 5-year treasury constant maturity and adding a market risk spread to it. This spread is constructed by using Moody's seasoned BAA-rated corporate bonds and Moody's seasoned AAA-rated corporate bonds. I further adjust the interest rate for inflation by using expectations for one-year-ahead annual average inflation measured by the GDP price index. The next global variables are the transitory and permanent components of global shocks to output. Finally, I use inflation-adjusted oil prices to control for the investment surge hypothesis of defaults. The hypothesis, largely related to the Latin American defaults of 1982, suggests that a decrease in oil prices can cause defaults. The

[30] This data is available from Uribe and Schmitt-Grohé (2017).

[31] The series on net foreign assets as a percentage of GDP is available only to 2011; thus, the paper uses the series on government debt as a fraction of GDP for robustness checks. The series on government debt is available for recent years and is highly correlated with the series on net foreign assets as a fraction of GDP (correlation coefficient of -0.84).

mechanism starts with a rise in oil prices that causes a surge in investment by oil-rich countries in emerging economies. This leads to overindebtedness, which results in default when oil prices plummet and investments dry up. Since this channel is expected to work through the debt level of a country, which the specification has already controlled for, it is unclear whether controlling for oil prices will matter. Oil price fluctuations can also lead to global shocks in output through the supply channel. Thus, global output shocks, both transitory and permanent, that are already added as explanatory variables, might capture the effect of oil price fluctuations in themselves.Hence, it again becomes unclear whether controlling for oil prices matter.

Before I move on to the results and compare the two specifications, I check whether the regression coefficients concur with common beliefs in the literature about the effects of different explanatory variables on a default decision. First, negative output shocks lead to defaults. Second, high indebtedness or a low new foreign asset position as a percentage of GDP leads to default. Third, high world real interest rates lead investors to withdraw money from borrowing countries, making it harder for the borrower to obtain new loans and service existing debt. This difficulty eventually leads the borrower to default. Finally, plummeting oil prices cause investments to dry up in developing countries, which eventually results in default.

Returning to the specifications, the two regression specifications suggest two different hypotheses. The first specification suggests that a country's decision to default depends, for the most part, on the borrowing country itself. A priori, we can expect that adverse output shocks to the borrowing country and too much debt as a percentage of GDP for the borrowing country can lead the country into default. The second specification also takes global variables into account. These global variables are proxies for shocks to global fundamentals that affect all borrowers together. In this specification, therefore, we expect worsening global fundamentals to cause default. Thus, the specification means that the default decisions depend not only on borrower-specific variables but also global variables.

Each regression specification and the corresponding hypothesis seem to fit one category of defaults better than the other. The first specification, which attributes defaults only to country-specific explanatory variables, seems to fit idiosyncratic defaults better. Since these defaults occur in isolation compared to clustered defaults, in which default by a country is accompanied by defaults in multiple other countries, it is plausible that global shocks do not make a significant difference in leading countries to idiosyncratic defaults. For clustered default episodes, in contrast, global fundamentals usually face worsen at approximately the same time that countries decide to default. Thus, it seems appropriate to assume that clustered default episodes are a much better fit for the specification and the hypothesis that include global shocks as explanatory variables.

Since each specification and the corresponding hypothesis fit one category of default better than the other, we reformulate the hypotheses according to the default category. For idiosyncratic default episodes, we hypothesize that moving from specification 1 to specification 2 does not make a great difference in predicting idiosyncratic defaults, on average. In other words, adding global shocks to a specification that already has country-specific shocks does not make a significant difference in predicting idiosyncratic defaults compared to a specification with only country-specific shocks. For clustered defaults, we hypothesize that specification 2 significantly improves the predictive power of clustered defaults in comparison to specification 1.

To test the reformulated hypotheses, we perform regression for both the specifications. Once we obtain the regression coefficients, we predict the probability of default for each of the specification. We then examine the probability of default for the 87 default events in our sample. If the hypothesis is true, we expect the specification 1 to be better—or both specifications to be almost the same—for the idiosyncratic default events in our sample. Additionally, specification 2 must yield significantly higher default probabilities for the clustered default events in our sample. Mathematically,

$$\hat{Pr}(\hat{D}_{c,t} = 1 | D_{c,t} = 1, S_1) \geq \hat{Pr}(\hat{D}_{c,t} = 1 | D_{c,t} = 1, S_2)$$

$$\hat{Pr}(\hat{D}_{c,t} = 1 | D_{c,t} = 1, S_1) < \hat{Pr}(\hat{D}_{c,t} = 1 | D_{c,t} = 1, S_2)$$

B.4 Results

As emphasized in the literature, the results confirm that the debt level in a country as a percentage of GDP and country-specific shocks to the output of the borrowing economy are both good predictors of default. Additionally, real interest rate shocks and global shocks to the transitory component of the GDP are also good predictors of default events. For idiosyncratic defaults, the results show that the predicted probability of default events conditional on default is almost the same for both specifications. For clustered defaults, however, the predicted probability of default conditional on default events is more than twice as high in specification 2 as in specification 1. Thus, global shocks make a great difference in leading countries to default in the case of clustered default events.

B.4.1 Specification with Country-Specific Variables

Motivated by the set of stylized facts discussed in section B.2, I choose a 2-year change in the country-specific and global shocks to the transitory component of output as explanatory variables. The results are reported in Table OA8. I also show that the results are robust to choosing the level of country-specific and global shocks to the transitory component of output rather than 2-year changes. The results with levels instead of changes are reported in Table OA5 in the appendix. Table OA8 shows that although all three country-specific explanatory variables have the expected signs, only the debt level and the country-specific shocks to the permanent component of the output are statistically significant in predicting the default decision of the borrowing country.

Columns 2 and 4 of Table OA8 report the regression coefficients. Since the empirical specification uses logistic regression, the coefficient estimates have a lesser quantitative appeal beyond the signs. For this reason, I also report the marginal effects of changing an explanatory variable on the probability of default in columns 3 and 5 of Table OA8. For example, Column 3 shows that 1 standard deviation decrease in net foreign asset as a fraction of output increases the probability of default by 0.09. Similarly, 1 standard deviation decrease in the growth rate from its average increases the probability of default by 0.13. A decrease in the 2-year difference of the country-specific shock to the transitory component of output decreases the probability of default, but the magnitude of this change is not significantly different from 0.

B.4.2 Specification with Country-specific and Global Variables

Column 4 of Table OA8 shows the results of specification 2. As in specification 1, the coefficients related to all the country-specific variables remain very similar in terms of magnitude and effect on the default decision of the country. Among global variables, only the real interest rate in the US and the 2-year change in the transitory component of real output have a significant effect on the probability of default.

Column 5 of Table OA8 shows that a 1 standard deviation increase in the US interest rate causes the default probability to increase by almost 0.10. This finding is in line with the belief that when credit becomes expensive, countries find it more difficult to roll over the existing debt, and they tend to default more often. It also supports the commonly held belief that increased risk-free rates have a substantial negative impact on default decisions. Negative global shock to the transitory component of the output also increases the default probability, as expected. A 1 standard deviation decrease in $\Delta z^w_{t,t-2}$ causes the default probability to increase by 0.06. The sign on the coefficient of global permanent growth shock to output is surprising, even if it is statistically indistinguishable from 0. This finding is also evident from the bottom-left panel of Figure OA5. Clearly, during and near the default episodes, the fluctuations in the global component of permanent growth are nonexistent compared to other output shocks. The coefficient on oil prices, though not statistically significant, confirms our expectation that an oil price decrease leads to decreased lending in emerging countries. The decreased lending causes difficulties in repayment of the interest and the principal on existing debt, which lead to more frequent defaults. For oil-exporting developing economies, a decrease in oil prices leads to a decrease in export revenues and output which can also lead to default.

Considering the changes in probability when we change an explanatory variable by 1 standard deviation, whether we can interpret the change in probability by directly multiplying the marginal effect and the standard deviation together might be a concern because of the shape of the logit function. It shows very small changes in probability with increases in the explanatory variable, both at low and high values of the explanatory variable. This concern is addressed in Figure OA3 in the appendix. This figure shows that our estimates in column 5 of Table OA8 are close estimates of the actual marginal changes.

With summary statistics of the explanatory variables in Table OA4 and the marginal effects of these explanatory variables in Figure OA3 in the appendix, we can return to examine the contributions of different global shocks in leading countries to clustered defaults vis-*à*-vis idiosyncratic defaults. As shown in Figure OA6, the median real interest rate during a default is higher by almost 2.5% for clustered default episodes than for for idiosyncratic defaults. This finding shows that, all other variables remaining the same, real interest rate alone can account for an increase in the probability of default of 0.12. Figure OA5 shows that a 2-year change in country-specific shock to the transitory component of output is -0.05 for clustered default episodes and close to 0 for idiosyncratic episodes. Thus, ceteris paribus, global shocks increase the probability of default by 0.15 during clustered default episodes compared to idiosyncratic default episodes. Both of these observations suggest a substantial role for global shocks when it comes to clustered defaults. The same global shocks, on the other hand, do not seem to play a major role in increasing the probability of default for idiosyncratic default episodes. In the next section, I test this hypothesis more formally.

B.4.3 Comparing Specifications: Clustered and Idiosyncratic Defaults

Given the predicted probability of default from both specifications, this paper compares the two specifications across clustered and idiosyncratic defaults. Figure OA7 shows the predicted probabilities for all the default events. The y-axis shows the predicted probabilities from specification 1, and the x-axis measures the same from specification 2. Additionally, there is a 45-degree line to determine whether the predicted probabilities are the same in both specifications or whether they are systematically higher in one specification than in the other. A default episode on the right side of the 45-degree line means that specification 2 beats specification 1 at predicting that particular default, while opposite means that specification 1 wins. The figure also attaches different markers to idiosyncratic and clustered defaults.

In an ideal scenario, since the predicted probabilities are conditional on the respective country defaulting in the data, all these predicted values should be close to 1. Figure OA7 shows that this is clearly not the case, as the predicted probabilities are substantially lower than 1. This finding signifies the inability of the explanatory variables to predict default, which is also evident from the low pseudo-R^2 values in Table OA8. Even though the values of the predicted probabilities are low, Figure OA7 shows that clustered defaults lie systemically towards the right of the 45-degree line, while idiosyncratic defaults events appear to be evenly distributed on both sides of the 45-degree line. This finding shows that both specifications do equally well in predicting idiosyncratic defaults; hence, global variables play virtually no role in predicting idiosyncratic defaults. In contrast, adding global variables increases the probability of default for most of the defaults that occurred during the 1982 cluster.

