World Interest Rate and Emerging Market Spread: A Tale of Two Shocks*

Alessandro Dovis†, Xiang Fang‡, Yang Liu§

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Abstract

The world interest rate is often viewed as a key determinant of emerging market (EM) borrowing costs, yet its empirical correlation with EM spreads is weak. We show that the source of world interest rate movements is crucial. Using a structural VAR, we distinguish between two types of U.S. shocks that drive the world interest rate: procyclical shocks, which raise U.S. output and interest rate jointly, and countercyclical shocks, which move them in opposite directions. While both raise the world interest rate, they have opposite effects on EM spreads: procyclical shocks lower spreads, whereas countercyclical shocks raise them substantially. To interpret these findings, we develop a quantitative sovereign default model with long-term debt, risk-averse lenders, inconvenience yield, and both shocks. The model replicates the differential responses of EM spreads to procyclical and countercyclical shocks. We decompose such responses into a default risk, a risk premium, and an inconvenience yield component. Countercyclical shocks raise spreads primarily through higher default probabilities linked to lower EM output, while procyclical shocks reduce spreads despite higher financing costs because they are associated with higher EM output.

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†Department of Economics, University of Pennsylvania

‡Faculty of Business and Economics, The University of Hong Kong

§Faculty of Business and Economics, The University of Hong Kong

1 Introduction

The world interest rate is regarded as a key determinant of the sustainability of external debt and interest rate spreads in emerging markets (EMs). The underlying logic is that a higher world interest rate raises the cost of debt servicing for EM borrowers and can increase the likelihood of sovereign default, leading to wider credit spreads. For instance, the sharp rise in U.S. interest rates during the early 1980s is widely viewed as a major contributor to the Latin American debt crisis. This relationship is especially relevant in the current environment of elevated global rates and high debt levels. Yet, despite this financing cost channel, the empirical correlation between EM spreads and the world interest rate remains weak.

In this paper, we show that the source of world interest rate movements is critical for understanding their effects on EM spreads. We classify world interest rate shocks into two types—*procyclical* and *countercyclical*—based on their correlation with U.S. output. Increases in world interest rates driven by procyclical shocks are associated with lower EM spreads and higher EM output, whereas increases driven by countercyclical shocks are linked to higher EM spreads and lower EM output. These patterns are especially pronounced for countries with higher credit risk.

We interpret this evidence through the lens of a quantitative Eaton and Gersovitz (1981) model with risk-averse international lenders and a world interest rate and output process calibrated to match the data. When an increase in the world interest rate is driven by procyclical shocks, the EM spread declines because the higher financing cost is more than offset by the improvement in EM output, which reduces default risk. In contrast, countercyclical shocks lower EM output, amplifying the effect of a higher financing cost and leading to a wider EM spread. Our analysis shows that while the pure financing cost channel plays a moderate role, the interaction between EM output and global shocks is the key driver of spread dynamics.

We start our empirical analysis by constructing a consistent measure of the *risk-free cost of financing* faced by EM borrowers. That is, the interest rate that EM borrowers would pay if they issue dollar debt without default risk. This measure has two components: a *world interest rate* and an *inconvenience yield* component. The latter captures the shadow value of EM debt due to intermediary constraints, market liquidity, collateral value, and other potential factors not directly linked to default risk. Following Fleckenstein and Longstaff (2024), we use the US repo-based interest rate swap rate as the measure of the world interest rate, as it is free from convenience yield associated with other money-like assets such as Treasury securities. We measure the inconvenience yield using the bond-CDS basis, defined

as the difference between the yield spread of a bond and the CDS spread of the same maturity.[1] Importantly, while the world interest rate is procyclical, the inconvenience yield is strongly countercyclical, making the combined measure largely acyclical.

Next we show that the weak correlation between the world interest rate and the EM spread is obscured by the different structural drivers of the world interest rate, which have opposite impacts on the EM spread. In particular, a high world interest rate is sometimes associated with a boom in the US, and sometimes associated with a bust. We term the first type of world interest rate driver as a procyclical shock, and the second type as a countercyclical one. Using a structural vector-autoregressive (SVAR) model with sign restrictions, we decompose the world interest rate movements into procyclical and countercyclical structural shocks. Procyclical (countercyclical) shocks induce positive (negative) correlation between the world interest rate and US real output growth. We are agnostic about the exact nature of the shock. For example, procyclical shocks can include aggregate demand shocks, uncertainty shocks, etc. Countercyclical shocks can include monetary policy shocks, TFP shocks, markup shocks, etc.

We study the effects of procyclical and countercyclical shocks on the EM spread separately. A procyclical shock that raises the world interest rate reduces the EM spread, whereas a countercyclical shock that raises the world interest rate increases it. Quantitatively, a 1 percentage point increase in the world interest rate driven by a procyclical (countercyclical) shock lowers (raises) the EM spread by about 27 (72) basis points. This asymmetric relationship is particularly pronounced for countries with higher credit risk. Exploring the underlying mechanisms, we find that a procyclical (countercyclical) increase in the world interest rate is associated with higher (lower) EM output growth and lower (higher) EM inconvenience yield.

We compare EM spread responses to procyclical and countercyclical shocks with those to identified structural shocks, including monetary policy, fiscal policy and uncertainty shocks. While both monetary policy and fiscal policy shocks are countercyclical – affecting output and the world interest rate in opposite directions, uncertainty shocks are procyclical, impacting them in the same direction. When either monetary or fiscal policy shocks raise the world interest rate, the EM spread increases. Conversely, the EM spread decreases when the uncertainty shock leads to a higher world interest rate. The magnitude of the EM spread response is similar to our SVAR evidence.

We construct a quantitative sovereign default model in the tradition of Eaton and Gersovitz (1981) with long-term debt, risk-averse lenders and two structural shocks that drive the world interest rate, lender's stochastic discount factor (SDF) and EM output differently. The

[1] See Jiang et al. (2020) for a similar exercise for the eurozone.

inconvenience yield is modeled as a reduced-form friction in the pricing of the defaultable bond. Lenders can recover a fraction of their investment if the borrower defaults.

Calibrating the model to the structural VAR evidence, the model largely matches the aggregate moments of average debt-to-GDP level, average EM spread, as well as the response of the EM spread to procyclical and countercyclical shocks separately. The EM spread has three components: current and future default probability, inconvenience yield, and risk premium. While we measure the inconvenience yield using the bond-CDS basis, it is not easy to observe risk premium and default probability components directly in the data. Therefore, we use the model to decompose the EM spread into the three components. Among the average EM spread of 5.1 percent, about 20% (0.93 percent) comes from the risk premium, defined as the covariance of the lenders' SDF and the default decision and the fluctuating price of debt. We examine the response of the EM spread to procyclical and countercyclical shocks in the subsample with high and low credit risk. Indeed, the spread response to both procyclical and countercyclical shocks are more pronounced in the high-credit-risk subsample, consistent with empirical evidence.

We use the model to study the underlying mechanism of why the world interest rate affects the EM spread. We focus on two distinct mechanisms: the cost of financing and EM output. The cost of financing channel refers to an increase in the risk-free cost of financing, including both the world interest rate itself and the inconvenience yield. To quantify this mechanism, we solve an alternative, hypothetical model where we set the impact of the two structural shocks on the EM output to zero. In this economy, a one-percent increase in world interest rate due to procyclical (countercyclical) shock is associated with a 16-basis-point (35-basis-point) rise in the EM spread. Through the cost of financing channel, the source of interest rate fluctuations only matters due to the heterogeneous responses of inconvenience yield. With the cost of financing channel only, the response of spread to the procyclical shock changes in sign, and the response of spread to the countercyclical shock is roughly halved.

The second exercise considered the sole EM output correlation channel. In this hypothetical world, we assume that the risk-free rate at which the EM can borrow is a constant. In this alternative model, the EM spread response to the procyclical shock, which increases EM output, is even more negative, because the positive effect of a higher cost of financing is muted. The spread response to the countercyclical shock, that are associated with a reduction in EM output, is about 80% as large as in the benchmark model. These results indicate that the EM output channel plays the major role, and the cost of financing channel only has a moderate effect.

We then examine which component of the EM spread responds mostly to the structural

drivers of world interest rate. Although there exists a sizable risk premium component in the average EM spread, the response of spread to the world interest rate mainly arises from the default probability component. The risk premium component response is weak even when we allow for an increased price of risk when the world interest rate rises.

Lastly, we study the role of the recovery value at default. The literature has shown that the world interest rate change plays little role in standard sovereign default models (see, for example, Almeida et al. (2024); Singh (2024)). Almeida et al. (2024) demonstrate that if world interest rate affects the endogenous renegotiation outcome of recovery value upon default, the world interest rate will have a much larger impact on EM spread. Our model does not feature an endogenous recovery value. Instead, we impose a constant share of recovery and show that it could already propagate the impact of world interest rate on the EM spread because the debt pricing schedule is smoother with recovery.

Related literature. Our paper is first related to the literature on how the world interest rate affects the emerging market business cycle, default and EM spread. The seminal papers of Neumeyer and Perri (2005) and Uribe and Yue (2006) show that the world interest rate drives both real economic activities and spread in EMs. Subsequent works provide different modeling frameworks studying how the world interest rate and its uncertainty are transmitted into the emerging market economies, including Fernández-Villaverde et al. (2011); Guimaraes (2011); Johri et al. (2022); Almeida et al. (2024). Empirically, several studies have documented the impact of the world interest rate on the sovereign spread, including Arora and Cerisola (2001); Foley-Fisher and Guimaraes (2013); Doshi et al. (2017); Gilchrist et al. (2019). We contribute to this literature by highlighting the importance of the source of world interest rate movement and identify interest rate movements with different natures using the structural VAR approach.

A second literature studies the drivers of the sovereign spread, particularly highlighting the role of global vs. local factors. Longstaff et al. (2011) show that sovereign spreads are more correlated than output, and these correlations mostly stem from risk premium. Jeanneret (2015) estimates a model of sovereign spread with both local and global factors. Augustin and Tédongap (2016) show that US real economic activities commove with sovereign spreads. Augustin (2018) uses the term structure of CDS spread to identify the local and global drivers of sovereign spread. Augustin et al. (2022) further document that the price of sovereign debt is mainly explained by global factors but the quantity of debt is driven by local factors. Andrade et al. (2023) show exposures to global cycle increases a country's default risk. We contribute to this literature by showing through the lens of a quantitative sovereign default model that a large part of the effect of shocks to the world

interest rate comes from the correlation between the interest rate and local output.

Lastly, our work relates to the quantitative sovereign default literature, especially those that highlight the risk premium and market frictions. Our basic model framework follows the standard literature of sovereign debt, i.e., Arellano (2008); Aguiar and Gopinath (2006); Chatterjee and Eyigungor (2012); Mendoza and Yue (2012). See Aguiar et al. (2016) for a survey. Verdelhan and Borri (2011) and Lizarazo (2013) propose models with risk-averse lenders and sizable risk premium. Morelli et al. (2022) study the role of financial market frictions as a driver for sovereign spreads. Borri and Shakhnov (2021) study the global risks in long-term government debt. Bai et al. (2025) use a quantitative model to identify the role of global and local shocks in different episodes. Tourre (2017) develop a continuous-time quantitative model that reproduces the basic stylized facts of sovereign debt both in terms of prices and quantities. We focus on the role of the world interest rate and emphasize the two different types of global shocks that affect EMs differently and quantify their importance.

2 EM Spread and the World Interest Rate

2.1 Risk-free Cost of Financing: Measurement

Our first objective is to measure the *risk-free cost of financing* for EM borrowers. That is, the interest rate that EM borrowers would pay if they issue debt absent default risk. This measure has two components: a *world interest rate* component and an *inconvenience yield* component. Distinguishing between these two component is important because they have a different cyclicality and the inconvenience yield component will mechanically contribute to the EM spread.

Consider first the world interest rate. The literature commonly uses the Treasury yield as a proxy for the world interest rate. However, recent studies suggest that the Treasury yield is a poor proxy. For example, Treasuries contain a significant convenience yield component (see, e.g., Krishnamurthy and Vissing-Jorgensen (2012)). Moreover, the swap spread, defined as the difference between the interest rate swap rate and the Treasury yield of the same maturity, turned negative after the financial crisis (Jermann, 2020; Du et al., 2023), suggesting important frictions for holding Treasuries. Following Fleckenstein and Longstaff (2024), we use the interest rate swap rate, rather than Treasury yield, as the benchmark world interest rate.

The EM inconvenience yield component captures the difference in the cost of borrowing for EM economies beyond the world interest rate and the compensation for default risk. This term captures several channels. For example, Morelli et al. (2022) find that constraints faced

by global financial intermediaries increase EM borrowing costs beyond the levels justified by the world interest rate and default risk. Chari et al. (2020) and Perez (2015) show that domestic banks' debt holdings—driven by regulatory constraints or financial repression—can induce a non-pecuniary value of sovereign debt. Furthermore, in a search-and-match framework, the borrowing cost reflects the liquidity value of debt (see, e.g., Passadore and Xu (2022), Chaumont (2024)).

