Oil Price Uncertainty and Sovereign Spreads of Oil Importers

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Abstract

This paper examines how global oil price volatility affects sovereign spreads in oil-importing countries. Using data from 35 emerging economies, I first establish a positive empirical relationship between oil price volatility and spreads. I then develop a sovereign default model where oil prices follow a stochastic volatility process estimated via Bayesian MCMC methods. The model reveals that spread responses to oil price changes are highly state-dependent. During high volatility periods, spreads respond three times more sharply to price fluctuations than during normal times. Debt levels amplify this sensitivity—more indebted economies experience larger spread increases. Importantly, governments strategically borrow more during high volatility periods when oil prices are expected to rise, effectively using debt as insurance against future import costs and higher borrowing rates. These findings highlight oil price uncertainty as a quantitatively important macroeconomic risk for oil-importing nations.

Keywords: Sovereign default, country spreads, stochastic volatility, oil price
JEL codes: D73, F34, F41, G15, H63

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1. Introduction

There has been a significant increase in the number of sovereign defaults over the past five years. The Bank of Canada (BoC) sovereign default database, as documented by Beers et al. (2023), has recorded 14 such instances occurring in nine countries from 2020 onwards. This represented a notable upswing in the default rate, with the average default rates recording a 34% increase in 2020 compared to 2019, driven largely by the COVID-19 pandemic.

Simultaneously, there have been notable fluctuations in global oil prices in recent years, especially during the trough of the COVID-19 pandemic when oil prices hit a low of $16.55 per barrel, and the subsequent peak caused by the Russia-Ukraine conflict when oil prices surged to $108.5 per barrel in March 2022. While soaring oil prices benefit nations reliant on commodity exports, they pose considerable challenges for most import-dependent countries. For instance, Sri Lanka encountered difficulties in meeting expenses for importing food and fuel, eventually resulting in the government suspending payments on all sovereign bonds in April 2022, leading to a declaration of default. Similarly, other emerging nations such as Belarus, Lebanon, Ghana, and Zambia have grappled with default issues. Given the pivotal role of oil in various economies' production processes, uncertainties surrounding oil prices can significantly impact sovereign spreads, particularly in nations dependent on oil imports. Concerns stemming from abrupt spikes in oil prices imply potential increases in expenses linked to oil imports, consequently impacting a country's ability to fulfill external debt obligations. This sequence of events directly influences default risk and sovereign spreads in oil-importing nations. [1]

Figure 1 presents the dynamic relationship between oil price volatility and sovereign spreads for major oil-importing countries from 1995 to 2019. Panel A displays quarterly estimates of oil price volatility based on a stochastic volatility framework (detailed estimation using stochastic volatility methods is presented in Section 4.1), while Panel B reports the quarterly average sovereign spread across oil-importing countries. The sovereign spread is de-

[1] In this study, I focus on oil-importing countries, an area that has received limited attention. Most studies on oil prices and sovereign default tend to concentrate on resource-rich or oil-exporting nations. (see Wegener et al. (2016), Hamann et al. (2018), Ploeg (2011), Esquivel (2020))

fined as the difference between the yields of a country's sovereign bonds and the yield of the US 10-year treasury bond. Gray shaded regions mark major crisis periods. The figure reveals a striking co-movement between oil price volatility and sovereign spreads: both series exhibit notable spikes during periods of global financial stress, particularly around the 2008 global financial crisis and the 2014–2016 oil price shock. During periods of elevated oil price uncertainty, oil importers face substantially wider spreads, reflecting investors' heightened risk premiums. This pattern suggests that oil price volatility represents a significant macroeconomic risk for countries dependent on oil imports, transmitted through financial markets' repricing of sovereign credit risk.

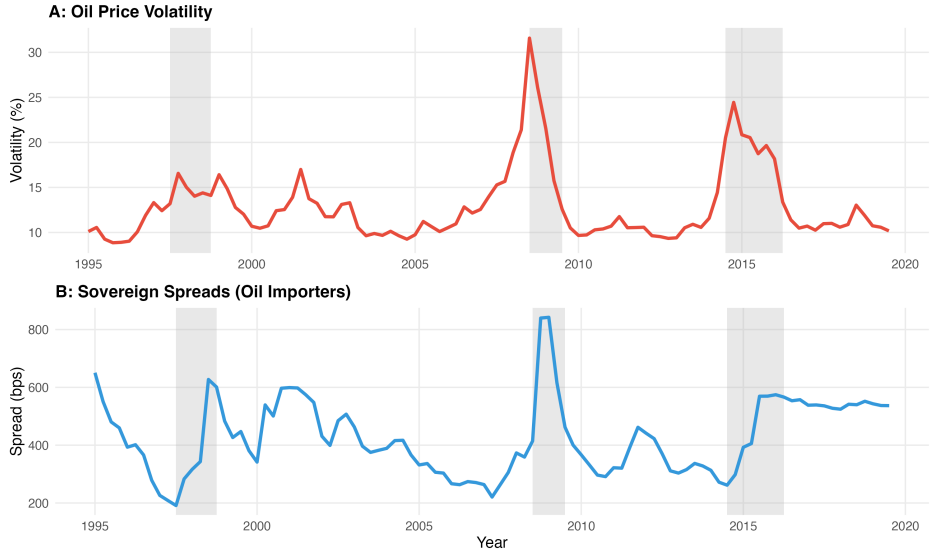


Figure 1: Oil Price Volatility and Sovereign Spreads: Oil-Importing Countries, 1995–2019. Note: This figure presents the quarterly oil price volatility (Panel A) and the quarterly average sovereign spread across 35 oil-importing countries (Panel B) from 1995 to 2019. Oil price volatility, expressed as percentages, is estimated using stochastic volatility methods as described in Section 4.1. Gray shaded regions indicate major crisis periods.

In this paper, I explore how changes in the volatility of global oil prices affect sovereign spreads. To begin, I establish that there exists a positive relationship between the percentage change in sovereign spread and the volatility of oil prices, after controlling for the percentage change in oil price levels. Im-

portantly, this connection remains robust even when conditioned on several global and domestic variables such as changes in US Tbill, debt/GDP, foreign exchange reserves, and real exchange rates. To estimate the uncertainty surrounding oil prices, a stochastic volatility process is employed to model the oil price, and the stochastic volatilities are estimated using a Bayesian Markov Chain Monte Carlo (MCMC) method.

Subsequently, I develop a sovereign default model with long-term debt for a small open economy that imports oil as a factor of production. The price of oil displays fluctuations in level as well as in volatility. The model is calibrated with data available at a quarterly frequency, using information from 35 emerging market economies that are net importers of oil. This dataset covers the period from the first quarter of 1995 to the third quarter of 2019. As a key quantitative finding, this paper illustrates the intricate connection between sovereign spreads and both the level and volatility of oil prices in an oil-importing economy. According to my model, the average spread slope, defined as the change in spread resulting from a change in the level of oil price, is approximately 0.05 when the volatility of oil prices is at or below the mean. However, this response increases to 0.15 under conditions of high volatility. Specifically, a 10% increase in oil price leads to a 0.5 basis point rise in the spread during low volatility periods, while the same price change results in a 1.5 basis point increase during high volatility periods. This indicates that the spread's sensitivity to oil price changes is three times greater during high volatility periods. The borrowing decision also becomes more responsive to fluctuations in oil prices in a state characterized by heightened volatility. Particularly, during phases of heightened volatility, the economy tends to lean toward increased borrowing when not only are oil prices high but also subject to higher volatility. This choice is primarily driven by the uncertainty prevailing in the oil market during these periods of high volatility.

The underlying rationale for this heightened borrowing is to serve as a form of insurance, enabling the government to shield itself against potential future increases in production costs resulting from expected high oil prices. It might be tempting to consider that the government could simply delay borrowing until the higher prices materialize rather than borrowing in advance when prices are projected to rise. However, the economy accumulates a larger debt as a safeguard because the spread experiences a much more pronounced increase in response to a price shock in a highly volatile economy. Consequently, the economy would be compelled to borrow more at substantially higher interest rates, all while oil prices are already elevated. As a result,

this escalated borrowing elevates the risk of default and, subsequently, raises borrowing costs.

To highlight the significance of incorporating time-dependent fluctuations in global oil price volatility, I draw a comparison between the benchmark calibrated model, termed the "full model," and two alternative models: the "intermediate model," where oil price volatility remains fixed at its mean, while the level fluctuates, and the "basic economy," maintaining a constant oil price with both level and volatility fixed at their averages. This comparative analysis reveals that the "full model" generates a higher average spread, increased spread variability, and an elevated default rate for an equivalent average debt/GDP ratio. Consequently, substantial welfare gains are observed when comparing the full economy to either the basic or intermediate economy, resulting in an average welfare gain of 0.2 to 1.1% increase in consumption.