Table OA9 presents the results of Figure OA7 more formally. It shows that on average, the predicted probability of default for idiosyncratic defaults is 0.063 when we use specification 1. Including global variables along with country-specific variables to predict idiosyncratic defaults does not make much of a difference. The average predicted probability of default in specification 2 is 0.056. The predicted probabilities of clustered defaults differ greatly based on the specification used. On average, the predicted probability of clustered default is 0.115 in specification 1. This average is higher than the one for idiosyncratic defaults with either specification. This finding informs us that country-specific fundamentals were also poor during the clustered default episode of 1979-1983. With Specification 2, the average predicted probability of clustered default events jumps to 0.285. The difference of the mean t-statistic is negative and significant at 0.1%. An increase of close to 150% results just from adding global variables to the specification. Thus, even though country fundamentals were poor during the clustered default period, global fundamentals were much worse. This finding shows that including global variables in the specification makes a great difference in explaining the probability of default for clustered default episodes but makes no difference in explaining idiosyncratic default episodes. This signals a role of worsening global fundamentals in leading multiple countries to default during the clustered default period of 1979-1983.

The results in Figure OA7 and Table OA9 are robust to alternative specification in which we use the levels of country-specific and global shock to the transitory component of output instead of their 2-year changes, as shown in Figure OA4 and Table OA6 in the appendix.

The results are also robust to using government debt data instead of net foreign assets and to using HP-filtered data on the output of countries instead of the Kalman-smoothed data from the estimation exercise. However, these results are not attached in the appendix to avoid repetition.

The final issue of concern is the predicted probabilities of default conditional on nondefault. First, since the default probabilities conditional on countries defaulting in a nonclustered period are already low, the default probabilities conditional on nondefault in the same period must be even lower. Second, in the clustered period, the probabilities of default conditional on countries defaulting is high. Conditional on countries not defaulting, the probability of default should not be high. It should not be the case that worsening global fundamentals predicted high probabilities of default even in cases when countries did not default.

Table OA10 shows that in nonclustered periods, the predicted probability of default conditional on no default is almost half of the probabilities conditional on default in the same period. This finding shows that on average, in relatively calmer times, the predicted probability of default for nondefault cases is lower in magnitude. To address the concern that poor global fundamentals in the clustered period might make the predicted default probabilities sky-high even conditional on nondefault cases, I focus on row 2 of Table OA10. The table shows that the predicted probabilities conditional on no default are very low compared to the predicted probabilities conditional on default during the clustered default period. Table OA7 in the appendix shows that both results are robust to change in the explanatory variables.

C Model Equations

C.1 Basic Version of The Model: Equations

Households

In the basic version, the household gets utility only from consumption of the final good

$$U(C_t, L_t^s) = \left[\frac{C_t^{1-\gamma}}{1-\gamma}\right]$$

where γ represents the Arrow-Pratt measure of relative risk aversion

Every period households gets exogenous endowment in the form of output and transfer from the government. The household budget constraint is therefore given as:

$$C_t = Y_t + T_t \tag{12}$$

Since both output and transfers are given, households consumption level is also given and there is no optimization problem to solve for the household. The government decides the level of transfer in order to maximize household utility. The equations of the basic version of the model are kept in a similar as the full model. Alternatively, we can allow household to borrow from rest of the world and make debt, default and consumption decisions. In terms of the model equations and the solution, this alternative way is exactly the same as the current version of the of the baseline model.

Government

The aim of benevolent social planner or the government is to maximize the utility of the households. Therefore, the government's problem remains the same as in the full version of the model.

The amount borrowed, net of repayments, is again the transfer when government decides not to default:

$$T_t = q_t d_{t+1} - d_t \tag{13}$$

When the government decides to default, there is no additional borrowing and government transfer is 0.

The the continuation payoff i.e. value function when the agent doesn't default and continues to repay the debt, is given as:

$$V^C(d_t; z_t, z_t^w, X_t, X_t^w, r_t^*) = \max_{c_t, d_{t+1}} [u(c_t) + \beta E_{y,r}[V^G(d_{t+1}; z_{t+1}, z_{t+1}^w, X_{t+1}, X_{t+1}^w, r_{t+1}^*)] \tag{14}$$

subject to the household budget constraint and the government transfer condition. Here V^G represents the value function when the agent enters the period with good financial standing ($f = 0$).

The continuation payoff in bad standing is given as:

$$\begin{aligned} V^B(z_t, z_t^w, X_t, X_t^w, r_t^*) = u(c_t^A) + \beta E_{y,r}\{\lambda V^G[(0; z_{t+1}, z_{t+1}^w, X_{t+1}, X_{t+1}^w, r_{t+1}^*) \\ + (1-\lambda) V^B(z_{t+1}, z_{t+1}^w, X_{t+1}, X_{t+1}^w, r_{t+1}^*)\} \end{aligned} \tag{15}$$

subject to the household budget constraint and that the transfer to households is now 0. In this case, the function ϕ, that governs output loss in default, will also be non-zero. The function ϕ and thus, the output loss in default depends on individual technology shocks.

The continuation payoff when agent starts a period in good standing:

$$V^G(d_t; z_t, z_t^w, X_t, X_t^w, r_t^*) = \max\{V^C(d_t; z_t, z_t^w, X_t, X_t^w, r_t^*), V^B(z_t, z_t^w, X_t, X_t^w, r_t^*)\} \quad (16)$$

The default rule is therefore be given as:

$$F(d_t; z_t, z_t^w, X_t, X_t^w, r_t^*) = \begin{cases} 1 & \text{if } V^B(z_t, z_t^w, X_t, X_t^w, r_t^*) > V^C(d_t; z_t, z_t^w, X_t, X_t^w, r_t^*) \\ 0 & \text{otherwise} \end{cases} \quad (17)$$

Lender

The last piece of the model is to explain the lender side. I assume a large number of risk neutral lenders. Risk free return is therefore adjusted for the probability of default to get rate of return on debt.

$$(1+r_t)\times Prob_{y,r}(V^C(d_{t+1}; z_{t+1}, z_{t+1}^w, X_{t+1}, X_{t+1}^w, r_{t+1}^*) > V^B(z_{t+1}, z_{t+1}^w, X_{t+1}, X_{t+1}^w, r_{t+1}^*)) = 1+r_t^*$$

Given that the price of debt, $q_t = 1/(1 + r_t)$, we have

$$q_t(d_{t+1}; z_t, z_t^w, X_t, X_t^w, r_t^*) = \frac{Prob_{y,r}(V_{t+1}^C > V_{t+1}^B)}{1 + r_t^*} \quad (18)$$

C.2 Full Model: Autarky and Borrowing Equilibria

Autarkic Equilibrium

If the government enters the period in autarky, it does not have an optimization problem to solve. It makes no transfer to households, $T_t = 0$, and it has no debt or default choice to make. Alternatively, if the government enters the period in good standing but finds that the utility from defaulting is higher than the utility from borrowing and repayment, then it defaults. Again, the government does not have any choice variables once it decides to default. The transfers are, by default, $T_t = 0$, and no debt choice is possible. Thus, in autarky, only firms and households will make equilibrium choices.

The first thing to note is that firms face an output cost of default during autarky. Thus, the output produced decreases depending on the state of the economy. Sine the output cost is convex in nature, the output loss in autarky will be higher when the economy is doing relatively better (relatively greater shocks to different components of the technology level in the economy). Firms' optimality conditions will therefore be given by:

$$\alpha_L(1-\phi_t(\cdot)) \cdot A_t(L_t^{Aut})^{\alpha_L-1} = (1+\eta r_t^*)w_t^{Aut}$$

which is the same condition that captures the effect of the working-capital constraint on the cost of hiring an additional worker. The profit for the firm will be:

$$\Pi_t^{f,Aut} = (1-\phi_t(\cdot)) \cdot A_t(L_t^{Aut})^{\alpha_L} - w_t^{Aut}L_t^{Aut} - \eta r_t^* w_t^{Aut}L_t^{Aut}$$

where $\phi_t(\cdot) = \phi(z_t, z_t^w, g_t, g_t^w)$ is a function of states.

Households solve their first order conditions and supply labor such that:

$$\Gamma_{t-1}(L_t^{Aut})^{\omega-1} = w_t^{Aut}$$

Solving household and firm first order conditions will give closed-form solutions to the equilibrium quantity of labor and wage level in autarky as a function of state variables and parameters. These values are then used to obtain the values of equilibrium output and profit that households receive. These profits through the household budget constraint provide the value of household consumption in autarky.

$$C_t^{Aut} = (1-\phi^{Aut}) \cdot A_t(L_t^{Aut})^{\alpha_L} - \eta r_t^* w_t^{Aut}L_t^{Aut}$$

Equilibrium with borrowing

Equilibrium with borrowing is the equilibrium in which the government is able to choose a debt level, d_{t+1}, in the current period. This can occur in two ways: is the government enters a period with good standing or if it enters the period in bad standing but is allowed to re-enter the market[32] and finds it optimal to continue with the repayment of debt in either case. In the former case, the government enters the period with a debt, d_t, to be repaid, while in the latter case, $d_t = 0$.

The first order conditions of the firm and the household provide us with a closed-form solution for the equilibrium quantity of labor:

$$L_t = \left(\frac{\alpha_L A_t}{\Gamma_{t-1}(1+\eta r_t^*)}\right)^{\frac{1}{\omega-\alpha_L}}$$

which can be used to obtain the equilibrium wage rate from the household first order condition. Given the value of the wage rate, equilibrium quantity of labor, and an initial debt

[32] An event that occurs with probability λ after entering the period in bad standing.

level d_t, the government chooses a new debt level, d_{t+1}, to maximize its continuation utility

$$V^C(d_t; z_t, z_t^w, g_t, g_t^w, r_t^*) = \max_{C_t, d_{t+1}} \{u(C_t, L_t) + \beta E_y[V^G(d_{t+1}; z_{t+1}, z_{t+1}^w, g_{t+1}, g_{t+1}^w, r_{t+1}^*)]\}$$

subject to:

$$C_t = A_t L_t^{\alpha_L} - \eta r_t^* \Gamma_{t-1} L_t^{\omega} + q_t(d_{t+1}; z_t, z_t^w, X_t, X_t^w, r_t^*) \cdot d_{t+1} - d_t$$

$$L_t = \left(\frac{\alpha_L A_t}{\Gamma_{t-1}(1 + \eta r_t^*)} \right)^{\frac{1}{\omega - \alpha_L}}$$

$$q_t(d_{t+1}; z_t, z_t^w, X_t, X_t^w, r_t^*) = \frac{Prob_y(V_{t+1}^C > V_{t+1}^B)}{1 + r_t^*}$$

where V_{t+1}^B is the value function in autarky which can be solved using equations 8, 9 and the autarky equilibrium.