We are agnostic about the sources of the inconvenience yield and measure it as the deviation from the sum of the world interest rate and default risk compensation as Jiang et al. (2020) did for eurozone bonds. We measure the inconvenience yield using the bond-CDS basis, defined as the difference between the bond yield spread and the CDS spread of the same maturity. If the bond yield spread exceeds the CDS spread, the bond is "inconvenient," and the bond-CDS basis captures its inconvenience yield. Conversely, if the bond yield spread is below the CDS spread, the bond offers convenience, and the basis reflects its convenience yield.

To fix ideas, consider the Euler equation for a representative global investor in EM bonds, with a real stochastic discount factor (SDF) $M_{t,t+1}$. Let $r_{f,t}$ be the log real risk-free rate faced by this investor, namely the US 3-month interest rate swap rate. The following Euler equation holds:

$$E_t \left[M_{t,t+1} \right] \exp(r_{ft}) = 1.$$

Suppose there exists a defaultable long-term EM bond trading at par with maturity T. Let $\mathcal{I}_{t+1}$ be a default indicator equal to 1 if the borrower defaults. Denote $\Omega_{t+\tau}$ as the recovery value at time $t+\tau$, and η_t as the inconvenience yield that the investor sacrifices each period. The corresponding Euler equation is:[2]

$$1 = E_t \sum_{\tau=1}^{T} M_{t,t+\tau} \left[(1 - \mathcal{I}_{t+\tau})(y_t - \eta_t) + \mathcal{I}_{t+\tau} \Omega_{t+\tau} \right]$$

If the investor combines a long position in the bond with a CDS contract at spread s_t, the resulting risk-free synthetic asset satisfies:

$$1 = E_t \sum_{\tau=1}^{T} M_{t,t+\tau} (y_t - s_t - \eta_t)$$

[2]More precisely, the sum of cash flow should be from time $\tau = 1$ to a stochastic stopping time when the sovereign chooses to default. Fleckenstein and Longstaff (2024) estimates the hazard rate and address this issue. However, we find that incorporating the stochastic stopping time yields only minor quantitative differences in the measured inconvenience yield.

Meanwhile, a risk-free bond with the same maturity structure and trading at par satisfies:

$$1 = E_t \sum_{\tau=1}^{T} M_{t,t+\tau} y_t^{rf}$$

Comparing the two Euler equations leads to the following expression for the inconvenience yield

$$\eta_t = y_t - s_t - y_t^{rf}$$

Note that η_t is the yield that investors require to be compensated in every period for holding the EM defaultable bond at maturity T.

We define the *risk-free cost of financing* as

$$r_{ft}^* = r_{ft} + \eta_t$$

This effective risk-free rate is associated with an augmented stochastic discount factor $M_{t,t+1} \exp(-\eta_t)$. It can be interpreted as the EM borrowers' hypothetical short-term cost of borrowing in the absence of default risk, but incorporating the same inconvenience yield consideration (e.g., intermediary constraint, liquidity value, etc).

2.2 Risk-free Cost of Financing : Descriptive Statistics

Table 1 reports the statistical properties of our measure of the world interest rate, the 5-year U.S. repo swap rate, net of expected inflation, the "Swap" column. Expected inflation is proxied by the average realized inflation over the prior 12 months. We also report the statistical properties of 5-year U.S. Treasury nominal yield net of expected inflation. The Treasury-based real rate is 1.02 percent on average, while the swap-based real rate is 1.05 percent on average over the 1997Q4–2020Q1 sample. Both real rates are strongly procyclical, with correlations of 0.43 and 0.41, respectively, with U.S. consumption growth. The swap rate exhibits slightly weaker procyclicality than the Treasury-based rate.

The next four columns report statistics for the Treasury-based real rate, swap-based real rate, and the inconvenience yield over the 2004Q1–2020Q1 period. This shorter sample is constrained by the availability of CDS spread data. The earliest available 5-year EM CDS spread data begin in 2001Q1. We drop the first three years due to unusually large CDS spread values, which likely reflect liquidity issues in early-stage EM CDS markets.

The mean, standard deviation, and cyclicality of both the Treasury- and swap-based real rates decline in the later sample, reflecting the secular decline in the world interest rate. Even in the shorter sample, world interest rate correlations with U.S. consumption growth

Table 1: World interest rate: summary statistics

	Treasury	Swap	Treasury	Swap	Risk-free cost of financing	Inconvenience yield
mean	1.02	1.05	0.35	0.28	0.49	0.21
st. dev.	1.63	1.75	1.25	1.34	1.31	0.37
corr. w/ Δc	0.43	0.41	0.17	0.13	-0.04	-0.61
Sample	97Q2-20Q1		04Q1-20Q1			

Notes: The table reports the summary statistics of different measures of world real interest rates. The column "Treasury" reports statistics using 5-year Treasury yield net of expected inflation. The column "Swap" uses US 5-year repo swap rate net of expected inflation. The column "Risk-free cost of financing" is a sum of US 5-year repo swap based real rate plus the inconvenience yield. The column "Inconvenience yield" reports the statistics of the inconvenience yield alone. Expected inflation is measured as the average realized inflation in the past 12 months. The last row reports the sample period.

remain positive at 0.17 (Treasury) and 0.13 (swap). The third column, "Risk-free cost of financing" is constructed as the sum of the swap-based real rate and the inconvenience yield .[3]

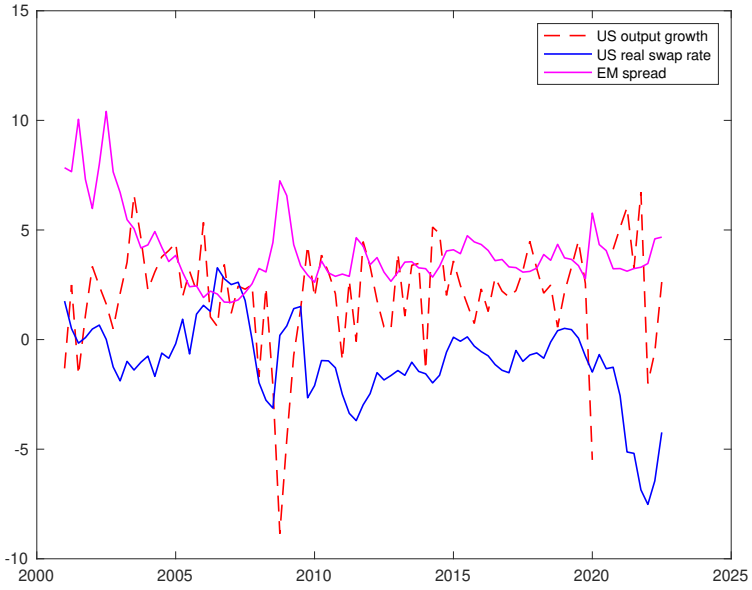
The average inconvenience yield for EM bonds is 21 basis points, suggesting that EM defaultable bonds are more inconvenient than U.S. real interest rates—likely due to market frictions faced by investors. Including the inconvenience yield reduces the correlation of the risk-free cost of financing with U.S. consumption growth to -0.04, primarily due to the strongly countercyclical inconvenience yield component. The inconvenience yield displays a correlation of -0.61 with U.S. consumption growth. A typical example of this countercyclicality is the Global Financial Crisis of 2007–08, during which U.S. consumption growth fell sharply and the inconvenience yield spiked. The spike in inconvenience yield manifested as a sharp rise in EM bond yields, without a corresponding increase in CDS spreads—reflecting tighter intermediary constraints during the crisis.

By examining the summary statistics of different measures of the world interest rate, we show that these measures differ in both their average levels and cyclical properties. The presence of a countercyclical inconvenience yield component renders the effective risk-free cost of financing faced by EM borrowers acyclical, whereas the swap-based real interest rate remains procyclical with respect to U.S. consumption growth. In the next subsection, we dig deeper into the U.S. short-term (3-month) real interest rate and analyze its underlying drivers across different cyclicality.

Figure 1 plots the time series of US real interest rate, output growth and EM spread. In the figure, it is evident that the US real interest rate and EM spread do not have a stable

[3]"Inconvenience yield" is the average bond-CDS basis across 12 countries of Brazil, Chile, Colombia, Egypt, Indonesia, Israel, Korea, Mexico, Peru, Philippines, South Africa and Turkey.

Figure 1: Time series of US real interest rate, output growth and EM spread



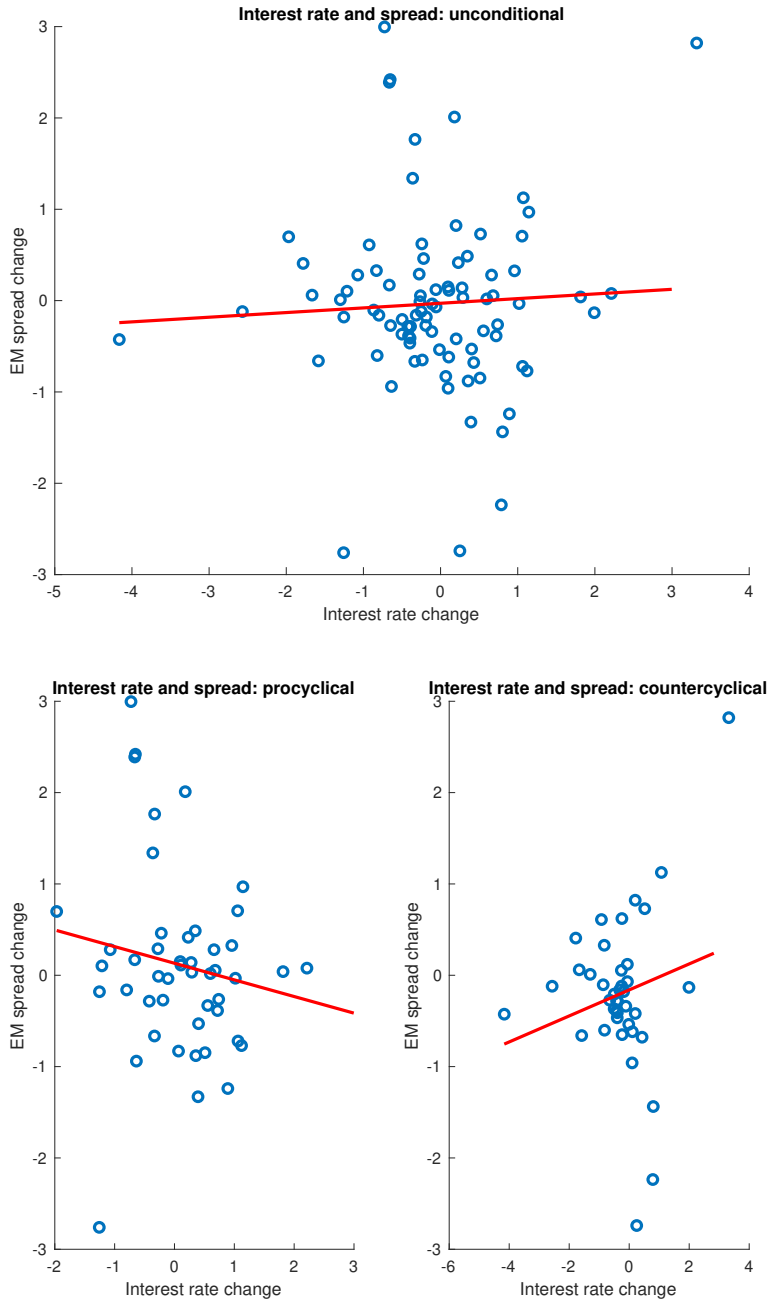
Notes: This figure plots the time series of US output growth, real interest rate (3-month swap rate) and the EM spread.

relation.

Figure 2 provides a clearer picture of the relation between the US real interest rate change and the EM spread change. The upper figure shows the unconditional relation, revealing a near flat fitted regression line. The lower figure separates the sample into two subsamples.

We define the news on US real interest rate as its first difference, and the news on US output growth as the residual to an AR(1) model. Interest rate is procyclical if the news on interest rate is in the same direction as the news on output growth, while interest rate is countercyclical if the news on interest rate is in the opposite direction as the news on output growth. The lower left panel shows the scatterplot conditional on procyclical interest rate and the lower right panel shows the scatterplot conditional on countercyclical interest rate. It is clear that when interest rate is procyclical, a higher US interest rate is associated with a lower EM spread. But when interest rate is countercyclical, a higher US interest rate is associated with a higher EM spread. The contrast of the two figures suggests that not all interest rate fluctuations are alike and it is important to distinguish different sources of interest rates movements. In the next section, we carry this idea to a formal structural VAR framework to decompose movements in the US real interest rate into two types of procyclical and countercyclical structural shocks and examine their impacts on EM spread separately.

Figure 2: US real interest rate and EM spread: scatter plot



Notes: The upper figure scatter plots the unconditional relation between the US real interest rate change and the EM spread change. The lower left panel plots the scatter plot conditional on procyclical US real interest rate, defined as episodes where news on US real interest rate and US output growth are in the same sign. The lower right panel plots the scatter plot conditional on countercyclical US real interest rate, defined as episodes where news on US real interest rate and US output growth are in the opposite signs. The red line is the fitted regression line. News on US real interest rate is defined as its first difference, while news on US output growth is defined as the residual of an AR(1) model.