Layout.. The rest of the paper proceeds as follows. Section 2 reviews the related literature. Section 3 presents the empirical findings. Section 4 introduces a benchmark model of sovereign borrowing and default with oil imported as an input to production and the dynamics of oil price modeled with a Stochastic Volatility (SV) framework. Section 5 discusses the calibration of the model, and section 6 studies the main results and quantitative implications of the theory. Section 7 concludes.

2. Related literature

This paper builds upon the existing body of quantitative research on sovereign default, drawing from the work of Aguiar and Gopinath (2006) and Arellano (2008) which expand upon the framework initially developed by Eaton and Gersovitz (1981). Arellano (2008) employs a sovereign default model to analyze the economic behavior of Argentina during its 2002 default. It demonstrates that defaults are more likely to occur during times of economic downturns marked by asymmetric output losses. Aguiar and Gopinath (2006), on the other hand, delves into the impact of permanent shocks and default decisions. Subsequent research efforts by Hatchondo and Martinez (2009), as well as Chatterjee and Eyigungor (2012), extend the foundational framework to incorporate long-term debt. These extensions allow the models to comprehensively consider factors such as the debt level, the level and volatility of spreads around default episodes, and other cyclical influences. Yue (2010) investigates default decisions within the context

of debt renegotiation. Cuadra and Sapriza (2008) take an optimal policy approach, modeling the default decision for a government with access to distortionary taxation. Mendoza and Yue (2012) examine the default decision with endogenous output, seeking to reconcile observed patterns in default episodes with the broader business cycle.

While a substantial body of literature has been dedicated to exploring the dynamics of sovereign spreads, a consensus on the factors influencing this variable remains elusive. One branch of this research reveals that the sovereign risk premium is influenced externally, or at the very least, a significant portion of it is not reliant on domestic factors. Conversely, another branch argues that a substantial portion of the variability in sovereign spreads is contingent on domestic factors. Some empirical studies highlighting the role of global factors in determining spread levels and default risk include Uribe and Yue (2006), Reinhart et al. (2016), Eichengreen et al. (2001), Longstaff et al. (2011), and González-Rozada and Yeyati (2008). For instance, Longstaff et al. (2011) propose that sovereign credit risk is primarily driven by global financial market variables, such as U.S. stock and high-yield bond markets, as well as global risk premia, rather than local economic forces. Similarly, Garcia Cicco et al. (2012) suggests that global risk shocks impact the real economic conditions of smaller and highly globally integrated countries. Kennedy and Palerm (2014) and Csontó (2014) conclude that during periods of distress, emerging market bond spreads are predominantly influenced by external factors, with the importance of global factors becoming more pronounced during high-volatility periods. Additionally, Johri et al. (2022), in a quantitative study, find that fluctuations in the level and volatility of the world interest rate have an impact on sovereign spreads in emerging economies. In contrast, another strand of quantitative literature underscores the significance of country-specific factors, such as income inequality, fiscal regulations, political considerations, and corruption, as indicated by studies including Jeon and Kabukcuoglu (2018), Alamgir and Johri (2022), Alamgir et al. (2023), Cotoc et al. (2021), Hatchondo and Martinez (2010), Hatchondo et al. (2022), and Bianchi et al. (2018).

Another related strand of literature examines the connection between terms of trade and sovereign default risk. For example, Cuadra and Sapriza (2006) shows that a negative terms of trade shock can lead a highly indebted country to default on its sovereign debt, especially when the productive sector relies heavily on foreign inputs. Similarly, Kikkawa and Sasahara (2020) investigates how a country's access to bond markets influences its welfare

gains from international trade. Additionally, Gu (2021) and Serfaty (2024) explore how default risk interacts with terms of trade and real exchange rates in the period leading up to a sovereign default.

This paper also adds to the existing body of literature that examines the role of oil price shocks in explaining various macroeconomic outcomes. Numerous studies have explored the relationship between oil price movements and different aspects of the economy, such as stock price returns and term structure of interest rates. (see Arouri et al. (2011), Bhar and Nikolova (2009), Hilscher and Nosbusch (2010), Liu et al. (2016), Ioannidis and Ka (2018)). For example, Basher and Sadorsky (2006), Bouri (2015), Kang et al. (2017), Aloui et al. (2012), and Basher et al. (2012) all suggested that fluctuations in oil prices have an impact on stock market performance. Filippidis et al. (2020) explored how oil price shocks affect sovereign bond yield spreads. In a related study, Wegener et al. (2016) proposed that positive oil price shocks can lead to lower sovereign credit default swaps (CDS) spreads in oil-producing countries because higher oil prices enhance the fiscal stability of these nations. Hooper (2015) argued that oil reserves can increase spreads when there is a high level of corruption and political risks, but they can lower spreads in politically stable and non-corrupt countries. Hamann et al. (2018) demonstrated that although being a larger oil producer reduces sovereign risk due to improved repayment capacity, having more oil reserves can increase sovereign risk by making self-sufficiency more appealing. Similarly, Ploeg (2011) concluded that resource-rich countries are susceptible to the volatility of commodity prices, especially if their financial systems are underdeveloped. Notably, capital-intensive resources like oil are more prone to civil conflicts than labor-intensive resources like rice, coffee, or bananas. In a recent study, Esquivel (2020) documented that interest rate spreads of emerging economies increased by 1.3 percentage points following the discovery of oil reserves of median size. After such a discovery, borrowing and investment increased, and capital shifted away from manufacturing towards oil and non-traded sectors, leading to greater volatility in tradable income. Borrowing increased default risk, and the heightened volatility contributed to an increase in the risk premium, subsequently resulting in higher spreads.

This paper is closely aligned with another body of literature concerning stochastic volatility and uncertainty. An early study by Bloom (2009) revealed that heightened uncertainty contributes to economic downturns and increased unemployment. Cuadra and Sapriza (2008) demonstrated that political uncertainty is associated with higher default rates and increased

levels of volatility in sovereign interest rate spreads. Fernández-Villaverde et al. (2011) observed that an increase in real interest rate volatility triggers declines in output, consumption, investment, hours worked, and notable changes in the current account of the economy. Swallow and Céspedes (2011) suggested that emerging economies are more susceptible to severe declines in investment and private consumption following exogenous uncertainty shocks. Fernández-Villaverde et al. (2015) concluded that fiscal volatility shocks can have a substantial adverse impact on economic activity. Fountas and Karanasos (2007) explored the causal effects of real and nominal macroeconomic uncertainty on inflation and output growth, as well as the influence of inflation on inflation uncertainty. Lee et al. (1995) highlighted the significant role of oil price uncertainty in explaining economic growth across different sample periods. Sutton and Catão (2002) introduced the concept of uncertainty into the literature on sovereign default and found that countries with historically higher macroeconomic volatility are more prone to default, particularly when part of this volatility is policy-induced. Other studies exploring uncertainty and time-varying volatility include Kim et al. (1998), Lopez-Martin et al. (2019) and Fernández-Villaverde and Rubio-Ramírez (2010). In the realm of sovereign default research, this paper shares close connections with two prior studies. The first, as discussed in Seoane (2019), delves into the impact of alterations in aggregate income volatility on sovereign spreads. The second, as explored in Johri et al. (2022), establishes a connection between uncertainty in world interest rates and sovereign default risk.

While several studies have established links between sovereign default risk and fluctuations in macroeconomic variables, it is important to highlight that another potential cause of sovereign default could be the uncertainty surrounding future oil prices. Interestingly, none of the existing research has addressed the impact of oil-related volatility shocks within the framework of sovereign default literature. This paper aims to bridge this gap and contribute to the existing body of literature by introducing the concept of stochastic volatility in oil prices within the context of a standard open economy sovereign default model.

3. Empirical findings

In this section, I estimate the correlation between sovereign spread and oil price volatility using international data. As a measure of spread, I use JP Morgan's Emerging Market Bond Index (EMBI), which captures the dif-

ference between the yield of a country's sovereign bonds in basis points and the yield of US 10-year treasuries between 1995-2019. My analysis is based on the intersection of the availability of the EMBI dataset and nations that are net oil importers, resulting in a sample of 35 emerging economies with quarterly data covering the period from January 1995 to September 2019. In order to determine whether a country is a net exporter or importer of oil, I calculate the net export of oil to GDP ratio based on the export and import of oil data from World Integrated Trade Statistics (WITS). The price of crude oil is obtained from the historical crude oil price database of the US Department of Energy, which consists of the quarterly spot price of the West Texas Intermediate (WTI) crude oil contracts traded on the New York Mercantile Exchange. The contract refers to 1,000 US barrels (42,000 gallons) of light-sweet crude oil. Growth in oil price level is calculated as the difference in consecutive natural log prices. Following Fernández-Villaverde et al. (2011), I model the oil price growth as an AR(1) process, where volatility follows a mean reverting AR(1) process.[2] A detailed discussion on the stochastic volatility framework is presented in Section 4.1

In order to study the correlation between oil price volatility and sovereign spreads, I use the following empirical specification:

$$\Delta spread_{it} = \beta_0 + \beta_1 \Delta oil\ price_t + \beta_2 oil\ price\ volatility_t + \Lambda' X_{it} + \Phi' Y_t + u_{it} \quad (1)$$

where Y_t refers to a vector of global variables that are common to all countries but vary over time, while X_{it} refers to other control variables that vary over time and across countries. The vectors (Λ, Φ) consist of coefficient estimates of the corresponding variables.

