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A Neoclassical Model of the World Financial Cycle*

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Abstract

Emerging markets face large and persistent fluctuations in sovereign spreads. To what extent are these fluctuations driven by local shocks versus financial conditions in advanced economies? To answer this question, we develop a neoclassical business cycle model of a world economy with an advanced country, the North, and many emerging market economies, the South. Northern households invest in domestic stocks, domestic defaultable bonds, and international sovereign debt. Over the 2008-2016 period, the global cycle phase, the North accounts for 68% of Southern spreads' fluctuations. Over the whole 1994-2024 period, however, Northern shocks account for less than 20% of these fluctuations.

Keywords: International Business Cycles, Sovereign Debt, Default, Long Run Risk, Epstein-Zin preferences, Global Banks, Global Cycles

JEL codes: E32; F44; G15; H63

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Emerging market economies face large and persistent fluctuations in the interest rate spreads they pay on the dollar debt they issue on world financial markets. These fluctuations are a first-order issue for these countries and there is an enormous literature that studies the mechanism behind them. The *traditional view*, stemming from the work of Eaton and Gersovitz [1981] and Arellano [2008], is that the main drivers of these fluctuations are local shocks in these economies.

Recently, this view has been challenged by Longstaff et al. [2011], Rey [2013], and Morelli et al. [2022] and others who put forth a *global cycle view*. This work documents that for some periods, sovereign bond spreads are more related to US financial conditions than they are to measures of economic activity in emerging economies, such as output growth. It has also documented that there is a large common component in sovereign bond spreads across countries. These findings underlie the view that there is a common movement in risk premia across countries that arises from shocks to global investors' pricing kernels that jointly price risky assets in the United States and emerging markets. In short, this work has argued that there is a financial cycle driven by shocks to investors in advanced economies.

Here we develop a simple framework that encompasses both views. Our contribution is to build a framework that includes, along with the standard model of emerging economies, an explicit model of stocks and corporate debt in advanced economies. This framework allows us to use data on financial assets in the United States to identify shocks to global investors. We also consider comovements between international asset prices over three decades, 1994-2024, a longer period than that studied in the global cycle literature. We find that, instead of a single phase in which all of these prices move closely together, the data are best described as consisting of four phases, described below, that we refer to as the *world financial cycle*.

Our minimalist neoclassical model has asset pricing preferences, long-run risk, and standard ways of modeling endogenous default. Our main quantitative result is that this model can account well for the patterns in the data and that the global cycle view prevails only during the period 2008-2016. In developing our model, we purposely abstract from popular frictions, including segmented markets, exogenous collateral constraints, risk-bearing capacity constraints, net worth constraints, value-at-risk constraints, and noise traders. In models with such frictions, movements in asset prices are often intimately connected to the risk-bearing capacity of global intermediaries and how this capacity varies with net worth or holding of various assets. Our model has none of these features. Hence, our results are not driven by specific institutional structures governing how assets are traded, but instead arise from the change in the willingness of the consumers in the economy to bear different types of risk in response to shocks.

Specifically, we build a real business cycle model with a large advanced economy—the *North*—and many small open emerging market economies—the *South*. To produce sensitivity to risk, we assume that consumers in all countries have Epstein-Zin preferences. For the North, we extend a standard asset pricing setup in the spirit of Bansal and Yaron [2004] to a production economy in which firms choose labor and capital and finance their operations by issuing defaultable debt and paying dividends. For the South, we extend a standard sovereign default model, along the lines of Arellano [2008] and Aguiar et al. [2016], to an environment in which southern countries have Epstein-Zin preferences and stochastic endowments, and issue long-term defaultable bonds. All the borrowing and lending transactions go through a global intermediary that is owned by northern households. Since this intermediary has no added-on frictions, the intermediary uses the stochastic discount factor of northern households to price all assets.

As for shocks, in the North, the growth rate of productivity is the sum of a persistent component—northern long-run risk—and an i.i.d. component referred to as short-run shocks. Both components are subject to a persistent *northern volatility shock* that affects the variances of their innovations. In the South, the growth rate of output in each country is the sum of a persistent component that is correlated across southern countries—*southern long-run risk*—and an idiosyncratic component. Since in the data, outside of global crisis events, there is essentially no correlation between North and South output growth, we assume that the primitive stochastic processes in the North are independent of those in the South. Nonetheless, our model endogenously generates a correlation between northern and southern asset prices because they are all priced by the same global intermediaries.

Our model has two mechanisms to generate comovements in spreads. First, the key northern shocks, long-run risk and volatility, affect spreads through the *common lender mechanism*: both shocks impact the stochastic discount factor of the northern households that prices all assets in the economy. These shocks induce northern firms and southern countries to default more in a way that is correlated with northern shocks and thus generate changes in the risk premium and the expected default rates on both types of debt. Hence, they generate an *endogenous* correlation between corporate and sovereign spreads. For example, *bad times* in the North, due to either high volatility or poor growth prospects arising from worsened long-run risk, make northern households less willing to invest in risky assets and generate high spreads on both northern and southern debt.

Second, the key southern shocks—the common component of southern long-run risk shocks—operate through a *common shock mechanism*: they directly affect all southern countries' default choices simultaneously. For example, *bad times* in the South due to poor growth prospects lead them to default more both now and in the future. Thus, they generate high spreads on the southern debt even though they have no effect on risk premia, since the global intermediary's pricing kernel is not affected by southern shocks.

We discipline our model's parameters using data from the US and 12 emerging market economies. We focus on moments of output growth, corporate spreads, and price-dividend ratios from the US, as well as output growth and EMBI spreads from emerging market economies.

Our first result is that our neoclassical model reproduces well a wide range of moments that are usually studied in isolation in three areas of research: international business cycles, sovereign default, and corporate finance. It reproduces the observed levels of volatility, within-country correlations, and cross-country correlations for real and financial variables. Also, the model accounts for several puzzles that have arisen in these fields, such as the sovereign spread puzzle, the corporate spread puzzle, and the equity premium puzzle.

We then provide intuition for how the mechanisms work in practice by examining the resulting impulse responses, and use them to help understand our key quantitative results from the particle filter. In particular, we run the particle filter on the observed growth rates of output and spreads for the United States and the 12 emerging market economies, along with the price-dividend ratios for the United States. This filter uses the model's nonlinear decision rules to reconstruct the most likely set of historical shocks that account for these observations. A useful way to summarize our results is to divide our full sample into four different phases, which are highlighted in four shaded areas in Figure 1.

During 1994-2002, a period we label the *emerging market crises* phase, the US stock market booms, and corporate spreads are low (see the blue lines in panels a and b), while at the same time, emerging market spreads are high and volatile (red lines). The exuberant asset prices in the North lead the filter to infer that growth prospects are good and volatility is low. Through the lens of the model, these patterns imply that global intermediaries in the North are eager to lend. Relying on the realized growth rates in the South and the high spreads on sovereign debt from this phase, the filter infers that growth prospects in the South are poor and volatile, namely, large negative southern long-run-risk shocks. Given these shocks, the global intermediary forecasts that southern bonds are particularly risky and hence charges high spreads on sovereign debt.

During 2002-2007, a period we label the great spread moderation phase, stocks and spreads in the North are fairly stable, but spreads in the South fall sharply. Through the lens of the model, the patterns in the North imply that global intermediaries have little change in their willingness to invest in risky assets. In the South, the high realized growth rates and falling spreads lead the filter to infer that southern growth prospects have markedly improved. The global intermediary forecasts that southern bonds have less risk than in the previous phase, and thus charges lower spreads.

During 2008-2016, the *global cycle* phase, the huge spikes in southern and northern spreads, the collapse in the stock market, and poor growth in output imply bad times in the North and the South. The filter attributes the bulk of the movements in asset prices to a combination of increased volatility in the North and poor growth prospects there.

Finally, during 2016-2023, a period the IMF calls the geoeconomic fragmentation phase, in the North there are stable then booming stocks and fairly stable spreads on corporate debt. In many economies in the South, however, we observe a large increase in spreads. These patterns lead the filter to attribute the movements in southern spreads to bad long-run risk shocks.

Panels (c) and (d) in Figure 1 plot the spreads for all the emerging markets in our sample, together with the interquartile range of these spreads. Intuitively, if spreads are driven by the northern shocks we should see low dispersion of spreads, as they have a common driver. If, instead, spreads are driven by southern shocks, dispersion should be higher. The panels show that during the global cycle phase, the dispersion of spreads is indeed low, suggesting a major role for the northern shocks. During the other phases, the dispersion of spreads is higher, and that pushes our model to attribute a larger role to Southern-specific shocks.

We summarize our findings with variance decompositions. Overall, the southern shocks account for over 80% of the fluctuations in the average southern spread. During the *global cycle* phase, however, Northern shocks account for the bulk of the fluctuations in the average southern spread—about two-thirds—and they do so mainly through the common lender effect. In the North, the fluctuations in stocks are mostly accounted for by movements in long-run risk, and the fluctuations in corporate spreads are mostly accounted for by fluctuations in volatility.

We then consider two robustness exercises. First, we assume that northern spreads in the model correspond to spreads on investment-grade bonds in the data. We do so because the vast majority of US corporate bonds are investment-grade bonds—on the order of 85% in value. Authors such as Longstaff et al. [2011], however, have documented that spreads on noninvestment-grade bonds or *junk bonds* are more correlated with southern spreads than are investment-grade bonds. To see if our results are robust to this evidence, we extend our model to include junk bond firms as well as investment-grade firms and back out shocks that simultaneously account for the spreads on both. When we do so, we find that our results are virtually unchanged.

Second, our benchmark model uses a broad measure of stock prices. In contrast, some of the work on global financial cycles, such as Morelli et al. [2022], uses financial sector stocks as the measure of the stock market. To see if our results are robust to using this measure, we run a counterfactual in which we replace our broad measure of the stock market with one reflecting only financial sector stocks. When we do so, we also find little change in our results.

The key discipline our model uses to identify the underlying forces driving the world financial cycle is that it must simultaneously account for the movements in northern and southern asset prices. To highlight the role of this discipline, we ask whether the North shocks alone can account for the observed movements in southern spreads while ignoring movements in northern asset prices. We find that, even if the model is restricted to using only northern shocks, it can account well for the southern spreads but the implied asset prices for the North are wildly counterfactual.

The rest of the paper is organized as follows. Section 1 discusses related literature. Sections 2 and 3 present the model economy and describe how we set parameters. Section 4 presents the main results. Section 5 presents robustness exercises and Section 6 concludes.

1 Related Literature

We build on work on asset pricing, sovereign default, and global cycles.

In terms of the asset pricing literature, our framework for modeling preferences and shocks extends a version of the two-country models developed in a series of papers by Colacito and Croce [2011], Colacito and Croce [2013], and Colacito et al. [2018] to a model with one large country and many small open economies. In addition, we model endogenous default on corporate debt in the large country and on sovereign debt in small open economies. We note that the presence of defaultable debt in the North is essential for our purposes because it allows us to directly measure variations in the appetite of northern investors for risky debt, and thus the impact of this variation on southern spreads.

A major success of the Colacito and Croce [2011] model is that it generates a much higher correlation across countries in asset prices than in output growth, a pattern observed in the data. It does so through a *correlated-long run risk* mechanism, which has two parts. First, most of the correlation in asset prices is driven by the correlation in long-run risk across countries—so if long-run risk is very correlated across countries, so are asset prices. Second, most of the volatility in output is driven by short-run growth shocks, which are independent across countries—so even if long-run risk is very correlated across countries, output is not. For southern countries, our model delivers the same feature of the data, but through a combination of Colacito and Croce's correlated long-run risk mechanism and our common lender mechanism.

