THREE ESSAYS ON SOVEREIGN DEFAULT

- UNVEILING GLOBAL AND DOMESTIC DRIVERS

Three Essays on Sovereign Default

- Unveiling Global and Domestic Drivers

by

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Abstract

This thesis consists of three chapters on sovereign default. The first chapter, "*Oil Price Uncertainty and Sovereign Spreads of Oil Importers*", studies how changes in the volatility of global oil prices affects sovereign spreads. This study introduces time-varying volatility in global oil prices within a sovereign default model featuring long-duration bonds for a small open economy that relies on oil as a production input. The second chapter, "*International Sovereign Spread Differences and the Poverty of Nations*" (co-authored with Alok Johri), explores the role of poverty in explaining the differences in sovereign default across countries. By constructing a sovereign default model with poor and non-poor households and a government that wishes to run a social safety net using a tax-transfer scheme, we show that the higher default risk associated with a higher proportion of poor households implies much worse credit terms from international lender. The third chapter, "*The Bribe Rate and Long Run Differences in Sovereign Borrowing Costs*" (co-authored with Alok Johri and Johnny Cotoc), and published in the Journal of Economic Dynamics and Control, Volume 151(2023), shows that sovereign spreads and the level of bureaucratic diversion of government spending vary widely across emerging economies and are correlated with each other. By building a sovereign default model where the government is constrained to use corrupt bureaucrats to deliver public goods and service, we show that economies with low monitoring efficiency display higher diversion levels and higher default risk (and spreads) than those with higher efficiency.

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Declaration of Academic Achievement

Chapter 2 is co-authored with Professor Alok Johri. Chapter 3, co-authored with Professor Alok Johri and Johnny Cotoc, is published in the Journal of Economic Dynamics and Control, Volume 151(2023). I am the sole author of Chapter 1. I participated in all stages of the research.

Introduction

Sovereign default continues to be a highly contemplated subject among policymakers and academics due to its significant consequences. Sovereign default occurs when a government is unable or unwilling to meet its debt obligations, specifically those associated with government bonds or loans. This means that the government fails to make scheduled interest payments or repay the principal amount borrowed, leading to a breach of its debt contracts. There has been a substantial surge in the number of sovereign defaults in the past three years. Since 2020, there have been 14 such instances in nine countries. This marks a notable uptick compared to the previous two decades, from 2000 to 2019, during which there were 19 defaults in 13 different countries. Emerging economies characterized by elevated poverty rates and insufficient financial reserves were ill-equipped to effectively handle the profound shocks triggered by the pandemic and the consequences of Russia's invasion of Ukraine.

Understanding the dynamic processes around sovereign default holds significant importance due to its far-reaching consequences for the global economy, financial stability, and the well-being of countries and their citizens. While there exists a substantial body of literature dedicated to examining the dynamics of sovereign spreads (defined as the difference between the yields of sovereign bonds issued by emerging economies and the yields of U.S. Treasury bonds), there is no consensus regarding the factors influencing this variable. One branch of this literature uncovers findings that indicate the sovereign risk premium is determined externally, or at the very least, a significant portion of it is not contingent upon domestic circumstances, while another branch believes a large share of sovereign spread variability depends on domestic factors.

Studies underlining the importance of global factors on determining spread levels and default risk include Uribe and Yue (2006), Reinhart et al. (2016) and Longstaff et al. (2011). For instance, Longstaff et al. (2011) suggest that sovereign credit risk is driven much more by global financial market variables such as U.S. stock and high-yield bond markets, and global risk premia than by local economic forces. Johri et al. (2022) find that fluctuations in the level and volatility of the world interest rate affect sovereign spreads in emerging economies. The other strand of literature has stressed on the significance of country-specific factors such as income inequality, fiscal rules, political factors and corruption (Jeon and Kabukcuoglu (2018), Cotoc et al. (2021), Alamgir et al. (2023), Hatchondo and Martinez (2010), Hatchondo et al. (2022) and Bianchi et al. (2018)).

In my thesis, I contribute to both of these strands of literature in order to explain sovereign default in emerging nations. In my first chapter "Oil price uncertainty and sovereign default" (Alamgir, 2023), I study sovereign default risk through the lens of a global factor namely oil price volatility. Oil price fluctuations are a major source of instability in the global economic condition and it is highly probable that shifts in market sentiment regarding sovereign risk, as well as major macroeconomic conditions, will coincide with fluctuations in oil prices (Kilian (2009), Ploeg (2011), Arezki and Blanchard (2014)). First, I establish a positive correlation between sovereign spreads and oil price volatility across 35 oil-importing countries. Subsequently, I introduce time-varying volatility in the global oil price within a sovereign default model with long-duration bonds for a small open economy that imports oil as a factor of production. The price of oil is subject to fluctuations governed by a stochastic volatility process. By incorporating a stochastic volatility framework for oil prices, this chapter illustrates 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 significant fluctuations. This choice is primarily driven by the uncertainty prevailing in the oil market during these periods of high volatility. Consequently, substantial welfare gains are observed when comparing the benchmark calibrated economy to economies where there are no variations in the level or volatilities of oil price, resulting in an average welfare gain of 1.2 to 1.4% increase in consumption.

My second chapter "International sovereign spread differences and the poverty of nations" (with Alok Johri) (Alamgir and Johri (2022)), makes a slight departure from this body of literature and explores the role of poverty in explaining the differences in sovereign spread across countries. The main idea hinges on the fact that governments of low-income nations, when confronted with bad income shocks face incredibly challenging decisions. There's an inclination to boost revenue and tighten expenditure to reduce debt levels and lower borrowing costs, but reducing expenditure has dire consequences when sizeable portions of the population living at or near poverty line are at risk of starvation without government support. Additionally, the government's ability to collect revenue is constrained by the willingness of non-poor citizens to pay taxes when debt repayment burdens are high. Given this complex dynamic, governments might opt for default as the preferred course of action. In recognition of this, lenders expect higher interest rates on their sovereign bonds to compensate for the additional default risk, further intensifying fiscal pressures. By constructing a sovereign default model with poor and non-poor households and a government that wishes to run a social safety net using a tax-transfer scheme, we show that the higher default risk associated with a higher proportion of poor households implies much worse credit terms from international lender.