The global variables, which include changes in the ten-year US treasury bill rate and the Chicago Board Options Exchange's volatility index (VIX), are taken from the Federal Bank of St Louis FRED database.

[2]Further estimation details for the stochastic volatility process are in Appendix Appendix C

Table 1: Oil price volatility and Spread: quarterly Regressions

	Dependent variable: Δspread				
	(1)	(2)	(3)	(4)	(5)
Oil price volatility	0.02***	0.02***	0.01***	0.01***	0.01***
	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)
Δ Oil Price	0.19***	0.18***		0.14***	0.14***
	(0.04)	(0.04)		(0.04)	(0.04)
Oil price volatility * oil price dummy			0.002***		
			(0.001)		
Δ Debt/GDP				0.003*	0.003*
				(0.01)	(0.01)
Δ US Tbill(10 year)				0.13	0.13
				(0.20)	(0.20)
Δ Reserves/GDP				−0.004**	−0.004**
				(0.002)	(0.002)
Δ Real exchange rate				0.0003***	0.0003***
				(0.0001)	(0.0001)
VIX				0.003***	0.003***
				(0.001)	(0.001)
Constant	−0.20***	−0.21***	−0.17***	−0.21***	−0.16***
	(0.02)	(0.04)	(0.02)	(0.03)	(0.06)
Time FE	No	Yes	No	No	Yes
R^2	0.10	0.10	0.09	0.17	0.18
Adjusted R^2	0.09	0.09	0.08	0.17	0.16
Residual Std. Error	0.19	0.19	0.19	0.20	0.20
F Statistic	110.39***	6.54***	97.89***	44.44***	8.57***

Standard errors are clustered at the country level, and reported in parentheses. ***,**,* represent significance level at 1%, 5% and 10% respectively.
I verify that the main results are robust to alternative specifications. Appendix B reports results using levels of spreads as the dependent variable, with a lagged dependent variable, at monthly frequency. The positive and significant effect of oil price volatility on sovereign spreads is preserved across all specifications.

Data on other macroeconomic variables, such as changes in total foreign reserves (excluding gold) as a share of GDP, and exchange rate changes, are taken from the International Monetary Fund's International Financial Statistics (IFS). Since my data are at a quarterly frequency, annual GDP data is smoothed to a quarterly frequency using splines. I also include the debt-to-GDP ratio as a domestic control variable because higher levels of debt relative to repayment capacity are expected to be correlated with higher spreads both in theory and in previous empirical work.

Table 1 presents the baseline results from Equation 1 with standard errors reported in parentheses. In column (1), the simplest specification of Equation 1 is displayed, featuring the growth in real oil price level and the corresponding volatility of oil price levels. As evident from the table, both the growth in real oil price and its volatility exhibit positive associations with changes in sovereign spreads. Specifically, a one-unit increase in oil price volatility[3] is projected to result in approximately a 0.02-unit rise in the percentage change of sovereign spreads. Moving to column (2), this analysis is expanded by introducing controls for country fixed effects, and the results remain consistent despite the inclusion of these fixed effects. Subsequently, in column (3), oil price volatility interacts with oil price level dummies to examine how the effect of volatility on spreads varies with different price levels. These price dummies are constructed such that values exceeding the mean are assigned a value of 1, while they are set to 0 otherwise. The findings in Column 3 indicate that the impact of volatility on spreads is more pronounced during periods of elevated oil price levels.

Columns 4 and 5 present regression results after incorporating additional global variables, such as changes in the US treasury bill rate, the VIX, and other country-specific factors, including changes in reserves/GDP, changes in debt/GDP, and changes in real exchange rates. Previous studies have suggested that global factors play a significant role in determining spread levels and default risk. For instance, an increase in global financial risk is expected to correspond to higher emerging market bond spreads and, consequently, increased default risk. This is illustrated by the positive and statistically significant coefficients on the global variables introduced in columns (4) and (5). Country-specific control variables, like changes in foreign exchange reserves and exchange rates, are included as they signal a nation's ability to

[3]here volatility of oil price is measured in percentages

repay foreign debt and thus have a deterministic role in determining spreads. A decline in foreign reserves (ΔReserves/GDP <0) signifies a reduced ability to meet foreign debt obligations, while a depreciation in the exchange rate (ΔReal ex rate >0) amplifies the domestic currency's debt burden. Notably, all the domestic variables exhibit the expected signs, and the positive correlation between sovereign spreads and oil price volatility remains robust, even with the inclusion of customary conditioning factors.

As a result, the subsequent section delves into constructing a model where an economy heavily relies on oil imports as an input to its production process and is susceptible to fluctuations in both the level and volatility of oil prices. These fluctuations introduce uncertainty into the economy, consequently affecting its default risk and borrowing costs.

4. The Model Environment

Consider a small open economy with three key actors: households, foreign lenders, and a benevolent government. This government has access to the international credit market, allowing it to borrow long-term bonds without any commitment to repay. In this economy, households consume a tradable good, denoted as x, which is produced using two essential inputs: an exogenously determined stochastic endowment labeled as y and oil, denoted as m, which is imported from the rest of the world.

Building on the quantitative sovereign default literature, particularly the approach outlined by Arellano (2008), the per-period utility function can be expressed as follows:

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma} \tag{2}$$

where c signifies domestic consumption of the tradable good, and γ represents the coefficient of risk aversion. The production of the tradable good x utilizes a constant elasticity of substitution (CES) technology, defined as:

$$x = [(1-\alpha)y^{\theta} + \alpha m^{\theta}]^{\frac{1}{\theta}} \tag{3}$$

where α corresponds to the share of the intermediate good and θ determines the elasticity of substitution which equals $\frac{1}{\theta}$. In this context, the government holds the crucial and exclusive responsibility of importing oil and using it to produce the final good x, which is then consumed by households.

The government has the ability to borrow and lend in the international credit market through non-contingent long-duration bonds. As in Hatchondo and Martinez (2009), a bond issued in period t promises an infinite stream of coupons, which decrease at a constant rate δ. That is, a bond issued in period t promises to pay $\kappa(1-\delta)^{j-1}$ units of the tradable good in period $t+j$, for all $j \geq 1$. Hence, the number of long-term bonds issued in the current period is given by:

$$\nu = b' - (1-\delta)b,$$

where b refers to the number of coupons due at the beginning of the current period and b' to the number of coupons due at the beginning of the next period, and κ is a parameter that controls the size of the per-bond coupon payment. Each period, the government makes two decisions: first, it decides whether to default or repay and then it decides how many bond to purchase or issue in the next period. In case the government decides not to default, it then repays existing claims and can issue new debt ν. The government budget constraint under repayment is then given by:

$$c + pm = x + [b' - (1-\delta)b]\, q(b', y) - \kappa b \tag{4}$$

where the left-hand side denotes the domestic consumption expense plus the import cost of oil. Here, the tradable good x is assumed to be the numeraire while the price of the foreign good (oil) is given by p, which is exogenous to the economy.

Alternatively, if the government chooses to default, it defaults on all existing claims and is excluded from the financial market for a stochastic number of periods. During financial autarky, the government is restricted from issuing new debt, or it may regain access to the international credit market with probability Φ with no outstanding debt claims, which means $b = 0$. Default also has some direct output cost, which implies domestic endowment is also reduced by $h(y)$, so that $y_a = y - h(y)$ during the autarky period. The budget constraint for the default case is then given by:

$$c_a + pm_a = x_a \tag{5}$$

where c_a, m_a, and x_a refer to consumption, oil import, and production during autarky, respectively, and $x_a = [(1-\alpha)y_a^{\theta} + \alpha m_a^{\theta}]^{\frac{1}{\theta}}$

4.1. Oil price dynamics

Following the stochastic volatility literature (see, for instance, Fernández-Villaverde et al. (2011)), the oil price is modelled as an AR(1) process with

a stochastic variance. In a discrete-time framework, the Stochastic Volatility model assumes the volatility to be a random variable, unlike a GARCH model in which the conditional variance is a deterministic function of the model parameters and past data. Accordingly, the SV model can be specified as follows:

$$log(p_t) - \bar{p} = \rho_p(log(p_{t-1}) - \bar{p}) + exp(\sigma_t)u_t \qquad u_t \sim IID(0,1) \tag{6}$$

$$\sigma_t - \mu = \rho_\sigma(\sigma_{t-1} - \mu) + \eta\varepsilon_t \qquad \varepsilon_t \sim IID(0,1) \tag{7}$$

where p_t represents the real price of oil. The standardized mean and variance innovations u_t and ε_t are assumed to be normal. ρ_σ and ρ_p are estimated jointly using the Bayesian Markov Chain Monte Carlo (MCMC) methods. The prior distributions of $\bar{p}$ and μ are assumed to be normal and η^2 is assumed to follow an inverse-gamma distribution. In order to ensure stationarity, ρ_p and ρ_σ are constrained to the interval $(-1, 1)$ by assuming $\frac{\rho_p+1}{2} = \rho_p^*$ and $\frac{\rho_\sigma+1}{2} = \rho_\sigma^*$ have beta priors. Estimating the above SV model involves the estimation of the mean parameters $\{\bar{p}, \rho_p\}$ and the volatility parameters $\{\mu, \rho_\sigma, \eta\}$. The parameters μ and η measure the degree of mean volatility and stochastic volatility in the international oil price return process. A high μ corresponds to a high mean volatility, and a high η implies a high degree of stochastic volatility in the oil price process.