Next, nearly all of the sovereign default literature focuses solely on modeling emerging market defaultable debt and thus shies away from explicitly modeling corporate bonds and stock prices in the United States. Hence, it is silent about exactly the comovements across countries we seek to explain. We contribute to this literature by building an equilibrium model that can reproduce well the patterns of comovements of US spreads and stock prices with the spreads on emerging market debt. Also, our model reproduces well the volatility of both US corporate spreads and stock prices. We find this encouraging because our model goes beyond most of the literature following Bansal and Yaron [2004], which simply treats dividends as exogenous processes unconnected to underlying firm decisions. In contrast, our endogenous dividends are governed not only by underlying shocks but also by firms' endogenous financing choices.

The underlying structure of the southern countries builds on work in the sovereign default literature, including Eaton and Gersovitz [1981], Aguiar and Gopinath [2006], Arellano [2008], and Yue [2010], which is a small part of the large literature surveyed by Aguiar et al. [2016] and Aguiar and Amador [2023]. We include long-term debt as in Arellano and Ramanarayanan [2012], Chatterjee and Eyigungor [2012], and Hatchondo and Martinez [2009]. These papers focus on a single southern country that borrows from a northern lender, often risk neutral, and on the comovement between this country's spreads and its local economic conditions. In contrast, we study the comovement between asset prices across the South and between the South and the North, and emphasize the changing phases of the world financial cycle.[1]

Our work is also motivated by a growing literature on global financial cycles. In terms of empirical work, Longstaff et al. [2011] document a high comovement between southern spreads and northern asset prices in their sample. They argue that a promising model is one in which all of these assets are priced by a global investor. Empirical work in this area has been comprehensively surveyed and extended by Miranda-Agrippino and Rey [2022]. In our model, all assets are also priced by a global investor, but in contrast to the work in this area, we give our model a neoclassical flavor by not adding extra frictions to the global investor's problem. Also, in contrast to this work, we emphasize how a comprehensive model must contend with four distinct phases of the world financial cycle, of which the global cycle phase is only one, lasting from 2007-2016. The view that the global cycle phase is simply one of four phases we have witnessed in the last three decades differs from the view promoted by the global cycle literature.

Our paper is complementary to that of Morelli et al. [2022], which assumes that northern consumers are risk-neutral and that a global intermediary prices southern defaultable loans subject to a collateral constraint and an equity issuance cost. Their work links the fall in net worth of the global intermediary to increases in spreads in emerging market economies, with the main episode of interest being the global cycle phase. Both our model and our focus differ from theirs. In terms of the model, we extend the standard asset pricing model with Epstein-Zin preferences and Bansal-Yaron-type shocks. We explicitly model the default decision of northern firms and, hence, have endogenous default rates, corporate spreads, and stock prices. Also, our analysis focuses on a three-decade-long panel of data, while their main results focus on the period around the 2008 crisis.

2 The World Economy

The world is composed of a northern country, the *North*, and a continuum of small southern countries, the *South*. All countries have Epstein-Zin preferences. The North is a production economy with a continuum of firms issuing long-term debt with default risk. Northern households lend to both northern firms and southern countries with long-term defaultable debt through

[1]An exception to this work is Arellano et al. [2017], which formulates a model with two advanced economies bargaining with a common lender.

competitive intermediaries. Each southern country is a pure exchange economy with sovereign default risk. Southern countries are more impatient than northern ones, so on average, they borrow from the North. We assume that the South as a whole is small in the world economy. We are motivated to make this assumption because the stock of emerging country debt that we focus on held by US investors amounts to only 0.3% of total US household wealth. This framework is set up to analyze the behavior of spreads in those emerging market economies that perennially borrow from advanced economies. Therefore, we exclude from the analysis countries such as China that perennially save and that are large in the world economy.

All countries have shock structures that feature long-run risk shocks, time-varying volatility shocks, and idiosyncratic shocks. In the North, these shocks are to the productivity of firms, whereas in the South, these shocks are to each country's output.

2.1 The Northern Country

The North has a representative household, a continuum of competitive intermediaries, and a continuum of heterogeneous firms. The setup of the firm financing problem in the North borrows some ingredients from Miao and Wang [2011], Gomes et al. [2016], Croce et al. [2022] and Gourio [2013].

Northern Household. Households have Epstein-Zin preferences over aggregate consumption C_{Nt} with risk aversion γ given by $V_{Nt} = (1-\beta)\log(C_{Nt}) + \beta \log\left[\left(E_t V_{Nt+1}^{1-\gamma}\right)^{\frac{1}{1-\gamma}}\right]$.[2] In period t, households purchase a financial asset B_{Nt+1} from the intermediaries with a stochastic return R_{Nt+1} in period $t+1$. Households inelastically supply labor and earn labor income $W_{Nt}N_{Nt}$, where W_{Nt} is the wage rate, receive aggregate dividends D_{Nt} from all firms, and pay lump-sum taxes T_{Nt} to the northern government. Their budget constraints are $C_{Nt} + B_{Nt+1} \leq W_{Nt}N_{Nt} + R_t B_{Nt} + D_{Nt} - T_{Nt}$. In the initial period, households have no debt, and they own the capital

[2] We assume that the elasticity of intertemporal substitution, EIS, is 1. In much of the literature, an EIS> 1 is required to generate a positive risk premium on a consumption claim with Epstein-Zin preferences. But, as Bansal and Yaron [2004] showed, an EIS > 1 is not necessary to generate a positive premium for dividends that are a levered version of consumption, such as the dividends that are endogenously produced by our model. While the EIS also impacts the level and volatility of the risk-free rate, our model successfully matches both the equity premium and the average and volatility of the risk-free rate, so we deliberately set the EIS=1 to limit the number of parameters.

stock K_{j0} in each firm j. Households' stochastic discount factor is

$$M_{t,t+1} = \beta \frac{C_{Nt}}{C_{Nt+1}} \frac{V_{Nt+1}^{1-\gamma}}{E_t V_{Nt+1}^{1-\gamma}}. \tag{1}$$

Northern Firms. Firms produce with constant returns to scale production function using capital and labor given by $Y_{jt} = (A_{Nt}N_{jt})^{1-\alpha_k} K_{jt}^{\alpha_k}$. Capital accumulation follows $K_{jt+1} = (1-\delta)K_{jt} + I_{jt}$. The technology shock $a_{Nt} = \log A_{Nt}$ is the sum of a serially correlated component, $x_{Nt+1} = \log(X_{Nt+1})$, referred to as *long-run risk*, and a serially uncorrelated component, $\sigma_{Nt}u_{Nt+1}$, referred to as the *short-run shock*, where σ_{Nt} is the stochastic volatility of all northern shocks. Specifically, similarly to Bansal and Yaron [2004], the growth rate of productivity follows

$$\begin{aligned} \Delta a_{Nt+1} &= \mu_N + x_{Nt} + \sigma_{Nt}u_{Nt+1}, \\ x_{Nt+1} &= \rho_{xN}x_{Nt} + \phi_{xN}\sigma_{Nt}u_{xNt+1} \\ \sigma_{Nt+1}^2 &= (1-\rho_{\sigma N})\sigma_N^2 + \rho_{\sigma N}\sigma_{Nt}^2 + \phi_{\sigma N}\sigma_{Nt}u_{\sigma Nt+1} \end{aligned} \tag{2}$$

where the shocks $[u_{Nt}, u_{xNt}, u_{\sigma Nt}]$ are independent of each other, i.i.d. over time, and normally distributed with zero means and variance 1. Note that the mean standard deviation of the short-run shock is σ_N and that of the innovation to long-run risk is $\phi_{xN}\sigma_N$.[3]

A firm j chooses labor to maximize its operating profits

$$\pi_{jt} = \max_{N_{jt}} \, (A_{Nt}N_{jt})^{1-\alpha_k} K_{jt}^{\alpha_k} - \kappa_{jt}K_{jt} - W_{Nt}N_{jt}$$

where W_{Nt} is the wage rate and κ_{jt} is an i.i.d, normally distributed variable with mean zero and standard deviation σ_κ with c.d.f. Ψ. As in Gomes et al. [2016], we interpret these shocks as direct shocks to firms' operating income and refer to them as *idiosyncratic profit shocks* . The shocks are meant to capture the overall firm-specific component of their business risk and are a crucial driving force of firm default. Letting Y_{Nt} and K_{Nt} denote aggregate output and capital and maximizing for labor, the firm's operating profit $\pi_{jt} = \left(\alpha_k Y_{Nt}/K_{Nt} - \kappa_{jt}\right) K_{jt}$ is linear in individual capital and the aggregate return on capital is $R_{kt} = \alpha_k Y_{Nt}/K_{Nt} + 1 - \delta$.

Financial Frictions and Asset Structure. We consider financial frictions that break the

[3] We depart slightly from the process for volatility in Bansal and Yaron [2004] by scaling innovations to volatility by the past value of volatility. This change is made to avoid negative values for volatility.

Modigliani-Miller theorem and lead to a determinate capital structure with positive capital and debt. We do so in a way that extends the setup in Gourio [2013] to include long-term debt.

In period t each firm j issues claims to B_{jt+1} units of long-term defaultable bonds. One unit of such a claim represents a promise to pay the sequence of payments, $1, 1-\varphi, (1-\varphi)^2, \ldots$, which begins with one unit at period $t+1$ and then decays at a geometric rate. A firm j can default on its inherited debt B_{jt}. After a default, the household, in its role as a shareholder in the firm, receives zero value, whereas in its role as the debt holder of the firm, it receives the residual value of the firm after a costly restructuring. We assume that the debt holders end up with a fraction θ of firm value and are entitled to that fraction of the flow of future dividends. The remaining fraction $1-\theta$, which stands in for legal costs in the restructuring process, is distributed in a lump-sum manner to all northern households. In this sense, the northern households always receive the dividend flows of the firm.

Firms receive a subsidy on their borrowing from the northern government. In particular, if a northern firm has outstanding B_{jt+1} units of claims to long-term bonds at t with value $Q_{jt}B_{jt+1}$ the northern government gives the firm a subsidy of $\chi Q_{jt}B_{jt+1}$ with $\chi > 0$, which it finances with a lump-sum tax on households. We assume that $\theta(1+\chi) < 1$, which is necessary for both debt and equity to be used.[4] The subsidy captures the tax advantage of debt or, in a reduced-form way, the advantages that debt has over equity as discussed in the corporate finance literature (see Gourio [2013] and Tirole [2010]).

Individual Firm's Problem. Firm j's state includes its capital K_{jt}, debt B_{jt}, idiosyncratic shock κ_{jt}, and the aggregate state. The aggregate state in the North at t is $(\Lambda_t(K_t, B_t, \kappa_t), a_{Nt}, x_{Nt}, \sigma_{Nt})$ where $\Lambda_t(K_t, B_t, \kappa_t)$ is the measure over individual firm's states and $a_{Nt}, x_{Nt}, \sigma_{Nt}$ are the aggregate shocks. In terms of timing, at the beginning of the period, the aggregate and idiosyncratic shocks are realized. The firm then makes its default decision. Next, conditional on not defaulting, the firm chooses its new capital K_{jt+1} and debt promises B_{jt+1}. A key element of the firm's problem is the schedule of bond prices $Q_t(K_{jt+1}, B_{jt+1})$ that a firm faces for different choices of K_{jt+1} and B_{jt+1} where the subscript t on this function stands in for the aggregate state.