C.3 Equations in Detrended Form

All the equations and time t variables are detrended by $\Gamma_{t-1}^c \equiv X_{t-1}^c (X_{t-1}^w)^{\alpha_X^c} \cdot \mu_g^c (\mu_g^w)^{\alpha_X^c}$ and a detrended variable ν after detrending becomes $\tilde{\nu}_t = \frac{\nu_t}{\Gamma_{t-1}}$. Thus the detrended output is given as:

$$\tilde{Y}_t = e^{z_t + \alpha_z z_t^w} g_t (g_t^w)^{\alpha_X} / (\mu_g (\mu_g^w)^{\alpha_X})$$

The budget constraint of the household when not in default is given as:

$$c_t = y_t + q_t d_{t+1} - d_t$$

$$\implies \frac{c_t}{\Gamma_{t-1}} = \frac{y_t}{\Gamma_{t-1}} + \frac{q_t d_{t+1}}{\Gamma_{t-1}} - \frac{d_t}{\Gamma_{t-1}}$$

$$\implies \tilde{c}_t = \tilde{y}_t + \frac{\Gamma_t}{\Gamma_{t-1}} \frac{q_t d_{t+1}}{\Gamma_t} - \tilde{d}_t$$

$$\implies \tilde{c}_t = \tilde{y}_t + g_t (g_t^w)^{\alpha_X} \cdot q_t \tilde{d}_{t+1} - \tilde{d}_t$$

In a similar fashion, we can detrend the utility function and hence the value functions too. The only difference is that we detrend them by $(\Gamma_{t-1})^{1-\gamma}$ instead of Γ_{t-1}. This is because of the peculiar form of utility function used.[33] The detrended utility function can thus be

[33] which is why we use $u(c) = \frac{c^{1-\gamma}}{1-\gamma}$ instead of $u(c) = \frac{c^{1-\gamma}-1}{1-\gamma}$

written as:

$$\tilde{u}(\tilde{c_t}) \equiv \frac{u(c_t)}{(\Gamma_{t-1})^{1-\gamma}} = \frac{\tilde{c_t}^{1-\gamma}}{1-\gamma}$$

The value functions can also be detrended in the same way. The continuation value is given as:

$$v^c(y_t, d_t) = \max_{d_{t+1}} \{u(y_t + q_t d_{t+1} - d_t) + \beta \cdot E\left[v^g(y_{t+1}, d_{t+1})\right]\}$$

$$\implies \frac{v^c(y_t, d_t)}{(\Gamma_{t-1})^{1-\gamma}} = \max_{\tilde{d}_{t+1}} \left\{ \tilde{u}(\tilde{y_t} + g_t(g_t^w)^{\alpha_X} \cdot q_t \tilde{d}_{t+1} - \tilde{d}_t) + \beta \cdot \frac{(\Gamma_t)^{1-\gamma}}{(\Gamma_{t-1})^{1-\gamma}} \frac{E\left[v^g(y_{t+1}, d_{t+1})\right]}{(\Gamma_t)^{1-\gamma}} \right\}$$

$$\implies \tilde{v^c}(\tilde{y_t}, \tilde{d_t}) = \max_{\tilde{d}_{t+1}} \left\{ \tilde{u}(\tilde{y_t} + g_t(g_t^w)^{\alpha_X} \cdot q_t \tilde{d}_{t+1} - \tilde{d}_t) + \beta \cdot (g_t(g_t^w)^{\alpha_X})^{1-\gamma} \cdot E\left[\tilde{v^g}(\tilde{y}_{t+1}, \tilde{d}_{t+1})\right] \right\}$$

The value function when the country defaults or is in bad standing is given by:

$$v^b(y_t) = u\left(y \cdot (1 - \phi(z_t, z_t^w, g_t, g_t^w))\right) + \beta \cdot E\left[\lambda v^g(y_{t+1}, 0) + (1-\lambda) v^b(y_{t+1})\right]$$

$$\implies \tilde{v^b}(\tilde{y_t}) = \tilde{u}\left(\tilde{y_t} \cdot (1 - \phi(z_t, z_t^w, g_t, g_t^w))\right) + \beta \cdot (g_t(g_t^w)^{\alpha_X})^{1-\gamma} \cdot E\left[\lambda \tilde{v^g}(\tilde{y}_{t+1}, 0) + (1-\lambda)\tilde{v^b}(\tilde{y}_{t+1})\right]$$

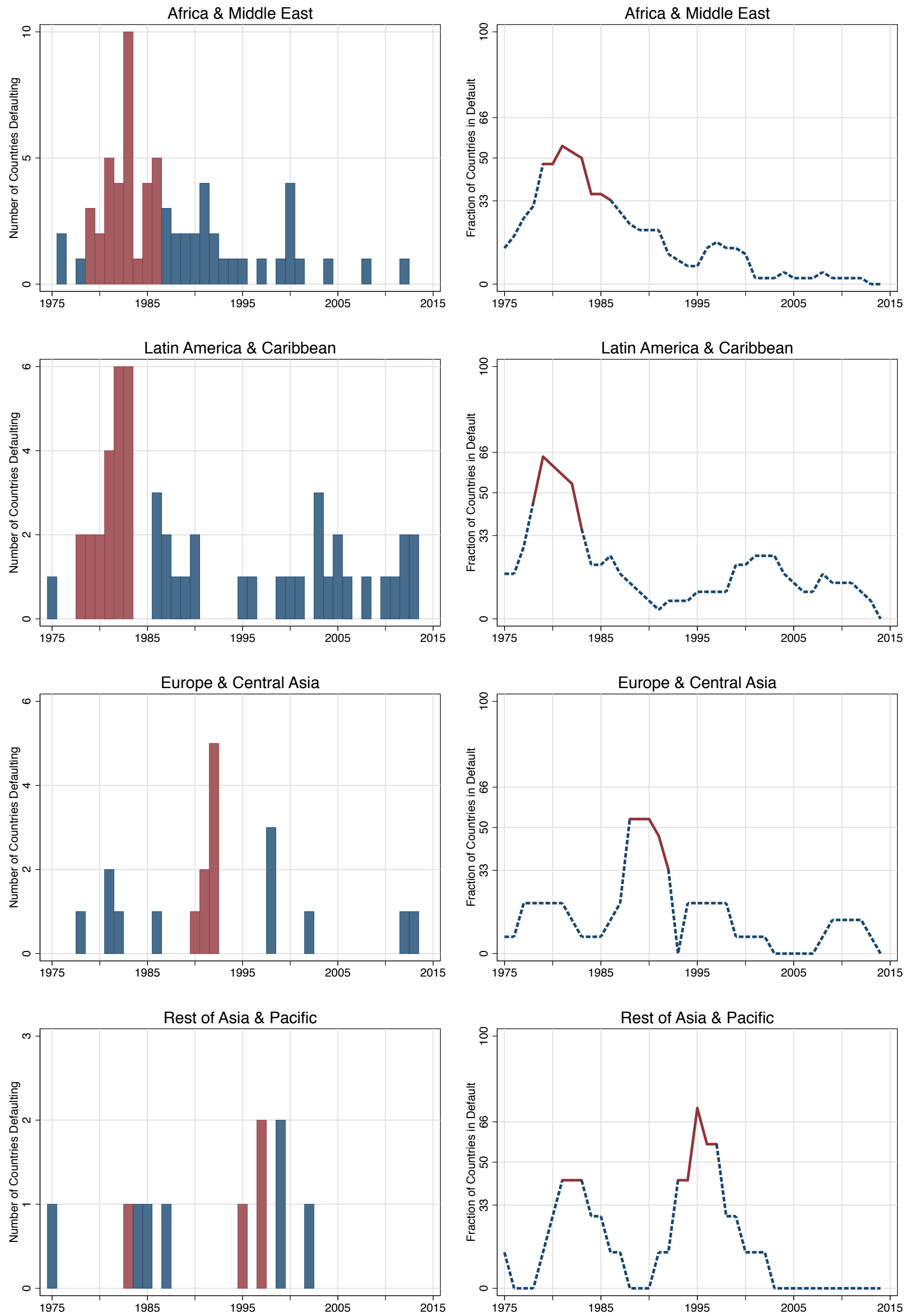
Detrended version of value function in good standing is:

$$v^g(y_t, d_t) = \max\left\{v^b(y_t), v^c(y_t, d_t)\right\}$$

$$\implies \tilde{v^g}(\tilde{y_t}, \tilde{d_t}) = \max\left\{\tilde{v^b}(\tilde{y_t}), \tilde{v^c}(\tilde{y_t}, \tilde{d_t})\right\}$$