The oil price in the model is expressed in logarithms and normalized relative to its sample mean. Specifically, I estimate equations (6) and (7) using quarterly data on the real price of West Texas Intermediate (WTI) crude oil, deflated by the U.S. CPI, for the period 1995-2019. The estimated mean of the log oil price is $\bar{p} = 0.12$, which implies a normalized mean price level of $e^{\bar{p}} \approx 1.13$. In the model, a price of $p = 1$ corresponds approximately to the sample mean of real oil prices, so that deviations from unity represent percentage deviations from this mean. The tradable good x serves as the numeraire, meaning all prices (including the oil price p) are expressed relative to the domestic tradable good.

4.2. Timing

The sequence of events that the government faces is as follows:

- The endowment shock y, the oil price level shock p and volatility shock σ are realized

- The government starts with an initial bond position b_t and observes the realizations of the endowment, oil price level, and its volatility, and then decides whether to honor its outstanding debt. If it chooses to continue repayment, it decides the amount of debt b' to borrow subject to the budget constraint and given the bond price schedule $q(b', y, p, \sigma)$.

- Subsequently, the import of oil, domestic production, and consumption are finalized.

On the contrary, if the government decides to default, it gets excluded from the international credit market for a stochastic number of periods and suffers a direct income loss. As default is followed by financial autarky, there is no debt choice to be made, and consumption is simply equal to the output value net of import cost.

4.3. Government value functions and recursive equilibrium

Each period, provided the sovereign is in good financial standing, it must decide whether to honor its outstanding foreign debt or default. Default results in temporary exclusion from international financial markets and reduced endowment levels, but it also frees up fiscal space for government spending, as the debt is not repaid. This intertemporal decision-making process can be formulated as a dynamic programming problem. Given a level of debt obligations b, a realized endowment y, and realized level and volatility of oil price p and σ, the value function when the government chooses to honor its debt is given by:

$$v^c(b, y, p, \sigma) = \max_{b'} \left\{ u(c) + \beta \mathbb{E}_{y', p', \sigma' | y, p, \sigma} v^o(b', y', p', \sigma') \right\}, \tag{8}$$

subject to its budget constraint $c + pm = x + [b' - (1 - \delta)b]\, q(b', y) - \kappa b$

In the event of default, the economy is excluded from international credit markets but can regain access in any future period with probability Φ. Upon reentry, the economy returns without any debt, represented by the value function $v^0(0, y', p', \sigma')$. Alternatively, the economy may remain in autarky with probability $1 - \Phi$. Consequently, the value function associated with default, referred to as $v^d(y, p, \sigma)$, is given by:

$$v^d(y, p, \sigma) = u(c_a) + \beta \mathbb{E}_{y', p', \sigma' | y, p, \sigma} \left(\Phi v^o(0, y', p', \sigma') + (1 - \Phi) v^d(y', p', \sigma') \right) \tag{9}$$

subject to $c_a + pm_a = x_a$. By comparing the value functions corresponding to the default and repayment options, the government decides whether to repay or default, such that the optimal value function is expressed as:

$$v^o(b, y, p, \sigma) = \max_{d \in \{0,1\}} \{(1-d)v^c(b, y, p, \sigma) + dv^d(y, p, \sigma)\} \tag{10}$$

where d is the default indicator that takes the value of 1 when the government chooses to default and 0 otherwise.

4.4. Foreign Lenders

The global credit market operates under perfect competition, featuring a multitude of identical and risk-neutral lenders who are capable of borrowing or lending at the world interest rate denoted as r^*. These lenders possess complete information regarding various aspects of the borrowing economy, including its income (y), price level (p), and the volatility (σ) associated with oil. The condition of perfect competition dictates that bond prices must adhere to a zero-profit condition, which can be expressed as follows:

$$q(b', y, p, \sigma) = E_{y', p', \sigma' | y, p, \sigma} \frac{(1 - d(b', y', p', \sigma'))(\kappa + (1-\delta)q(b'', y', p', \sigma'))}{1 + r^*} \tag{11}$$

where $d(b', y', p', \sigma')$ and $q(b'', y', p', \sigma')$ refer to the default decision and bond price in the next period.

4.5. Recursive equilibrium

Definition 1.. The recursive equilibrium for this economy is characterized by

1. a set of value functions v^o, v^c, and v^d,
2. a default policy rule d and a borrowing policy rule b' for the sovereign government,
3. policy rules for domestic consumption c, import of oil m and production of the tradable good x, and
4. a bond price schedule q,

such that:

(a) given the default and borrowing policy functions of the government and the optimal policies for import, consumption, and production, v^o, v^c, and v^d satisfy equations (10), (8) and (9) when the government can trade bonds at q;

(b) given the default and borrowing policy functions, and the optimal policies for import, consumption, and production, the bond price function q is given by equation (11);

(c) the default and borrowing policy functions d and b' solve the recursive problem defined by equations (10), (8) and (9) when the government can trade bonds at q and given the domestic consumption policy c, import policy m and production x.

5. Calibration

The model is solved numerically using value function iteration on a discrete state space for b, y, p, and σ.The state space is discretized as follows: debt b uses $N_b = 100$ evenly-spaced grid points, endowment y uses $N_y = 21$ grid points, oil price level p uses $N_p = 7$ grid points, and oil price volatility σ uses $N_\sigma = 5$ grid points, yielding a total state space of 73,500 points. The endowment shock and oil price volatility are discretized using Tauchen (1986)'s method, which is well-suited for highly persistent AR(1) processes. The oil price level is discretized using Rouwenhorst's method, as recommended by Kopecky and Suen (2010), because it provides more accurate transition probabilities when the conditional variance varies across states—a key feature of the stochastic volatility specification. A central feature of the model is that the transition probabilities for oil prices depend on the current volatility state. Specifically, I construct separate transition matrices for the oil price process for each volatility regime $\sigma_i, i = 1, ...N_\sigma$. The variance of innovations to the oil price in volatility state σ_i is given by $Var(\epsilon_p \mid \sigma_i) = (\sigma_u.exp(\sigma_i))^2$, where σ_u is the scaling parameter. This yields a family of transition matrices $\{\Pi_p(. \mid ., \sigma_i)\}_{i=1}^{N_\sigma}$

When computing expectations in the value function iteration, agents correctly condition on the current volatility state:

$\mathbb{E}[V(b', y', p', \sigma')|y, p, \sigma] = \sum_{\sigma'} \sum_{p'} \sum_{y'} \Pi_\sigma(\sigma'|\sigma) \cdot \Pi_p(p'|p, \sigma) \cdot \Pi_y(y'|y) \cdot V(b', y', p', \sigma')$

This ensures that agents understand that high volatility today implies a wider distribution of future oil prices, which is central to the mechanism through which volatility affects sovereign spreads.

The model is calibrated to a quarterly frequency using data from a sample of 35 emerging economies who are net importers of oil covering the period 1995 q1 to 2019 q3. The choice of 35 economies is made from the 67 emerging

economies contained in the EMBI dataset such that the country's trade of oil to GDP ratio is less than 0.

The aggregate productivity process in the economy is assumed to follow an AR(1) process:

$$lny_t = \rho lny_{t-1} + \epsilon_t, \tag{12}$$

with $|\rho| < 1$ and $\epsilon_t \sim N(0, \sigma_\epsilon^2)$. The parameters governing the productivity process are set as $\rho = 0.9$ and $\sigma_\epsilon = 0.03$, which are standard in the literature.