We begin by setting up the firm's problem for some given bond price schedule and later show how this bond price schedule is determined. Suppose firm j enters period t with (K_{jt}, B_{jt}) and

[4] Note that when $\theta = 1$ and $\chi = 0$, the capital structure is indeterminate, and the Modigliani-Miller theorem holds. When $\chi = 0$ debt has no advantage, and firms issue only equity. When $\theta = 1$, or more generally, when $\theta(1+\chi) \geq 1$, the subsidy to debt outweighs the cost of default, and firms issue only debt.

the idiosyncratic shock κ_{jt} is realized. The firm then chooses to default on the current coupon payment or to repay it. If the firm defaults, its value is 0, and if it repays, its value is denoted J_{rt}. Let $J_t = \max\left\{0, J_{rt}(K_{jt}, B_{jt}, \kappa_{jt})\right\}$ be the present value of its dividend stream prior to its default decision. The value under repayment is $J_{rt}(K_{jt}, B_{jt}, \kappa_{jt}) = (R_{kt} - \kappa_{jt})K_{jt} - B_{jt} + V_t(K_{jt}, B_{jt})$ where

$$\begin{aligned} V_t(K_{jt}, B_{jt}) = & \max_{B_{jt+1}, K_{jt+1}} Q_t(K_{jt+1}, B_{jt+1}) \left[(1+\chi)B_{jt+1} - (1-\varphi)B_{jt}\right] - K_{jt+1} \\ & - \Gamma_\omega \left(\frac{B_{jt+1}}{K_{jt+1}}\right) K_{jt+1} - \Gamma_K \left(\frac{K_{jt+1}}{K_{jt}}\right) K_{jt+1} + E_t M_{t,t+1} \int J_{t+1}(K_{jt+1}, B_{jt+1}, z) d\Psi(z), \end{aligned} \tag{3}$$

where $\Gamma_K\left(K_{jt+1}/K_{jt}\right) K_{jt+1}$ and $\Gamma_\omega\left(B_{jt+1}/K_{jt+1}\right) K_{jt+1}$ capture the costs of adjusting capital and *leverage* B_{jt+1}/K_{jt+1}, respectively. In (3), if a firm pays its coupon on outstanding debt B_{jt} at t and issues L_{jt+1} new units of debt, the outstanding debt at $t+1$ is $B_{jt+1} = (1-\varphi)B_{jt} + L_{jt+1}$. The total resources from new issues are $Q_{jt}\left[(1+\chi)B_{jt+1} - (1-\varphi)B_{jt}\right]$ where $Q_{jt}\chi B_{jt+1}$ is the subsidy.

From the form of J_t, the firm defaults if $J_{rt} < 0$. From the form of $J_{rt}(K_{jt}, B_{jt}, \kappa_{jt})$ the firm defaults if it receives a sufficiently large shock, $\kappa_{jt} \geq \kappa_{jt}^* = \kappa_t^*(K_{jt}, B_{jt})$ where the cutoff satisfies $J_{rt}(K_{jt}, B_{jt}, \kappa_{jt}^*) = 0$. So the cutoff is $\kappa_{jt}^* = [R_{kt}K_{jt} - B_{jt} + V_t(K_{jt}, B_{jt})]/K_{jt}$. The repayment probability is $\Psi(\kappa_{jt}^*)$. A firm that repays its debt will pay out that period's dividend given by

$$D_{j,Nt} = (R_{kt} - \kappa_{jt})K_{jt} - B_{jt} + Q_t[(1+\chi)B_{jt+1} - (1-\varphi)B_{jt}] - K_{jt+1} - \Gamma_\omega K_{jt+1} - \Gamma_K K_{jt+1}.$$

2.2 Southern Countries

Southern country i has Epstein-Zin preferences $V_{it} = (1-\beta_S)\log(C_{it}) + \beta_S \log\left(EV_{it+1}^{1-\gamma}\right)^{\frac{1}{1-\gamma}}$, where β_S and $1/\gamma$ are common to southern countries. Southern countries are more impatient than the North in that $\beta_S < \beta$, and so that, on average, they borrow from the North. In southern country i the growth rate of output $y_{it} = \log Y_{it}$ has a serially correlated component, x_{it}, *long-run risk* along with a short-run component e_{it}. Specifically, this growth rate follows

$$\Delta y_{it} = \mu_S + x_{it-1} + \sigma_S e_{it}, \qquad e_{it} = u_{it} + v_S u_{St}, \tag{4}$$

$$x_{it} = \rho_{xS} x_{it-1} + \phi_{xS}\sigma_S e_{xit}, \qquad e_{xit} = u_{xit} + v_{xS} u_{xSt}. \tag{5}$$

The shocks (u_{it}, u_{xit}) for all i, the common southern shocks (u_{St}, u_{xSt}), and the North shocks $(u_{Nt}, u_{xNt}, u_{\sigma Nt})$ are mutually independent, jointly normal, mean zero, variance 1, and i.i.d. over time. The output growth innovations, e_{it}, have an idiosyncratic part u_{it} and a common southern part u_{St}. Here v_S is the loading of each country i on the common southern short-run shock u_{St}. The long-run risk shocks, e_{xit}, have a similar structure: an idiosyncratic part u_{xit} and a common southern long-run part u_{xSt} with a common loading v_{xS}. Here the standard deviations of the innovations to short-run shocks and long-run risk are $\sigma_S\sqrt{1+v_S^2}$ and $\phi_{xS}\sigma_S\sqrt{1+v_{xS}^2}$.

We assume the shocks in the South are uncorrelated with those in the North, since they are essentially so in the data. Moreover, this assumption is useful from a modeling perspective because it makes clear that all correlations between spreads in the South and the North are driven by *endogenous* mechanisms in the model rather than by the correlation of primitive shocks.

We allow the primitive shocks in southern countries to have the modest positive correlation needed to match the data. Hence, the correlation of endogenous variables across southern countries results both from the correlation of the primitive shocks across southern countries and from the equilibrium response of these southern variables to shocks in the North.

Debt and Default. The only asset that is traded across countries is a long-term state-uncontingent bond upon which countries may default. Southern countries issue debt similar to that issued by northern firms: one unit of a bond in time t is a promise to pay one unit in period $t+1$, $1-\varphi$ in period $t+2$, $(1-\varphi)^2$ in period $t+3$, and so on. At date t the country services the debt by paying B_{it} and issues L_{it} new units of debt, where $L_{it} = B_{it+1} - (1-\varphi)B_{it}$.

The government can default on its long-term bond. After default, $1-\theta_s$ fraction of debt is written off and the country goes into financial autarky—the *default phase*—for a stochastic number of periods and then returns to the *normal phase*. In each period in the default phase, with probability λ the defaulting country regains access to the international financial market. In the period in which it regains access, it owes θ_s fraction of the stream of payments it owed in the period t that started this default phase. That is if a country defaults at t on the debt B_{it} and reenters in period $\tau > t$, then on the legacy debt B_{it} it owes $\theta_s B_{it}$ at τ , $\theta_s(1-\varphi)B_{it}$ at $\tau+1$, and so on. Here, we are not explicitly charging interest on the unpaid stream of payments during the default phase.

Next, when a country is in the default phase, there are also direct costs that decrease the effective output of the country. As discussed by Mendoza and Yue [2012], these costs stand in for various difficulties that countries have in trading, such as importing specialized inputs for production. We parameterize the default cost similarly to that in Aguiar et al. [2016], so that consumption during default is given by $C_{idt} = e^{\kappa_{it}} h(x_{it}) Y_{it}$ where κ_i is normally distributed with mean 0 and standard deviation of σ_κ and $h(x_{it}) = 1 - a_0 e^{a_1 x_{it}} \leq 1$. The term κ_{it} makes the cost of default fluctuate in each period and immediately implies a cutoff rule for default in κ. As Aguiar et al. [2016] noted, having such a cutoff rule makes computations tractable with long-term debt.

A Southern Country's Problem. At the beginning of period t, the idiosyncratic shocks of southern country i and the aggregate shocks in the South and the North are realized. The state of southern country i is $(B_{it}, \kappa_{it}, s_{it})$ where $s_{it} = (Y_{it}, x_{it})$. The country then decides to default by comparing the values of repayment W_{irt} and default W_{idt}. The value $V_{it}(B_{it}, \kappa_{it}, s_{it}) = \max \{W_{irt}(B_{it}, s_{it}), W_{idt}(B_{it}, \kappa_{it}, s_{it})\}$ is the maximum over the value of each option.

If the government chooses to repay, it can use its output and new borrowing to pay for both its consumption and current debt payment so that the budget constraint under repayment is

$$C_{irt} + B_{it} = Y_{it} + Q_{it}(B_{it+1}, s_{it}) \left(B_{it+1} - (1-\varphi) B_{it}\right) - \Gamma_B \left(\frac{L_i}{Y_i}\right), \tag{6}$$

where $L_{it+1} = B_{it+1} - (1-\varphi)B_{it}$ and Γ_B is an adjustment cost on new debt to output. Here, conditional on repayment, the government is in the *normal phase* and it chooses B_{it+1} to solve

$$W_{irt}(B_{it}, s_{it}) = \max_{B_{t+1}} \,(1-\beta_S)\log(C_{rt}) + \beta_S \log\left[E_t V_{it+1}(B_{it+1}, \kappa_{it+1}, s_{it+1})^{1-\gamma}\right]^{\frac{1}{1-\gamma}} \tag{7}$$

subject to (6) with policy function $B_{it+1} = \bar{B}_t(B_{it}, s_{it})$. If instead, the country defaults, it enters the *default phase* and consumes its output net of the penalties from default. In period $t+1$ with probability λ it reenters the market with reduced debt claims to $\theta_s B_{it}$ and with probability $1-\lambda$ it stays in the default phase for another period. The implied value is

$$\begin{aligned} W_{idt} \;&=\; (1-\beta_S)\log\left[e^{\kappa_{it}} h(x_{it}) Y_{it}\right] \\ &\quad + \beta_S \log\left\{\left[\lambda E_t\left[V_{it+1}(\theta_s B_{it}, \kappa_{it+1}, s_{it+1})^{1-\gamma}\right] + (1-\lambda)\int E_t W_{idt+1}(B_{it}, \kappa, s_{it+1})^{1-\gamma} d\Psi_S(\kappa)\right]^{\frac{1}{1-\gamma}}\right\}. \end{aligned}$$

Notice that the value of default is increasing with κ_{it} since $\partial W_{idt}/\partial \kappa_{it} = (1-\beta_S) > 0$. Hence, the government defaults if κ_{it} is above the cutoff $\kappa^*_{it} = \kappa^*_{it}(B_{it}, s_{it})$ defined by $W_{idt}(B_{it}, \kappa_{it}, s_{it}) = W_{irt}(B_{it}, s_{it})$. The probability of repaying is given by $\Psi_{St}(\kappa^*_{it}) = \int_{\kappa \leq \kappa^*_{it}} d\Psi_S(\kappa)$.

2.3 Financial Intermediaries

Lending to northern firms and southern countries is done through competitive global financial intermediaries owned by northern households. These intermediaries borrow at the risk-free rate from northern households. Since these intermediaries face no frictions and act on behalf of northern households, all assets are priced by the northern household stochastic discount factor. Hence, this environment is equivalent to one in which northern households directly lend to both northern firms and southern countries. We prefer our setup because it emphasizes that the only asset decisions that northern households make are how much to deposit with the financial intermediary in an account that pays the risk-free rate.