In my third chapter "The bribe rate and long run differences in sovereign borrowing costs" (with Johny Cotoc and Alok Johri) (Alamgir et al, 2023), we explain the long run differences in sovereign spread across countries through another local factor which is bureaucratic corruption. To comprehend the positive relationship between sovereign spreads and bureaucratic corruption, we construct a model of sovereign default for a small open economy in which the government wishes to deliver public goods and services but is compelled to engage corrupt bureaucrats for budget management and the execution of public projects. The model calibrated to international data implies a positive link between the average diversion of public resources and the average spread. The primary insight behind the increased default risk in nations with lower monitoring efficiency is that the diversion policy becomes more pronounced as more resources enter the budget. In the absence of diversion, when government revenue is low, there may be an inclination to default to prevent a significant outflow of funds to international creditors. In our model, the government understands that bureaucratic diversion decreases in the event of default. In cases where a nation's monitoring efficiency is lower, the reduction in diversion is more substantial, making default a more appealing option. Consequently, the default risk is larger for nations with weaker monitoring efficiency, leading to higher sovereign spreads and necessitating reduced borrowing to manage their borrowing costs.

Hence, my thesis contributes to the ongoing discourse by examining the interplay of oil price volatility, poverty, and corruption on sovereign default risk. The findings highlight the heightened sensitivity of sovereign spreads to oil price fluctuations, the exacerbating role of poverty in sovereign risk, and the detrimental impact of bureaucratic corruption on borrowing costs. These insights are crucial for developing more effective economic policies and risk management strategies to mitigate the adverse effects of sovereign defaults.

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Chapter 1

Oil Price Uncertainty and Sovereign Spreads of Oil Importers

1.1 Introduction

There has been a significant increase in the number of sovereign defaults over the past three 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 since 2020. This represents a notable upswing in the default rate, recording a 34% increase in the average default rates per year in 2020 compared to that in 2019. According to the BoC's database, debt in default surged by 52% for Heavily Indebted Poor Countries and 47% for sovereigns in emerging and frontier markets in 2020 compared to 2019. 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]

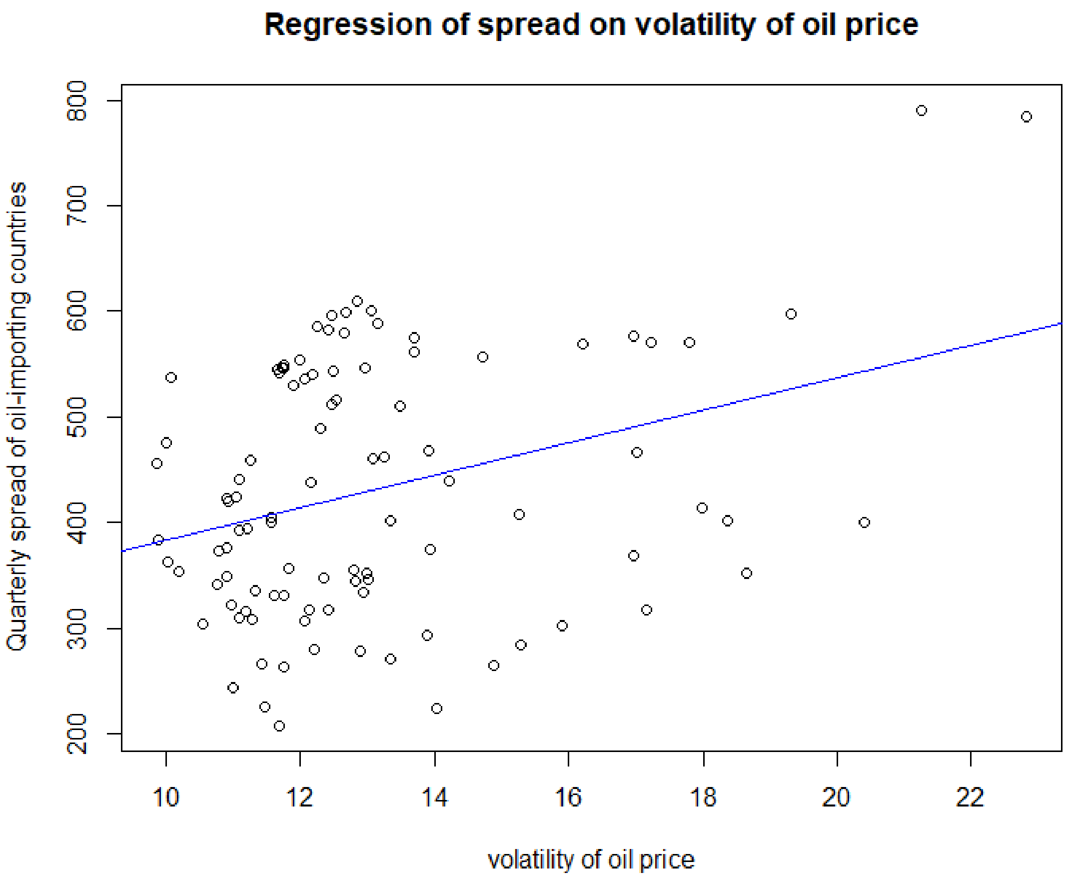
Figure 1.1 depicts the correlation between country spreads and oil price volatility in major oil-importing nations spanning 1995 to 2019. The horizontal axis represents my quarterly estimates of the standard deviation for West Texas Intermediate (WTI) crude oil prices. (detailed explanations can be found in section 1.4.1). The vertical axis reports the quarterly spread averaged across 35 oil-importing countries. The spread is defined as the difference between the yields of a country's sovereign bonds and the yield of the US 10-year treasury bond. As illustrated in Figure 1.1, there is a significant positive correlation between country spreads and the volatility of worldwide oil prices. For instance, the quarterly spread is 250 basis points on average when oil price volatility hovers around 11 %, but escalates to 550 basis points when oil price volatility reaches approximately 18 %.