Following Chatterjee and Eyigungor (2012), the output loss due to default is assumed to be quadratic and is specified as follows:

$$y_a = y - h(y) \text{ where } h(y) = max\{0, \psi_o y + \psi_1 y^2\},\ \psi_0 < 0,\ \psi_1 > 0$$

A quadratic output loss function allows for an asymmetry in default costs, implies higher losses during higher income periods, and is also helpful in matching the standard deviation of spread. This form of output loss function resembles Arellano (2008)'s specification when $\psi_0 < 0$ and $\psi_1 > 0$. Following

Table 2: Parameter values

Description	**Parameter**	**Value**	**Target/Source**
Persistence	ρ	0.90	Prior literature
Std dev of ϵ	σ_ϵ	0.03	Prior literature
Risk aversion	γ	2.00	Prior literature
World interest rate	r	0.01	Prior literature
Re-entry probability	Φ	0.08	Prior literature
Coupon decay rate	δ	0.03	Prior literature
Intermediate good share	α	0.20	Oil import/GDP
Elasticity of substitution	$\frac{1}{\theta}$	2.00	Prior literature
Discount factor	β	0.96	Average debt/GDP
Default cost	ψ_0	-0.25	Standard dev of spread
Default cost	ψ_1	0.37	Average spread
Autocorrelation of oil price level	ρ_p	0.98	Estimation
Mean of oil price level	$\bar{p}$	0.12	Estimation
Mean volatility of oil price	μ	-4.33	Estimation
Autocorrelation of oil price volatility	ρ_σ	0.66	Estimation
Stochastic volatility of oil price	η	0.44	Estimation

the standard values used in the real business cycle literature for small open economies as well as in the quantitative sovereign default literature, I assume a coefficient of relative risk aversion of 2 and a world real interest rate of 1 percent per quarter. The probability of re-entry Φ following default into the international credit market is set to 0.083, such that the government remains in financial autarky for a period of approximately 12 quarters, consistent with Mendoza and Yue (2012) and Gelos et al. (2011). The coupon decay rate is set to $\delta = 0.033$ and used with the average yield to produce an average bond duration of 11 quarters in the simulation, which is commonly seen in the sovereign default literature. The parameter θ is set to $\theta = 0.5$, so the elasticity of substitution between domestic and foreign input is equal to 2, which is standard in international trade literature.

The intermediate good (oil) share α is calibrated so that the model matches the share of oil import to GDP for the 35 countries in my dataset. According to the WITS data, the import of oil comprises approximately 9% of GDP on average in the international dataset over the period 1995-2019. This target is achieved by setting foreign input share α equal to 0.2. Finally, I am left with three parameters to assign values to: the discount factor β and default cost parameters ψ_0 and ψ_1. These parameters are calibrated to jointly target the following moments from the data:(i) a mean external debt-to-GDP ratio of 34.1%, (ii) a mean sovereign spread of 4.1%, and (iii) a standard deviation of 2.0% for the spread. All the data counterparts correspond to the average values in the 35 oil-importing countries from 1995-2019 extracted from the World Development Indicators dataset of the World Bank and JP Morgan's EMBI Global Index.

6. Results

6.1. Model fit

Having calibrated the model, I then compute the sovereign spread by taking the difference between long duration yield r^b[4] that would be earned on a riksy bond held till maturity with no default and a constant yield-to-

[4]Yield r^b satisfies $q_t = \frac{1}{1+r^b} + \frac{1-\delta}{(1+r^b)^2} + \frac{(1-\delta)^2}{(1+r^b)^3} + ...$

maturity r^{f5} earned on an identical but default-free bond. Since the model is calibrated at a quarterly frequency, I annualize the yields by compounding before computing the spread. Specifically, the annualized spread is calculated as $(1 + r^b)^4 - (1 + r^f)^4$.

To evaluate the performance of the calibrated model in terms of matching key statistical measures and reproducing fundamental features of an emerging economy's business cycle, the targeted moments generated through model simulations are presented in table 3. Column 1 displays the moments derived from international panel data. These moments have been calculated individually for each of the 35 countries over the period spanning 1995 to 2019, with the reported values representing the mean of these moments.

In column two, I present the corresponding moments generated by simulating the calibrated model. This simulation involved running the model across 500 sample paths, each spanning 1500 periods. To ensure accuracy, the first 500 periods from each sample were discarded to eliminate any initial guess bias, and default periods were excluded from the calculations. It's important to note that GDP and trade balance figures were logged and linearly de-trended prior to moment calculation.

As indicated by the data presented in table 3, the model is successful in matching its calibrated targets for the average spread and the standard deviation of the spread. Additionally, it closely approximates the mean debt-to-GDP ratio and the mean oil import as a percentage of GDP. Furthermore, the model aligns with the essential characteristics of business cycles in emerging economies. It produces a countercyclical spread and trade balance and effectively establishes a positive connection between the spread and trade balance. These correlations in the model reflect the empirically observed patterns and align with the typical sovereign default models featuring long-term debt (see Hatchondo and Martinez (2009), Chatterjee and Eyigungor (2012) and Alamgir et al. (2023)).

Table 3: Targeted and non-targeted moments

	Data	Model
Targeted moments		
Mean spread (%)	4.1	4.0
Mean debt/GDP (%)	34.0	34.7
Standard deviation of spread	2.0	2.3
Mean oil import/GDP (%)	9.0	8.0
Non-targeted moments		
Correlation(spread, GDP)	-0.4332	-0.6816
Correlation(tb/GDP, GDP)	-0.4104	-0.5472
Correlation(spread, tb/GDP)	0.3566	0.7207

Note: The first column refers to the average value of moments calculated individually for each of the 35 oil-importing countries over the period from 1995 to 2019. The second column refers to the moments generated by simulating the calibrated model across 500 sample paths, each covering 1500 periods. All moments are computed at quarterly frequency and expressed in %.

6.2. Implications of time-varying volatility of oil price

A key contribution of this paper is to isolate the effect of oil price *volatility* shocks from oil price *level* shocks on sovereign spreads. To accomplish this, I compare three model specifications: (i) the "full model", which includes both oil price level and volatility shocks; (ii) the "intermediate model" in which oil prices fluctuate but volatility is held constant at its mean ($\epsilon_t = 0$ in equation 7); and (iii) the "basic model", in which both oil price level and volatility are fixed at their means ($u_t = \epsilon_t = 0$).

The comparison between the full and intermediate models is of particular interest, as it isolates the pure effect of stochastic volatility - the novel feature of this paper. If volatility shocks were unimportant, the full and intermediate

[5]The default-free yield r^f satisfies the following default-free bond price schedule

$$q_t^{df} = \frac{1}{1+r^f} + \frac{1-\delta}{(1+r^f)^2} + \frac{(1-\delta)^2}{(1+r^f)^3} + ...$$

Table 4: Key moments: Full, Intermediate and Basic models

	Full model	**Intermediate model**	**Basic model**
Mean spread (%)	4.0	3.1	2.5
Mean debt/GDP (%)	34.7	33.8	33.3
Standard deviation of spread	2.3	2.0	1.7
Mean default rate (%)	0.72	0.70	0.42

Note: This table presents quarterly moments calculated from the "full model," the "intermediate model," and the "basic model." The full model features the benchmark calibrated model where both the level and volatility of oil prices vary over time. The basic model keeps both the oil price level and volatility fixed at their mean values. The intermediate model allows the oil price level to vary over time while keeping its volatility fixed at the mean.

models would generate similar predictions. Table 4 demonstrates that this is not the case.

Several findings emerge from this comparison. First, the full model generates a mean spread that is 29% higher than the intermediate model (4.0% vs. 3.1%), indicating that volatility shocks alone account for a substantial portion of the spread level. Second, the standard deviation of spreads is 15% higher in the full model (2.3% vs. 2.0%), showing that volatility shocks contribute to spread variability beyond what price level shocks alone can generate. Third, the default rate in the full model is also higher than in the intermediate model (0.72% vs. 0.70%).

Importantly, this decomposition reveals that oil price level shocks and volatility shocks operate through distinct channels. Comparing the intermediate model to the basic model shows that price level shocks increase the mean spread by 24% (from 2.5% to 3.1%). Thus, volatility shocks have a quantitatively larger effect on spreads than price level shocks alone.

These results address the question of whether incorporating stochastic volatility is necessary for understanding sovereign spreads in oil-importing economies. A model with only price level shocks (the intermediate model) would underpredict mean spreads by approximately 90 basis points and miss the amplification mechanism through which volatility affects borrowing costs. This underscores that volatility shocks are not merely a source of consumption risk that risk-averse agents dislike mechanically, but rather a distinct

channel that affects sovereign creditworthiness through expectations about future oil price distributions.

Figure 2 further illustrates the implication of uncertainty in the world oil price by comparing the spread-debt menus across the three different models. For the mean equilibrium debt level in the full model (roughly 34% of GDP), the equilibrium spread level would be about 150 basis points lower in the basic model without oil price shocks even when both the level and the volatility states are at the mean. On the other hand, the economy in the intermediate version of the model faces a mean spread that is around 65 basis points lower than the full model. These results are consistent with Seoane (2019) and Johri et al. (2022), both of which explore the influence of volatility[6] on sovereign spreads. For instance, Seoane (2019) documents that volatility shocks alone can lead to significant fluctuations in spreads, impacting both their first and second moments.