2.3 Structural VAR

In this section we study how different drivers for the U.S. short-term real interest rate (world interest rate hereafter), r_{ft}, have different effects on the EM spread. The world interest rate may be influenced by a range of underlying drivers, including aggregate supply factors (e.g., total factor productivity, markups), aggregate demand factors, and policy factors. We classify these drivers into two broad categories: procyclical and countercyclical shocks. A procyclical shock is associated with a rise in interest rate with an increase of US output growth. A countercyclical shock is associated with a rise in interest rate with a US output growth decline.

We estimate a structural vector autoregression (SVAR) of the world interest rate, U.S. real output growth, and the EM spread.

The model identifies these two types of structural shocks and assess their differential effects on the EM spread. Identification is achieved by imposing sign restrictions on the responses of the world interest rate and U.S. output growth to each structural shock.

The three-variable reduced-form VAR is specified as follows:

$$\begin{bmatrix} o_t^{US} \\ r_{ft} \\ z_t \end{bmatrix} = B \begin{bmatrix} o_{t-1}^{US} \\ r_{f,t-1} \\ z_{t-1} \end{bmatrix} + u_t \tag{1}$$

where r_{ft} is the world interest rate measured as the 3-month repo swap rate net of expected inflation. o_t^{US} is the output growth in the US. z_t is the global EMBI spread. u_t is the reduced-form shock of VAR. We assume that $B_{13} = B_{23} = 0$ so that the lagged EM spread does not feed back into the dynamics of the US variables.

Let e_t be the diagonal structural shock vector. The reduced-form shocks u_t and the structural shocks e_t are related by the following structural relation:

$$u_t = Qe_t = \begin{bmatrix} 1 & q_{12} & 0 \\ q_{21} & 1 & 0 \\ q_{31} & q_{32} & q_{33} \end{bmatrix} \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}, var(e) = \begin{bmatrix} d_1 & 0 & 0 \\ 0 & d_2 & 0 \\ 0 & 0 & d_3 \end{bmatrix} \tag{2}$$

where e_{1t}, e_{2t} are the two structural shocks originating from the US and e_{3t} is the structural shock specific to the EM spread. The first two elements of the third column of Q are zero, which implies that the shock to the EM spread does not contemporaneously affect US variables. We impose the following sign restrictions:

$$q_{12} < 0, q_{21} > 0 \tag{3}$$

where q_{21} is the impact of e_1 on the world interest rate and q_{12} is the impact of e_2 on US output growth. Under the imposed sign restrictions, e_1 affects U.S. output growth and the world interest rate in the same direction, while e_2 affects them in opposite directions.

Accordingly, we interpret e_{1t} as a procyclical interest rate shock, and e_{2t} as a countercyclical shock. We rewrite equation (1) by multiplying both sides by $A = Q^{-1}$ as

$$A \begin{bmatrix} o_t^{US} \\ r_{ft} \\ z_t \end{bmatrix} = AB \begin{bmatrix} o_{t-1}^{US} \\ r_{f,t-1} \\ z_{t-1} \\ 1 \end{bmatrix} + e_t$$

where

$$A = \begin{bmatrix} 1 & \theta_1 & 0 \\ \theta_2 & 1 & 0 \\ \theta_3 & \theta_4 & 1 \end{bmatrix},$$

The sign restrictions of $q_{12} < 0, q_{21} > 0$ in equation (3) is equivalent to $\theta_1 > 0, \theta_2 < 0$. θ_3 and θ_4 face no restrictions in their values.

Our approach does not rely on identifying specific types of structural shocks—such as monetary or fiscal shocks. Instead, we classify all shocks into two broad categories: procyclical and countercyclical, and examine their differential effects on the EM spread. While we do not disentangle individual shocks within each cyclical category, we argue that the cyclical nature of structural shocks is a fundamental reason why not all movements in the world interest rate have uniform implications. Our strategy is in the spirit of the classical distinction between aggregate demand and aggregate supply shocks in business cycle analysis, where shocks are categorized based on their cyclical comovement with output and prices.

2.4 Structural VAR: Results

We estimate the SVAR using the Bayesian methodology proposed by Baumeister and Hamilton (2019). Estimation details are provided in Appendix 1.

World interest rate and US output growth. Figure 3 presents the impulse responses of the world interest rate and U.S. output growth to one-standard-deviation procyclical and countercyclical shocks. A one-standard-deviation procyclical interest rate shock e_1 raises the world real interest rate by 0.8 percent and increases U.S. output growth by 0.97 percent. Upon procyclical interest rate shocks, a one-percent increase in the real interest rate is associated with a 1.21-percent increase in output growth (0.97/0.8=1.21). The effects of

the procyclical shock on both the world interest rate and U.S. output growth persist for approximately four quarters.

In contrast, a one-standard-deviation countercyclical interest rate shock e_2 decreases U.S. output growth by 2.11 percent while increasing the world interest rate by 0.56 percent. Upon the countercyclical shocks, a one-percent increase in the world interest rate would be associated with a 3.77-percent decline in output growth (2.11/0.56=3.77). The impact of the countercyclical shock on the world interest rate is notably more persistent—lasting up to four years—whereas its effect on output growth persists for approximately four quarters, similar to the duration of the procyclical shock's output response.

EM spread. Figure 4 displays the impulse responses of the EM spread to one-standard-deviation procyclical and countercyclical shocks.. The spread used in this analysis is the composite EMBI+ Emerging Market Government Bond Spread provided by J.P. Morgan.

The EM spread response differs sharply to procyclical and countercyclical shocks that lead to an increase in the world interest rate. A one-standard-deviation procyclical shock has a negative and immediate effect on the EM spread, reducing it by 22 basis points on impact. Although the spread response is persistent, statistical power is limited by the relatively short sample period.

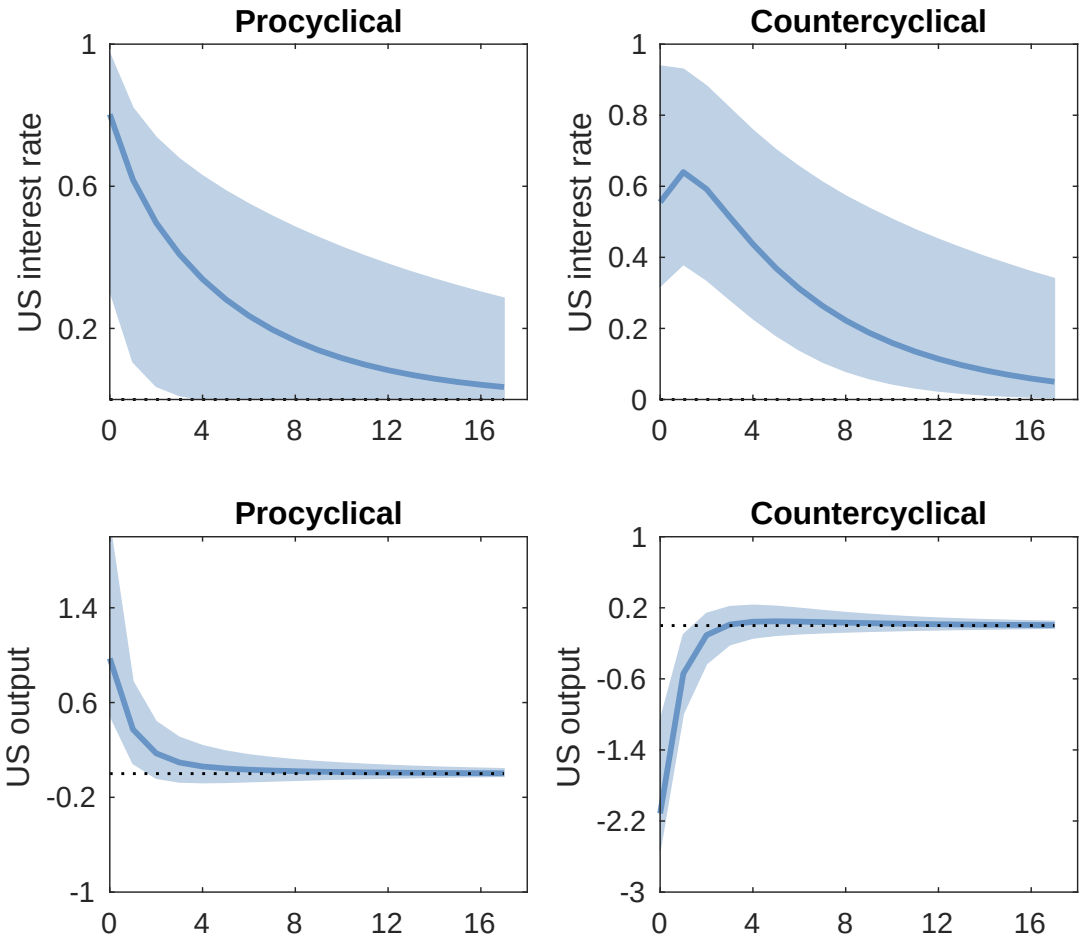
In contrast, a one-standard-deviation countercyclical shock that raises the world interest rate increases the EM spread by 40 basis points. This effect is both economically sizable and statistically significant. When normalized to a one-percentage-point increase in the world interest rate, a procyclical interest rate shock reduces the EM spread by 0.27 percent, while a countercyclical shock increases the spread by 0.72 percent.

EM output growth. To explore the economic mechanism linking the world interest rate to the EM spread, we examine how EM output growth responds to changes in the world interest rate. The EM output growth is constructed as the simple average of real GDP growth across 15 emerging market economies.[4] Given the relatively short sample period, we maintain a three-variable SVAR system by substituting EM output growth for the EM spread, instead of including all EM variables together in the VAR system.

Figure 5 reports the impulse responses of the EM output growth to procyclical and countercyclical interest rate shocks. On impact, a one-standard-deviation procyclical shock increases EM output growth by 0.79 percent, with the effect gradually decaying over the subsequent four quarters. In contrast, a countercyclical shock decreases EM output growth

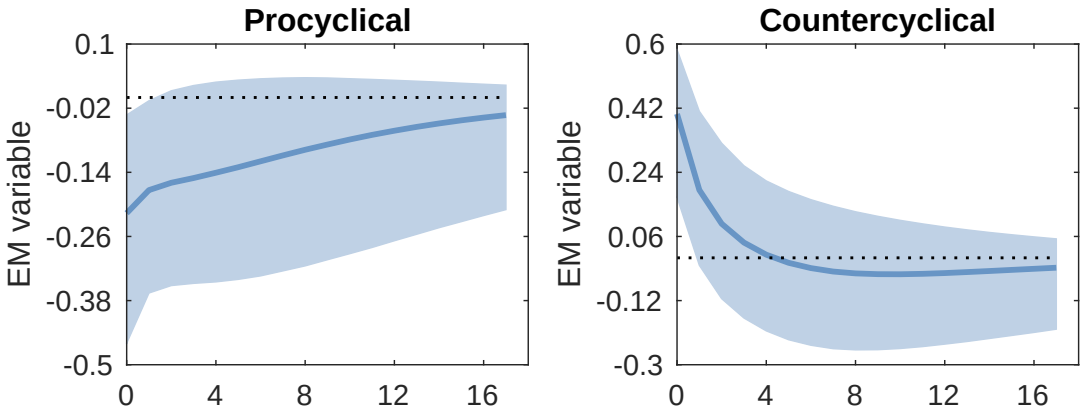
[4]The 15 countries are Brazil, Bulgaria, Chile, Ecuador, Hungary, India, Indonesia, Kazakhstan, Korea, Mexico, Philippines, Poland, Serbia, South Africa and Turkey.

Figure 3: Impulse Responses: World interest rate and US output growth



Notes: This figure plots the impulse responses of the world interest rate and the US output growth to a one-standard-deviation increase of the procyclical and countercyclical shocks for 18 quarters, respectively. The shaded areas are 90% confidence intervals.

Figure 4: Impulse Response: EM Spread



Notes: This figure plots the impulse responses of the EM spread to one-standard-deviation procyclical and countercyclical shocks. The EM spread uses the EMBI+ Emerging Market Government Bond Spread Index. The shaded areas are 90% confidence intervals.

by 1 percent on impact.

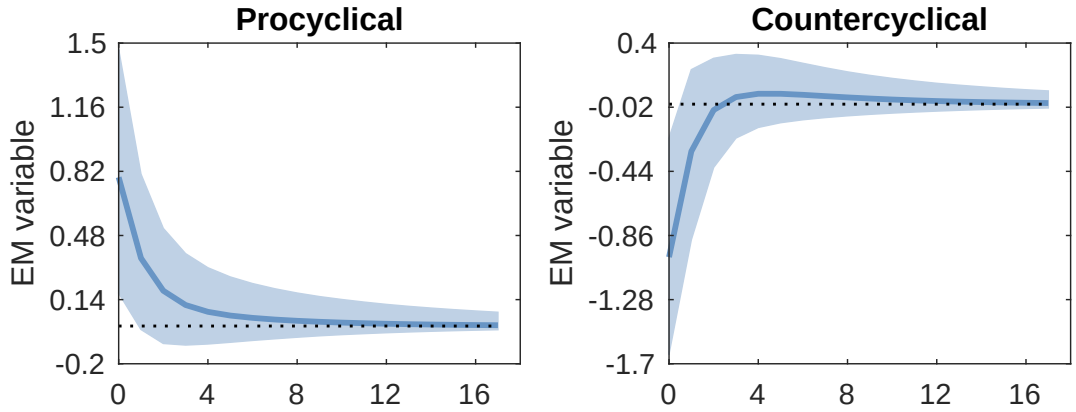
Normalizing the shock magnitudes so that the world interest rate rises by 1 percentage point, EM output increases by approximately 0.98 (1.98) percentage points when the world interest rate increase is driven by a procyclical (countercyclical) shock.