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. Importantly, 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 encompasses the period from Q1 1995 to Q3 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

[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))

Figure 1.1: Country spreads vs. oil price movements in major oil-importing countries



Note: This figure plots the quarterly spread for oil-importing countries against oil price volatility. The oil price volatility, expressed as percentages, is reported in section 1.4.1. Each point on the graph represents the quarterly spread averaged across 35 oil-importing countries at a specific level of oil price volatility.

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 1.2 to 1.4% increase in consumption.

Layout. The rest of the paper proceeds as follows. Section 1.2 reviews the related literature. Section 3.2 presents the empirical findings. Section 3.3 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 3.4 discusses the calibration of the model, and section 3.5 studies the main results and quantitative implications of the theory. Section 3.6 concludes.

1.2 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.

1.3 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 difference 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 1.4.1

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

$$\Delta spread_{it} = \beta_0 + \beta_1 \Delta oil\ price_t + \beta_2 oil\ price\ volatility_t + \Lambda' X_{it} + \Phi' Y_t + u_{it} \tag{1.1}$$

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. 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 1.1 presents the baseline results from Equation 1.1 with standard errors reported in parentheses. In column (1), the simplest specification of Equation 1.1 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

[2]Further estimation details for the stochastic volatility process are in Appendix 1.7.2

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

Table 1.1: 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)
Year 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.

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 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.

1.4 The Model Environment

Consider a small open economy that comprises 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:

$$u(c) = \frac{c^{1-\gamma}}{1-\gamma} \tag{1.2}$$

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:

$$x = [(1-\alpha)y^{\theta} + \alpha m^{\theta}]^{\frac{1}{\theta}} \tag{1.3}$$

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 guarantees an infinite stream of coupons, which decline at a constant rate δ. Specifically, a bond issued in period t will 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 start of the current period and b' to the number of coupons due at the start 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 chooses between defaulting or repaying, and subsequently determines the quantity of bonds to purchase or issue for the following 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:

$$c + pm = x + [b' - (1-\delta)b]\, q(b', y) - \kappa b \tag{1.4}$$

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 opts for default, it will default on all current obligations and be barred from the financial market for an uncertain 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:

$$c_a + pm_a = x_a \tag{1.5}$$

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

1.4.1 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:

$$log(p_t) - \bar{p} = \rho_p(log(p_{t-1}) - \bar{p}) + exp(\sigma_t)u_t \qquad u_t \sim IID(0,1) \tag{1.6}$$

$$\sigma_t - \mu = \rho_\sigma(\sigma_{t-1} - \mu) + \eta\varepsilon_t \qquad \varepsilon_t \sim IID(0,1) \tag{1.7}$$

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.

1.4.2 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.

1.4.3 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:

$$v^c(b,y,p,\sigma) = \max_{b'} \left\{ u(c) + \beta \mathbb{E}_{y',p',\sigma'|y,p,\sigma} v^o(b',y',p',\sigma') \right\}, \tag{1.8}$$

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:

$$v^d(y,p,\sigma) = u(c_a) + \beta \mathbb{E}_{y',p',\sigma'|y,p,\sigma} \Big(\Phi v^o(0,y',p',\sigma') + (1-\Phi) v^d(y',p',\sigma') \Big) \tag{1.9}$$

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:

$$v^o(b,y,p,\sigma) = \max_{d\in\{0,1\}} \{(1-d)v^c(b,y,p,\sigma) + dv^d(y,p,\sigma)\} \tag{1.10}$$

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

1.4.4 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:

$$q(b', y, p, \sigma) = E_{y',p',\sigma'|y,p,\sigma} \frac{(1 - d(b', y', p', \sigma'))(\kappa + (1 - \delta)q(b'', y', p', \sigma'))}{1 + r^*} \tag{1.11}$$

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

1.4.5 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 (1.10), (3.8) and (3.10) 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 (1.11);

(c) the default and borrowing policy functions d and b' solve the recursive problem defined by equations (1.10), (3.8) and (3.10) when the government can trade bonds at q and given the domestic consumption policy c, import policy m and production x.

1.5 Calibration

The model is solved numerically by employing value function iteration on a discretized state space encompassing b, y, p, and σ. The endowment shock and oil price volatility shock are discretized using Tauchen (1986)'s method, while the oil price level shock is discretized using the Rouwenhorst's method (Kopecky and Suen (2010)). The parameterization of the stochastic processes that govern the behavior of the oil price is done by estimating equations 1.6 and 1.7 using quarterly data on the real oil price for the period 1998 to 2019. The values of the mean parameters $\{\bar{p}, \rho_p\}$ and the volatility parameters $\{\mu, \rho_\sigma, \eta\}$ are presented in table 2.3.

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 1998 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:

$$lny_t = \rho lny_{t-1} + \epsilon_t, \tag{1.12}$$

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 the standard values used in the real business cycle literature for small open economies as well as in the quantitative sovereign default literature, I adopt 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.

Table 1.2: 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
Bond coupon	κ	0.12	$(r^* + \delta)/(1 + r^*)$
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	m	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 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 1998-2019. 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 1998-2019 extracted from the World Development Indicators dataset of the World Bank and JP Morgan's EMBI Global Index.

1.6 Results

1.6.1 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-maturity r^f[5] earned on an identical but default-free bond. Since the model is calibrated at a quarterly frequency, the annualized spread is then calculated as $4(r^b - r^f)$.

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 3.4. 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 3.4, 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)).