[6]Seoane (2019) refers to volatility in aggregate income and Johri et al. (2022) refers to volatility in world interest rate

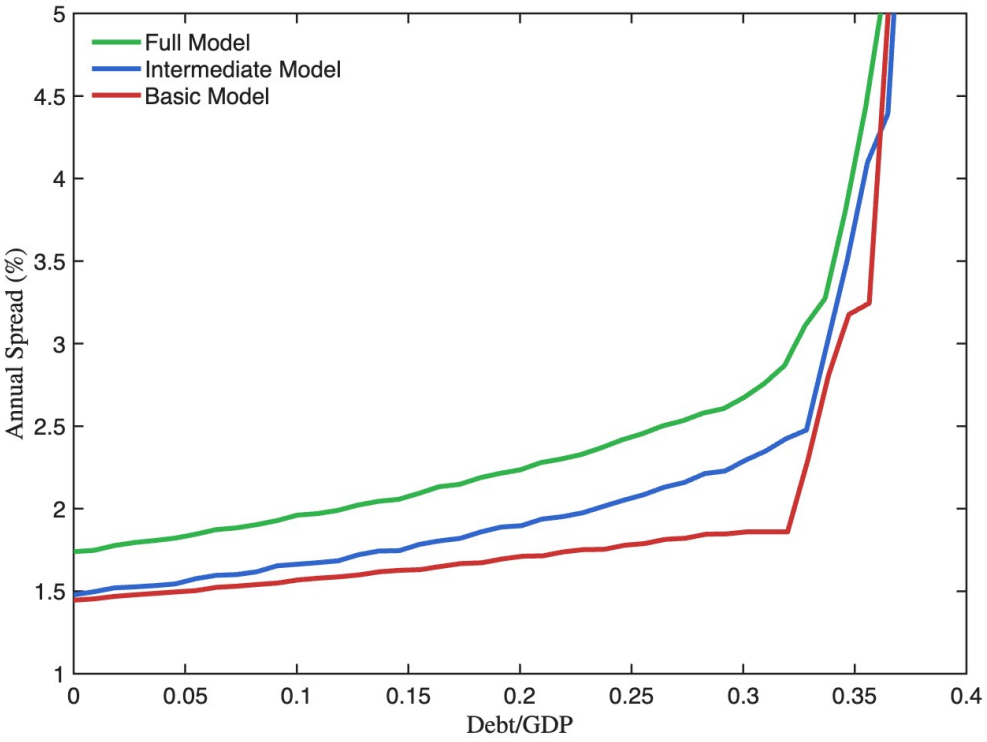


Figure 2: Spread-debt menu in Full vs Basic model

Note: This figure plots the spread menu as a function of the debt/GDP level for the two different types of economies.

6.2.1. Effect of the changes in oil prices on sovereign spread

In this section, I analyze the effect of changes in oil price level and its volatility on sovereign spread and highlight how this response of sovereign spread is highly state-contingent, strongly depending on realizations of state variables, namely the level and volatility of price.

Figure 3 illustrates how the sovereign spread responds to global oil price fluctuations as the output level x varies. The vertical axis quantifies the spread's slope due to price changes, denoted by $\frac{\Delta Spread}{\Delta \text{oil price}}$. Two key economic insights emerge. First, there is an asymmetrical reaction in the spread concerning the output dimension: when output levels are low, the spread slope is significantly higher, whereas this slope tends to approach zero when output exceeds the mean level.

Second, the response of spreads, as measured by the slope, is contingent on the volatility of the global oil price. While maintaining debt at the mean level, the volatility varies among the three economies depicted in Figure 3. The blue line corresponds to a state of mean volatility, the red line signifies a state with volatility below the mean [7], and the green line represents a state of high volatility [8]. Notably, all else being equal, the response of the spread to changes in oil price levels is most pronounced for the high volatility state and least pronounced for the low volatility state. Once again, this difference is particularly significant for low output levels but essentially negligible above the mean output level.

[7] low volatility state refers to a volatility state that is 2 standard deviations below the mean

[8] high volatility state refers to volatility state that is 2 standard deviations above the mean

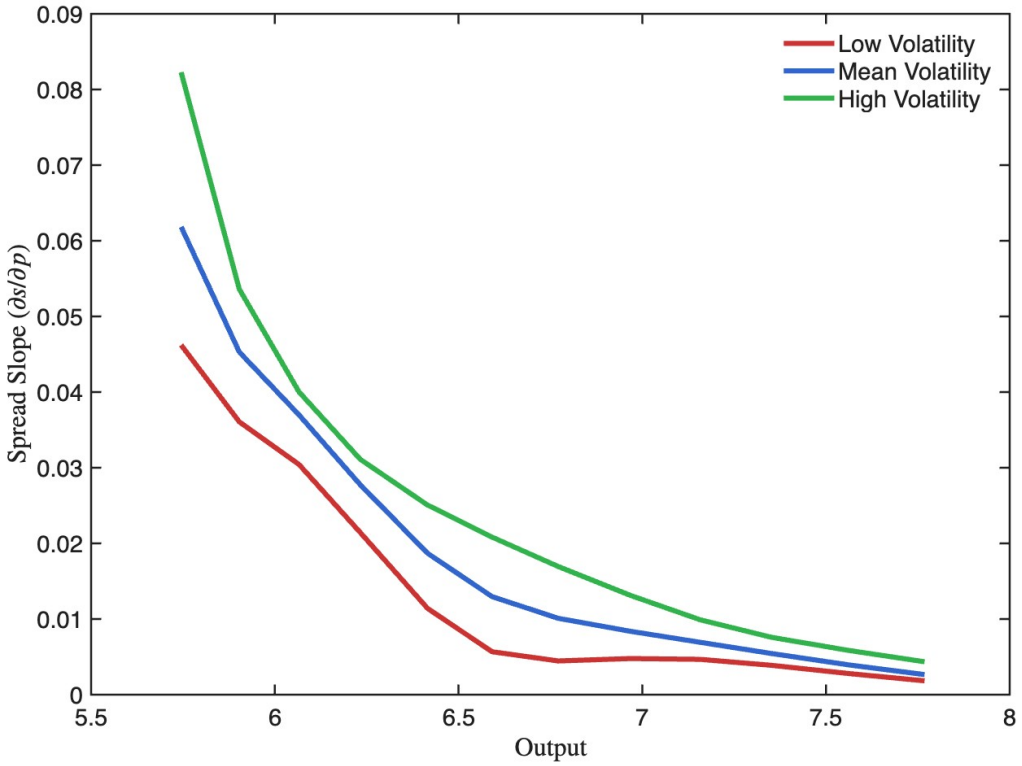


Figure 3: Effect of volatility on spread slope

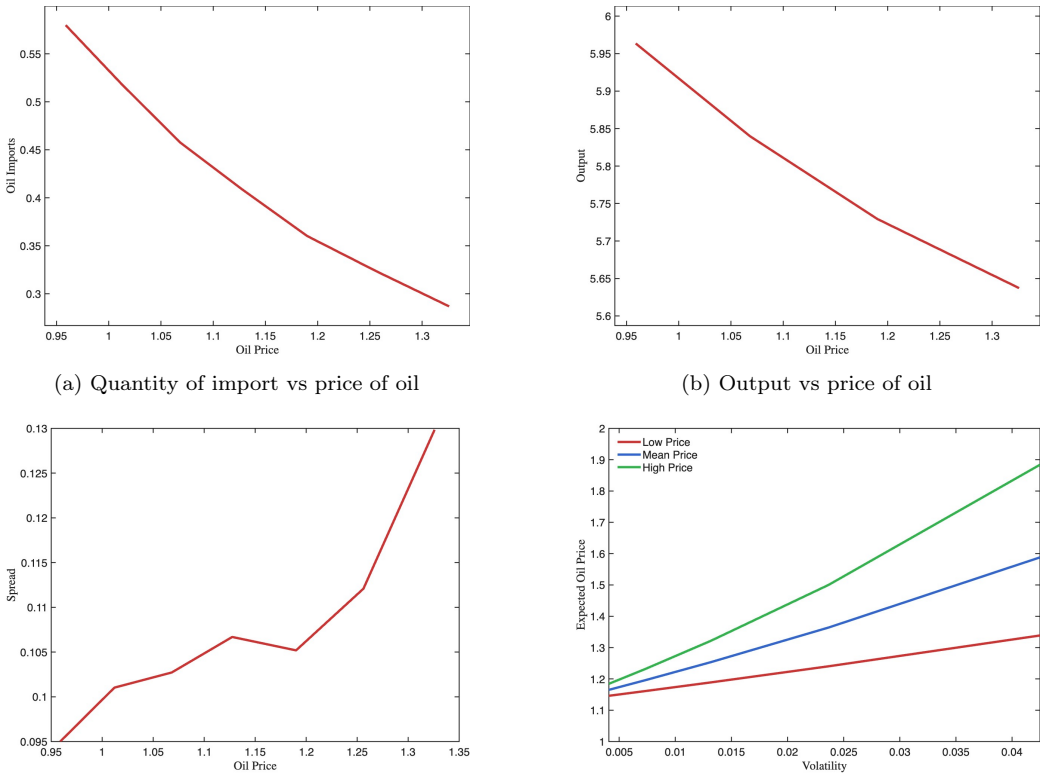
Note: This figure plots the sovereign spread slope against output levels for three different states of volatilities. "Low volatility" refers to a volatility state that is 2 standard deviations above the mean while "high volatility" refers to a volatility state that is 2 standard deviation above the mean. Spread slope measures how sovereign spread responds to global oil price fluctuations and is measured as $\frac{\Delta Spread}{\Delta \text{oil price}}$.