EM inconvenience yield. Figure 6 presents the impulse responses of the inconvenience yield η_t to procyclical and countercyclical shocks. In response to a procyclical shock, the inconvenience yield declines slightly—by 2.6 basis points—but the effect is statistically insignificant. In contrast, a one-standard-deviation countercyclical shock leads to a statistically significant increase in the inconvenience yield of 11 basis points.

Overall, the SVAR results highlight the importance of distinguishing between the two structural drivers of the world interest rate movements, as they have markedly different effects—not only on the U.S. output growth, but also on the EM spread, EM output growth, and the inconvenience yield. When an increase in the world interest rate is driven by a countercyclical shock, EM borrowing costs rise significantly. In contrast, a world interest rate increase caused by a procyclical shock is good news that lowers EM borrowing costs, representing favorable conditions for EM borrowers. The different responses of EM output growth and the inconvenience yield suggest potential underlying transmission mechanisms.

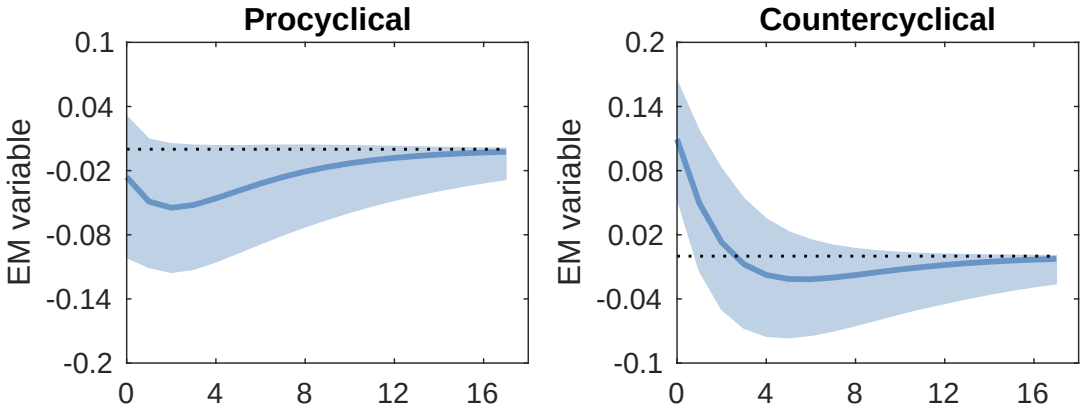
These results are related to the phenomena of the "global financial cycle" documented by Miranda-Agrippino and Rey (2022). They find strong commonalities in global capital flows and risky asset prices, characterized by a global financial factor and a global real (commodity) factor. Our empirical evidence of the differential impact on EM output resembles the global real transmission channel and the cost of financing effect (including through the

Figure 5: Impulse Response: EM Output Growth



Notes: This figure plots the impulse responses of the EM output growth to a one-standard-deviation procyclical and countercyclical shocks. The EM output growth is the average real output growth of 15 countries: Brazil, Bulgaria, Chile, Ecuador, Hungary, India, Indonesia, Kazakhstan, Korea, Mexico, Philippines, Poland, Serbia, South Africa and Turkey. The shaded areas are 90% confidence intervals.

Figure 6: Impulse Response: EM Inconvenience yield



Notes: This figure plots the impulse responses of the EM inconvenience yield to a one-standard-deviation procyclical and countercyclical shocks. The inconvenience yield is measured as the bond-CDS basis over 11 countries of Brazil, Chile, Colombia, Indonesia, Israel, Korea, Mexico, Peru, Philippines, South Africa, and Turkey. The shaded areas are 90% confidence intervals.

inconvenience yield) works through the financial transmission channel. In the next section, we develop a quantitative model to decompose and further examine how these two distinct structural shocks differentially affect the EM spread and quantify the importance of these two channels.

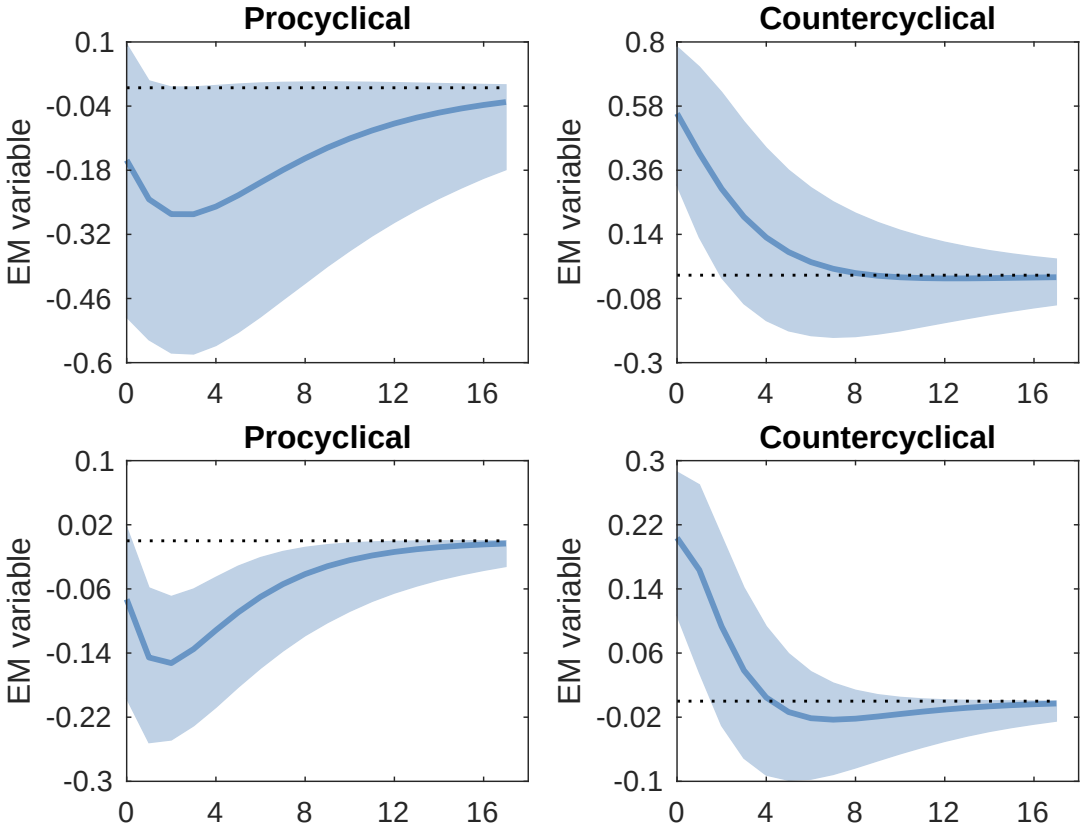
2.5 Spread Response for High- and Low-Spread Countries

We further investigate the cross-sectional heterogeneity in the response of the EM spread to the two types of structural shocks to the world interest rate. Specifically, we focus on countries with different credit risk profiles. Intuitively, bonds issued by low-credit-risk countries should behave more like risk-free assets and exhibit less sensitivity to changes in the world interest rate, whereas bonds issued by high-credit-risk countries may be more susceptible to world interest rate fluctuations. To empirically test this hypothesis, we divide the sample into high- and low-spread groups. For each period, we compute the deviation of each country's spread from the cross-sectional average as a measure of the country's relative creditworthiness. These deviations are then averaged over time and construct an unconditional measure of a country's credit risk.[5] Countries with an unconditional credit risk above the median are classified as "high-credit-risk countries", while the remaining are classified as "low-credit-risk countries".

Figure 7 presents the impulses responses of the EM spread for high- and low-credit-risk countries in response to procyclical and countercyclical shocks. These responses reveal notable cross-sectional heterogeneity in magnitude. High-credit-risk countries' spreads respond more strongly to both types of shocks. Specifically, a one-percentage-point world interest rate increase induced by the procyclical shock leads to a 19-basis-point decrease in the EM spread for high-credit-risk countries, compared to only a 10 basis-point decrease for low-credit-risk countries. Similarly, a countercyclical shock induced one-percentage-point world interest rate rise leads to a 1.10 percent increase in the EM spread among high-credit-risk countries, whereas the increase is only 39 basis points among low-credit-risk countries. The heterogeneity suggests that the default risk associated with EM bonds issued by high-credit-risk countries is more sensitive to world interest rate movements, particularly when such movements are driven by the countercyclical shock.

[5]We demean the spread using cross-sectional average because different countries' spread data start from different dates. In general, there is significant time-variation of EM spread over time. The raw spread average can be contaminated with data availability induced bias.

Figure 7: Impulse Response: EM Spread of High- and Low-spread Countries



Notes: This figure plots the impulse responses of the average spread of high-spread and low-spread countries to a one-standard-deviation procyclical and countercyclical shocks. The high-spread (low-spread) countries are defined as countries that have higher (lower) average credit risk than the median. The average credit risk is the average of each country's spread relative to the cross-sectional mean in every quarter. The shaded areas are 90% confidence intervals.

2.6 Discussion and Examples

We compare our structural VAR approach with an alternative strategy that uses well-identified shocks to trace the effects of interest-rate variation. The two approaches are complementary. The structural VAR is agnostic about the specific nature of the shocks driving the world interest rate. Procyclical and countercyclical shocks can be interpreted as composites of multiple underlying shocks that share the feature of moving the world interest rate and U.S. output in the same or in opposite directions. For example, a procyclical interest-rate shock may reflect aggregate demand, uncertainty, or flight-to-safety shocks, whereas a countercyclical interest-rate shock could reflect monetary policy or markup shocks. The advantage of the SVAR is that it allows us to account for the full set of fluctuations in U.S. output growth and real interest rates. By contrast, the well-identified-shocks approach typically isolates the effect of a specific shock and can explain only the share of fluctuations in U.S. output and real interest rates attributable to that particular shock.

To illustrate the nature of our structural shocks, we examine the impact of three typical shocks—monetary policy, fiscal policy, and uncertainty shocks—and compare the response of the EM spread to these identified shocks with our SVAR results. This comparison facilitates interpretation of the structural shocks and provides cross-validation. We estimate asset price responses over the 10 days following each shock using local projections, allowing us to incorporate high-frequency information and achieve tighter identification. The world interest rate is measured by the 1-month SOFR OIS rate, which, unlike the Treasury yield, is not affected by the convenience yield.

Monetary policy shock. The monetary policy shock follows Bauer and Swanson (2023), who use FOMC policy surprises that are orthogonal to real economic activities. As shown in 8, a rate hike significantly increases the world interest rate. Since monetary policy shocks are contractionary, they are countercyclical shocks in our structural shock classification. The EM spread rises with the rate hike, consistent with the effect of countercyclical interest rate shocks in the SVAR. Quantitatively, taking the ratio of the two effects, a one-percentage-point increase in the interest rate is associated with a 1.04 percent increase in the EM spread over the subsequent five days.

Fiscal policy shock. To harness the rich information embedded in high-frequency financial data, we construct fiscal shocks following the methodologies of Fisher and Peters (2010) and Auerbach and Gorodnichenko (2016). Specifically, fiscal information is captured through the stock prices of large defense corporations listed in Auerbach and Gorodnichenko (2016). The fiscal shock is measured as the equal-weighted excess return of these stocks over the

market index, which helps to remove other aggregate factors. Figure 8 shows that expansionary fiscal policy significantly decreases the world interest rate and is thus countercyclical. The EM spread declines with an expansionary fiscal policy, in the same direction of world interest rate change. A one-percentage-point decrease in the world interest rate is associated with a 0.85 percent decrease in the EM spread over the subsequent five days.

Uncertainty shock. We use the daily change in the VIX, the stock market's implied volatility index, to proxy for uncertainty shocks Basu and Bundick (2017); Bloom (2009), which capture broad variations of market uncertainty. Figure 8 shows that an increase of uncertainty decreases the world interest rate. As uncertainty shocks are contractionary, they are procyclical shocks. The EM spread increases significantly with higher uncertainty. A one-percentage-point increase in the real rate is associated with a 0.90 percent decrease in the EM spread over the next five days.

In sum, we map the major identified shocks from the literature to the procyclical and countercyclical shocks obtained from our structural VAR. The effects are statistically significant, and the magnitudes from the two approaches are comparable.

3 A Quantitative Sovereign Default Model

This section presents a quantitative model of sovereign default with long-term debt and risk-averse lenders. Unlike the standard literature, we explicitly model the three structural shocks: US procyclical and countercyclical interest rate shocks, as well as an EM-specific shock that affects the output of the borrower country. The procyclical and countercyclical shocks jointly drive US output and the world interest rate, while also impacting EM output, inconvenience yield and the EM spread.