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

[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 1.3: Targeted and non-targeted moments

	Data	**Model**
Targeted moments		
Mean spread (%)	4.1	4.1
Mean debt/GDP (%)	34.0	34.9
Standard deviation of spread	2.0	2.1
Mean oil import/GDP (%)	9.0	10.1
Non-targeted moments		
Correlation(spread, GDP)	-0.4332	-0.8289
Correrlation(tb/GDP, GDP)	-0.4104	-0.8624
Correrlation(spread, tb/GDP)	0.3566	0.8523

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 in %

1.6.2 Comparing the model to the data

In order to compare the model's ability to generate the positive correlation between spread and oil price volatility found in section 3.2, I generate simulated data from the full model with all parameters kept at their benchmark values. I simulate the model economy along 500 sample paths with 1500 periods each and then remove the first 500 observations from each sample as burn-in. Next, from the remaining data, I extract 500 samples with 100 periods before default in order to make it comparable to the empirical results. I then regress the log difference in spread on the log difference in oil price, the volatility of oil price and external debt to GDP ratio and a constant and report the results in column 3 in Table 3.5. Table 3.5 also reports the analogous regression coefficients from the data.

Table 1.4: comparing model to data

Dependent variable: Δ log(Spread)	**Data**	**Simulation**
Constant	-0.208***	-0.990***
	(0.015)	(0.000)
Volatility of Oil price	0.016***	0.001*
	(0.001)	(0.000)
Δ log(Oil price)	0.196*	0.025***
	(0.032)	(0.011)
Δ Debt/ GDP	0.039*	0.287*
	(0.004)	(0.028)

Standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

Like the actual international data, the simulated model-generated data produces a positive correlation between log difference in spread and the log difference in level and volatility of oil price once we control for indebtedness. The model based coefficients on the level as well as volatility of oil price is smaller than that found in the data. In contrast, the coefficient of the debt to revenue ratio is bigger than in the data, though also of the correct sign.

1.6.3 Implications of time-varying volatility of oil price

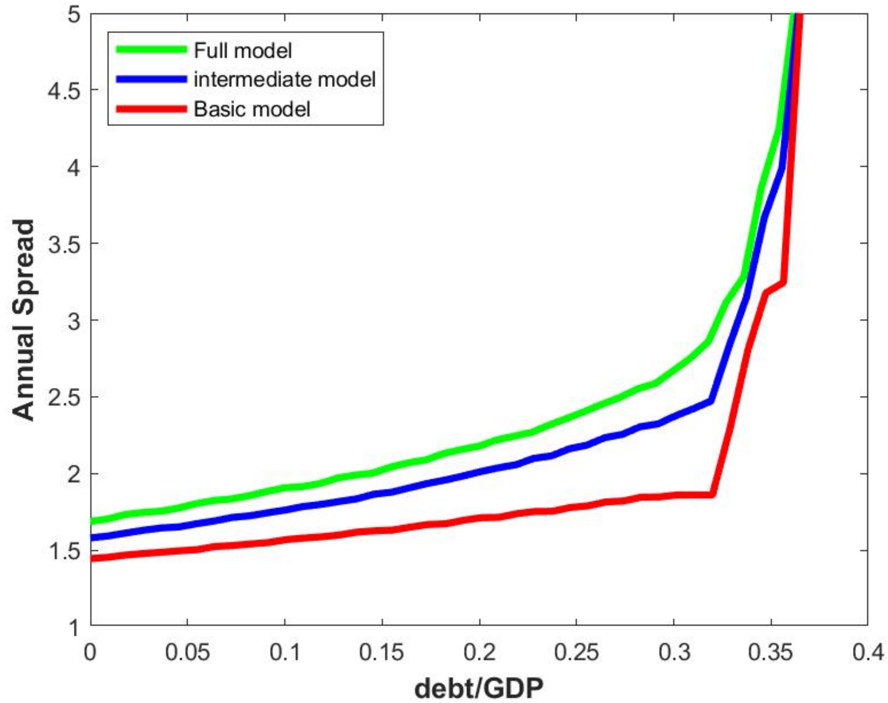
Table 1.5: Key moments: Full, intermediate and basic models

	Full model	**Intermediate model**	**Basic model**
Mean spread (%)	4.10	3.65	2.49
Mean debt/GDP (%)	34.9	34.9	33.4
Standard deviation of spread	2.4	1.9	1.6
Mean default rate (%)	0.77	0.66	0.41

Note: This table presents 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.

In this section, I study whether volatility shocks can have a quantitatively important effect on the dynamics of the sovereign risk premium. To illustrate this point, I compare the benchmark calibrated model which will be termed as the "full model" to two variant models: one is the intermediate model in which the innovations to volatility is set to zero, implying that the volatility of oil price is fixed at its mean, and the "basic model" in which the oil price is held constant ((i.e. I set $u_t = \epsilon_t = 0$ in the basic model while leaving all other parameters unchanged at their values in the full model)). This will help me to disentangle the results of the full model to study the relative contribution of u_t and ϵ_t. I simulate and compute statistical moments from the basic model and the intermediate models in the same way as I did for the full model. Table 1.5 presents a comparative analysis of various aspects related to debt and default decisions across these three model economies. Comparing across the columns for the full and basic models, my simulations indicate that on average the full model faces a higher and more volatile spread to hold the same amount of debt. The average spread in the full model is 64% higher than in the basic model, and the volatility of the spread is 56% greater in the full model compared to the basic model with no oil price shocks. These oil price shocks also result in a default rate that is 92.5% larger than what the model would produce with a constant world oil price. Now, introducing the intermediate model