Lending to Northern Firms. In period t, the intermediary borrows B_{Nt+1} from households and lends out these funds to firms so that $B_{Nt+1} = \int Q_{jt}(K_{jt+1}, B_{jt+1})B_{jt+1}dj$ holds. In period $t+1$, the intermediary pays households $R_{Nt+1}B_{Nt+1}$ using the claims paid to it from the firms. Since intermediaries are competitive, the price of the bond equates to the value of resources the intermediary gives to firm j at t, $Q_{jt}B_{jt+1}$ to the value of payments that firm j makes to the intermediary where future payments are valued using the northern household's stochastic discount factor. For any firm j, this logic implies that the bond price $Q_{jt}(K_{jt+1}, B_{jt+1})$ satisfies

$$\begin{aligned} Q_{jt}B_{jt+1} = {} & E_t M_{t+1}\Psi(\kappa^*_{jt+1})\left[1 + (1-\varphi)Q_{jt+1}\right]B_{jt+1} \\ & + \theta E_t M_{t+1}\int^{\kappa^*_{jt+1}}\left[J_{jrt+1}(K_{jt+1}, B_{jt+1}, \kappa) + B_{jt+1} + (1-\varphi)Q_{jt+1}B_{jt+1}\right]d\Psi(\kappa), \end{aligned} \tag{8}$$

where the value of the firm $J_{rt+1} + B_{jt+1} + (1-\varphi)Q_{jt+1}B_{jt+1}$ is the value of equity and bonds.

The first term on the right side of (8) is the value of payments on the long-term bond conditional on no default at $t+1$. The second term is the value of payments received conditional on a default at $t+1$. In this case, the debt holders become the sole owners of the firm and are entitled to collect the current value of the firm, which, after a costly restructuring, leaves the holders with a fraction θ of the firm's pre-default value. We assume that these restructuring costs are paid in a lump sum to all consumers so that total resources in the economy are unchanged by default. It will turn out that this way of modeling default will imply that defaulting firms have the same leverage as non-defaulting firms. The main difference is that a defaulting firm pays a cost of $1-\theta$ of its total value in restructuring payments and that the incumbent debt holders become the new owners of all equity and debt claims in the defaulting firms.

Using familiar logic, the value function of a firm $J_t(K_{jt}, B_{jt}, \kappa_{jt})$ is homogeneous of degree 1 in (K_{jt}, B_{jt}) and the price function $Q_{jt}(K_{jt+1}, B_{jt+1})$ is homogeneous of degree 0 in (K_{jt+1}, B_{jt+1}) and independent of j so that $J_t(K_{jt}, B_{jt}, \kappa_{jt}) = J_t(\omega_{jt}, \kappa_{jt})K_{jt}$ and $Q_{jt}(K_{jt+1}, B_{jt+1}) = Q_t(\omega_{jt+1})$, where $\omega_{jt} = B_{jt}/K_{jt}$ is the *leverage* of a firm with debt B_{jt} and capital K_{jt}. As we discuss later, these *homogeneity* properties of the firm's problem imply aggregation results for our equilibrium.

Lending to Southern Countries. Northern households invest in southern country debt through intermediaries. To derive the bond price schedule, the intermediary evaluates the stochastic stream of repayments it receives from the southern country with its stochastic discount factor. To do so, consider the payments a northern household expects to receive when it lends $Q_t B_{it+1}$ to a southern country i at t that is currently in normal times with shocks s_{it}.

In terms of $t+1$, for states s_{it+1} in which the southern country does not default, it expects that the government will repay B_{it+1} and that the value of the remaining debt will be $Q_{t+1}(B_{it+2}, s_{it+1})(1-\varphi)B_{it+1}$ where in the pricing function $B_{it+2} = \bar{B}_{t+2}(B_{it+1}, s_{it+1})$ is the borrowing of the government at $t+1$ in state s_{it+1} given that it has borrowed B_{it+1} at t.

Next, consider states s_{it+1} in which the northern lender expects the southern country to default in period $t+1$. Consider the two branches that follow such a default: one with reentry and one without reentry. With probability λ, the government reenters the normal phase and owes the recovery amount $\theta_s B_{it+1}$. Hence, this value is $Q_{t+1}(\theta_s B_{it+1}, s_{it+1})\theta_s B_{it+1}$, which is equal to the value received from a government that was in the normal phase in period $t+1$ and borrowed $\theta_S B_{it+1}$. With probability $1-\lambda$, the government remains in the default phase at $t+1$. The value of debt recovery at $t+1$ of a claim to B_{it+1} is the expected value over these two branches, and it can be recursively written as

$$\Omega_{t+1}(B_{it+1}, s_{it+1}) = \lambda Q_{t+1}(\theta_s B_{it+1}, s_{it+1})\theta_s B_{it+1} + (1-\lambda)E_t M_{Nt+2}\Omega_{t+2}(B_{it+1}, s_{it+2}). \tag{9}$$

Now moving back to period t, we can define the value of a claim to B_{it+1} at t for a country with state (B_{it+1}, s_{it}). This value is given by the right side of the following equation, and this value defines the price $Q_t = Q_t(B_{it+1}, s_{it})$ on the left side of it, namely

$$Q_t B_{it+1} = E_t \left[M_{Nt+1} \left\{ \Psi^*_{St+1} \left[1 + (1-\varphi)Q_{t+1}(B_{it+2}, s_{it+1}) \right] B_{it+1} + [1-\Psi^*_{St+1}]\Omega_{t+1}(B_{it+1}, s_{it+1}) \right\} \right]. \tag{10}$$

where $B_{it+2} = \bar{B}_{t+2}(B_{it+1}, s_{it+1})$. Notice that the right side of (10) is the value of the stream of payments from such a claim valued at the northern discount factor. As noted at the price $Q_t(B_{it+1}, s_{it})B_{it+1}$ the northern household is indifferent to holding such a claim.

Spread Decomposition. We turn to defining the spreads on northern firms' long-term bonds and southern countries' long-term bonds. To do so, we set up a notation that covers both types of bonds. Both types of bonds are indexed by their initial level, say, $\bar{D}$ at t, which represents a promise to pay a stream of *deterministically decaying payments*, $\bar{D}_{t+\tau} = (1-\varphi)^{\tau-1}\bar{D}$ for $\tau \geq 1$. Let $(1-\varphi)^{\tau-1}D_{t+\tau}(s^{t+\tau})$ denote the actual (expected across idiosyncratic shocks) payments in aggregate state $s^{t+\tau}$. For both northern firm bonds and southern country bonds the actual payments differ from the promised payments solely because of default.

Given the kernel $M_{t,t+\tau} = \prod_{j=1}^{\tau} M_{t+j-1,t+j}$, the claim to $\left\{(1-\varphi)^{\tau-1}D_{t+\tau}(s^{t+\tau})\right\}$ has a price

$$Q_t\bar{D} = \sum_{\tau=1}^{\infty}(1-\varphi)^{\tau-1}E_t\left(M_{t,t+\tau}D_{t+\tau}\right) = \sum_{\tau=1}^{\infty}(1-\varphi)^{\tau-1}\left[cov_t(M_{t,t+\tau}D_{t,t+\tau}) + E_t\left(M_{t,t+\tau}\right)E_t(D_{t+\tau})\right],$$

where the second equality holds by the definition of covariance. Next, we define the *risk-neutral* price Q_{nt} of this defaultable bond as the value of the stream of payments that would be charged by a risk-neutral lender with the cost of funds equal to the risk-free rates derived from the pricing kernel $M_{t,t+\tau}$. This price equals the second term on the right side of the equation, $Q_{nt}\bar{D} = \sum_{\tau=1}^{\infty}(1-\varphi)^{\tau-1}E_t(D_{t,t+\tau})/R_{ft,t+\tau}$, where we used that the risk-free rate between t and $t+\tau$ is given by $R_{ft,t+\tau} = 1/E_t(M_{t,t+\tau})$.

Following Arellano et al. [2023], the spread on such long-term bonds is the difference in the yield to maturity on the defaultable bond and the yield to maturity on a risk-free bond with the same maturity. Such a risk free long-term bond pays $\bar{D}_{t+\tau} = (1-\varphi)^{\tau-1}\bar{D}$ for $\tau \geq 1$ and hence has a price of $Q_{ft}\bar{D} = \sum_{\tau=1}^{\infty}(1-\varphi)^{\tau-1}E_tM_{t,t+\tau}\bar{D}$. Letting $\tilde{Q}_t$ stand in for any of the bond prices Q_t, Q_{nt}, and Q_{ft} we define the associated yield to maturity $\tilde{\gamma}_t$ by $\tilde{Q}_t \equiv \sum_{\tau=1}^{\infty}(1-\varphi)^{\tau-1}/\left(1+\tilde{\gamma}_t\right)^{\tau}$ so that $\tilde{\gamma}_t = 1/\tilde{Q}_t - \varphi$. Hence, the spread is $sp_t = \gamma_t - \gamma_{ft} = 1/Q_t - 1/Q_{ft}$. Defining $\gamma_t - \gamma_{nt}$ as the *risk premium* and $\gamma_{nt} - \gamma_{ft}$ as the *default risk*, this spread can be decomposed into $sp_t = (\gamma_t - \gamma_{nt}) + (\gamma_{nt} - \gamma_{ft})$, or with some algebra

$$sp_t = \frac{1}{Q_tQ_{nt}}\sum_{\tau=1}^{\infty}(1-\varphi)^{\tau-1}cov_t\Big(M_{t,t+\tau}, 1-\frac{D_{t,t+\tau}}{\bar{D}}\Big) + \frac{1}{Q_{ft}Q_{nt}}\sum_{\tau=1}^{\infty}\frac{(1-\varphi)^{\tau-1}}{R_{t,t+\tau}}E_t\Big[1-\frac{D_{t,t+\tau}}{\bar{D}}\Big]. \tag{11}$$

Here $D_{t,t+\tau}/\bar{D}$ is the repayment rate at $t+\tau$, so $1 - D_{t,t+\tau}/\bar{D}$ is the default rate. The first term on the right side of (11), the risk premium, measures how the default rate covaries with the marginal utility of consumption—this premium is high for bonds that tend to default more when the marginal utility of consumption is high. The second term in this expression, the default risk, measures the value of the expected default rates discounted by the risk-free rate—default risk is high on bonds with high expected default rates. In our quantitative section, we apply this decomposition to northern firm bonds and southern country bonds.

2.4 Aggregation and Equilibrium

The endogenous aggregate states consist of the aggregate capital stock K_t and the common leverage of northern firms $\bar{\omega}_t$. This follows because all firms start with the same leverage $\omega_{j0} = \omega_0$, the firm homogeneity properties discussed earlier, and the result that firms that begin a period with the same leverage, choose the same leverage in both the default and non-default states.