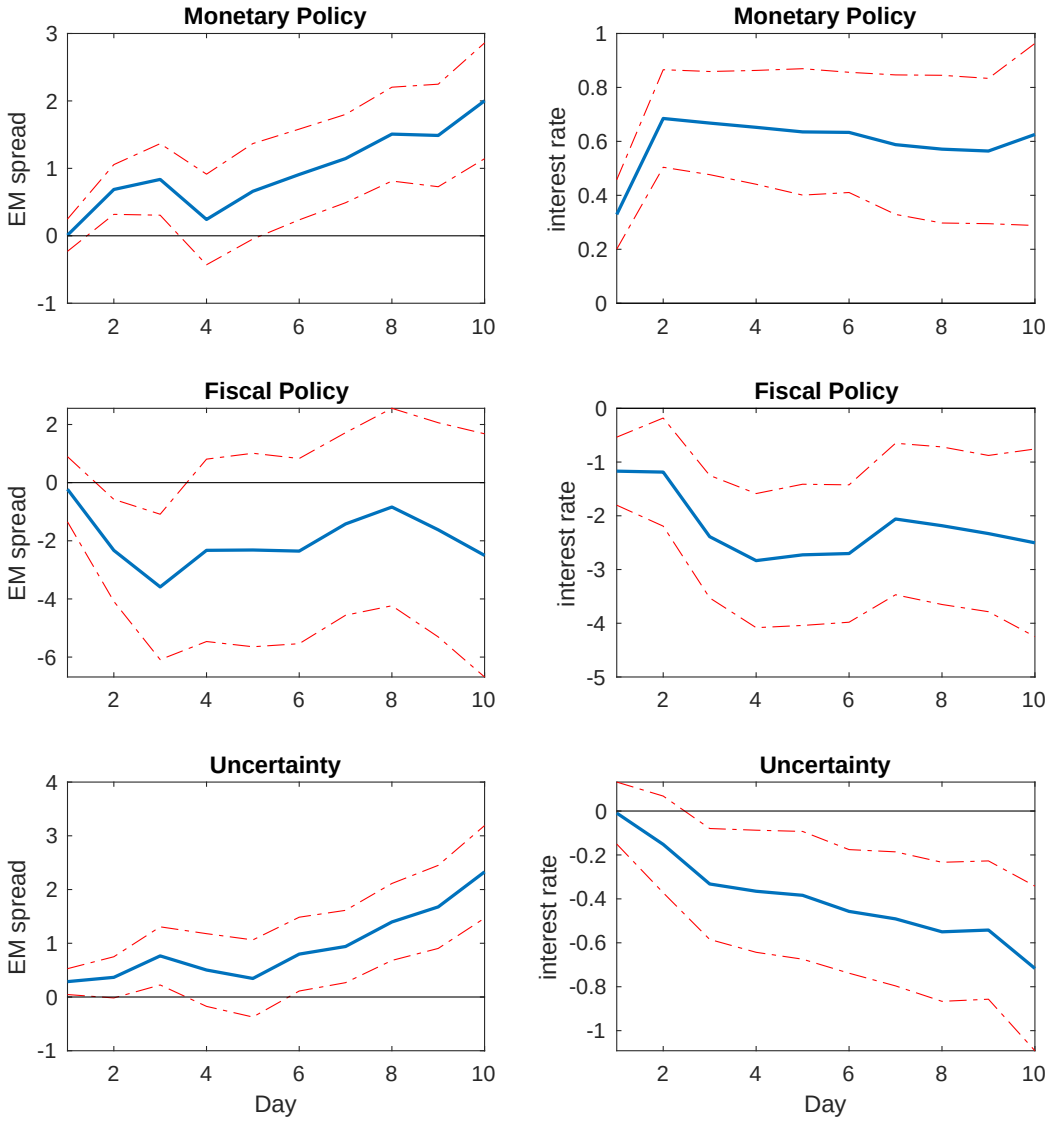
3.1 Environment

Time is discrete and indexed by $t = 0, 1, ..., \infty$. We consider a small-open emerging market (EM) economy with a single consumption good in each period. The economy is populated by stand-in households, a benevolent government that borrows from the rest of the world on behalf of the households, and foreign lenders.

The stand-in representative household has preferences over the unique consumption good given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(c_t\right)$$

Figure 8: Impulse Response: EM Spread and Interest Rate



Notes: This figure plots the cumulative responses of the EM spread and interest rate to monetary policy, fiscal policy, and uncertainty shocks. The responses are estimated through local projections. The figure also plots the 90% confidence intervals.

where the flow utility function is $u(c) = \frac{c^{1-\gamma}-1}{1-\gamma}$ with relative risk aversion γ, and β is the time discount factor. The stand-in household has a stochastic endowment of the consumption good y_t.

Foreign lenders are risk-averse and evaluate cash-flows with a stochastic discount factor

$$M_{t,t+1} = \exp\left(-c_t - \kappa_t y_{t+1}^{US}\right) \tag{4}$$

where y_t^{US} is US output, κ_t is the price of US output risk, and c_t is such that

$$E_t M_{t,t+1} \exp(r_{ft}) = 1 \tag{5}$$

where r_{ft} is the time-varying world real interest rate. In the benchmark case, we treat κ_t as a constant and allow it to vary over time in the extension. The lender incurs an inconvenience yield, denoted as η_t, when investing in debt issued by the EM borrower.

There are three types of structural shocks: the US procyclical shock, u_t, the US countercyclical shock, v_t, and an emerging market-specific idiosyncratic output shock, w_t. The US procyclical shock u_t influences the world interest rate and US output simultaneously in the same direction, while the US countercyclical shock v_t affects them in opposite directions. We write the logarithm of US output and the world interest rate as

$$y_t^{US} = \theta_1 u_t + \theta_2 v_t \tag{6}$$

$$r_{ft} = \psi_1 u_t + \psi_2 v_t \tag{7}$$

where $\theta_1, \psi_1 > 0$ and $\theta_2 > 0, \psi_2 < 0$.

The EM domestic output is influenced by both the emerging market-specific shock w_t and the two US structural shocks u_t and v_t. The log of EM output follows

$$y_t = \xi_1 u_t + \xi_2 v_t + w_t \tag{8}$$

where ξ_1, ξ_2 represent the loadings of EM output on the two global shocks. According to the structural VAR evidence in Section 2.4, we have $\xi_1 > 0, \xi_2 < 0$.

Finally, we model the inconvenience yield η_t exogenously as

$$\eta_t = \omega_1 u_t + \omega_2 v_t \tag{9}$$

where $\omega_1 < 0$ and $\omega_2 > 0$, as suggested by the structural VAR evidence in Section 2.4.

3.2 Market structure

The benevolent government cannot commit to repaying its foreign debt. Following Chatterjee and Eyigungor (2012), we restrict the debt to be a non-contingent, long-term defaultable bond. The government issues a perpetuity that promises to pay a coupon $\lambda^k z$ in k periods from issuance. Let b_t be the total amount of outstanding debt and x_t the new issuance at time t, the next-period debt b_{t+1} can be expressed as

$$b_{t+1} = (1 - \lambda)b_t + x_t$$

The government has the option to default on its debt. When default occurs, the EM is excluded from the international financial market for a stochastic period, during which lenders can seize the recovery value of the outstanding debt. In each period, the probability that the EM regains access to the international financial market is θ. If the borrower default at debt level b_t, the debt obligation is reduced to ζb_t once the borrower regains financial market access, where $0 < \zeta < 1$ represents the recovery share. During the period of exclusion, the EM experiences an output cost $c(y)$.

3.3 Recursive Equilibrium

Following the standard literature, we consider equilibria with a Markovian structure in which equilibrium strategies and prices depend only on the current state of the economy if a default flag is clear .

Let $s = (u, v, w)$ be the exogenous states of the economy in the current period, and s' be the exogenous state in the following period. Let b be the inherited external debt at the beginning of the current period, and b' the debt level at the start of the next period.

The value of the government is

$$V(s, b) = \max \left\{ V^c(s, b), V^d(s, b) \right\} \tag{10}$$

where $V^c(s, b)$ and $V^d(s, b)$ are the value function of repaying and default. The borrower government chooses to repay or default, whichever derives higher utility. We let $\mathcal{I}$ the binary variable that takes the value 1 if the government chooses to default:

$$\mathcal{I}(s, b) = \begin{cases} 0 & \text{if } V^c(s, b) \geq V^d(s, b) \\ 1 & \text{if } V^c(s, b) < V^d(s, b) \end{cases} \tag{11}$$

The value of repaying $V^c(s,b)$ is given by

$$V^c(s,b) = \max_{c,b'} u(c) + \beta E_{s'|s} V(s',b') \tag{12}$$

subject to

$$c \leq y - [\lambda b + z(1-\lambda)b] + q(s,b')(b' - (1-\lambda)b) \tag{13}$$

where $q(s,b')$ is the price schedule for the debt faced by the EM government.

The value of default $V^d(s,b)$ is given by

$$V^d(s,b) = u(y - c(y)) + \beta E_{s'|s} \left[\theta V^c(s',\zeta b) + (1-\theta)V^d(s',b)\right] \tag{14}$$

If the government chooses to default, it incurs an output cost of $c(y)$ and is excluded from international borrowing in the current period. In the next period, there is a probability of θ that the country will regain access to the international financial market, and a probability of $1-\theta$ that it remains in autarky. Upon regaining access, the country's debt level is reduced to ζb. The output cost is a quadratic function of y, following Chatterjee and Eyigungor (2012), as $c(y) = \max\left[\phi_1 \exp(y) + \phi_2 \exp(2y), 0\right]$. The output cost increases with the EM output y, which induces the borrower to default more likely in bad times.

The pricing schedule must be consistent with the lenders' SDF, which is modeled exogenously as

$$M(s,s') = \exp(c(s) - \kappa(s) y^{US}(s')) \tag{15}$$

The lenders' SDF satisfies

$$\exp(-r_{ft}(s)) = E_{s'|s} M(s,s') \tag{16}$$

Therefore, the EM debt is priced as

$$\begin{aligned} q(s,b') = {} & E_{s'|s}\left[M(s,s')\left(1 - \mathcal{I}(s',b')\right)\left(\lambda + (1-\lambda)(z + q(s',b''(s',b'))\right]\exp\left(-\eta(s)\right) \\ & + E_{s'|s}\left[M(s,s')\mathcal{I}(s',b')\Omega(s',b')\right]\exp\left(-\eta(s)\right) \end{aligned} \tag{17}$$

where $\Omega(s,b)$ is the recovery value of debt, determined by the following equation:

$$\Omega(s,b) = \theta q(s,\zeta b)\zeta + (1-\theta) E_{s'|s} M(s,s')\Omega(s',b) \tag{18}$$

The yield to the sovereign debt is

$$\text{yield}(s,b') = \frac{\lambda + (1-\lambda)z}{q(s,b')} - \lambda \tag{19}$$

The spread is calculated as the difference of yield(s, b') and the yield to a risk-free bond of the same maturity structure.

A recursive equilibrium is the value functions for the borrower $\left\{V(s,b), V^c(s,b), V^d(s,b)\right\}$ and associated decision rules $\mathcal{I}(s,b)$ and $b'(s,b)$ and a pricing schedule $q(s,b')$ such that the value functions solves the government problems (10), (12), and (14), the default decision satisfies (11), debt issuances solve (12), and the pricing schedule q satisfies (17).

3.4 Spread Decomposition: Default Probability, Risk Premium and Inconvenience Yield

To understand the movements of EM spread, we decompose the EM spread into three components: the current and future default probability (referred to as "default probability" for short), the risk premium and the inconvenience yield. The "default probability" component is measured as the EM spread priced by a risk-neutral lender facing the same default decision without inconvenience yield. The "inconvenience yield" component is measured as the difference between the current model's EM spread and the hypothetical spread computed for the same default decision without the inconvenience yield η. The remaining part of the EM spread is denoted as the "risk premium" component. A full description of the decomposition and implementation details is provided in Appendix 2.

4 Quantitative Analysis

We now use the quantitative model to understand how movements in the world interest rate driven by procyclical and countercyclical shocks transmit to the EM spreads. Section 4.1 describes our calibration strategy. Section 4.2 describes the overall fit of the model and shows that it is able to replicate the SVAR evidence in Sections 2.4 and 2.5.

We conduct two main exercises. First, in section 4.3, we study the relative importance of two mechanisms through which the two global shocks transmit to the credit spreads: the cost of financing channel and the EM output channel. We show that the EM output channel plays a dominant role in accounting for the response of credit spreads to international interest rate shocks and the cost of financing channel only plays a moderate role.

Second, in Section 4.4, we decompose the movements in credit spreads in response to procyclical and countercyclical shocks into movements in default probabilities, risk premia, and inconvenience yields. We show that although there exists a sizable risk premium component in the average EM spread, the response of spread to world interest rates mainly arises from the default probability component.

Finally, we study the role of the recovery value at default.

4.1 Calibration and Aggregate Moments

The model is solved at a quarterly frequency and calibrated to the evidence presented in the structural VAR in Section 2.4. All model parameters are reported in Table 2. We can divide the model parameters in two groups. The parameters on the left column follow the literature or are calibrated to average debt level and EM spread. These parameters include borrower's preferences, debt characteristics , EM output process, output cost and the price of risk. We set the time discount factor β to 0.954 and the risk aversion coefficient σ to 2, both are standard values. The probability of reentering the market is 0.0385, implying an average period of exclusion of 26 quarters after default, close to the experience of Argentina after defaulting on their debt. The maturity of the debt is set to 5 years and the quarterly coupon payment is 0.03, corresponding to an annual coupon rate of 12 percent. These values align with their empirical counterparts. The output cost of default is calibrated to the average debt-to-GDP ratio and the average spread. We assume the three structural shocks share the same persistence of 0.933 and calibrate the price of output risk to 30. The recovery value upon default is set at 0.3, indicating that creditors can recover 30% of their lending if the borrower reenters the market after the default event.