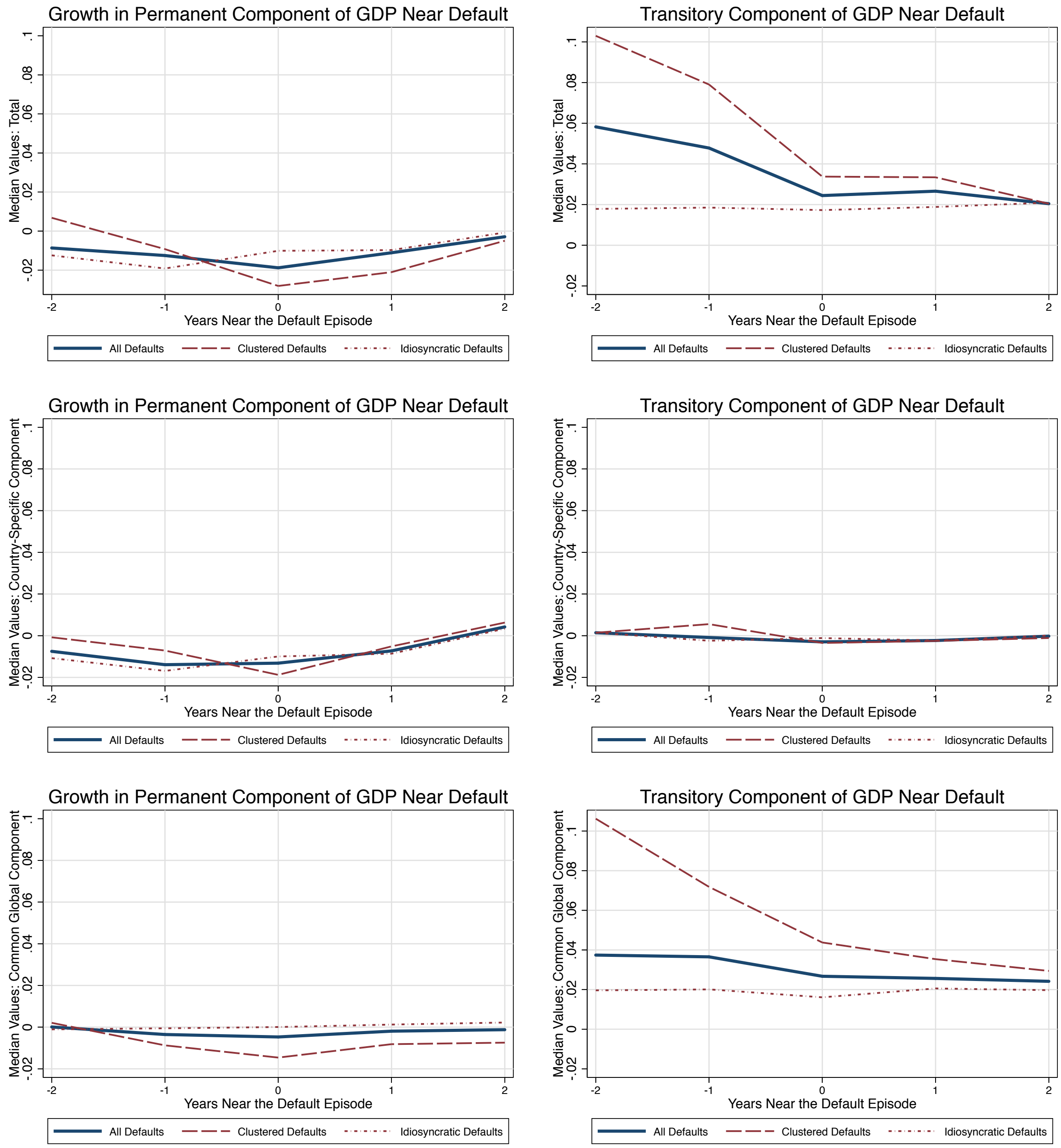
D Figures and Tables

Figure OA1: Countries defaulting in a 5-year rolling window by Region



The top panel shows number of countries in default in every year from 1975-2014 at the region level. The bottom panel shows fraction of countries defaulting in a 5-year rolling window starting every year at the region level. Maroon line highlights the period of clustered default while navy line highlights idiosyncratic defaults.

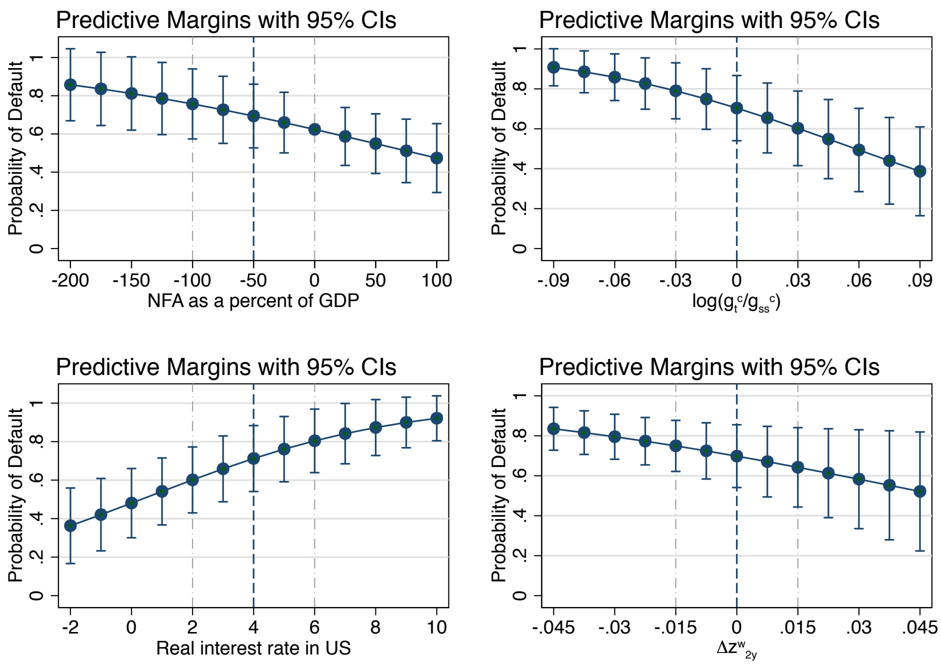
Figure OA2: Transitory and Permanent Components of Output Near Default



Note: (1) 0 depicts the crisis year. -1 and -2 depict 1 and 2 years before the crisis while 1 and 2 depict 1 and 2 years after the crisis. (2) The diagram is based on components of output process obtained from estimation using data from 49 defaulting countries and 10 developed countries.

The left panels plot growth rate in the permanent component of GDP. It starts with the total growth rate of permanent component—$\log(g_t^c/g_{ss}^c) + \alpha_X^c \log(g_t^w/g_{ss}^w)$—in the first row and then decomposes its country-specific and global parts—$\log(g_t^c/g_{ss}^c)$ and $\alpha_X^c \log(g_t^w/g_{ss}^w)$—respectively. The right panels plot the transitory component of GDP. It starts with the total transitory component—$z_t^c + \alpha_z^c z_t^w$—in the first row and then decomposes its country-specific and global parts—z_t^c and $\alpha_z^c z_t^w$—respectively.

Figure OA3: Change in Probability with changes in one explanatory



The figure depicts marginal change in probability of default if one explanatory variable changes (keeping all other explanatory variables fixed). The mean value of explanatory variables are highlighted with the vertical dashed line. The dash-dot line represents one standard deviations for respective explanatory variables.

Figure OA4: Predicted probabilities: Specifications 1 vs Specifications 2

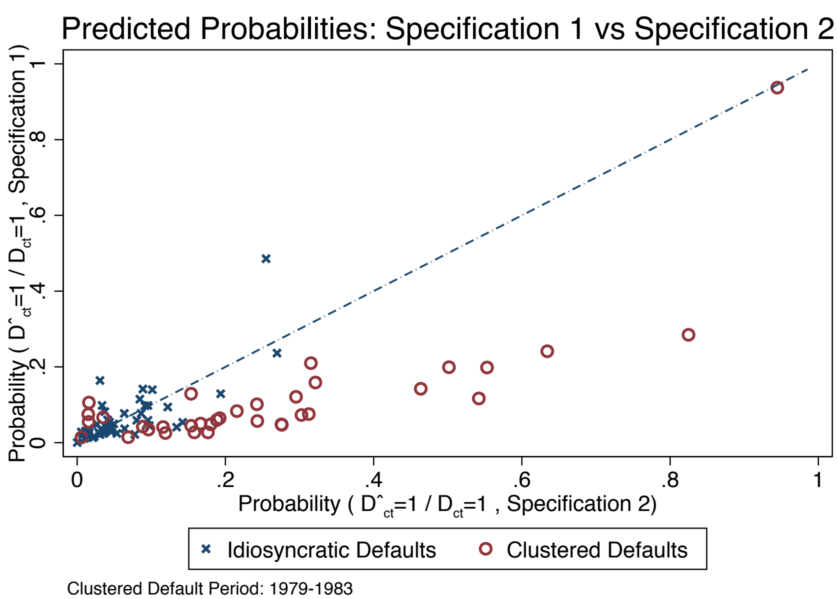
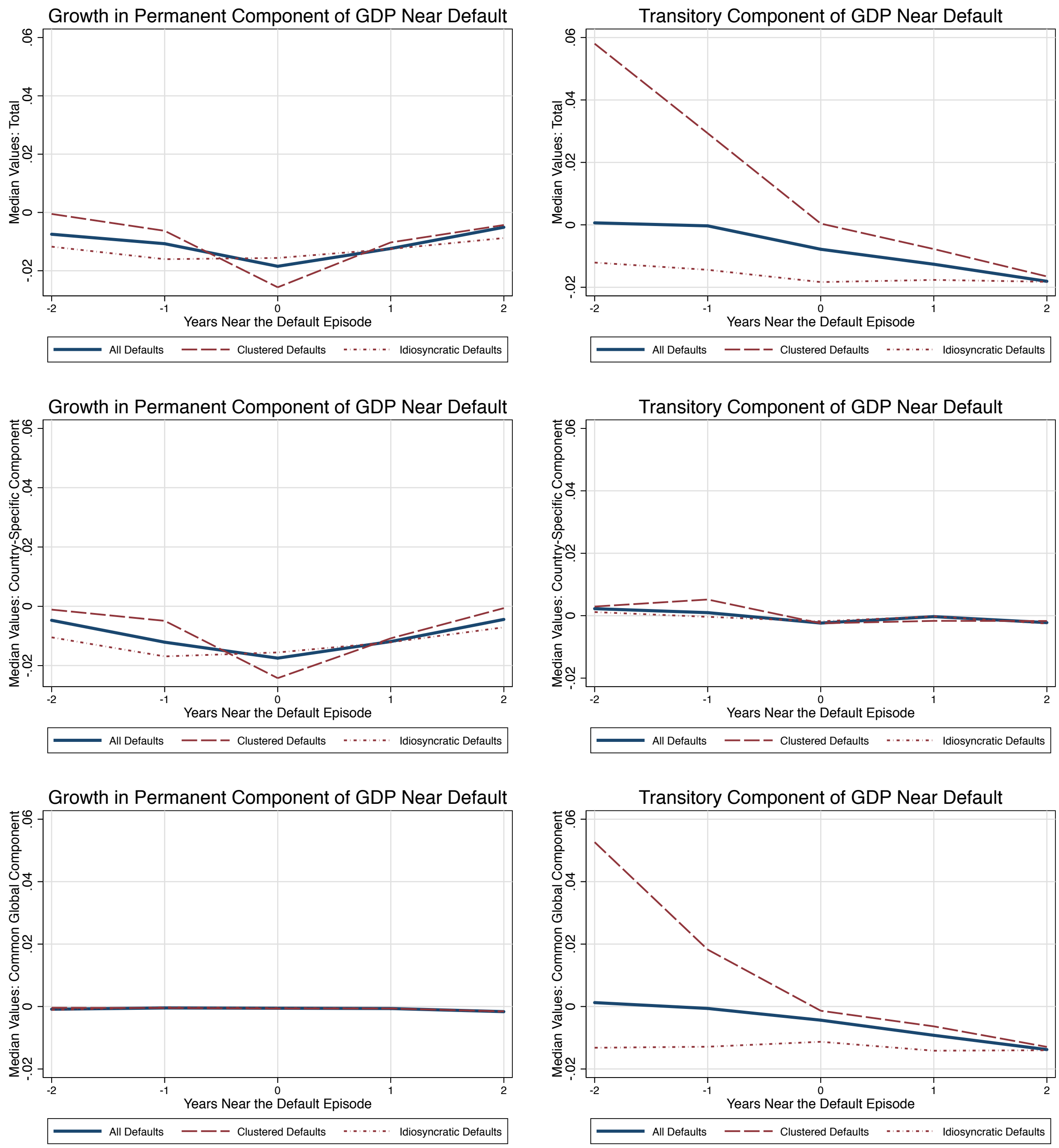