Figure 1.2: Spread-debt menu in Full vs Intermediate vs Basic model

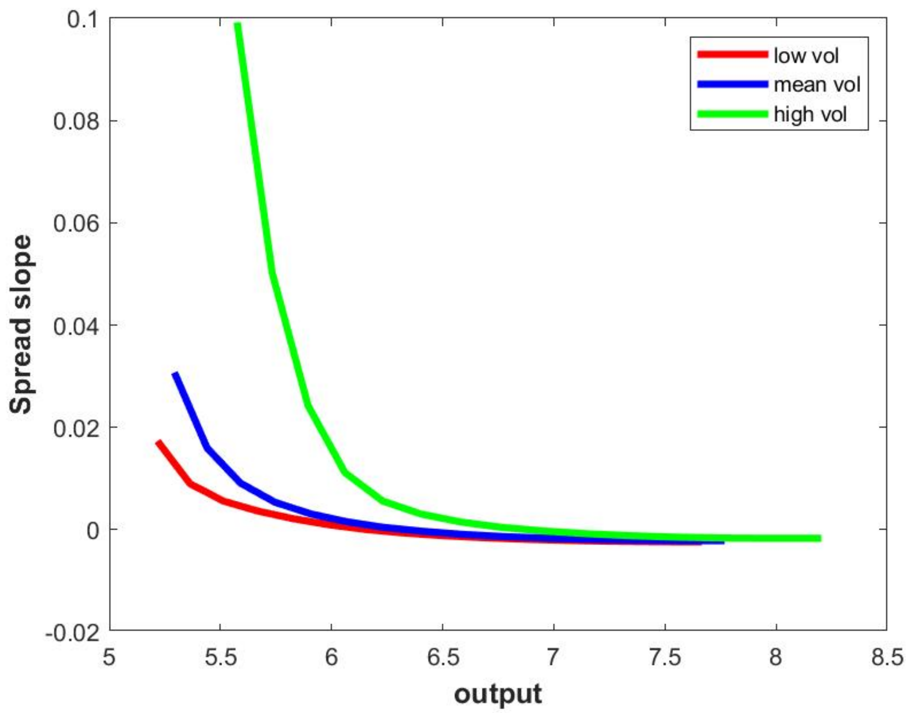


Note: This figure plots the spread menu as a function of the debt/GDP level for the three different types of economies.

demonstrates that, as anticipated, the intermediate version of my model (in which there are oil price level shocks but not volatility shocks, $\epsilon = 0$) generates default statistics that lie between those of the basic and full models. the world oil price: in particular, I see that including volatility shocks increases the mean spread by 45 basis points and the volatility of the spread by 50 basis points; while keeping the debt-to-income ratio roughly unchanged (it increases by 1%). Figure 1.3 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

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

Figure 1.3: 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 $\frac{\Delta Spread}{\Delta \text{oil price}}$.

spreads, impacting both their first and second moments.

1.6.4 Effect of the changes in oil prices on sovereign spread

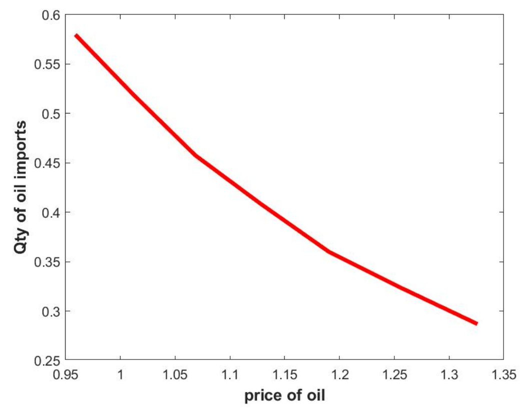
In this section, I analyze the effect of changes in oil price level and its volatility on sovereign spread and highlight how this response of sovereign spread is highly state-contingent, strongly depending on realizations of state variables, namely the level and volatility of price. Figure 1.3 illustrates 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 noteworthy observations emerge from this exercise. Firstly, 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. Secondly, 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 1.3. 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.

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 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 $\frac{\Delta Spread}{\Delta Log(OilPrice)}$, 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 1.3.

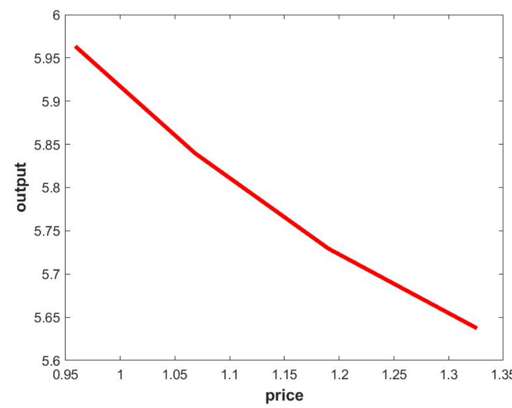
To grasp the mechanism underlying the correlation between spread and volatility, it's valuable to revisit equation 1.11. Here, it becomes evident that the bond price schedule is influenced by default probabilities and bond prices in the subsequent period, indicating that the bond price is dependent not 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.

Figure 1.4 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 1.4, 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 1.4d). Elevated expectations about future oil prices suggest a potential

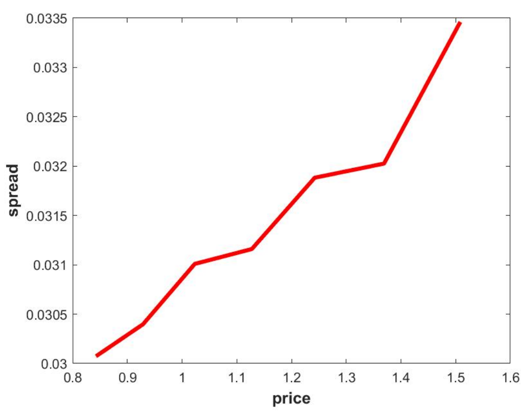
[7] low volatility state refers to a volatility state that is 2 standard deviations below the mean
[8] high volatility state refers to volatility state that is 2 standard deviations above the mean
[9] Various ranges of price level changes have been applied, yielding similar results