The parameters in the right column are calibrated to the SVAR evidence, including the unconditional standard deviation of the three structural shocks u, v, w, as well as the loadings of US output and interest rate, EM output and inconvenience yield on these structural shocks. The volatilities of u and v are calibrated to match a 1% standard deviation of world interest rate and the ratio of $std(u)/std(v)$ in the data. The variance of w, $var(w)$ is calibrated to an unconditional volatility of emerging market output of 3.75 percent.

Table 3 presents the aggregate moments from both the model and the data. We select model simulated data periods during which the economy has experienced at least 20 consecutive quarters of good credit standing, which means it is not excluded from the international financial market. The model produces a debt-to-annual-GDP ratio of 0.44, closely aligning with its empirical counterpart of 0.45. The average default rate in the model is equal to 3.92 percent per annum, which is close to what the literature typically reports. The average spread from the model is 5.19 percent, comparable to the observed 4.60 percent in the data. Additionally, the model produces a risk premium of 0.93 percent, calculated based on the procedure in Section 3.4. The model also captures several features of EM business cycles, such as the higher volatility of consumption than output and a countercyclical spread. Overall, the model performs well in matching the aggregate moments in a typical EM economy.

Table 2: Calibration

Time discount rate	β	0.954	Unconditional vol of u	$var(u)$	4.64
Risk aversion	σ	2	Unconditional vol of u	$var(v)$	2.66
Reentry prob	θ	0.0385	Unconditional vol of u	$var(w)$	4.60
Maturity	$1/\lambda$	20	u on US output	θ_1	0.24
Coupon	z	0.03	v on US output	θ_2	-0.53
Output cost	a_1	-0.36	u on US real rate	ψ_1	0.20
	a_2	0.46	v on US real rate	ψ_2	0.14
Persistence	ρ	0.933	u on EM output	ξ_1	0.20
Price of risk	κ	30	v on EM output	ξ_2	-0.25
Recovery value	ζ	0.3	u on wedge	ω_1	-0.0075
			v on wedge	ω_2	0.0275

Notes: The table reports the calibrated parameters of the model.

Table 3: Aggregate Moments

	Model	Data
b/y	0.44	0.45
default rate	3.92	
spread	5.19	4.63
risk premium	0.93	
std(c)/std(y)	1.47	1.09
corr(y,spread)	-0.27	-0.20

Notes: The table reports the aggregate moments in the data and in the model. The model moments are based on a simulation of 1e6 periods. We select periods where the prior 20 quarters are in good credit standing, i.e., not excluded from international financial market.

It is well-known that the sovereign default model with long-term debt often face convergence challenges. To address this, we solve the model by incorporating an idiosyncratic taste shock into the EM borrowers' debt choice decision, as detailed in Mihalache (2025). The specifics of the numerical solution algorithm are provided in Appendix 3.

4.2 EM Spread, Risk Premia, and World Interest Rate

Table 4 presents the average EM spread, the magnitude of risk premia defined in Section 3.4, and the spread sensitivity to world interest rate changes, both in the model and in the data.

The first two columns report moments derived from data and the model simulations. Of the 5.19 percent average EM spread, approximately 20% (0.93 percent) is attributable to the risk premia component.

The third and fourth rows show the response of spread to procyclical and countercyclical shocks. All shocks are normalized so that the world interest rate changes by 1 percent. The data column is obtained from the contemporaneous response of spread to these two structural shocks, as illustrated in Figure 4. The model column is obtained via a regression of $\Delta spread_t = a + b\Delta x_t + \varepsilon_t$, where x is either u or v. The last row reports the regression coefficient of $\Delta spread_t = a + b\Delta r_{ft} + \varepsilon_t$ in both the data and the model, capturing the spread response to overall changes in the world interest rate.

In the model simulations, a 1% increase in the world interest rate driven by the procyclical shock, results in a reduction of the EM spread by 23 basis points, close to the 27 basis points in the data. Conversely, a 1% world interest rate increase caused by a countercyclical shock raises the spread by 76 basis points in the model, similar to the 73 basis points observed in the data. The different signs of spread responses explains why the raw correlation between EM spread and world interest rate is close to 0. We highlight that not all world interest rate movements are alike and the source of world interest rate change matters for the direction of EM spread change.

Next, we analyze the average spread, risk premia, and the response of spread to world interest rate within subsamples of high and low credit risk in the model. In model simulations, we divide the full sample into two subsamples based on whether the spread is above and below the mean. The results are reported in Columns 3-6 labeled, as "High credit risk" and "Low credit risk". The corresponding data subsamples follow the definition we use in Section 2.5.

The high-credit-risk subsample has an average spread of 6.99 percent, close to the empirical average of 6.76 percent, while the low-credit-risk subsample's average spread is 3.38

Table 4: EM Spread and World Interest Rate

	EMBI index		High credit risk		Low credit risk	
	data	model	data	model	data	model
Spread	4.63	5.19	6.76	6.99	2.12	3.38
Risk premia		0.93		0.90		0.97
pro. Δu	-0.27	-0.23	-0.19	-0.24	-0.10	-0.12
count. Δv	0.73	0.76	1.10	1.07	0.39	0.18
Δr_f	0.04	-0.09	0.33	-0.06	0.13	-0.08

Notes: The table reports the average spread, risk premia, and sensitivity of sovereign spread change with respect to changes in the procyclical shock u, countercyclical shock v and the raw change of world real interest rate. We obtain the sensitivity coefficients through the regression $\Delta\text{spread}_t = a + b\Delta\text{Interest rate}_t + u_t$, where the variable Interest rate_t uses u, v, r respectively. All regressors are normalized such that the change of world interest rate is one percent. The first column report the regression coefficient using the full sample of model simulated data. The third column report the coefficients using the half subsample of model simulated data where spread is higher than the median to represent the high credit risk scenario. The fifth column report the coefficients using the other half sample of model simulated data where spread is lower than the median to represent the low credit risk scenario. The data counterparts are reported in Column 2, 4 and 6. Column 2 is the simple regression coefficient of change of EMBI spread index onto the change of world interest rate. Columns 4 and 6 correspond to the contemparenous response of IRFs of spread to u and v reported in Figure 4.

percent, slightly higher than 2.12 percent observed in the data.Regarding the sensitivity of spreads to world interest rate fluctuations, both in the data and in the model, the responses are larger when credit risk is high — particularly for the countercyclical shock.[6] Intuitively, when a borrower is far from default, a rise in the world interest rate has little impact on its default prospects. However, as the country approaches the default threshold, an increase in the world interest rate exerts a larger marginal impact on the borrower's default likelihood.

4.3 Mechanism: EM Output and Cost of Financing

Next, we use the model to quantify the economic mechanisms through which the world interest rate influences EM spread. We focus on two primary mechanisms: the impact via EM output and through financing cost. On one hand, shocks to world interest rate are linked to changes in EM output, which subsequently affects EM spreads. On the other hand, an increase in the world interest rate raises financing cost, both directly through the higher

[6]The EMBI index data column does not lie between the data columns for high and low credit risk column because the spread are constructed from two different sources. The EMBI index column uses a composite index which consists of a cross-section of multiple countries with pre-specified weights. For high- and low-credit risk columns, we use the simple average of a fixed set of countries that feature high and low credit risk measures constructed in Section 2.5.

Table 5: EM Spread and World Interest Rate: Mechanisms

	Data	Model	Cost of financing		EM output
			$\xi_1 = \xi_2 = 0$ same calibration	$\xi_1 = \xi_2 = 0$ recalibrate	$\psi_1 = \psi_2 = \eta_1 = \eta_2 = 0$
Spread	4.63	5.19	4.37	5.10	4.62
Risk premia		0.93	-0.18	-0.21	0.99
pro. Δu	-0.27	-0.23	0.06	0.16	-0.32
count. Δv	0.73	0.76	0.22	0.35	0.57
Δr_f	0.04	-0.09	0.08	0.19	-0.20

Notes: The table reports the average spread, risk premia, and sensitivity of sovereign spread change with respect to changes in the procyclical shock u, countercyclical shock v and the raw change of world real interest rate. We obtain the sensitivity coefficients through the regression $\Delta\text{spread}_t = a + b\Delta\text{Interest rate}_t + u_t$, where the variable Interest rate_t uses u, v, r respectively. All regressors are normalized such that the change of world interest rate is one percent. The first two columns replicate the numbers in Table 4. Columns 3 and 4 report the numbers under the counterfactual experiment where there is only the cost of financing channel. Column 3 keeps the same set of parameters as the benchmark model and Column 4 recalibrates the output cost parameters to maintain a similar average spread. Column 5 reports the numbers under the counterfactual experiment where there is only the EM output channel.

interest rate itself and indirectly via a change in inconvenience yields and risk premia. We assess the relative importance of each channel through a series of counterfactual experiments within the model.

The Cost of Financing Channel

A common narrative of EM sovereign default is the rise of the world interest rate. When the world interest rate increases, EM borrowers find it more difficult to roll over their debt, making default more likely. To assess the importance of this channel, we set $\xi_1 = \xi_2 = 0$ and adjust $var(w)$ to keep EM output volatility the same as the benchmark model. The cost of financing channel has three components: the increase in the world interest rate charged by the lenders, changes in the inconvenience yield, and risk premia. Column 3 and 4 of Table 5 present the same set of moments from Table 4 based on simulated data under this counterfactual scenario. For comparison, the first column displays the data and benchmark model results.

Column 3 maintains all other parameters values as in the benchmark model, except for setting $\xi_1 = \xi_2 = 0$ and adjusting $var(w)$. When the world interest rate no longer affects EM output, the average spread decreases from 5.19% to 4.37% and the risk premia turn negative at -0.18%. The spread response to the procyclical and countercyclical shocks

are both positive at 0.06 and 0.22, respectively, while the spread response to changes in world interest rate is 0.08. Without their differential impacts on EM output, the procyclical and countercyclical shock only affects the EM spread via the cost of financing mechanism. Absent inconvenience yield and risk premia, a rise in the world interest rate due to procyclical or countercyclical shock should impact the EM spread similarly. The inconvenience yield responds differently to procyclical and countercyclical shocks, reflected in ω_1 and ω_2, The difference in spread response to the underlying procyclical and countercyclical shock is 0.16, which is largely explained by different loadings of the inconvenience yield.

When we shut down the EM output channel, the response of the EM spread to world interest rate change becomes much weaker than in the benchmark model, regardless of whether the change originates from the procyclical or countercyclical shock. However, we observe that the credit risk is also significantly reduced. Results in Table 4 suggest that the spread response depends on the overall credit risk in the economy. The weaker response of spread may simply reflect the lower credit risk in the economy.

In Column 4, we recalibrate the model by setting output cost parameters a_1, a_2 so that the average spread is 5.10%, close to the benchmark. The risk premium is then negative at -0.21%, similar to Column 3. The spread responses to world interest rate driven by procyclical and countercyclical shocks are 0.16 and 0.35, respectively, with a difference of 0.19. This difference closely aligns with the contribution of the inconvenience yield. Indeed, higher overall credit risk amplifies the spread responses to changes in the world interest rate, regardless of whether these changes are driven by the procyclical or countercyclical shock.

The responses are still much weaker than those reported in the benchmark model. In the case of procyclical shocks, the response switches from negative to positive because the primary mechanism — higher EM output — is muted. When considering only the cost of financing effect, the spread response to the countercyclical shock is halved. Overall, the cost of financing channel plays a moderate role in influencing the spread responses to world interest rate changes driven by both procyclical and countercyclical shocks.

Lastly, we observe that risk premia become negative when the world interest rate affects the EM borrower solely through the cost of financing channel. Without considering the EM output effect, a higher interest rate induced by a procyclical shock is associated with a lower value of SDF and a higher probability of default. The negative correlation between SDF and default makes the sovereign bonds act as a hedge, which leads to a negative risk premium. Conversely, if the world interest rate rise results from the countercyclical shock, the correlation between SDF and default is positive, making the sovereign bond risky. Therefore, through the cost of financing channel only, a procyclical shock leads a negative risk premium and a countercyclical shock leads to a positive risk premium. In the model, the procyclical

shock is the primary driver of world interest rate fluctuations, which causes the average risk premium component of sovereign spread to be negative.

The EM Output Channel

Next, we assess the quantitative importance of the EM output channel. To isolate this channel, we eliminate the influence of the procyclical and countercyclical shocks on the cost of financing by setting $\psi_1 = \psi_2 = \eta_1 = \eta_2 = 0$. This assumption implies that the risk-free cost of financing faced by the EM is a constant.

When the procyclical and countercyclical shocks affect EM output only, the average EM spread is lower because the impact of world interest rate on default is asymmetric. Specifically, an increase in the cost of financing has a larger effect on EM spreads than a decrease, so removing fluctuations in the cost of financing results in a lower average EM spread. The risk premia in this scenario is slightly higher than the benchmark model because the force that makes sovereign debt a hedge is abstracted in this counterfactual exercise.