In order to assess a comparable impact of changes in both the level and volatility of oil prices on the spread within my model simulations, I emphasize on reasonable variations in the oil price level. Specifically, I examine the logarithmic difference in oil prices, ranging from 0.05 to 0.35 [9]. Throughout this analysis, the current level of debt is held as a constant while permitting

[9]Various ranges of price level changes have been applied, yielding similar results

potential variations in future debt choices. Furthermore, I allow for output to fluctuate within a range of up to 2 standard deviations around its mean value. Within these empirically relevant bounds, I calculate the spread slope, represented as $\frac{\Delta Spread}{\Delta OilPrice}$, and observe that at mean volatility, the spread slope is 0.051. In the context of low volatility, the spread slope remains at 0.050, while it increases to 0.15 under high volatility conditions. This underscores the fact that the interplay between the magnitude and volatility of oil prices is highly state-contingent. Remarkably, the most pronounced response in the spread due to fluctuations in oil price levels is observed during periods of high volatility, aligning with the findings in Figure 3.

To grasp the mechanism underlying the correlation between spread and volatility, it's valuable to revisit equation 11. Here, it becomes evident that the bond price schedule is influenced by default probabilities and bond prices in the subsequent period, indicating that the bond price is dependent not just on current state variables but also on future period state variables. Essentially, the current period's bond price hinges on the anticipated ability to repay in the future.



(a) Quantity of import vs price of oil

(b) Output vs price of oil

(c) Spread vs price of oil

(d) Expected price vs volatility of oil price

Figure 4: Mechanism underlying the response of spread to the volatility of oil price

Figure 4 vividly illustrates the operation of this mechanism. To gain a clearer understanding of the mechanism, it's essential to grasp the relationship between oil prices and key variables in the economy. As depicted in the first three panels of Figure 4, the quantity of imports and output produced in the economy exhibit a negative response to oil price shocks, while the spread shows a positive correlation with oil prices (similar to what is observed in terms of trade literature such as Cuadra and Sapriza (2006)). Conversely, an increase in uncertainty surrounding current oil prices implies heightened expectations regarding future oil prices (Figure 4d). Elevated expectations about future oil prices suggest a potential decrease in future oil imports, resulting in a decline in future output (Figure 4a and Figure 4b). A decrease in future output forecasts reduced capacity to repay loans in the future, indicating an increase in future default probabilities. Consequently, this leads to a decline in bond prices and an increase in sovereign spread (Figure 4c).

Next, in order to understand how the relationship between the spread's response to oil price fluctuations is influenced by debt levels, I expand upon the previous analysis by modifying the debt levels while keeping volatility at the mean level. Figure 5 displays the spread slope due to oil price changes across three debt regimes (25.6%, 35.0%, and 56.3% debt-to-GDP). The highly indebted economy (green) exhibits the highest slope, while the lightly indebted economy (red) shows the lowest. This demonstrates that debt amplifies the transmission of commodity price shocks to sovereign borrowing costs, with the amplification effect strongest during moderate downturns.

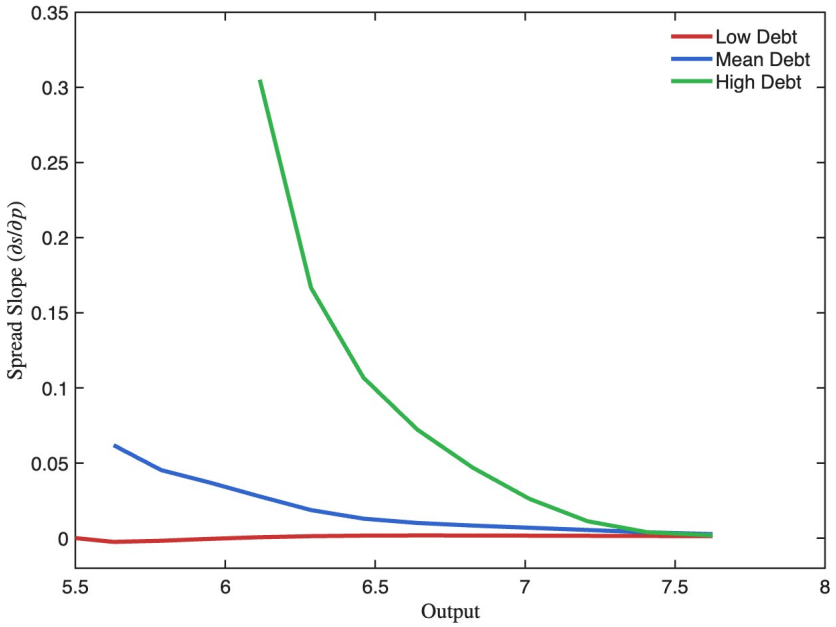


Figure 5: Effect of debt on spread slope

Note: This figure plots the response of sovereign spread changes to oil price level across three debt levels (25.6%, 35.0%, and 56.3% debt-to-GDP).

6.3. Effect on borrowing decisions

Figure 6 illustrates how oil price levels influence borrowing decisions under different volatility regimes. The left panel corresponds to a low volatility state, while the right panel corresponds to a high volatility state. In each panel, the red line represents the borrowing policy when oil prices are low,

and the blue line represents the borrowing policy when oil prices are high. Output is held at its mean level throughout.

Two key observations emerge. First, in the low volatility state (Figure 6a), oil price levels have virtually no effect on borrowing decisions - the two lines nearly overlap. This occurs because when volatility is low, agents expect oil prices to remain close to their current level, so the current price contains little information about future borrowing conditions.

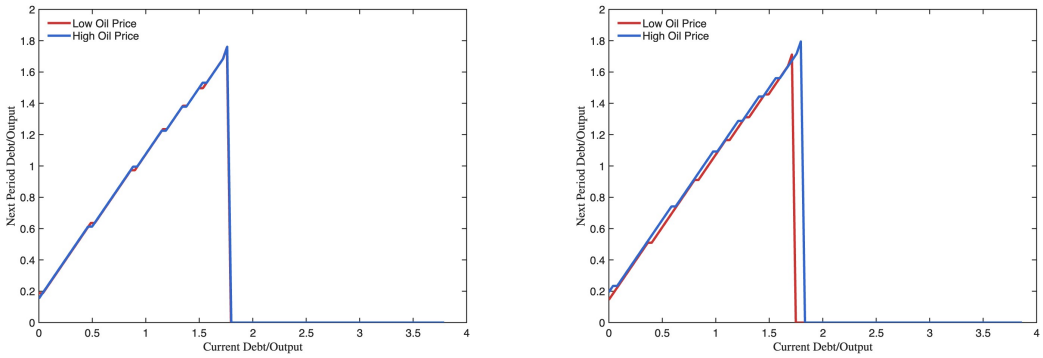
Second, in the high volatility state (Figure 6b), borrowing decisions become responsive to oil price levels. At intermediate debt levels, the government borrows *more* when oil prices are high (blue line above red line). This may appear counterintuitive, as high oil prices reduce current output and raise current spreads. However, the mechanism operates through expectations: high volatility implies that oil prices are expected to rise further in the future (Figure 4d). Anticipating higher future prices - and thus lower future output and higher future spreads - the government increases borrowing today while credit conditions are relatively more favorable than what they may become tomorrow.

This behavior reflects *precautionary borrowing* which means the government accumulates debt in anticipation of potentially worse future borrowing conditions, effectively front-loading its financing needs. However, this strategy is not costless: higher debt levels increase default risk. This is evident in Figure 6b, where the debt threshold triggering default (the point where the policy function drops to zero) shifts leftward under high oil prices, indicating that the government defaults at lower debt levels when oil prices are elevated.

To quantify the responsiveness of borrowing to oil price fluctuations, I compute the "debt slope," defined as $\frac{\Delta \text{Debt/GDP}}{\Delta \text{Oil Price}}$. At mean volatility, the average debt slope is 0.25. The influence of volatility on this response is substantial: the debt slope falls to 0.16 during low volatility periods but rises to 0.70 during high volatility periods. This demonstrates that volatility amplifies the responsiveness of borrowing decisions to oil price fluctuations by a factor of more than four.

This precautionary borrowing mechanism is distinct from the standard countercyclical borrowing pattern documented in sovereign default models. In the canonical framework of Arellano (2008), borrowing increases when income is high and spreads are low. Here, I show that *conditional on income*, borrowing also responds to oil price volatility. When volatility is high, the government borrows more aggressively in response to oil price increases because it anticipates that waiting could result in even higher spreads. This

channel is absent from models without stochastic volatility in commodity prices and highlights the importance of incorporating time-varying uncertainty into sovereign default frameworks.



(a) Low σ_p (b) High σ_p

Figure 6: Effect of volatility on borrowing decisions

Note: This figure plots debt choice as a function of the current debt level for two different states of oil prices: "low price" state where the price level of oil is below the mean, and "high price" state where the price level is above the mean. The left panel corresponds to a state of low volatility level, while the right panel represents a state of high volatility level.