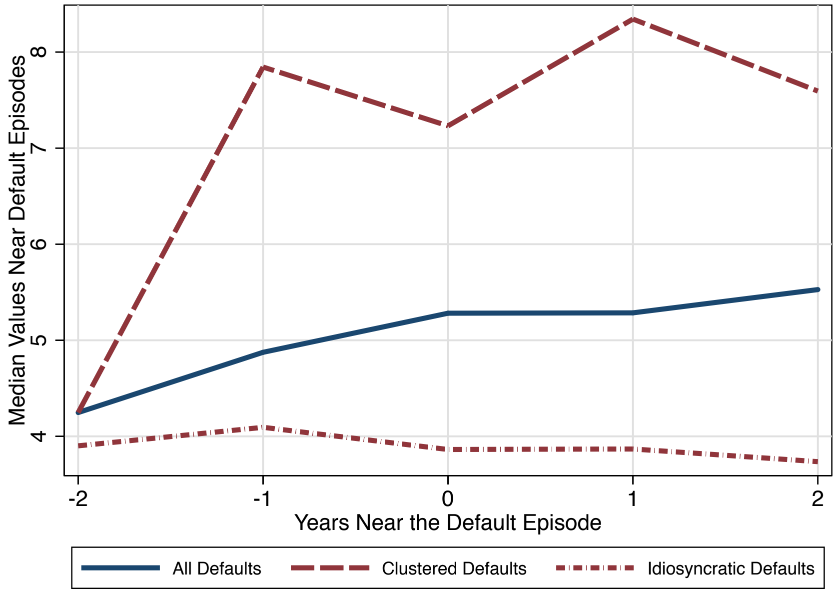
Figure OA5: Transitory and permanent components of output near default



Notes: (1) 0 depicts the crisis year. -1 and -2 depict 1 and 2 years before the crisis, while 1 and 2 depict 1 and 2 years after the crisis. (2) The diagram is based on components of the output process obtained from estimation using data from 19 defaulting countries and 5 developed countries.

The left panels plot growth rate in the permanent component of GDP. It starts with the total growth rate of the permanent component—$\log(g_t^c/g_{ss}^c) + \alpha_X^c \log(g_t^w/g_{ss}^w)$—in the first row and then decomposes its country-specific and global components—$\log(g_t^c/g_{ss}^c)$ and $\alpha_X^c \log(g_t^w/g_{ss}^w)$—,respectively. The right panels plot the transitory component of GDP. It starts with the total transitory component—$z_t^c + \alpha_z^c z_t^w$—in the first row and then decomposes its country-specific and global components—z_t^c and $\alpha_z^c z_t^w$—respectively.

Figure OA6: World interest rate near default



Note: 0 depicts the crisis year. -1 and -2 depict 1 and 2 years before the crisis while 1 and 2 depict 1 and 2 years after the crisis.

Figure OA7: Predicted probabilities of default using specification 1 and specification 2

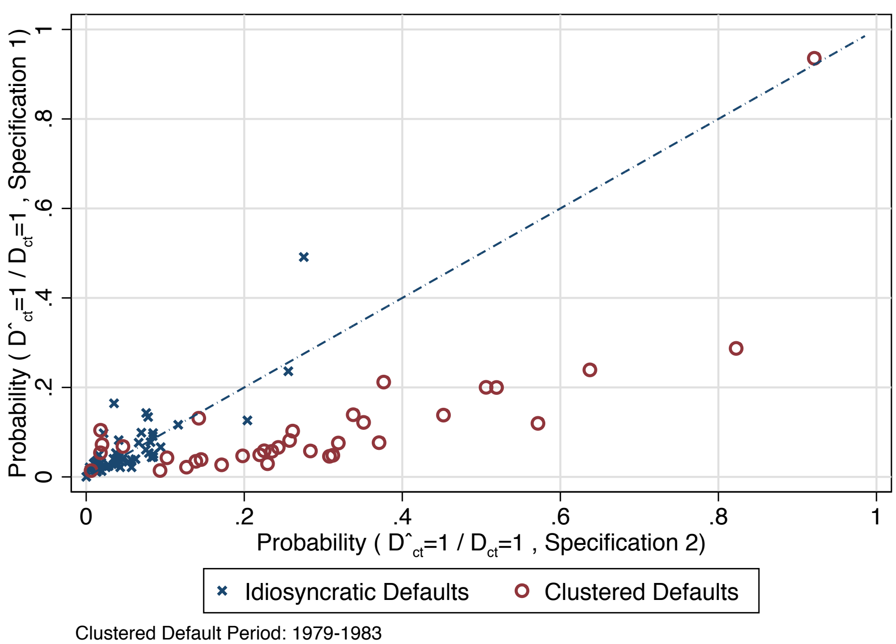
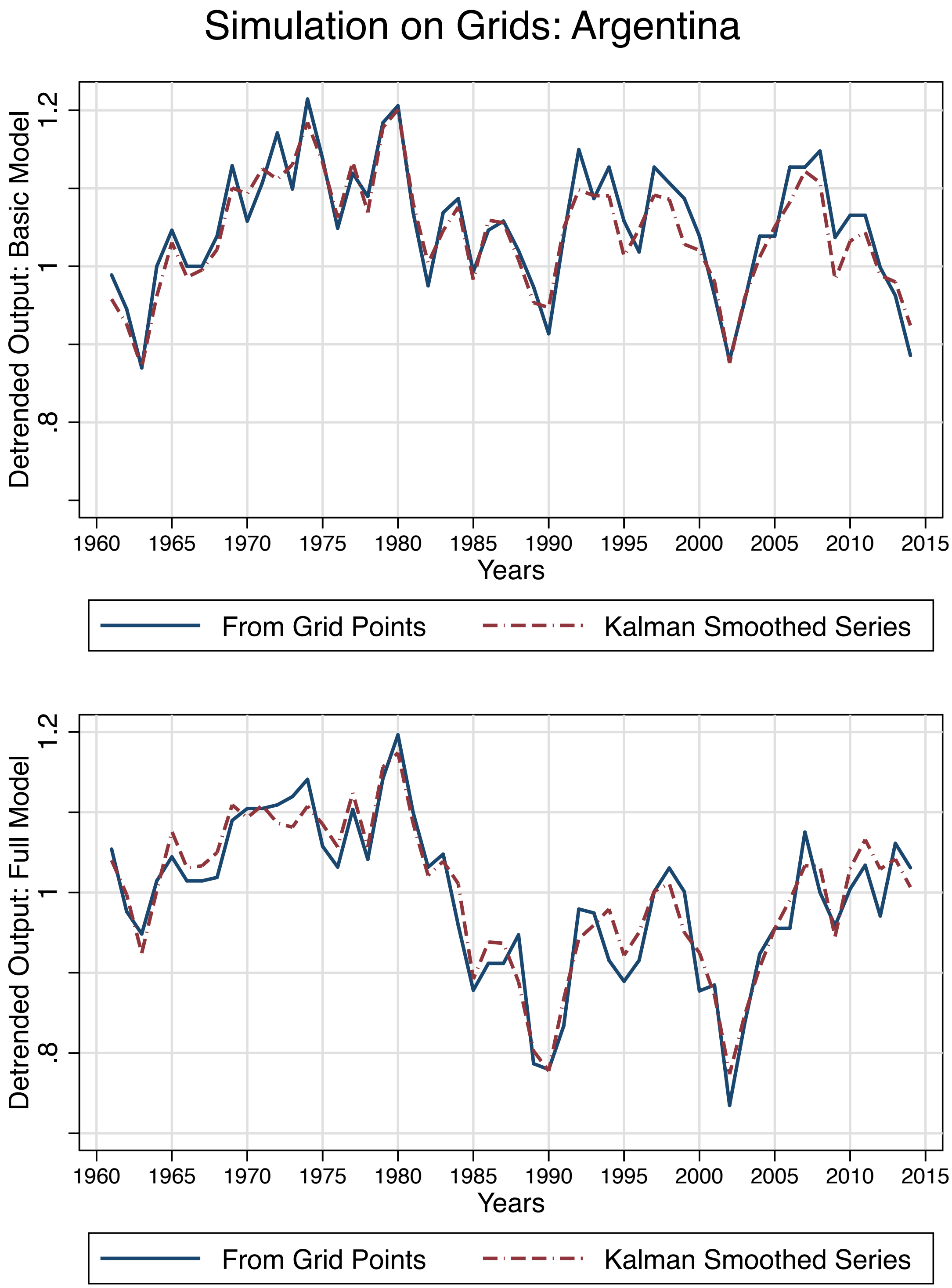
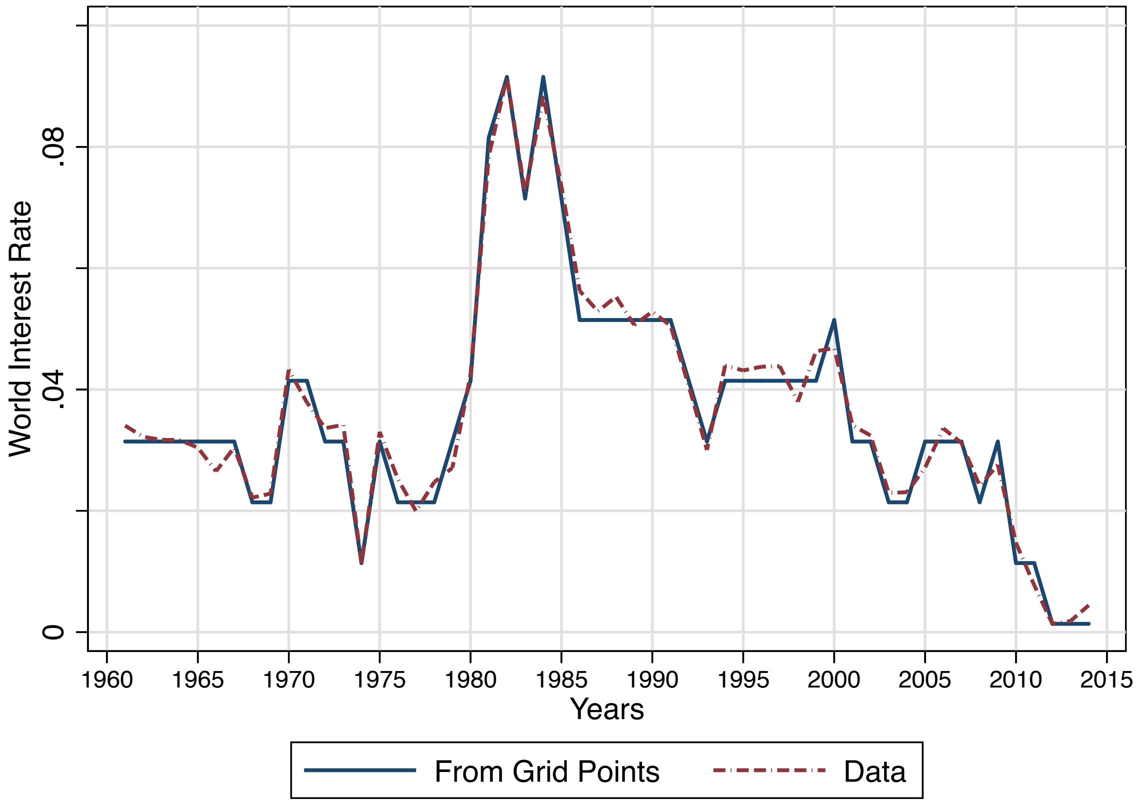