The procyclical shock causes a even more negative spread response because the abstracted cost of financing channel moves spread in the opposite direction as the EM output channel. The spread response to the countercyclical shock is approximately 80% of that in the benchmark model, indicating that the EM output channel is a primary mechanism through which the world interest rate affects EM spreads. The overall sensitivity of the EM spread to the world interest rate change is more negative under the EM output channel only.

4.4 Default Probability, Risk Premium and Inconvenience Yield

We next study whether the increase (decrease) in credit spreads after a countercyclical (procyclical) shock is driven by and increase (decrease) of default probability, risk premium and inconvenience yield using the decomposition in Section 3.4.

Table 6 reports the results. The Benchmark column shows that the majority of the spread response to the two structural shocks is driven by the default probability component. The risk premium moves little in response to the procyclical shock. For the countercyclical shock, the risk premium even moves negatively, although the magnitude remains small.

The column "Time-varying price of risk" introduces an additional channel through which the interest rate affects risk-by setting the price of risk $\kappa_t = \kappa_0 + \kappa_1(r_{ft} - \bar{r}_f)$ and $\kappa_1 > 0$. We set $\kappa_1 = 5$ so that a one-percent interest rate rise relative to its mean raises the price of risk from 30 to 35, resulting in a 1/6 increase of risk premium. Even when accounting for a time-varying price of risk linked to the world interest rate — which, by construction, should amplify the risk premium response — our results indicate that the risk premium response

Table 6: EM Spread and World Interest Rate: Decomposition

		Benchmark		Time-varying price of risk
		Data	Model	κ_t increase with r
pro. Δu	Δspread	-0.27	-0.23	-0.20
	default prob		-0.22	-0.21
	inconvenience		-0.02	-0.02
	risk premium		0.01	0.02
count. Δv	Δspread	0.73	0.76	0.79
	default prob		0.69	0.70
	inconvenience		0.13	0.13
	risk premium		-0.06	-0.04
Δr	Δspread	0.04	-0.09	-0.06
	default prob		-0.09	-0.08
	inconvenience		0.00	0.00
	risk premium		0.00	0.01

Notes: The table reports the spread response to structural drivers of world interest rates and decompose the spread change into default probability, inconvenience yield and risk premium. "Benchmark-Data" column reports the spread response in the data. "Benchmark-Model" column reports the decomposition in the benchmark model. The column "Time-varying price of risk" allows for a risk-taking effect of world interest rate by assuming $\kappa_t = \kappa_0 + \kappa_1(r_{ft} - \bar{r}_f)$ with $\kappa_1 = 5$.

remains relatively weak. Therefore, while the risk premium accounts for a significant portion of the average EM spread, it does not exhibit substantial variation with changes in the world interest rate, regardless of which structural shock is driving the interest rate movement.

4.5 The Role of Recovery

This section studies the role of recovery in the model. It is well-known that, in a typical sovereign default model, changes in the world interest rate have little impact on the borrower's default decision and spread (Johri et al., 2022). Recent research by Almeida et al. (2024) demonstrates that incorporating endogenous debt recovery value through negotiation can amplify the effect of a world interest rate shock. Unlike Almeida et al. (2024), we assume a constant recovery value of 30% on default and explore how recovery influences our results.

Table 7 reports the average spread, risk premium and spread responses to structural shocks under two different models: the benchmark model ($\zeta = 0.3$) and an alternative model with no recovery. The two columns under "Recovery: $\zeta = 0.3$" replicate the results in Table 5. The two columns under "No recovery: $\zeta = 0$" present results from an alternative model with zero recovery value. In this alternative model, output cost is recalibrated to generate an

Table 7: EM Spread and World Interest Rate: The Role of Recovery

	Recovery: $\zeta = 0.3$		No recovery: $\zeta = 0$	
	Cost of Financing and EM Output	Cost of Financing Only $\xi_1 = \xi_2 = 0$	Cost of Financing and EM Output	Cost of Financing Only $\xi_1 = \xi_2 = 0$
Spread	5.19	5.10	5.32	5.11
Risk premia	0.93	-0.21	1.37	0.08
pro. Δu	-0.23	0.16	-0.18	-0.01
count. Δv	0.76	0.35	0.36	0.11
Δr_f	-0.09	0.19	-0.11	0.01

Notes: The table reports the average spread, risk premia, and sensitivity of sovereign spread change with respect to changes in the procyclical shock u, countercyclical shock v and the raw change of world real interest rate under two alternative models with different recovery values. The columns under "Recovery: $\zeta = 0.3$" are replication of the results in Table 5. The columns under "No recovery: $\zeta = 0$" are obtained under an alternative model where the lenders get zero recovery value upon default. The left column allows for both the cost of financing and EM output mechanism. The right column includes the cost of financing channel only. Output cost parameters are recalibrated to generate an average spread close to the benchmark model.

average spread of similar magnitude. When both cost of financing and EM output channels are present, the economy without recovery exhibits much weaker spread responses, especially to the countercyclical shock. For example, the spread response to a one-percent interest rate rise due to the countercyclical shock is 0.36, roughly half that of the benchmark model. The difference becomes more pronounced in the last column, where the EM output channel is shut down. Compare to Column 2 under $\zeta = 0.3$, the spread bares responds to the world interest rate change except for through the inconvenience yield change. This result confirms previous findings in the literature that fluctuations in the world interest rate do not have significant impact on EM spread.

Recovery increases the sensitivity of spread to world interest rate changes because when lenders can recover a fraction of their investment upon default, their debt pricing schedule becomes smoother , resulting in smaller price jumps across different debt choices. In an economy without recovery, the debt pricing schedule is extremely steep, incentivizing borrowers to reduce borrowing to avoid higher debt prices when the world interest rate increases, which in turn lowers future default probabilities. With recovery, the lenders can recover part of their debt at default, leading to a smoother pricing schedule. Consequently, borrowers have less incentive to cut their borrowing in response to rising interest rates. Without this offsetting mechanism of endogenous debt cut in high-interest-rate times, the impact of world interest rate changes on EM spread is significantly larger when there is some recovery value

for the lenders at default.

5 Conclusion

This paper shows that the effect of global interest rate movements on EM spreads depends critically on the correlation of the underlying shocks with EM output. Procyclical shocks raise EM output and reduce default risk, lowering spreads despite higher financing costs, while countercyclical shocks contract EM output and sharply raise default risk, amplifying spreads. Our model further decomposes the response of spreads to procyclical and countercyclical shocks into default probability, risk premia, and inconvenience yield components, and we find that most of the response comes from changes in default probabilities, with negligible contributions from risk premia despite their sizable average level.

The relation between EM output and global shocks is treated as exogenous, and the inconvenience yield is also modeled exogenously. Our results suggest that a full account of sovereign risk requires endogenizing both EM output fluctuations and the inconvenience yield. Future work should integrate these endogenous mechanisms to fully capture the transmission of global financial conditions into EM borrowing costs.

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APPENDIX

1 Details of the Structural VAR Estimation

1.1 Estimation Method Details

As we state in the main text, the VAR system takes the following form:

$$Ay_t = ABx_t + e_t$$

where

$$y_t = \begin{bmatrix} o_t^{US} \\ r_{ft} \\ x_t \end{bmatrix}, x_t = \begin{bmatrix} o_{t-1}^{US} \\ r_{f,t-1} \\ z_{t-1} \\ 1 \end{bmatrix}$$

$$A = \begin{bmatrix} 1 & \theta_1 & 0 \\ \theta_2 & 1 & 0 \\ \theta_3 & \theta_4 & 1 \end{bmatrix}, B = \begin{bmatrix} B_{11} & B_{12} & 0 & B_{14} \\ B_{21} & B_{22} & 0 & B_{24} \\ B_{31} & B_{32} & B_{33} & B_{34} \end{bmatrix}, var(e_t) = \begin{bmatrix} d_1 & 0 & 0 \\ 0 & d_2 & 0 \\ 0 & 0 & d_3 \end{bmatrix},$$

with $\theta_1 > 0, \theta_2 < 0$ and θ_3, θ_4 being free parameters. We write $B_1 = \begin{bmatrix} B_{11} & B_{12} & B_{14} \end{bmatrix}$, $B_2 = \begin{bmatrix} B_{21} & B_{22} & B_{24} \end{bmatrix}$ and $B_3 = \begin{bmatrix} B_{31} & B_{32} & B_{33} & B_{34} \end{bmatrix}$.

The Bayesian estimation of the structural VAR follows Baumeister and Hamilton (2019). We outline the estimation steps here and refer interested readers to their paper for details.

There are three sets of parameters to be estimated: A, B and $D = diag(d_1, d_2, d_3)$.

Priors. Denote $p(A)$ the density of the prior distribution of elements of matrix A. θ_1 follows a positively truncated student-t distribution and θ_2 follows a negatively truncated student-$t$distribution. θ_3 and θ_4 both follow symmetric, untruncated student-t distributions. Specifically,

$$\theta_1 \sim t_+(c_1, \sigma_1, \nu_1), \theta_2 \sim t_-(c_2, \sigma_2, \nu_2), \theta_3, \theta_4 \sim t(c_3, \sigma_3, \nu_3)$$

We choose $c_1 = 1, \sigma_1 = 5, \nu_1 = 3$; $c_2 = -1, \sigma_2 = 0.5, \nu_2 = 3$; $c_3 = 0, \sigma_3 = 10, \nu_3 = 3$.

The prior for elements in matrix$D$ follows an inverse Gamma distribution, i.e., $d_i^{-1}|A \sim \Gamma(\kappa_i, \tau_i)$. We set $\kappa_i = 0.5, \tau_i = A_i' \hat{S} A_i$, where A_i is the ith row of matrix A, and $\hat{S}$ is the variance-covariance matrix of the AR(1) residuals of each variable. All non-diagonal elements of $\hat{S}$ are set to 0.

The prior for each row in B follows a normal distribution with standard Minnesota prior, i.e., $B_i|A, D \sim N(m_i, d_i M_i)$, where the details of m_i and M_i follows Baumeister and Hamilton (2019) exactly.

Posterior distribution. Define the transformed data as

$$\tilde{Y}_{it}' = \begin{bmatrix} A_i' Y_t & m_i' P_i \end{bmatrix}, \tilde{X}_{it}' = \begin{bmatrix} X_t' & P_i \end{bmatrix}$$

where P_i is the Choolesky decomposition of M_i^{-1} such that $P_i P_i' = M_i^{-1}$. Stack the time series of $\tilde{Y}_{it}'$ and $\tilde{X}_{it}'$ to be $\tilde{Y}_i$ and $\tilde{X}_i$.

Baumeister and Hamilton (2019) prove that the posterior of the structural matrix A has an analytical solution of the following:

$$p(A|Y_T) \propto \frac{p(A)\left[det(A\hat{\Omega}_T A')\right]^{T/2}}{\Pi_{i=1}^n \left[(2/T)\tau_i^*(A)\right]^{\kappa_i^*}} \Pi_{i=1}^n \tau_i(A)^{\kappa_i} \tag{A1}$$

where$\hat{\Omega}_T$ is the variance-covariance matrix of the reduced-form residuals, $\kappa_i^* = \kappa_i + T/2$ and

$$\tau_i^*(A) = \tau_i(A) + 1/2\left[\tilde{Y}_i'\tilde{Y}_i - \tilde{Y}_i'\tilde{X}_i(\tilde{X}_i'\tilde{X}_i)^{-1}\tilde{X}_i'\tilde{Y}_i\right]$$

Note each variable corresponds to different x_t. For $i = 1, 2$, x_t only includes the lagged US variables and the constant, while for $i = 3$, x_t includes four terms of the lagged US variables, the lagged EM variable and the constant.

Note that if $p(A) = 0$, then $p(A|Y_T) = 0$ no matter what values the data take. Therefore, the sign restrictions on A carries over from the prior distribution to the posterior distribution.

The posterior of d_i follows

$$d_i^{-1}|A, Y_T \sim \Gamma(\kappa_i^*, \tau_i^*)$$

where κ_i^* and τ_i^* are given above.

The posterior of B_i follows

$$B_i|A, D, Y_T \sim N(m_i^*, M_i^*)$$

where

$$m_i^* = \left(\tilde{X}_i'\tilde{X}_i\right)^{-1}\left(\tilde{X}_i'\tilde{Y}_i\right), M_i^* = \left(\tilde{X}_i'\tilde{X}_i\right)^{-1}$$

The posterior distribution is sampled through a Metropolis-Hasting sampler. We sample $N = 2e^6$ draws of (A, D, B) and burn the first half the draws. For each draw, we compute

the impulse response of the three variables in response to a one standard deviation shock by computing $B^{\tau-1}Q$, where t is the response of each variable after τ periods and $Q = A^{-1}$.

2 Details of Spread Decomposition

We decompose the EM spread into three components: the current and future default probability (referred to as "default probability" for short), the risk premium and the inconvenience yield. We begin with a conceptual overview of the decomposition and then illustrate how it is implemented in the model.