Even though in equilibrium, all firms choose the same leverage $\bar{\omega}_t$, each firm has to evaluate what happens when it chooses its leverage ω_{jt+1} different from aggregate leverage $\bar{\omega}_{t+1}$—so each firm's problem has the classic *big K- little k* form. Thus, when solving an individual firm's problem, its state is $(\omega_t; \bar{\omega}_t, K_t, x_{Nt}, \sigma_t)$. Then in equilibrium, once we impose symmetry, we need only record the aggregate state $(\bar{\omega}_t, K_t, x_{Nt}, \sigma_t)$. Hence, rather than having to record the entire distribution of (K_{jt}, B_{jt}) in the aggregate state, we only record $\bar{\omega}_t$ and K_t. Thus, the market clearing in goods markets can be stated in terms of aggregates rather than the entire distributions

$$C_t + K_{t+1} - (1-\delta)K_t + \Gamma_\omega\left(\frac{B_{t+1}}{K_{t+1}}\right)K_{t+1} + \Gamma_K\left(\frac{K_{t+1}}{K_t}\right)K_{t+1} = (A_{Nt}N_t)^{1-\alpha_k}K_t^{\alpha_k}.$$

3 Quantification

We use data on 12 emerging market economies' output and sovereign spreads along with US data on output, corporate spreads, and the stock market to discipline our model's parameters. We focus on these countries because they meet our criterion for having at least 80% of the observations for spreads and output during our sample period. We begin by discussing how we deal with the severe movements in output growth during the Great Recession and Covid. We then discuss how we set the parameters, how we solve the model, and how well our model reproduces the targeted moments.

3.1 Dealing with Disasters in Output Growth

In Figure 2, we plot the output growth in the US and a series constructed by taking the cross-section mean of output growth in our 12 emerging market economies, all expressed in annualized quarterly growth rates. Two periods stand out: the trough of the Great Recession, 2008Q4 and 2009Q1, and the Covid period, starting in 2020Q1. As we can see, during these two periods, the output growth in the US and the emerging markets move closely together, and these movements are large.

Consider first the Great Recession. We treat the trough of this recession as a *world disaster* in which every country has a negative shock to its growth rate at the same time. To handle it, we amend our stochastic processes for the northern productivity and southern outputs to have a world disaster in this period in a simple way. Specifically, we add a term $-\omega_{dN}\eta_{t+1}$ to the productivity process of the North given in (2) and add the term $-\omega_{dS}\eta_{t+1}$ to the output process of each southern country, where η_{t+1} is an i.i.d process that takes on 1 with probability p and 0 with probability $1-p$. We choose the parameter p to be such that, on average, one disaster occurs in our sample of 104 quarters, so that $p = 1/104$, and we choose ω_{dN} and ω_{dS} so that it accounts for the decline in average output growth in the North over the two-quarters of the trough of the Great Recession and for the average decline in southern countries' growth over this same period. This leads us to set $\omega_{dN} = 4.2\%$ and $\omega_{dS} = 5.1\%$.

Next, the Covid period has even more extreme growth rates than the Great Recession. For example, in 2020Q2, the average growth in emerging markets is -65% while in 2020Q3 it is 47%. Similarly, in 2020Q2, output growth in the US is -33%, and in 2020Q3, it is 30%. The later periods of Covid also have some extreme behavior. This behavior makes the statistics we use to quantify the model sensitive to exactly how we handle it. To avoid that sensitivity, we quantify the model from 1994Q1 to 2019Q4, thus ignoring the Covid period in the calibration. However, we conduct the particle filter analysis over the entire period, 1994Q1 to 2023Q2.

3.2 Parameters

Table 2 presents two sets of parameters. The first set includes *assigned* parameters such as the risk aversion parameter γ, mean output growth μ, debt maturity parameter φ, North capital share α_k, North depreciation rate δ, the persistence and standard deviation of the North volatility shock $(\rho_\sigma, \phi_\sigma)$, and the parameter λ that controls the exclusion periods after the South defaults. We assume that the capital adjustment cost function is $\Gamma_K = \frac{h_k}{2}(g_k - e^{\mu})^2$, the debt adjustment cost function for the North is $\Gamma_\omega = \frac{h_{\omega N}}{2}(\omega - \bar{\omega})^2$, and that for the South is $\Gamma_B = \frac{h_{\omega S}}{2}\left(\frac{L_i}{Y_i} - \bar{\ell}\right)^2$, where g_k is the growth rate of capital, ω is the leverage of a firm, and L_i/Y_i is the debt issuance to GDP.

We follow Bansal and Yaron [2004] and set the risk aversion parameter γ to 12. The mean growth rate of output per capita μ is set to 1.6% to match the average output growth rate globally from 1994Q1-2019Q4. To ensure an average debt duration of 5 years, we set the debt maturity parameter φ to be 1/20. The North capital share α_k is set to 0.3, which is consistent with the capital share in the United States. We choose δ such that the annual depreciation rate is 10%. The volatility shock parameters $(\rho_\sigma, \phi_\sigma)$ are taken from Bansal and Yaron [2004]. Following the literature, we assume that after default, a South country is excluded from international financial markets for an average of three quarters, which is captured by setting $\lambda = 1/3$.

The second set includes 13 *endogenously chosen* parameters. These parameters are chosen to target the 65 moments reported in Tables 3-5, which includes moments of output growth and asset prices in the North and the South. We compute each moment in the *overall* sample 1994Q1-2019Q4 and in the *normal times* sample, which excludes the two quarters, 2008Q4 and 2009Q1. The moments from the model we use are calculated from 5,000 draws of length 104 quarters in which we designate that a disaster occurs at the trough of the Great Recession.[5] When comparing our model to the data, we treat the model-simulated data the same way we do the actual data. In particular, when we simulate the overall sample, we include these two quarters, and for the normal-times sample, we exclude these two quarters. Note that this strategy is similar to that used in Wachter [2013] and Kilic and Wachter [2018].

This set comprises some parameters that have region-specific values, some unique to the North, and some unique to the South. The first set is those that all countries have but differ in

[5]Throughout, we assume that each observable variable we use is subject to normally distributed measurement errors, which are i.i.d., mean zero, and have a variance equal to 1% of the sample variance.

the North and the South. Suppressing the subscripts N and S, these are the discount factors β, short-run standard deviations σ, the persistence parameters of long-run risk ρ_x, the standard deviations of long-run shocks $\phi_x \sigma$, the standard deviations of idiosyncratic shocks σ_κ, the debt recovery parameters θ, and the adjustment cost parameters h_ω, $\bar{\omega}$, and $\bar{\ell}$, for leverage in the North and debt issuance in the South. The parameters that are specific to the North are the borrowing subsidy χ and the capital adjustment cost parameter h_k. The parameters that are specific to the South are the default cost parameters a_0 and a_1, the common components in southern short-run growth, ν_S, and in southern long-run growth, ν_{xS}.

Table 2's lower panel displays the parameters that are endogenously chosen to jointly target the moments in Tables 3-5. We choose these moments because they present a comprehensive summary of moments for the key variables, including output growth, North corporate spreads, South sovereign spreads, and North stocks. For southern countries, we consider the average of their time-series moments. That is, for each variable, for each of the 12 countries in the South, we first compute this moment over our sample periods and then take the mean of these 12 moments.

Our motivating evidence shows that the patterns of comovements in our relatively short sample vary greatly over the various phases. It is instructive to measure the range of the moments our model can generate in samples of similar length. In particular, we focus on the 5*th* and 95*th* percentiles of the simulated distribution for southern moments for samples of the same length as the data and record these percentiles in brackets below the means of the corresponding moments in the tables. As we elaborate on later, the range of these percentiles is important for our model's ability to generate the four phases of the world cycle, which have different patterns.

Although all parameters are essential in determining the moments, certain parameters have more influence on specific moments. The annualized discount factor of southern countries, 0.92, is lower than that of the North, 0.96, which makes the southern countries borrow on average and, hence, help generate the observed sovereign spreads. The short-run volatility of output growth in the South, 1.15%, is higher than that of the North, 0.74%, which helps account for the South's greater output growth volatility. Furthermore, the South's long-run growth prospects are more volatile, with a standard deviation of 0.23% compared to the North's value of 0.15%. This ranking is consistent with the findings of Aguiar and Gopinath [2007] that the low-frequency fluctuations in output in emerging market economies are larger than those in advanced economies.

Next, the debt recovery, default cost, and idiosyncratic shock parameters of the North matter greatly for the mean and volatility of corporate spreads for northern firms. Likewise, the corresponding parameters for the South matter greatly for the moments of sovereign spreads. In the North, the debt recovery parameter is 55%, while in the South, it is 32%, which helps account for the lower mean spreads in the North.

Finally, the cross-country correlations of output growth and spreads among southern countries discipline the common components of short- and long-run growth. From Tables 3 and 5, we see that in the data, output growth is much less correlated across the South than are spreads. For example, in normal times, these cross-correlations are 13.1% and 47.8%, respectively. The cross-correlation of southern output growth is low because of the small loading ν_S of 0.33 on the common short-run growth shock u_{St}. Recall that the correlation of southern spreads arises from two effects: a common shock effect and a common lender effect. The size of the common shock effect is determined by the loading ν_{xS} on the common southern long-run risk shock, u_{xSt}. The size of the common lender effect is determined by the endogenous transmission of northern shocks to southern spreads implied by the default model.

We solve the model using a global solution because the model displays important nonlinearities that require high-dimensional polynomials. Since the South is small, we can solve the problem in two steps: first solve the North problem and record the northern pricing kernel, then solve the problem of southern countries. For details, see the appendix.

3.3 Comparing Model and Data

Tables 3-5 show that the benchmark model captures the crucial aspects of the world financial fluctuations. First, as Table 3 shows, our model replicates the output growth patterns observed in the data, including standard deviations, serial correlations, and cross-country correlations in northern and southern countries. Notably, the model accounts for the feature that individual southern countries have much greater volatilities of output growth than the North, 2.6% vs. 1.1% overall in the data and 2.8% vs. 1.3% overall in the model. Next, notice that once the two-period-long disaster is removed from both the model and the data, the average correlation of output growth between the North and each southern country is low in the model, averaging about zero, and ranging from -14.7% to 14.4%, which encompasses the low correlation in the data of 4.3%. Hence, in normal times output growth in the North and the South is essentially uncorrelated. Finally, in normal times, both the data and the model exhibit a low average pairwise correlation of output growth across southern countries, at 13.1% and 16.6%, respectively.

Consider now moments of default rates and spreads in the North reported in Table 4. Our model can account for the *corporate spread puzzle*—that the spread on corporate bonds is higher than the expected default losses. Specifically, in both the model and the data, the average default rate on corporate debt is 0.5% but the average spread is double that. The spread is higher than the default rate in our model because consumers are risk averse, which generates risk premia, and debt is long-term, so spreads move today not only because of expectations of default in the next period but also in all periods in the future.

Next, the corporate spread is countercyclical. In the model, in normal times, the average correlation of northern corporate spreads with northern output growth is -24.6%, and in the data, it is -34.4%, which comfortably falls within our simulated range of -68.6% to 35.1%. As Table 4 also shows, our model reproduces well the stock volatility, average return, and equity premium in the data. Even so, the model and the data share similar dividend growth volatility. In normal times, the standard deviation of dividend growth is 13.1% in the data and 12.1% in the model. Moreover, the model's dividend growth is procyclical and exhibits a negative serial correlation in normal times, consistent with the data.

These successful dividend dynamics generate a price-to-dividend (P/D) ratio with moments similar to those in the data. In both the model and the data, a boom in stocks—a high P/D ratio—is associated with a low spread and high output growth. In particular, in normal times, the correlation between the P/D ratio and the corporate spread is negative, -65.9% in the model and -35.9% in the data, whereas the correlation of the P/D ratio with output growth is positive, 33.3% in the model and 25.6% in the data. Our model also produces a sizable equity premium.