Figure OA8: Simulation of Latent state variables on the Grid



The top panel shows the detrended output simulated using the grid points and the detrended output calculated from the series of four Kalman smoothed components of output. The middle panel shows the same two series of detrended output for the full model.

Figure OA9: Simulation of interest rate on grid vs the data



The figure shows the movement of interest rate on a grid of 10 points used in the model and for simulation. It also shows the movement of interest rate in the data.

Figure OA10: Decomposition of shocks to detrended output of Belize and Bolivia

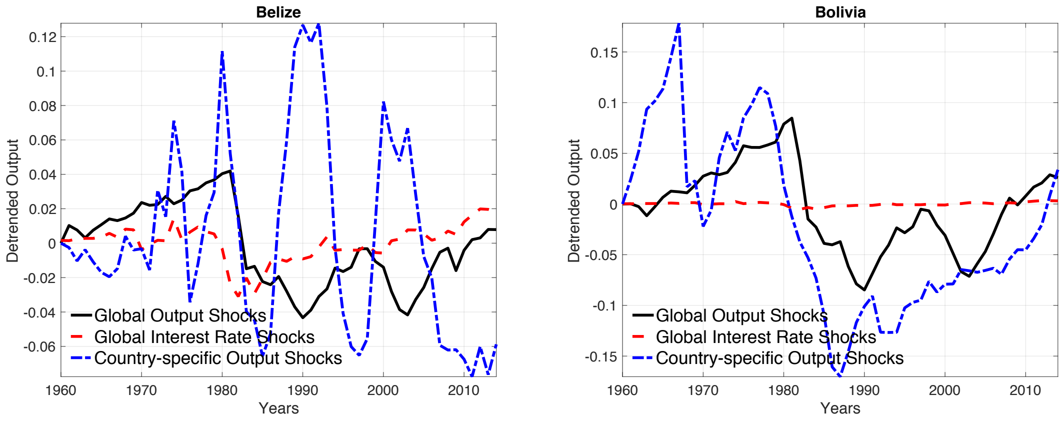


Figure OA11: Decomposition of shocks to detrended output of Brazil and Chile

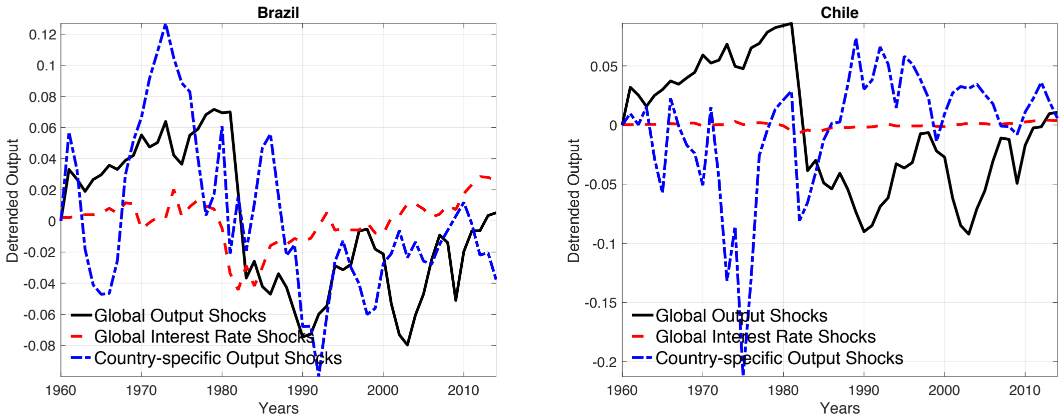


Figure OA12: Decomposition of shocks to detrended output of Costa Rica and Dominican Republic

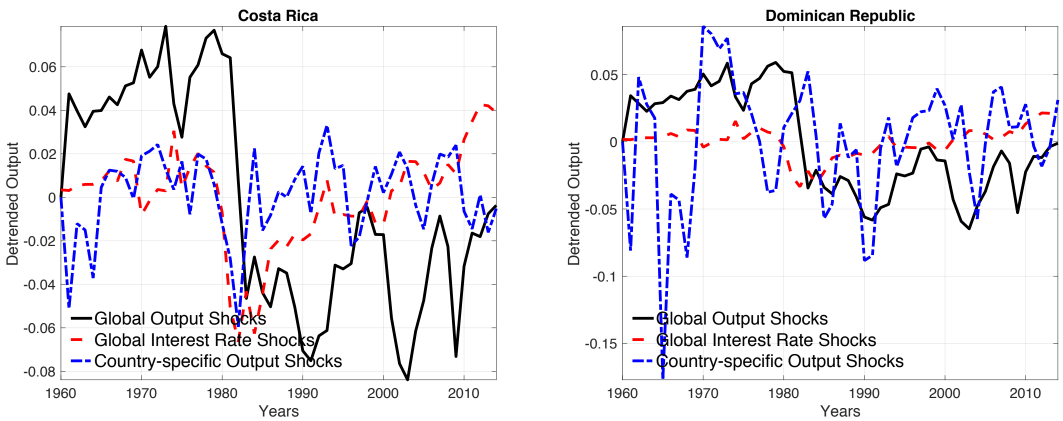


Figure OA13: Decomposition of shocks to detrended output of Ecuador and Guatemala