To fix ideas, consider a one-period zero-coupon defaultable debt with recovery value $\Omega(s, b)$. The pricing equation for this one-period debt is

$$q(s, b') = E_{s'|s} M(s, s') \left[(1 - \mathcal{I}(s', b')) + \mathcal{I}(s', b')\Omega(s', b')\right] \exp(-\eta(s)) \tag{A2}$$

It is straightforward to decompose the yield spread into three components: expected default probability, risk premium and inconvenience yield as follows:

$$\begin{aligned} spr &= -\log q(s, b') + E_{s'|s} M(s, s') \\ &= -\log E_{s'|s}(1 - \mathcal{I}(s', b') + \mathcal{I}(s', b')\Omega(s', b')) \\ &\quad - \log\left[1 + \frac{-cov_{s'|s}(M(s, s'), 1 - \mathcal{I}(s', b') + \mathcal{I}(s', b')\Omega(s', b'))}{E_{s'|s} M(s, s') E_{s'|s}(1 - \mathcal{I}(s', b') + \mathcal{I}(s', b')\Omega(s', b'))}\right] + \eta(s) \end{aligned} \tag{A3}$$

The first term is the expected default probability. The second term is the default risk premium that arises from the covariance between the debt payoff and the SDF. The third term is the inconvenience yield faced by creditors.

When the debt is longer-term, the same logic applies to each period's promised cash flows. A long-term debt is equivalent to a mix of zero-coupon debt with different maturities. Consequently, the yield spread of long-term debt can be decomposed into these three terms in a similar manner. Specifically, we write

$$spr = \sum_{k=1}^{\infty} a_k (\text{default prob}_k + \text{risk premium}_k + \text{Inconvenience yield}_k) \tag{A4}$$

where a_k is the fraction of bond value that comes from the cash flow in period k.

Implementation. In the model, we implement the decomposition as follows. First, we solve the model and obtain the equilibrium default decision $\mathcal{I}(s, b)$.

Second, we specify a hypothetical risk-neutral SDF $M^{rn}(s,s')$ that is consistent with the process of world interest rate. Then we compute the risk-neutral price of debt as $q^{rn}(s,b')$ as

$$q^{rn}(s,b') = E_{s'|s}M^{rn}(s,s')\left[(1-\mathcal{I}(s',b'))\left(\lambda+(1-\lambda)(z+q^{rn}(s',b''(s',b'))\right.\right. \\ \left.\left.+\mathcal{I}(s',b')\Omega^{rn}(s',b')\right] \tag{A5}$$

and

$$\Omega^{rn}(s,b) = \theta q^{rn}(s,\zeta b)\zeta + (1-\theta)E_{s'|s}M^{rn}(s,s')\Omega^{rn}(s',b)$$

Denote $spr^{rn}(s,b')$ the spread computed from $q^{rn}(s,b')$, which measures the spread contributed by current and future default probability.

Third, we compute another price of debt where risk-neutral creditors face the same default decision rule $\mathcal{I}(s,b)$ without inconvenience yield, i.e., $\eta = 0$. Specifically, this hypothetical price of debt satisfies

$$q^{rn,\eta=0}(s,b') = E_{s'|s}M^{rn}(s,s')\left[(1-\mathcal{I}(s',b'))\left(\lambda+(1-\lambda)(z+q^{rn,\eta=0}(s',b''(s',b'))\right)\right. \\ \left.+\mathcal{I}(s',b')\Omega^{rn,\eta=0}(s',b')\right] \tag{A6}$$

and

$$\Omega^{rn,\eta=0}(s,b) = \theta q^{rn,\eta=0}(s,\zeta b)\zeta + (1-\theta)E_{s'|s}M^{rn}(s,s')\Omega^{rn,\eta=0}(s',b)$$

Denote $spr^{rn,\eta=0}(s,b')$ the spread computed from $q^{rn,\eta=0}(s,b')$. The inconvenience yield component of spread is $inconv(s,b') = spr^{rn,\eta=0}(s,b') - spr^{rn}(s,b')$.

Lastly, the risk premium is the residual, computed as $spr^{\text{risk premium}}(s,b') = spr(s.b') - spr^{rn}(s,b') - inconv(s,b')$.

3 The Sovereign Problem with Taste Shock and Numerical Solution Algorithm

3.1 The Sovereign Problem with Taste Shock

This section presents the details of the solution to the model. Sovereign default models with long-term debt has the well-known property of poor convergence. We improve convergence by introducing a small taste shock following Mihalache (2025).

Specifically, denote $\eta_{b'}$ the independently, identically distributed taste shock associated

with each debt choice b'. In this way, we write the value function of the sovereign as

$$V(s,b) = \max\left[V^C(s,b), V^D(s,b)\right]$$

The value function of the sovereign with state (s,b) if it chooses to repay is

$$V^C(s,b;\eta_{b'}) = \max_{c,b'}(1-\beta)\frac{c^{1-\gamma}}{1-\gamma} + \beta\left(E_{s'|s}V(s',b')^{1-\gamma}\right) + \sigma_\eta\eta_{b'}$$

subject to

$$c \leq y - (\delta b + \kappa(1-\delta)b) + q(s,b')(b' - (1-\delta)b)$$

where δ is the fraction of debt that expires in the next period and it controls the maturity of debt. κ is the coupon rate per unit of debt. Note that coupon is paid on the non-matured debt $(1-\delta)b$ only. For each face value of debt b, the payoff in the next period is $\delta + (1-\delta)(\kappa + q_{t+1})$. We write the expected value function before observing $\eta_{b'}$ as

$$\begin{aligned}
V^C(s,b) &= E_{\eta_{b'}}\left[V^C(s,b;\eta_{b'})\right] = E_{\eta_{b'}}\left[\max_{b_i} W(s,b,b_i) + \sigma_\eta\eta_{b'}\right] \\
&= \sigma_\eta \log\left(\sum_{i=1}^{n}\exp(W(s,b,b_i)/\sigma_\eta)\right) \\
&= W(s,b,b^*) + \sigma_\eta\log\left(\sum_{i=1}^{n}\exp((W(s,b,b_i) - W(s,b,b^*))/\sigma_\eta)\right)
\end{aligned}$$

The value for default

$$V^D(s,b) = (1-\beta)u(\phi(y)) + \beta E_{s'|s}\left[\theta V(s',\zeta_s b) + (1-\theta)V^D(s',b)\right]$$

The sovereign makes default decision before observing the idiosyncratic taste shock realization $\eta_{b'}$. The bond pricing function is given by

$$q(s,b') = E_{s',\eta_{b''}|s}M(s,s')\left[(1-\mathcal{I}(s',b'))\left[\delta + (1-\delta)(\kappa + q(s',B(s',b';\eta_{b''})))\right] + \mathcal{I}(s',b')\Omega(s',b')\right]$$

where $B(s',b';\eta_{b''})$ is the next-period debt decision and

$$q(s,b') = \frac{1}{1+r}E(1-\mathcal{I}(s',b'))\left[\delta + (1-\delta)(\kappa + q(s',B(s',b';\eta_{b''})))\right] + \frac{1}{1+r}E\mathcal{I}(s',b')\Omega(s',b')$$

with

$$\Omega(s,b) = \theta q(s,\zeta_s b)\zeta_s b + (1-\theta)E_{s'|s}M(s,s')\Omega(s',b)$$

We don't associate an idiosyncratic taste shock with the default decision.

3.2 Numerical Solution Algorithm

- Initialization. $V^C(s,b), V^D(s,b), V(s,b) = \max\left[V^C(s,b), V^D(s,b)\right]$. Initialize $q(s,b') = \frac{1}{1+r}$.
- The optimal choice of b' given the pricing function $q(s,b')$:
  - Evaluate the period utility $\frac{c^{1-\gamma}-1}{1-\gamma}$ at every b' for each (s,b,b'), where $c(s,b,b_i) = y - (\delta b + \kappa(1-\delta)b) + q(s,b_i)(b_i - (1-\delta)b)$.
  - Use the value functions in the previous iteration to calculate expected value functions $E_{y'|y}(V^C(s',b')), E_{y'|y}(V^D(s',b')), E_{s'|s}V(s',b')$ for each pair of (s,b').
  - Denote $W(s,b,b')$ as the value function associated with choice b' at grid (s,b), so that

$$W(s,b,b_i) = (1-\beta)\frac{c(s,b,b_i)^{1-\gamma}}{1-\gamma} + \beta E_{s'|s}V(s',b')$$

- Calculate the probability for each individual to choose b_i as

$$p(b_i|b;s) = \frac{\exp(W(s,b,b_i)/\sigma_\eta)}{\sum_{i=1}^n \exp(W(s,b,b_i)/\sigma_\eta)} = \frac{\exp((W(s,b,b_i) - W(s,b,b^*))/\sigma_\eta)}{\sum_{i=1}^n \exp((W(s,b,b_i) - W(s,b,b^*))/\sigma_\eta)}$$

Note that $W(s,b,b^*)$ is the maximized value under the optimal b_i.

- Update the value functions and calculate default decisions.
  - Update $V^C(s,b), V^D(s,b)$

$$\begin{aligned} V^C(s,b) &= E_{\eta_{b'}}\left[\max_{b_i} W(s,b,b_i) + \sigma_\eta \eta_{b'}\right] = \sigma_\eta \log\left(\sum_{i=1}^n \exp(W(s,b,b_i)/\sigma_\eta)\right) \\ &= W(s,b,b^*) + \sigma_\eta \log\left(\sum_{i=1}^n \exp((W(s,b,b_i) - W(s,b,b^*))/\sigma_\eta)\right) \end{aligned}$$

The value of default is thus

$$V^D(s,b) = u(\phi(y)) + \beta E_{s'|s}\left[\theta V^C(s',\zeta_s b) + (1-\theta)(V^D(s',b))\right]$$

In this step, we need to find out grid in the debt space that is closest to $\zeta_s b$ because $\zeta_s b$ may not exactly fall onto the grids. We choose the grid that is smaller and closest to $\zeta_s b$.

- Default decision $\mathcal{I}(s,b) = 1$ if $V^C(s,b) \leq V^D(s,b)$.
- Update the bond pricing schedule.

$$\Omega(s,b) = \theta q(s, \zeta_s b)\zeta_s b + (1-\theta)E_{s'|s}M(s,s')\Omega(s',b)$$

$$q(s,b')b' = E_{s',\eta_{b''}|s}M(s,s')\left[(1-\mathcal{I}(s',b'))\left[\delta b' + (1-\delta)(\kappa b' + q(s', B(s',b';\eta_{b''}))b')\right] + \mathcal{I}(s',b')\Omega(s',b')\right]$$

Define $\tilde{q}(s',b') = \sum_{i=1}^{n} p(b_i|b')q(s',b_i)$, the bond price at state (y',b') averaged over the next-period idiosyncratic taste shock $\eta_{b''}$. Rewrite the equation above as

$$q(s,b') = E_{s'|s}M(s,s')\left[(1-\mathcal{I}(s',b'))\left[\delta + (1-\delta)(\kappa + \tilde{q}(s',b'))\right] + \mathcal{I}(s',b')\frac{\Omega(s',b')}{b'}\right]$$

3.3 Simulation

- Create an auxiliary variable, $x = 1$ if the sovereign has access to the international market and 0 otherwise. The key to simulation is to simulate the dynamics of the this variable.
  - $x_t = 1$ if $x_{t-1} = 1$ and $\mathcal{I}_t = 0$ OR $x_{t-1} = 0$ and the sovereign reenters the market at time t
  - $x_t = 0$ if $x_{t-1} = 0$ and the sovereign does not reenter the market at time t OR $x_{t-1} = 1$ and $\mathcal{I}_t = 1$
  - To simulate the x dynamics, we create another variable $\tilde{x}_t$ that represents the credit standing at the end of the period.
- Simulation procedure:
  - Initialize the first-period state, $x_1 = 0, (b_1, u_1, v_1, w_1)$ and assuming no default for the initial period. Determine default decision. Then simulate output y_1, real interest rate r_1, consumption c_1, bond price (spread) y_1, then next-period credit stance $\tilde{x}_2$ and the next-period debt b_2.
  - Starting from $t = 2$. If $\tilde{x}_t = 0$, simulate y_t, r_t and determine the default decision at time t . Update x_{t+1}. If $x_{t+1} = 0$, simulate consumption, bond price (spread) and next-period debt b_{t+1} and $\tilde{x}_{t+1} = 0$. Otherwise, simulate y_a, c_a and let the next-period debt $b_{t+1} = 0$, let bond price (spread) NaN and $\tilde{x}_{t+1} = 1$.

- If $\tilde{x}_t = 1$, simulate an auxiliary random variable between [0,1] and determine whether the sovereign regains market access. If so, $x_{t+1} = 0$ and simulate consumption, bond price (spread) and next-period debt b_{t+2}, $\tilde{x}_{t+1} = 0$. Otherwise, simulate y_a, c_a and let the next-period debt $b_{t+2} = 0$, let bond price (spread) NaN and $\tilde{x}_{t+1} = 1$.
- Repeat this procedure for every period.
- In every period, $b_{t+1}(b_t, y_t, r_t)$ is a random choice depending on the probability $Pr(b_{t+1} = b_i'|b_t, y_t, r_t)$ derived from simulation.

- Sample selection
  - Select the sample where the previous 20 quarters are at good standing to calculate the moments except for the default rate. The default rate is calculated based on a full sample with defaults.