Next, Table 4 shows that the model captures well standard business cycle moments: the volatility of consumption and investment relative to output and their procyclicality—all of these statistics lie comfortably within our 5% to 95% range.

We turn now to the patterns of sovereign default and spreads presented in Table 5. The model performs well in generating the key moments of defaults and spreads, including mean default and spreads, standard deviations of spreads, serial correlations of spreads, the correlation of a country's spread with its output growth, the correlation of spreads across southern countries, and the correlation of southern countries' spreads with the North's spread.

In particular, in both the model and the data, the average default rate in the South, 2%, is four times higher than that in the North. Similar to the patterns of corporate spreads in the North, sovereign spreads in the South are higher than their default rates. Specifically, the difference between spreads and their default rates is about 1.4% in the model and 1.2% in the data.

A crucial moment for southern spreads is their standard deviations. Our model generates the observed average volatility of spreads of 1.5%, which is a success for our model. In contrast, the comprehensive analysis of Aguiar et al. [2016] emphasizes that existing models of sovereign default have a *sovereign debt volatility puzzle* in that these models tend to generate significantly less volatility in spreads than that in the data, particularly for countries like Mexico. This puzzle holds for existing models with either deterministic trends and stationary shocks or stochastic trends. Indeed, as Table 9 in Aguiar et al. [2016] shows, their preferred baseline stochastic growth model has this puzzle in that it generates a standard deviation of spreads of only 0.2% which is only $1/15th$ of the corresponding standard deviation of 3% in their data.

A second major result of the model in terms of accounting for EM spreads is that it can produce spreads that are much more correlated across southern countries than their output growth. In normal times in the data, the spreads have an average correlation across southern countries of 47.8%, whereas output growth has an average correlation of only 13.1%. The model produces a comparable pattern, with spreads having a correlation of about 46.8% and output growth having a correlation of about 16.6%.

Our model also captures the well-studied negative correlation between a southern country's spreads and its output growth: -27.6% and -30.6% in the model in normal times. South and North spreads are not very correlated in normal times in either the data, 17.6%, or the model, 22.2%. The model also captures the negative correlation between southern spreads and the risk-free rate as in the data.

An important feature of the model is that it produces a wide dispersion in many of these statistics across simulations. For example, the model's dispersion in the correlations of southern spreads and northern spreads ranges from -19.8% to 67.5%. This large dispersion suggests that the model can generate both the type of strong positive comovement seen during the global cycle phase and the weak positive comovement seen during the EM crises phase. Likewise, our model produces a wide dispersion in the comovement between North stock prices and South spreads, with correlations that in normal times are about zero with a wide dispersion between -61.9% and 15.1%. As we show in the particle filter analysis, this intuition is correct: depending on the sequence of shocks, the model is consistent with the strong negative correlation in the data during the global cycle phase as well as the positive correlation in the EM crises phase.

In summary, our model produces a wide range of moments usually studied in isolation in three areas of research: international business cycles, sovereign default, and corporate finance.

4 The Drivers of the World Financial Cycle

Here we explore the driving forces of the world financial cycle. We begin by building intuition for the impact of each shock separately by analyzing the impulse responses to the key shocks. Then, we use particle filter analysis to back out the underlying shocks that drive the key asset market variables: emerging market spreads, the northern spreads, and the northern stocks. This analysis allows us to quantify the relative importance of the common shock mechanism and the common lender mechanism by phase of the cycle.

4.1 Inspecting the Mechanism

We now examine the impulse responses to South long-run risk shocks u_{xS}, North volatility shocks $u_{\sigma N}$, and North long-run risk shocks u_{xN}. We focus on these shocks rather than the short-run growth rate shocks, u_N, u_S, or u_i because the short-run shocks have minimal impact on spreads. To help with the interpretation of how spreads respond to these shocks, we use the spread decomposition developed earlier for both northern corporate bonds, $I = N$, and for southern sovereign bonds, $I = S$, namely

$$sp_t^I = \frac{1}{Q_t^I Q_{nt}^I} \sum_{\tau=1}^{\infty} (1-\varphi)^{\tau-1} cov_t\Big(M_{t,t+\tau}, 1 - \frac{D_{t,t+\tau}^I}{\bar{D}^I}\Big) + \frac{1}{Q_{ft} Q_{nt}^I} \sum_{\tau=1}^{\infty} (1-\varphi)^{\tau-1} \frac{1}{R_{t,t+\tau}} E_t\Big[1 - \frac{D_{t,t+\tau}^I}{\bar{D}^I}\Big]. \tag{12}$$

Figure 3a shows the responses to a one standard deviation negative innovation to the South long-run risk u_{xS}. This shock worsens the growth prospects of all southern countries and increases their chance of defaulting on their original level of debt. As Figure 3c shows, this growth rate shock also gives these countries an incentive to save more by reducing their debt since the current *level* of output is higher than it is expected to be in the future. This force tends to reduce their chance of defaulting. Here, the direct effect from the worsening debt schedule for any level of debt dominates, so as Figure 3d shows, the spread schedule faced by the country shifts out for any level of debt requested. To understand the effect on southern spreads, note that this shock has no effect on any northern variable (not plotted), including the kernel $M_{t,t+\tau}$ and the risk-free rate $R_{t,t+\tau}$. Hence, the only effect on southern spreads is that by increasing expected default rates, $E_t(1 - D^S_{t,t+\tau}/\bar{D}^S)$, the shock increases the second term in (12). In equilibrium, as Figure 3b shows, southern spreads increase by 54 basis points and slowly revert back.

Figure 4 graphs the responses to a one standard deviation increase in the volatility shock $u_{\sigma N}$. The increased level of uncertainty raises northern households' desire for precautionary saving. As a result, on impact, the risk-free rates decrease by 8.9 basis points and North price-dividend ratios decrease by 90 basis points. The higher volatility of productivity increases the risk premium on Northern bonds, the first term in (12), by driving up the expected marginal utility of consumption and driving down the expected repayment rate, thus making the covariance terms, $cov_t(M_{t,t+\tau}, 1 - D^N_{t,t+\tau}/\bar{D}^N)$, more positive. As Figure 4d shows, the resulting increase in the risk premium accounts for 88% of the increase in the corporate spread. The remaining 12% of this increase comes from an increase in the default risk, namely, from an increase in the present value of the expected default rates, $E_t(1 - D^N_{t,t+\tau}/\bar{D}^N)$, given in the second term in (12).

To understand the responses in the South, note that the spread results both from the expected probability of default and the positive covariance of this default with the stochastic discount factor—namely, that southern borrowers tend to default when northern marginal utility is high. Following a persistent increase in volatility, northern lenders anticipate that their marginal utility will be persistently higher and that southern countries will default more. The combination of these anticipations leads to a persistent increase in the covariance between the stochastic discount factor and the default rate, namely, $cov_t(M_{t,t+\tau}, 1 - D^S_{t,t+\tau}/\bar{D}^S)$. This increased covariance causes northern lenders to shift up the entire schedule of spreads facing southern countries. This shift in the schedule leads these countries to default more. Here, 55% of the increase in southern spreads comes from the increase in default risk and the rest from an increase in the risk premia.

Finally, Figure 5 shows the impulse responses to a negative one standard deviation innovation to the long-run risk in the North's productivity u_{xN}. In Figure 5a, we see that North's output growth falls on impact and then is expected to slowly return to its mean, leaving the level of output at a permanently lower level in the long run. Given this shock, northern consumers expect to be poorer in the future than they are now. Hence, to smooth consumption, northern consumers would like to save and thus move consumption from the present, with its high level of output, to the future, with its low level. As a result, as Figure 5b shows, the risk-free rate falls by about 23 basis points and remains low for a long time. Figure 5c shows that these worsened prospects for future growth lead the North price-dividend ratio to fall by about 644 basis points on impact and then slowly recover. Figure 5d shows that these worsened prospects also imply that corporate spreads rise by about 9.8 basis points. About 60% of this increase comes from an increase in the risk premium. Specifically, the long-run risk shock simultaneously drives up the marginal utility of consumption and drives down the repayment rate, thus making the covariance between these two more positive, which makes corporate bonds more risky. The remaining 40% of the spread increase comes from an increase in default risk.

The lower panels show the effects of this shock on a southern country. Figure 5e shows that the southern spread increases by about 12 basis points and that nearly all of this increase comes from an increase in the default risk, which in turn comes from a combination of an increase in the probability of default for a given level of borrowing and an increase in default resulting from an increase in the level of borrowing. Figure 5f shows that the country increases its debt to output ratio slowly over time so that by 8 quarters after the shock, its debt to output ratio has increased by about .2 percentage points from 24.5 to 24.7. This increase leads to a very small increase in defaults in each period, but, as Figure 5g shows, when added up it leads to a nontrivial increase in the spread schedule for any level of borrowing. Note that the spread schedule for southern countries is also pretty flat in the level of borrowing on impact for the same reason as for northern firms: even if the country chooses a lower level of debt today, lenders expect them to increase it from tomorrow on and default accordingly more in the future.

These impulse response functions provide intuition for how the model uses data on asset prices to uncover the underlying shocks to North long-run risk, North volatility, and South long-run risk. In what follows, we over-simplify the mechanics of how the model works to make the intuition simple. In the next section, we are more formal.

Consider first how the model uses asset prices to determine the relative sizes of the North volatility shock and the North long-run risk shock. The impulse responses show that for a given change in northern spreads, the stock market falls a lot less following a North volatility shock than it does following a North long-run risk shock. Indeed, on impact following a one standard deviation increase in the volatility shock, the fall in the stock market relative to the increase in the spread, expressed in basis points, is $91.7/5.2 = 17.6$, but following one standard deviation fall in growth prospect shock, this ratio is almost four times larger, namely, $644/9.8 = 65.7$.

Note that if we ask the model to match only the path of a single series, for example, the northern corporate spreads, then there are many combinations of northern volatility and long-run risk shocks that can do so. However, for nearly all of these combinations, the predicted movements for a second series, say, the stock market, will be far from its observed movements. Instead, when we ask the model to simultaneously match the movements in northern spreads and the northern stock market, it can determine the relative sizes of these shocks. In particular, for a given increase in the northern spread, the larger the fall in the stock market, the greater is the fraction of the increase in spreads that emanates from the long-run risk shock.

Finally, consider how we can back out the drivers of southern spreads. Both northern long-run risk shocks and volatility shocks shift the schedule that northern lenders offer to southern borrowers and, hence, move southern spreads. However, the common lender effect from these shocks necessarily implies that when these northern shocks drive the bulk of the movements in southern spreads, the northern asset prices—corporate spreads and stocks—and the South spreads must be highly correlated. In contrast, since southern shocks are independent of northern ones, when southern long-run risk shocks drive the bulk of the movements in southern spreads, northern and southern spreads are not very correlated. Hence, by simultaneously matching the comovements between the northern asset prices and the southern spread series, the model can uncover the relative size of southern shocks to northern ones.

Taken all together, when the model has to simultaneously match the comovements of northern and southern spreads along with the comovements of northern spreads and the northern stock market, it can uniquely uncover the underlying shocks. In practice, we also include data on the growth rate of output in the North and that of all southern countries. These growth-rate series should be thought of as primarily pinning down the short-run shocks.

4.2 Decomposing the Driving Forces

Here we decompose the driving forces underlying the world financial cycle.