6.4. Welfare implications

Having shown that variation in the world oil price can have state-contingent impacts on the borrowing costs of my "full model" economy, I now wish to quantify the welfare consequences of this variation. That is: what is the welfare cost of being exposed to shocks to the world oil price? Or equivalently, what are the welfare gains of getting rid of the global oil price uncertainty? The gain is computed as the constant proportional change in consumption that would leave a consumer indifferent between continuing to live in the alternative economy (either full or intermediate) and moving to the basic-model economy. Figure 7 plots these gains as a function of the endowment level, holding debt at the average level for both the economies[10]. In both

[10]this analysis has been repeated at different debt levels, and the results are found to be robust to the different levels of debt

cases (moving from the full to the basic economy, and moving from the intermediate to the basic economy) gains are positive and sizable. The average welfare gains of moving to the basic-model economy are 1.1% (from the full model) and 0.15% (from the intermediate model).

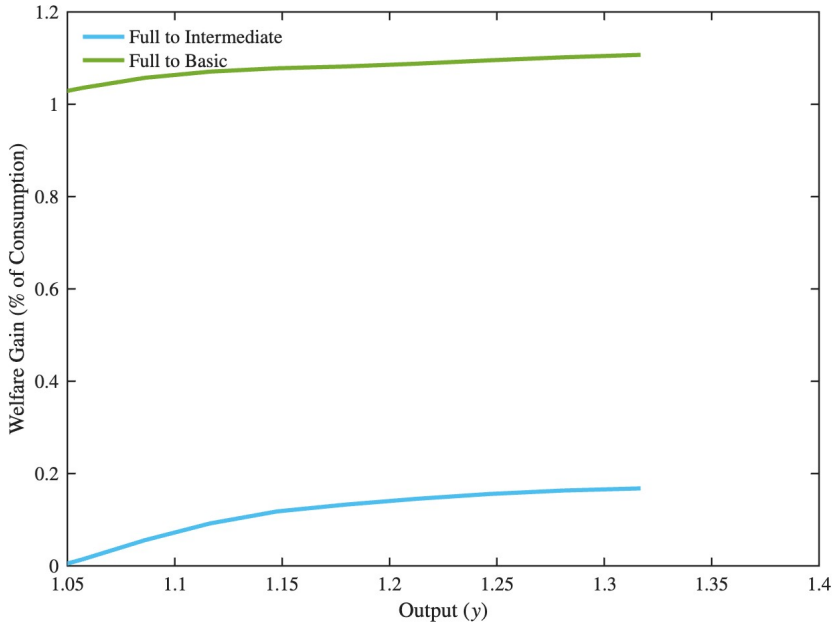


Figure 7: Welfare gains of moving from the full economy

Note: This figure plots the welfare gains of moving from the full to the basic or to the intermediate economies. The gains are computed as as a function of the endowment level, holding debt at the average level.

Hence, the welfare analysis demonstrates the crucial need to incorporate volatility shocks to oil prices into sovereign default models. Omitting this key aspect of oil price data would lead to an underestimation of the significance of oil price shocks on sovereign default risk. Recognizing the importance of including volatility shocks in default models is essential for policymakers to account for these shocks when designing economic policies. This understanding can lead to the development of better risk management strategies and policies that mitigate the adverse effects of such volatility.

7. Conclusion

In this paper, I have introduced time-varying volatility in the global oil price within a standard sovereign default model featuring long-term debt. The evolution of the global oil price encompasses both shocks affecting its level and shocks influencing its volatility. The dynamic nature of the global oil price interacts with default incentives, and its impact on borrowing and sovereign spreads is contingent on the prevailing economic state.

My findings reveal that the slope of sovereign spreads in response to changes in the oil price level is 0.15 during periods characterized by high volatility, whereas it diminishes to 0.05 when volatility is low. Notably, a higher level of debt intensifies the response of spreads to changes in the world oil price.

It's essential to underscore that borrowing decisions, in response to fluctuations in oil price levels, are also notably influenced by the current state of the economy. The impact of volatility on the debt slope is particularly significant, registering at 0.16 during phases of low volatility and surging to 0.7 during high volatility states.

The government's inclination to borrow more in times of oil price uncertainty is reinforced by the significantly higher spread slope observed during periods of heightened oil price volatility. Given that the increase in spreads due to a rise in oil price levels is notably higher during high volatility times, the government opts to borrow in advance whenever it foresees future oil price increases. This proactive borrowing serves as a type of insurance, allowing the government to cover the elevated import costs and higher borrowing rates that could ensue if oil prices surge in the future. As a result, this heightened borrowing increases the likelihood of default and, consequently, results in elevated borrowing expenses. While this paper addresses a distinct form of uncertainty as analyzed in Seoane (2019) and Johri et al. (2022), specifically, the time-varying volatility of the global oil price, the outcomes align: increased uncertainty corresponds to elevated sovereign spreads.

Finally, this paper emphasizes the critical need to incorporate volatility shocks in oil prices into sovereign default models by comparing the welfare effects of an economy with oil price uncertainty to one without it. The results from the welfare analysis highlight the importance of including oil price volatility shocks in these models. Recognizing the significance of these volatility shocks is also vital for policymakers, as it enables them to consider these fluctuations when formulating economic policies. This understanding

can lead to better risk management strategies and policies that mitigate the adverse effects of such volatility.

Appendix A. List of countries

Belarus, Bulgaria, Chile, China, Cote D'Ivoire, Croatia, Dominican Republic, El Salvador, Ghana, Hungary, India, Indonesia, Jamaica, Jordan, Kenya, Korea, Lithuania, Malaysia, Morocco, Pakistan, Peru, Philippines, Romania, Poland, Senegal, Serbia, Slovak Republic, South Africa, Sri Lanka, Thailand, Trinidad, Tunisia, Ukraine, Uruguay, Zambia

Appendix B. Empirical results (robustness check)

As a robustness check, I re-estimate the relationship between oil price volatility and sovereign spreads using monthly data and a levels specification with a lagged dependent variable. Table B.5 reports the results. The dependent variable is the level of the sovereign spread in basis points. Across all three specifications, oil price volatility enters with a positive and highly significant coefficient, reinforcing the baseline results from the quarterly first-difference specification. The magnitude of the volatility coefficient ranges from 5.85 to 6.14, indicating that a one-unit increase in oil price volatility is associated with an increase of approximately 6 basis points in the sovereign spread, after controlling for the lagged spread, oil price levels, and other macroeconomic variables. The log of the real oil price reports a positive but statistically insignificant coefficient, suggesting that once volatility is controlled for, the price level itself has a limited direct effect on spreads at the monthly frequency. The US T-bill rate is also insignificant in these specifications, consistent with the quarterly results and likely reflecting that the T-bill's effect on emerging market spreads operates primarily through global risk channels already captured by the spread's own persistence and the volatility measure.

Table B.5: Robustness: Monthly Dynamic Panel Specification (Levels)

	Dependent variable: Spread (level)		
	(1)	(2)	(3)
Spread_{t-1}	0.96***	0.96***	0.96***
	(0.01)	(0.01)	(0.01)
Oil price volatility	5.85***	6.14***	6.14***
	(1.32)	(1.34)	(1.34)
log(Oil price)	2.00	3.38	3.18
	(2.32)	(3.46)	(3.33)
Debt/GDP		−0.32	−0.33
		(0.62)	(0.63)
US T-bill		1.23	1.32
		(1.74)	(1.96)
Reserves/GDP			0.03
			(0.12)
Country FE	Yes	Yes	Yes
Observations	6,317	5,874	5,874
R^2	0.94	0.94	0.94
Adjusted R^2	0.94	0.94	0.94
F Statistic	32,966.42***	18,067.24***	15,053.67***

Standard errors clustered at the country level in parentheses.

***p<0.01; **p<0.05; *p<0.1

The dependent variable is the level of the sovereign spread (in basis points).

Data are at monthly frequency for 35 oil-importing countries, 1995–2019.

Oil price volatility is estimated from the stochastic volatility model described in Section 4.1

Appendix C. Oil Price Estimation

As explained in the main text, equations 6 and 7 are estimated using the stochvol R package. This package implements an efficient algorithm for Bayesian estimation of stochastic volatility models via MCMC methods (See Kastner (2019)).

Prior studies suggest that the time series of crude oil prices are often characterized by fat-tailed distribution, volatility clustering, mean reversion, and

asymmetry (see Abosedra and Laopodis (1995); Morana (2001); Bina and Vo (2007)). Other studies find evidence of structural changes and regime shifts in the volatility of oil prices due to exogenous factors such as political turmoil, and changes in OPEC oil policies (Wilson et al. (1996),Fong and See (2002)). Autoregressive conditional heteroskedasticity (ARCH) and GARCH models have been extensively used to model the dynamics of oil prices, but the stochastic volatility (SV) framework has drawn much attention in financial econometric literature.

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