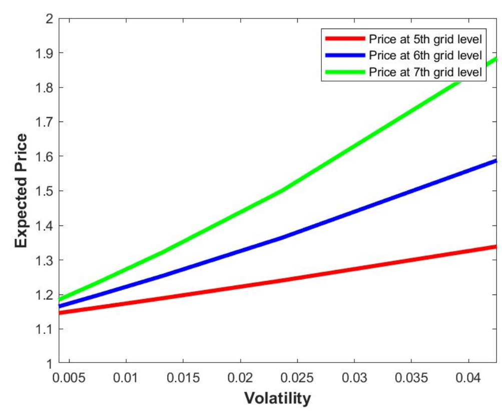
(a) Quantity of import vs price of oil



(b) Output vs price of oil



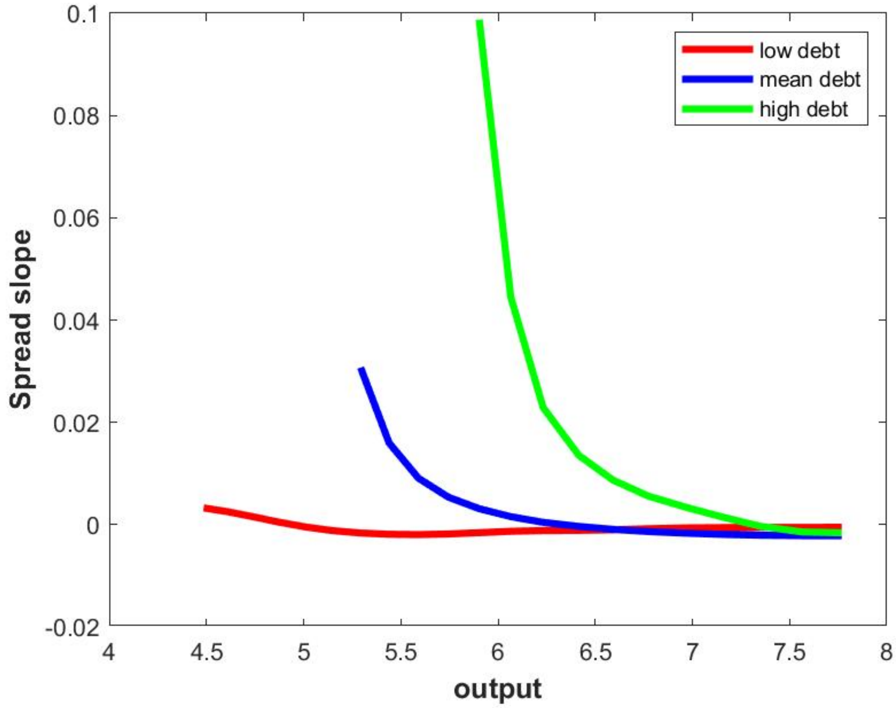
(c) Spread vs price of oil



(d) Expected price vs volatility of oil price

Figure 1.4: Mechanism underlying the response of spread to the volatility of oil price

Figure 1.5: Effect of debt on spread slope



Note: This figure plots the response of sovereign spread to changes in global oil price level against output for three different debt levels: below the mean, at the mean and above the mean level

decrease in future oil imports, resulting in a decline in future output (Figure 1.4a and Figure 1.4b). 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 1.4c).

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. In Figure 1.5 the red line signifies a debt-to-GDP ratio below the mean level, the blue line corresponds to the state of mean debt-to-GDP, and the green line represents an economy with a debt-to-GDP level above the mean. Figure 1.5 effectively illustrates that the effect of rising global oil prices on spreads becomes more pronounced as debt levels increase.

1.6.5 Effect on borrowing decisions

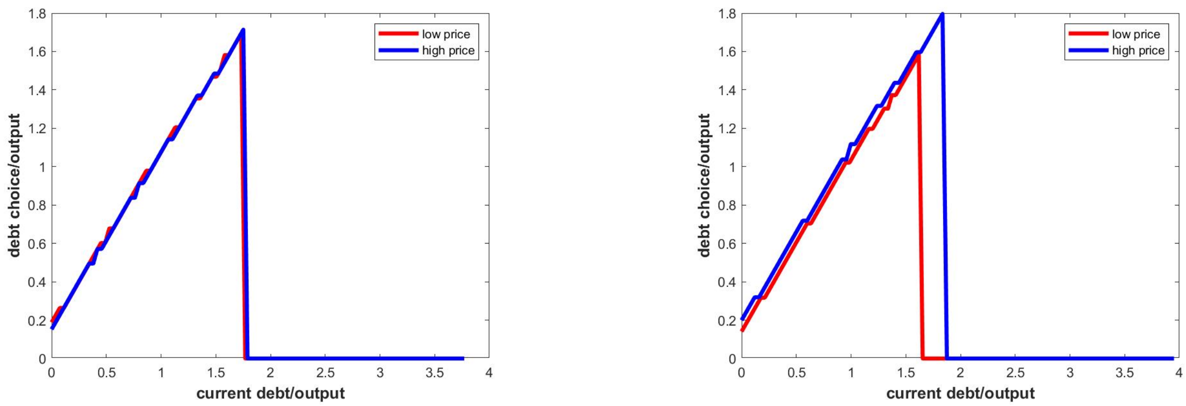
Figure 1.6 illustrates how varying levels of the global oil price influence borrowing decisions, specifically in terms of debt choice as a proportion of total output. This analysis considers two distinct volatility scenarios. While maintaining output at the mean level, I allow the oil price level to fluctuate, represented by the red and blue lines. The red line corresponds to a low-price state, while the blue line signifies a state with high oil prices. The left panel pertains to a low σ_p level, while the right panel relates to a high σ_p level. Figure 1.6 distinctly reveals that when the volatility state is low, changes in the oil price level have a negligible impact on borrowing decisions. However, in a high volatility state, the borrowing decision becomes responsive to price fluctuations. In fact, during periods of high volatility, the economy opts to borrow more when the oil price level is both high and volatile. The borrowing choices in response to fluctuations in oil price levels are similarly mirrored in the model simulations. To quantify these responses, I adopt the methodology described in the previous section, defining the debt slope as $\frac{\Delta Debt/GDP}{\Delta log(OilPrice)}$. With the volatility state held at its mean, the average debt slope is found to be 0.25. Notably, the influence of volatility on the debt slope is quite significant, registering at 0.16 during periods of low volatility and rising to 0.7 in states of high volatility. Once more, this underscores the profound influence of the volatility state on the model's responses.