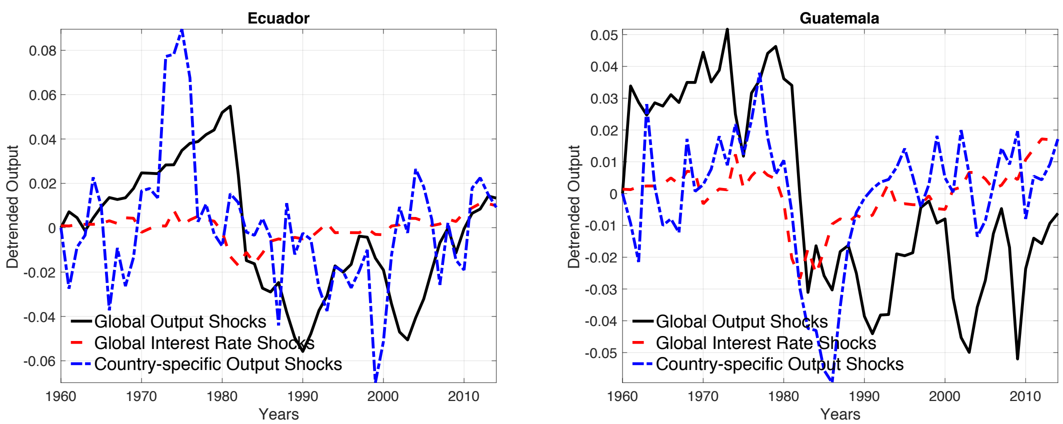


Figure OA14: Decomposition of shocks to detrended output of Guyana and Honduras

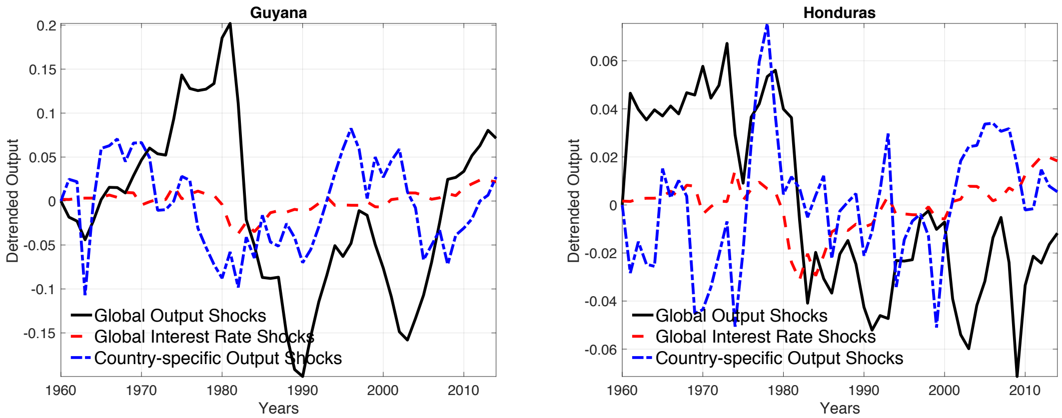


Figure OA15: Decomposition of shocks to detrended output of Mexico and Nicaragua

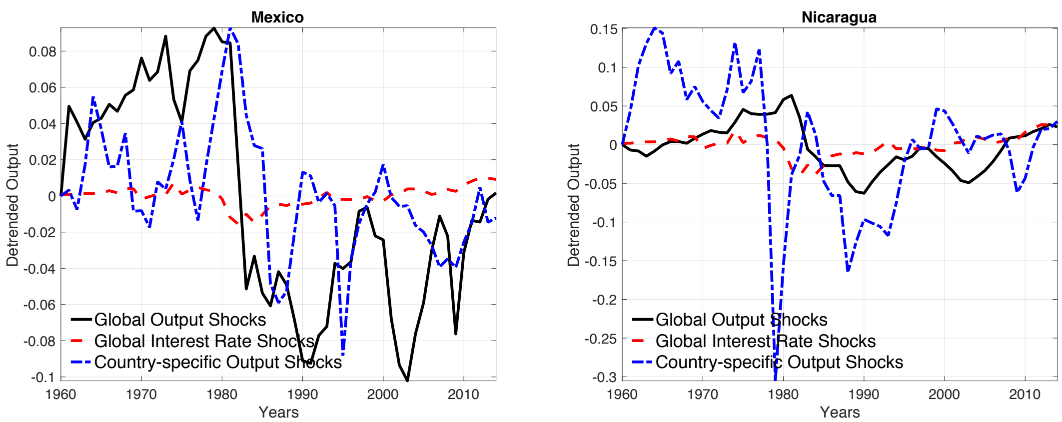


Figure OA16: Decomposition of shocks to detrended output of Panama and Paraguay

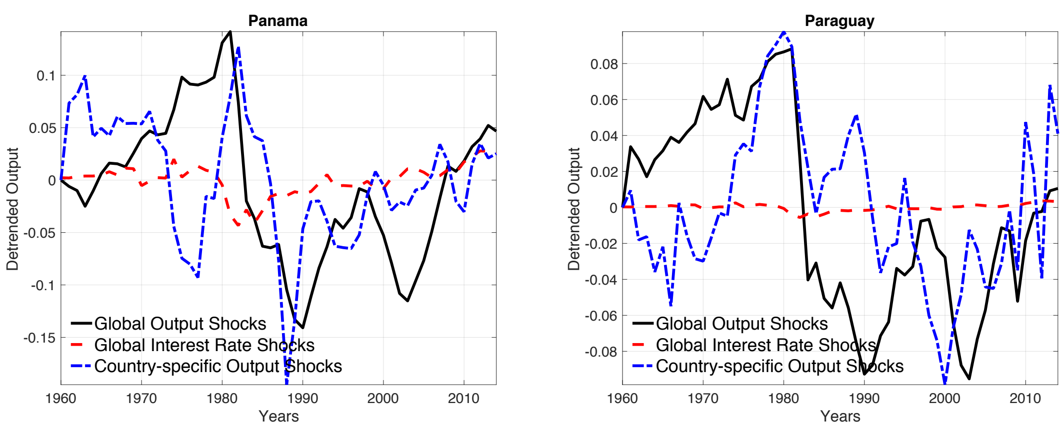


Figure OA17: Decomposition of shocks to detrended output of Peru and Trinidad & Tobago

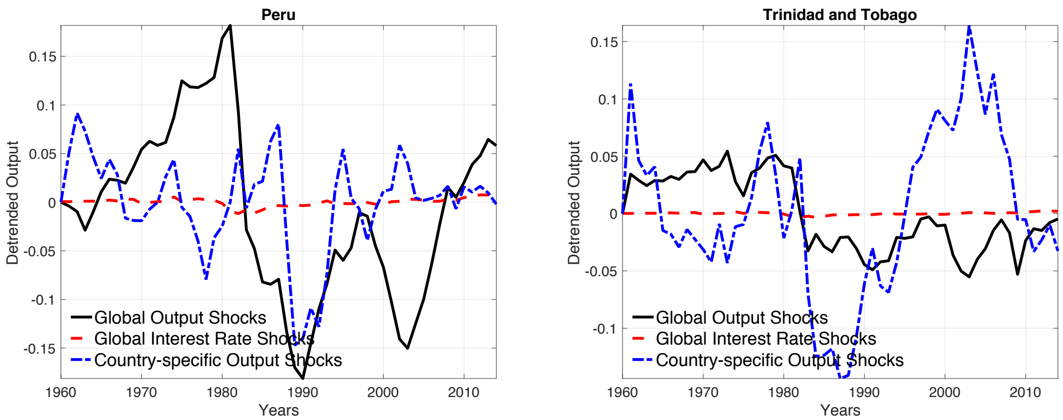


Figure OA18: Decomposition of shocks to detrended output of Uruguay and Venezuela, RB

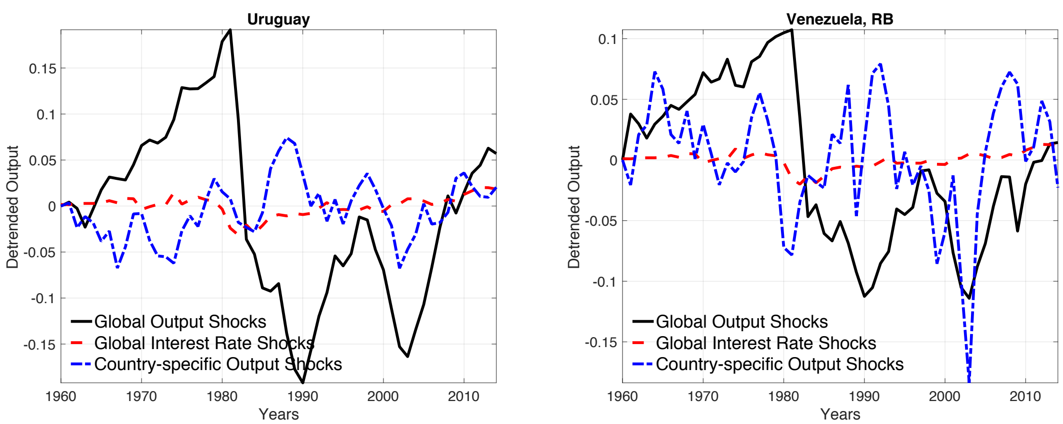


Table OA1: Bayesian Estimation Results from Basic Model: Posterior means

Country	Statistic	Posterior (Mean & Standard Deviation)					
		ρ_z^c	ρ_g^c	σ_z^c	σ_g^c	α_z^c	α_X^c
Argentina	Mean	0.5751	0.2774	0.0370	0.0190	0.0190	0.0157
	Std. Dev.	0.2075	0.2019	0.0117	0.0151	0.0207	0.0234
Belize	Mean	0.4532	0.5530	0.0094	0.0301	0.0058	0.0043
	Std. Dev.	0.2310	0.1441	0.0058	0.0047	0.0100	0.0104
Bolivia	Mean	0.6336	0.3433	0.0176	0.0238	0.0052	0.0080
	Std. Dev.	0.2917	0.2002	0.0091	0.0091	0.0110	0.0106
Brazil	Mean	0.2672	0.5619	0.0093	0.0248	0.0165	0.0045
	Std. Dev.	0.1914	0.1560	0.0049	0.0050	0.0123	0.0188
Chile	Mean	0.6647	0.5342	0.0185	0.0305	0.0234	0.0048
	Std. Dev.	0.2495	0.1635	0.0092	0.0083	0.0164	0.0229
Costa Rica	Mean	0.7120	0.2835	0.0158	0.0128	0.0190	0.0015
	Std. Dev.	0.1802	0.1802	0.0060	0.0072	0.0127	0.0162
Dominican Republic	Mean	0.7517	0.3894	0.0397	0.0190	0.0146	0.0025
	Std. Dev.	0.1498	0.2268	0.0117	0.0152	0.0129	0.0154
Ecuador	Mean	0.6620	0.4509	0.0125	0.0210	0.0064	0.0051
	Std. Dev.	0.2388	0.1922	0.0067	0.0063	0.0082	0.0091
Guatemala	Mean	0.4669	0.6373	0.0069	0.0112	0.0121	0.0001
	Std. Dev.	0.3095	0.1878	0.0030	0.0031	0.0088	0.0117
Guyana	Mean	0.6988	0.3202	0.0228	0.0277	0.0092	0.0229
	Std. Dev.	0.2267	0.1896	0.0111	0.0115	0.0258	0.0209
Honduras	Mean	0.5827	0.3248	0.0130	0.0142	0.0174	-0.0010
	Std. Dev.	0.2886	0.1823	0.0067	0.0067	0.0129	0.0141
Mexico	Mean	0.3328	0.3815	0.0094	0.0251	0.0176	0.0041
	Std. Dev.	0.2627	0.1451	0.0058	0.0049	0.0121	0.0183
Nicaragua	Mean	0.6416	0.4959	0.0268	0.0485	0.0026	0.0106
	Std. Dev.	0.2062	0.2308	0.0161	0.0145	0.0191	0.0175
Panama	Mean	0.7705	0.4015	0.0118	0.0313	0.0085	0.0152
	Std. Dev.	0.1549	0.1549	0.0082	0.0067	0.0182	0.0177
Paraguay	Mean	0.5821	0.7096	0.0184	0.0194	0.0173	0.0070
	Std. Dev.	0.2761	0.1758	0.0059	0.0068	0.0125	0.0194
Peru	Mean	0.8125	0.4263	0.0126	0.0329	0.0129	0.0214
	Std. Dev.	0.1149	0.1530	0.0089	0.0068	0.0245	0.0235
Trinidad and Tobago	Mean	0.6563	0.6455	0.0140	0.0322	0.0113	0.0024
	Std. Dev.	0.2137	0.1413	0.0075	0.0070	0.0117	0.0157
Uruguay	Mean	0.5996	0.4348	0.0096	0.0255	0.0151	0.0186
	Std. Dev.	0.2519	0.1715	0.0068	0.0062	0.0201	0.0207
Venezuela, RB	Mean	0.6204	0.3278	0.0333	0.0211	0.0227	0.0074
	Std. Dev.	0.2247	0.2298	0.0121	0.0148	0.0123	0.0213
World	Statistic	ρ_z^w	ρ_g^w				
	Mean	0.9414	0.5038				
	Std. Dev.	0.0433	0.1599				

The countries included in the estimation process are 24. 19 defaulting countries from Latin America & Caribbean and 5 non-defaulting developed countries. Parameter estimates are reported only for 19 Latin America & Caribbean countries.