Particle Filter Analysis. We run the particle filter on quarterly data over 1994Q1-2023Q2 to back out the 29 underlying shocks. From the North, we back out 3 shocks, $(u_{xN}, u_{\sigma N}, u_N)$, and from the South, we back out 2 common shocks (u_{xS}, u_S) and 24 idiosyncratic shocks $\{u_{xj}, u_j\}_{j=1}^{12}$. We then analyze the role of South and North shocks separately.

Our model has a block recursive form that we exploit for computational convenience. Since the South as a whole is assumed to be small in the world and the shocks in the North are independent of those in the South, the northern series does not depend on the realizations of the southern ones. Hence, we can solve the North independently of the South. In particular, we can back out the three northern shocks using three data series: North output growth Δy_{Nt}, price-dividend ratio pd_{Nt}, and corporate spreads sp_{Nt}. The long-run shocks u_{xNt} and the volatility shocks $u_{\sigma Nt}$ are identified using the intuition developed above. The output growth is mainly driven by the short-run shocks u_{Nt}. Putting the backed-out long-run shocks and volatility shocks together, we can construct the path of the North's stochastic discount factor.

In the second step, given the backed-out northern shocks, we pin down the southern shocks. To do so, we first plug the northern shocks into the pricing kernel and then use the particle filter as well as the southern series on growth rates and spreads to recover two series of the reduced-form i.i.d normally distributed shocks $e_{jt} = u_{jt} + \nu_S u_{St}$ and $e_{xjt} = u_{xjt} + \nu_S u_{xSt}$ for each country. A simple formula then gives the maximum likelihood estimate of the common component, u_{St} and u_{xSt} for each of the series, namely, $u_{St} = \frac{\nu_S}{1+12\nu_S^2} \sum_{j=1}^{12} e_{jt}$ and $u_{xSt} = \frac{\nu_{xS}}{1+12\nu_{xS}^2} \sum_{j=1}^{12} e_{xjt}$. Then, given the reduced-form series e_{jt} and e_{xjt} for each country and parameters ν_s and ν_{xS}, we construct these common components and then use the reduced-form shocks e_{jt} and e_{xjt} to back out the primitive shocks u_{jt} and u_{xjt}.

In practice, it is important to adapt the particle filter to reconstruct the shocks for a reasonable number of particles. We use an auxiliary particle filter in which we utilize the cubature Kalman filter (Arasaratnam and Haykin 2009) to construct the proposal distribution. The resulting auxiliary particle filter successfully reconstructs the time series for output growth and sovereign spreads for each individual country by our recursive method with small measurement errors, with the exception of Brazil in the 2002-2003 period.

Intuition. We first use intuition from the impulse response analysis to analyze these data informally. Figure 6 shows that in the emerging market crises phase, spreads in emerging markets are high and volatile. In the North, the high level of the stock market should imply good growth prospects for the North, and the low corporate spreads should imply low levels of volatility. These patterns imply that these are *good times* for northern consumers, and hence northern lenders should be willing to bear risk. Thus, given these patterns in the North, it is hard for the common lender channel to play much of a role during this phase. Hence, the only way left to explain the observed high and volatile spreads in emerging markets is through the common shock channel: the growth prospects in the EM were poor and worsened up to about 2003.

In contrast, these same panels show that during the great spread moderation phase from 2003 to 2007, there is a sharp decline in southern spreads. However, northern corporate spreads have only a modest fall followed by a modest rise, and the stock market is fairly flat. Here again, it is difficult for the model to blame the sharp decline in southern spreads on the North. Instead, the most obvious culprit for this decline is that growth prospects in the South are improving.

Next, the global cycle phase begins with the Great Recession in which all three key financial variables fare poorly: the stock market in the North collapses, and northern and southern spreads sharply increase. Hence, the impulse response intuition suggests that there are worsening growth prospects in the North and South and high volatility. So here, both the common lender channel and the common shock channel are likely to be important. From the end of the Great Recession to 2016, the stock market in the North is fairly stable, and corporate spreads track sovereign spreads pretty well. These patterns suggest that throughout this phase, the common lender channel may be able to account for a significant fraction of the southern spreads.

Finally, the data for the geoeconomic fragmentation phase suggest that several forces are present. First, as Figure 1d shows, there is a growing dispersion in the trends of emerging market spreads. This divergence is unlikely to result from the common lender channel—which makes southern spreads tend to move together. Second, as Figure 6 shows there is a large increase in the southern spreads in 2020Q2, even though both the US stock market and corporate spreads are fairly stable. Both of these features make it hard for adverse developments in the North to account for the spike in southern spreads. These patterns suggest that during this phase, most of the movements in southern spreads are driven by southern long-run-risk shocks. Interestingly, the geoeconomic fragmentation phase is reminiscent of the EM crises phase, suggesting that there was no one-time permanent change to a global cycle around the Great Recession.

Formal Analysis. Now let us turn to the formal analysis. Figure 6 shows the data and model implications for US corporate spreads, US price-dividend ratios, and the aggregate EM spread. This figure shows what the model predicts using the shocks backed out from the particle filter. The model successfully replicates the data. Figure 7 shows the backed-out states for the North's growth prospects x_N, the volatility shock σ_N, and the average of southern growth prospects

$\bar{x}_{St} = \sum_{j=1}^{12} x_{jt}/12$. Our model not only captures the large common component of spreads but, as Figure A2 in the appendix shows, it also captures well the patterns of individual countries' spread. This success is notable because we make the simplifying assumption of a common parameterization across EMs.

The backed-out shocks in Figure 7 are consistent with our informal analysis. During the EM crises phase, the growth prospects of the North are excellent; indeed, they are much higher in this phase than in any other. The volatility in the North is moderately high but nowhere near high enough to overwhelm the impact of the growth prospects on corporate spreads. In contrast, average growth prospects for the South are low and volatile. During the great spread moderation, the striking pattern is the sharp and prolonged improvement of the growth prospects of the South. In terms of accounting for the large drop in South spreads, the growth prospects of the North are going the wrong way—they are worsening throughout the phase. The volatility shocks in the North are going the right way—they are falling modestly, but the impact of these shocks on southern spreads is small.

Next, at the beginning of the global cycle phase is the Great Recession, in which all three shocks are worsening: growth prospects are falling in the North and the South, and volatility is increasing. For the latter part of this phase, there are modest fluctuations in all three series. Finally, in the geoeconomic fragmentation phase, northern growth prospects are increasing, volatility shocks are modestly increasing, and southern growth prospects are deteriorating. Figure A3 in the appendix shows that, during this phase, the backed-out growth prospect shocks for each individual country are gradually fanning out.

Comparing Asset Prices and Backed-Out Shocks. To understand how the movements in asset prices identify the shocks, we graph the backed-out shocks against the asset prices. Figure 8 graphs the EM spreads against the long-run growth prospects in the South and the North, x_S and x_N, and the volatility shock σ_N^2. In Figure 8a, we see that from the beginning of our sample up through the beginning of the Great Recession, there is an inverse relationship between South spreads and South growth prospects. Indeed, the large up-and-down swings in spreads from 1994 to 2000 are accompanied by large down-and-up swings in South growth prospects. Also, the slow and steady decline in spreads during the great spread moderation is accompanied by a slow and steady rise in South growth prospects. From the Great Recession onward, there is a tenuous relationship between South spreads and South growth prospects.

Figure 8b plots South spreads and North growth prospects. Up until 2008, we see little evidence that good times for North growth prospects are associated with low southern spreads. Indeed, from 1994 to 2000 there is a large, steady improvement in North growth prospects, whereas South spreads first rise sharply, then fall sharply, then again rise sharply. Then in the early 2000s North growth prospects are steadily weakening, but South spreads are smoothly declining. Starting from the Great Recession, we see more of an inverse relationship.

Next, Figure 8c shows that from 1994-1998, there is little relationship between North volatility shocks and South spreads: spreads are increasing sharply but volatility shocks are pretty stable. From the great moderation onward there is much more of a positive relationship.

We now turn to the comovements of asset prices in the North with northern shocks. Figure 8d shows that the price-dividend ratio closely tracks North growth prospects and Figure 8e shows that corporate spreads track volatility shocks fairly well. These results are consistent with the intuition developed from the impulse responses.

Decompositions. We turn to using these backed-out shocks to perform some decompositions to isolate the primitive driving forces behind the movements in asset prices. To set up these decompositions, consider a generic series, y_t, produced by the baseline model with all shocks. Then, given a partition of shocks into groups indexed by i, we define the *component of y_t due to shocks in group i*, denoted y_{it}, as the prediction of the model for this series given the shocks in this group backed out from the particle filter, with all other shocks set to their means.

We begin by partitioning the shocks into all the southern shocks, $i = S$, and all the northern shocks, $i = N$, and determining which movements in the average southern spread $\overline{sp}_t$ are due to each set of shocks. In Figure 9a, we graph the benchmark model's predictions, $\overline{sp}_t$, which match the data, along with the components $\overline{sp}_{St}$ and $\overline{sp}_{Nt}$ generated by feeding into the model only the southern shocks and only the northern shocks.

Figure 9a shows that northern shocks contribute little to southern spreads during the emerging market crises phase. Indeed in this early period, southern shocks account for nearly all of the movements in the southern spreads whereas northern shocks do little. So, as we intuited, during this period the common shock channel dominates. During the great spread moderation, the key force behind the large and steady decline in southern spreads is improving growth prospects in the south, whereas the northern shocks do little. Throughout the global cycle period, northern and southern shocks play a sizable role, with both playing about equal roles during the Great

Recession. From the end of the Great Recession to the end of the global cycle period, spreads in the South stay low because of the good growth prospects there. Indeed, if there were only northern shocks, the spreads in the South would have been several hundred basis points higher. Finally, during the geoeconomic fragmentation phase, the southern country's growth prospects play the dominant role in accounting for southern spreads.

In Figure 9b, we investigate which North shocks have the most impact on South spreads. During the Great Recession, long-run risk shocks and volatility shocks are about equally important but after that volatility shocks play a more important role. In Figures 9c and 9d, we break down the role of North shocks into growth rate shocks and volatility shocks in accounting for stocks and spreads in the North. As we intuited, most of the movements in stock prices are accounted for by movements in North growth prospects and most of the movements in corporate spreads are accounted for by movements in North volatility. In Figure A4 in the appendix, we perform a similar analysis of each country's spread.

Summary Statistics. So far, we have shown graphs of decompositions of series into the components due to various shocks. Here we use the decompositions to develop some summary statistics referred to as ϕ *statistics*, defined by $\phi_i(y_t) = \frac{1/var(y_t - y_{it})}{\sum_i 1/var(y_t - y_{it})}$.

These statistics capture how well a component, such as the component of average southern spreads due to northern shocks, tracks the underlying variable, namely, the average southern country spreads generated by the benchmark model. Note that since the benchmark model essentially reproduces the data, this ϕ statistic likewise captures how much of the movements in the series in the data can be accounted for by these shocks. The statistic $\phi_i(y_i)$ is the inverse of the mean square error for each group of shocks scaled by their sum.[6] More generally, these ϕ statistics have the desirable features that each lie in $[0, 1]$, sum to one across the components, and if a particular component tracks the benchmark series perfectly, in that $y_t - y_{it} = 0$ for all t, then $\phi_i(y_t)$ reaches its maximum of 1.