This decision is primarily motivated by the prevailing uncertainty within the oil market during periods of high volatility. To guard against the potential increase in production costs resulting from expected high oil prices in the future, the government opts to increase its borrowing. This borrowing essentially acts as a form of insurance, enabling the government to cover the heightened import expenses that could arise if oil prices surge in the future.

One might be tempted to think that the government could simply defer borrowing until higher prices become a reality, rather than securing loans in advance when price projections indicate an increase. However, in doing so, the country would accumulate a larger debt as a precautionary measure. This is because the spread exhibits a much more pronounced increase in response to a sudden oil price shock in a highly volatile economic environment as depicted in Figure 1.3. Consequently, the economy would find itself forced to borrow more at significantly higher interest rates, all while oil prices are already elevated. Consequently, this intensified borrowing heightens the risk of default and subsequently leads to higher borrowing costs.

1.6.6 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



(a) Low σ_p (b) High σ_p

Figure 1.6: 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 the "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 to a state of high volatility level.

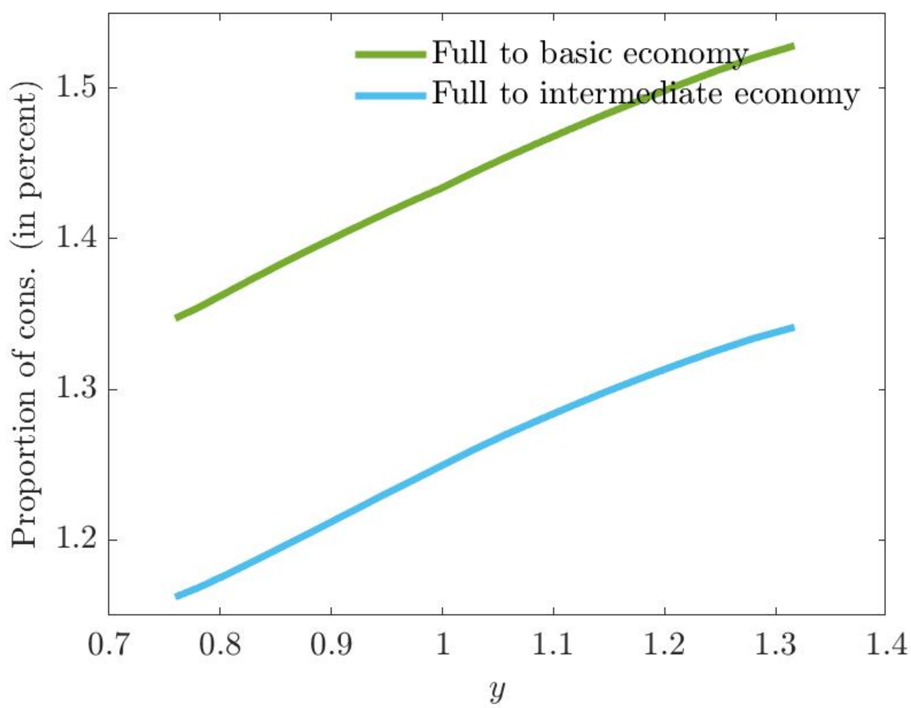


Figure 1.7: Welfare gains of moving from the full economy
Note: This figure plots the welfare gains of moving from the full to the basic or to the intermediate economies. The gains are computed as as a function of the endowment level, holding debt at the average level.

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 1.7 plots these gains as a function of the endowment level, holding debt at the average level for both the economies[10]. In both 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 1.4% (from the full model) and 1.25% (from the intermediate model).

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.

1.7 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

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

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

1.7.1 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

1.7.2 Oil Price Estimation

As explained in the main text, equations 1.6 and 1.7 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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Chapter 2

International Sovereign Spread Differences and the Poverty of Nations

2.1 Introduction

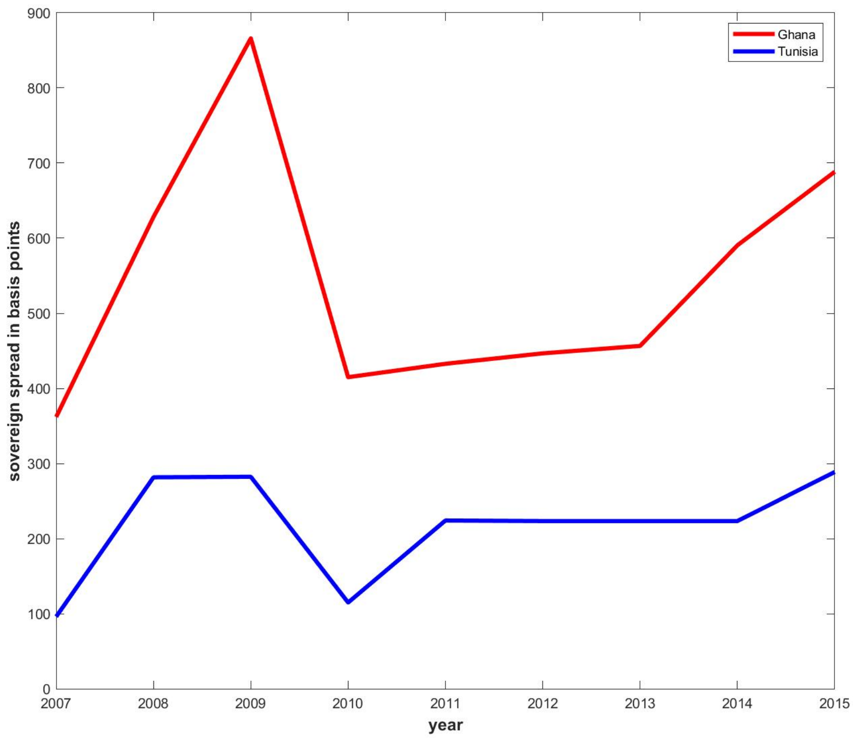
Countries vary widely in the number of citizens who live below the poverty line. For example, the proportion of the population that lives on less than \$1.90 per day is around 5 percent in Tunisia while it is about 25 percent in Ghana and South Africa.[1] Governments of such low-income nations wishing to borrow on international debt markets face very difficult choices when faced with low-income shocks such as a harvest failure. On the one hand is the impulse to raise revenue and control spending in order to lower indebtedness (since yields rise with debt). On the other hand is the desire to increase spending because large fractions of the populace living on the subsistence margin face starvation without government transfers. Revenue collection in these nations is also limited by the willingness of the non-poor to support the use of taxes for debt repayment, especially when debt repayment levels are a large proportion of tax collections. Faced with this difficult dynamic, governments may find defaulting on international debt to be an attractive solution and an incremental source of default risk not faced by economies with a small fraction of poor citizens. Recognizing this possibility, lenders expect higher yields on the sovereign bonds of these nations, exacerbating fiscal pressures.