Table OA2: Bayesian Estimation Results from Full Model: Posterior means

Country	Statistic	Posterior (Mean & Standard Deviation)							
		ρ_z^c	ρ_g^c	σ_z^c	σ_g^c	ψ^c	η^c	α_z^c	α_X^c
Argentina	Mean	0.2813	0.6431	0.0134	0.0141	2.0832	0.3924	0.0196	0.0029
	Std. Dev.	0.2314	0.0743	0.0064	0.0076	0.0769	0.0895	0.0055	0.0057
Belize	Mean	0.4934	0.7748	0.0028	0.0138	2.5386	0.3669	0.0041	0.0017
	Std. Dev.	0.0906	0.0757	0.002	0.0017	0.1036	0.148	0.0033	0.0033
Bolivia	Mean	0.9477	0.2448	0.0136	0.0036	2.3502	0.0713	0.0086	-0.0003
	Std. Dev.	0.041	0.1542	0.002	0.0026	0.1037	0.0506	0.0033	0.0032
Brazil	Mean	0.2023	0.8617	0.0025	0.0122	2.2738	0.6329	0.0078	0.0065
	Std. Dev.	0.1091	0.0538	0.0017	0.0016	0.1897	0.1084	0.0034	0.0033
Chile	Mean	0.9267	0.6321	0.011	0.021	1.7075	0.1645	0.0126	0.0082
	Std. Dev.	0.0446	0.1088	0.0067	0.0054	0.0786	0.0873	0.0065	0.0062
Costa Rica	Mean	0.2902	0.5339	0.0039	0.0069	2.3393	0.9032	0.0073	0.0092
	Std. Dev.	0.1159	0.1386	0.0023	0.0024	0.1737	0.0572	0.0028	0.0026
Dominican Republic	Mean	0.3735	0.543	0.0135	0.0235	1.7342	0.8289	0.0078	0.0089
	Std. Dev.	0.0965	0.0731	0.0069	0.0058	0.1156	0.0916	0.0068	0.0054
Ecuador	Mean	0.4392	0.7825	0.0084	0.0142	1.4405	0.7039	0.0092	0.002
	Std. Dev.	0.0925	0.0928	0.004	0.0034	0.1037	0.0857	0.0047	0.0044
Guatemala	Mean	0.7671	0.7034	0.0025	0.0083	1.7201	0.6772	0.0054	0.009
	Std. Dev.	0.0806	0.0687	0.0016	0.0013	0.1368	0.1588	0.0031	0.0029
Guyana	Mean	0.3798	0.6713	0.0037	0.0125	2.9785	0.3414	0.0159	-0.0035
	Std. Dev.	0.1044	0.1285	0.0024	0.002	0.1592	0.0869	0.0037	0.0044
Honduras	Mean	0.4223	0.6674	0.0043	0.0096	2.0775	0.5282	0.005	0.0103
	Std. Dev.	0.1067	0.0843	0.0022	0.0019	0.0552	0.1607	0.0035	0.0033
Mexico	Mean	0.7295	0.7787	0.0057	0.0104	2.0862	0.2603	0.0105	0.0107
	Std. Dev.	0.0982	0.0648	0.0033	0.003	0.0863	0.0706	0.004	0.0041
Nicaragua	Mean	0.9303	0.7011	0.0152	0.0254	2.0281	0.7145	0.0073	-0.0019
	Std. Dev.	0.0465	0.0787	0.0094	0.0082	0.1693	0.1683	0.0078	0.007
Panama	Mean	0.5375	0.8314	0.0039	0.0141	2.5912	0.4966	0.0129	-0.0016
	Std. Dev.	0.1635	0.075	0.0032	0.0026	0.2035	0.1027	0.0043	0.0039
Paraguay	Mean	0.5385	0.6997	0.0047	0.0162	1.8303	0.122	0.0121	0.0081
	Std. Dev.	0.1257	0.1002	0.003	0.0028	0.1154	0.0895	0.0048	0.0046
Peru	Mean	0.4378	0.7591	0.0051	0.0205	1.8	0.268	0.0239	-0.002
	Std. Dev.	0.1151	0.0907	0.0037	0.0029	0.1233	0.0781	0.0068	0.0062
Trinidad and Tobago	Mean	0.1823	0.8532	0.004	0.0177	1.9957	0.0632	0.0054	0.0079
	Std. Dev.	0.1085	0.049	0.0027	0.0022	0.0816	0.0516	0.0047	0.0045
Uruguay	Mean	0.9247	0.7466	0.0088	0.0117	1.7514	0.7631	0.0261	0.0001
	Std. Dev.	0.0489	0.107	0.0049	0.0051	0.0682	0.1214	0.0054	0.0065
Venezuela, RB	Mean	0.8535	0.5335	0.0174	0.0105	2.0829	0.3363	0.0129	0.008
	Std. Dev.	0.0943	0.1222	0.0062	0.0077	0.1941	0.1569	0.0054	0.0043

World	Statistic	ρ_z^w	ρ_g^w
	Mean	0.8897	0.7555
	Std. Dev.	0.0845	0.0957

The countries included in the estimation process are 24. 19 defaulting countries from Latin America & Caribbean and 5 non-defaulting developed countries. Parameter estimates are reported only for 19 Latin America & Caribbean countries.

Table OA3: Summary Stats: Default Episodes

	No. of Countries Defaulting	No. of Defaults
World	92	146
Africa & Middle East	42	65
Latin America & Caribbean	28	51
Europe & Central Asia	15	19
Rest of Asia & Pacific	7	11

Table OA4: Summary Stats: Explanatory Variables

	Mean	Std. Dev.
Country-Specific Variables		
(NFA as a % of GDP)$_t^c$	-50.160	51.8705
$\log(g_t^c/g_{ss}^c)$	0.001	0.0310
z_t^c	-0.001	0.0397
$\Delta z_{t,t-2}^c$	0.001	0.0387
Global Variables		
(Real interest rate in US)$_t$	3.898	1.9481
$\log(g_t^w/g_{ss}^w)$	-0.003	0.0056
z_t^w	-0.001	0.0238
$\Delta z_{t,t-2}^w$	-0.000	0.0158
(Inflation Adjusted Oil Prices)$_t$	64.560	27.8581
Observations	1220	

Table OA5: Logistic Regression Results

	Specification 1		Specification 2)	
	Coefficient	$\frac{d(Prob)}{dx_i}\sigma_{x_i}$	Coefficient	$\frac{d(Prob)}{dx_i}\sigma_{x_i}$
Country-Specific Variables				
(NFA as a % of GDP)$_t^c$	-0.00768***	-0.0876	-0.00678**	-0.0449
$\log(g_t^c/g_{ss}^c)$	-19.49***	-0.1331	-19.88***	-0.0787
z_t^c	-2.554	-0.0223	-2.911	-0.0147
Global Variables				
(Real interest rate in US)$_t$			0.364***	0.0905
$\log(g_t^w/g_{ss}^w)$			25.20	0.0180
z_t^w			-14.82*	-0.0450
(Inflation Adjusted Oil Prices)$_t$			0.00301	0.0107
Country Fixed Effects	Yes		Yes	
N	1220		1220	
pseudo R^2	0.101		0.215	

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

Table OA6: Predicted Probability of Default for Default Episodes

		Average(Predicted probability of default conditional on default)		t-stat
Default Type	N0.	Specification 1	Specification 2	$\hat{P}(D=1\|S_1)=\hat{P}(D=1\|S_2)$
Idiosyncratic Default	52	.0634	0.0604	0.4418
Clustered Default	35	0.1148	0.2631	-6.1837

Table OA7: Predicted Probability of Default for Non-Default Episodes

		Average(Predicted probability of default conditional on no default)		t-stat
Period	N0.	Specification 1	Specification 2	$\hat{P}(D=1\|S_1)=\hat{P}(D=1\|S_2)$
Non Clustered Default Period	968	0.0360	0.0274	8.0879
Clustered Default Period	165	0.0353	0.0555	-4.0970

Table OA8: Logistic Regression Results

	Specification 1		Specification 2	
	Coefficient	$\frac{d(Prob)}{dx_i}\sigma_{x_i}$	Coefficient	$\frac{d(Prob)}{dx_i}\sigma_{x_i}$
Country-Specific Variables				
(NFA as a % of GDP)$_t^c$	-0.008***	-0.0897	-0.007**	-0.0680
$\log(g_t^c/g_{ss}^c)$	-19.39***	-0.1325	-17.51***	-0.0949
$\Delta z_{t,t-2}^c$	-1.672	-0.0142	-2.774	-0.0188
Global Variables				
(Real interest rate in US)$_t$			0.282***	0.0960
$\log(g_t^w/g_{ss}^w)$			21.99	0.0215
$\Delta z_{t,t-2}^w$			-20.06**	-0.0554
(Inflation Adjusted Oil Prices)$_t$			-0.006	-0.0271
Country Fixed Effects	Yes		Yes	
N	1220		1220	
pseudo R^2	0.100		0.218	

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

Table OA9: Predicted Probability of Default for Default Episodes

		Average(Predicted probability of default conditional on default)		t-stat
Default Type	N0.	Specification 1	Specification 2	$\hat{P}(D=1\|S_1)=\hat{P}(D=1\|S_2)$
Idiosyncratic Default	52	0.0634	0.0561	1.2078
Clustered Default	35	0.1146	0.2853	-7.0813

Table OA10: Predicted Probability of Default for Non-Default Episodes

		Average(Predicted probability of default conditional on no default)		t-stat
Period	N0.	Specification 1	Specification 2	$\hat{P}(D=1\|S_1)=\hat{P}(D=1\|S_2)$
Non Clustered Default Period	968	0.0360	0.0254	11.0789
Clustered Default Period	165	0.0354	0.0635	-5.2251