Table 6 decomposes the average southern spread into the components explained by *Only North* shocks and *Only South* shocks, overall and across the different phases. The decomposition over the full sample attributes 18.4% of its fluctuations to northern shocks and 81.6% to southern shocks. Interestingly, only during the global cycle phase do northern shocks account for the majority of the fluctuations in southern spreads, namely, 68%. Indeed, for any other phase, they

[6]See Brinca et al. [2016] for similar use of such statistics.

account for less than a quarter of the fluctuations. Note that the average southern spread series is constructed by running the filter on each of the 12 countries separately and then taking averages. The details of this decomposition for each country are given in Table 7. Here we see a pattern for the individual countries similar to the one we saw in the aggregate.

The last two columns of Table 6 decompose the fluctuations in southern spreads driven by northern shocks into the component coming from northern growth rate shocks—the i.i.d shocks u_N and the North growth rate prospect shocks x_N— and the component coming from the volatility shocks, σ_N. Clearly, during the global cycle phase and the great spread moderation, the main driver from the North is the volatility shocks, but in the other two phases, the main driver is the growth rate shocks.

Table 8 decomposes the drivers of northern stocks and corporate spreads. In terms of stocks, overall and in each phase, the growth rate shocks are by far their largest driver. In terms of northern spreads, it is more mixed: overall, a bit over half of the movements in spread are driven by growth rate shocks, 58.5%, and the remainder are driven by the volatility shocks.

Risk Premia and Default Risk. Finally, in Figure 10, we decompose South spreads and North spreads into default risk and risk premia. Figure 10a shows that in the South, default risk accounts for the bulk of spreads, whereas Figure 10b shows that in the North, default risk accounts for only a modest part of the spreads. Interestingly, Figure 10c shows that the risk premium on North spreads is much larger than that on South spreads.

To understand this result recall that the risk premia on the corporate bonds in the North and the sovereign bonds in the South measure how the default rate covaries with the marginal utility of consumption of Northern households. In the North the same shocks, σ_N^2 and x_N, that drive the vast bulk of the movements in the northern marginal utility directly enter the productivity of northern firms and, hence, directly contribute to their default rates. Thus, it is not surprising the default rates in the North covary highly with northern shocks. In contrast, these two key northern shocks affect the default rates in the South only indirectly. That is, these shocks shift around the schedule of loans offered to southern countries and, through this lending channel, affect their borrowing and default behavior. This endogenous response of southern countries' default rates to northern shocks induces endogenously driven risk premia.

5 Robustness and Counterfactuals

We turn now to a combination of robustness and counterfactual exercises. We first show that our model gives similar answers when we use junk bond spreads or stock prices from the financial sector rather than the measures of spreads and stocks that we use in our baseline. We then perform a counterfactual that highlights the discipline imposed by simultaneously having to account for the comovement among our three key asset prices.

Robustness to Including Spreads on Junk Bonds. In the baseline model, for our measure of corporate spreads we used *investment-grade* spreads, namely, *Baa* yields minus *Aaa* yields. We did so because the vast majority of corporate bonds are investment-grade bonds, on the order of 85% in terms of value. Interestingly, however, as authors such as Longstaff et al. [2011] have documented, spreads on noninvestment-grade bonds or *junk bonds* are more correlated with southern spreads than are investment-grade bonds in the late 1990s and the early 2000s. Also, important complementary work by Morelli et al. [2022] uses these spreads in their analysis. This work leads us to ask: if we extend our model to include junk-bond spreads and use both investment-grade and junk-bond spreads to uncover the underlying shocks, will we find a larger common lender effect? Hence, will we find that northern shocks account for a substantially larger fraction of southern spreads than we found in our baseline?

To answer these questions, we extend our model to include a class of junk-bond firms in addition to our baseline firms. We show two results. First, our extended model can account well for all three northern asset price series: investment-grade spreads, junk-bond spreads, and stock prices. Second, in the extended model our main conclusion holds: outside of the global cycle period, northern shocks account for a modest fraction of southern spreads.

Table 9 shows four key differences between spreads on junk bonds and investment-grade bonds during normal times. First, the mean spread on junk bonds, 3.4%, is over three times as large as that on investment-grade bonds. Second, the standard deviation of junk bond spreads, 2%, is five times as large as that on investment-grade bonds. Third, the default rate on these bonds is five times as large as that on investment-grade bonds. Finally, the correlation of junk bond spreads with southern spreads, 36.4%, is double that of investment-grade spreads.

We purposely add junk-bond firms to the economy in a way that leads to minimal changes to our baseline economy. We do so by assuming that there is a mass of measure zero of junk bond firms that differ from the firms in our baseline only by the parameters governing the idiosyncratic shock process κ to revenues. Recall that for our baseline firms κ_{jt} is i.i.d, normally distributed, with mean zero and standard deviation σ_κ. For high-yield firms, we assume that the process κ_{ht} has a normal distribution with a positive mean ξ_h and a state-dependent variance which is the maximum of a fixed number $\bar{\sigma}^2_{kh}$ and $\sigma^2_{\kappa h}(1-\varpi+\varpi\sigma_{Nt}/\sigma_N)^2$. We choose the four new parameters $\xi_h, \bar{\sigma}_{\kappa h}, \sigma_{\kappa h}$ and ϖ to replicate the four statistics in Table 9.

Junk-bond firms face the same stochastic discount factor M_{t+1} and aggregate northern state as do investment-grade firms. Their idiosyncratic state is $(\kappa_{ht}, \omega_{ht})$, where ω_{ht} is their leverage. We then run the particle filter in a two-step procedure as before. The only difference from our baseline analysis is that when we back out the three northern shocks $(u_{xN}, u_{\sigma N}, u_N)$, we use four observables—North output growth Δy_{Nt}, price-dividend ratio pd_{Nt}, investment-grade spreads sp_{Nt}, and junk-bond spreads sp_{ht}—rather than the three we used in our baseline.

In Figure 11a, we see that the model reproduces well the patterns in the data for North stocks and the investment-grade spreads, and in Figure 11b, we see that it reproduces the patterns of junk-bond spreads and southern spreads. Figure 11c shows that the backed-out shocks from the extended model are very similar to those in Figure 7 from the baseline. Indeed, the correlation of North growth rate shocks in the baseline and extended model is 98.1% and the corresponding correlations for the North volatility shocks and southern growth rate shocks are 83.9% and 99.6% respectively. The decompositions of the southern spread in the baseline and extended models are nearly identical—see Figures 9a and 11d —and, as shown in Table 10, the corresponding correlations are all higher than 98.5%. Finally, comparing the φ statistics in Table 11 and Table 6, we see that the North shocks account for only a bit more of the southern spreads in the extended model than in the baseline model, 20% overall vs. 18.4% overall and are a bit higher in all the phases except for the great spread moderation. We conclude that our main result is robust to using spreads on both investment-grade bonds and junk bonds.

To understand these results, note that as we moved from the baseline model to the extended model, all we did was add new parameters governing junk bond firms that allowed them to have higher volatility and to be more responsive to volatility shocks than our investment-grade firms. We then asked the extended model to fit the junk bond spreads as well as the original series from the baseline—southern spreads, northern stock prices, and northern investment-grade spreads—with the same number of shocks as in the baseline model. The filter backed out shocks for long-run risk and volatility that traded off fitting the original asset prices and the new junk bond spreads. It found that it could do a good job of doing so with only minor changes to the backed-out shocks—mainly visible during the late 1990s and early 2000s. Indeed, given the discipline of having to fit all the asset prices simultaneously, the filter would never choose shocks in the extended model that are very different from the baseline shocks, because if it did so the fit of the model to the original asset prices would have deteriorated markedly. We further explore a version of this logic in our third experiment below.

Robustness to Using a Stock Market Index for the Financial Sector. In the baseline model, we used a broad measure of stocks, the MSCI USA Index, for our stock market series. Doing so is consistent with the view that the global intermediary represents all consumers in the North. Under this view, using a broad market-wide index of stocks is reasonable. An alternative approach, motivated by the literature that identifies the global intermediary with the US financial sector, such as Morelli et al. [2022], is to use a measure of stocks that only represent the financial sector—which has a value of about one-fifth that of the sum of the values of financial and non-financial stocks. In our second robustness exercise, detailed in the appendix, we explore the implications of this logic by replacing our measure of the stock market with a narrower one corresponding to the financial sector.

Comparing Table A4 to Table 6 we see that, overall, using financial stocks leads the fraction of southern spreads explained by southern shocks to *rise* from 81.6% to 88.5%, with the bulk of this increase coming from the EM crises phase and the great spread moderation phase. A similar pattern holds when comparing Table A6 and Table 7 for individual countries. Hence, our main result is also robust to using a narrower measure of stocks than in our baseline.

Role of North Asset Prices in Disciplining Backed-Out Shocks. Here we show that the discipline of forcing shocks to account for the joint behavior of northern and southern asset prices underlies our conclusion that, outside the global cycle period, northern shocks account for only a modest fraction of southern spreads.

We make this point by considering an extreme experiment. Here we take our baseline parameters as fixed and study the shocks the filter identifies if we set southern shocks to zero and drop northern asset prices from the set of observables, thus dropping the discipline that the model must explain both northern and southern asset prices. Specifically, we set the 2 common shocks (u_{xS}, u_S) and 24 idiosyncratic shocks $\{u_{xj}, u_j\}_{j=1}^{12}$ to zero and restrict the observables in the filter to southern average spreads and northern output growth. We then use the particle filter to back out the three North shocks $(u_{xN}, u_{\sigma N}, u_N)$. Note that even though there are more shocks than observables, three vs. two, the filter can find the most likely path for the shocks that are consistent with these observables.

In this experiment without southern shocks, the common lender effect has to explain all of the movements in the average southern spread. Nonetheless, Figure 12a shows that the model produces the average southern spread well. How did the filter choose shocks to accomplish this? Figures 12b and 12c make it clear that it did so by choosing the North growth prospects x_N and volatility shocks σ_N^2 to be highly correlated with southern spreads. In particular, the correlation of x_N and southern spreads is -1.5% in the baseline, but in this counterfactual, it is -79%. Likewise, the correlation of σ_N^2 and southern spreads is 16% in the baseline but is 73% in this counterfactual. Figures 12d and 12e show that these shocks generate northern spreads and stock prices that are highly correlated with southern spreads. In particular, the correlation of southern spreads and northern spreads is 94.9%, and northern stocks are highly negatively correlated with southern spreads, -69.4%. Finally, as Figures 12f and 12g show, these implied patterns on northern spreads and stocks are completely at odds with those in the data. Indeed, the correlation of the northern spread in the data with that implied by the counterfactual is essentially zero (0.4%) and the correlation of the price-dividend ratio on the data with that in the model is low (22.4%).

In sum, the model can indeed produce the observed southern spreads solely from northern shocks, and thus solely from the common lender effect. Critically, however, it can do so only if the implied asset prices in the North are wildly counterfactual.

6 Conclusion

We have proposed a parsimonious neoclassical international business cycle model in which a global investor jointly prices northern and southern assets in a way that can generate the changing patterns of the world financial cycle. When we quantify the model, we find that, except for a global cycle period, the bulk of the movements in southern country spreads are driven by local economic conditions in their countries. Importantly, the model can generate the observed positive comovements across northern and southern spreads even though the correlation of primitive shocks in the North and the South are zero, as they essentially are in the data. This endogenously generated correlation of spreads is driven by the common lender effect.

We have purposely kept our model simple and yet found it could go a surprisingly long way in explaining the data. Thus, we view this model as a promising framework that can be extended to include some of the frictions that we have abstracted from. Such extensions may enable the model to account for an even broader range of observations.

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