In this paper we first show that national poverty head-count ratios and country default risk (measured as sovereign bond spreads) are positively correlated. This correlation is robust to controlling for differences in debt to gdp ratios, inequality as measured by Gini coefficients, overall resource availability as measured by per capita GDP and various institutional quality measures. Before turning to the specifics of our model, we exemplify the long term differences in the terms at which credit is made available through the experience of Tunisia and Ghana. Figure 2.1 plots

[1] In comparison, developed economies have substantially fewer than 1 percent of their populations below the international poverty line (for example Canada (0.33), France (0.04) and Portugal (0.5).

the sovereign spread on the government debt of Tunisia and Ghana for the period 2007-2015. As is evident from the graph,the sovereign spread for Tunisia was less than half of that of Ghana at any given year between 2007 and 2015.

Figure 2.1: Sovereign spreads (2007-2015)



Note: Here spread refers to the difference between the yield of sovereign bonds of the respective country and the yield of US 10-year treasuries in basis points between the period 2007-2015.

Having shown in Section 2.2 that default risk and poverty head-count ratios are positively correlated in emerging economy data, we build a sovereign default model that can produce this correlation while capturing the key aspects of the fiscal-political dynamic discussed above. We build a sovereign default model of a small open economy in the tradition of Eaton and Gersovitz (1981) where there are two types of households – those earning average income and those at the poverty line.[2] The government runs a social safety net which taxes the average income household in order to transfer consumption to the poor as well as to repay debt. The government borrows on international markets using long-duration non-contingent bonds which are subject to default risk, so international lenders price the debt accordingly. The government maximizes utilitarian social welfare where the utility

[2]Clearly having only two levels of income ignores the rich heterogeneity in income dynamics of actual economies. Since our goal is to explain why the presence of a large number of extremely poor citizens creates incremental default risk relative to a representative agent sovereign default model, we believe this more stylized approach is sufficient.

of the poor and the rest are weighted according to social welfare weights. A political constraint ensuring that all households wish to participate in the safety net program constrains the tax and transfer rates chosen by the government and also influences its debt and default choices.

While taxes are required to be paid by law, it is well known that low-income economies suffer from considerable difficulties in tax collection. Moreover, elected governments are aware that there are political limits to how much revenue can be extracted from voters if they wish to retain power. With this in mind, in order to motivate why the non-poor pay taxes willingly while at the same time exercising control over how much they pay and whether it is used for debt repayment, we proceed as follows.

The income state of households is not permanent so that households can transition into and out of poverty. The government's social safety net operates using a tax and transfer system and acts as insurance against this risk. Non-poor households are willing to pay taxes into the system so long as they receive a "reasonable" level of transfers when their income falls to the poverty level. To implement this, we impose a political constraint on allocations that ensures that households are ex-ante better off participating in the tax-transfer scheme than in autarky in each period. Since transfers are funded by taxes and by borrowing on international markets, there are periods when the government would like to reduce transfers relative to taxes in order to be able to repay debt but these fiscal choices cannot be implemented because they violate the political constraint. Instead the government is forced to default on its debt in order to offer a more acceptable level of transfers relative to taxes. The tightness of the political constraint depends on the proportion of poor households in the economy, on the income gap between the non-poor and the poor as well as on the transition rates into poverty as well as on the debt to GDP ratio. In addition, the model features the usual defaults seen in the literature where the government wants to default in order to free up fiscal space even when the political constraint is not binding.

We calibrate the model parameters using available data from the South African economy on debt, sovereign spreads, real per capita income, the poverty head-count ratio and fiscal data. In addition, we use several waves of the National Income Dynamics Study to measure the proportion of households below the poverty line, and the transition rates of non poor into poverty. We use South Africa as our calibration target because it has a high proportion of households living at or below the poverty line (24 percent) allowing the dynamics we discussed above to be in play quantitatively. Moreover, the repeated nature of the income dynamics panel available from South Africa allows us to identify households in different waves and calculate the transition rate which is a key parameter of the model.

In order to show that our model is conceptually capable of linking poverty head-count rates to sovereign yield spreads, we build a variant of the benchmark economy – the High-Poverty economy that has a greater proportion of poor households than the Benchmark economy. By changing only one parameter, we can isolate the pure effect this has on sovereign yield spreads. We show that the High-Poverty economy faces worse borrowing terms and a higher default risk than the Benchmark economy. As a result, it is able to borrow less than the Benchmark economy and this lowers welfare considerably. Poor households have lower consumption levels in the High-Poverty economy than in the Benchmark economy despite households receiving the same endowment stream in both economies. This occurs because transfers to the poor are lower. We decompose these effects into those that can be attributed to the smaller number of households able to pay taxes and those that emerge from the worse credit terms available to the High-Poverty economy. If an international aid agency could replicate the spread-debt menu offered by private lenders to the Benchmark economy, not only would debt, welfare and consumption rise in the High-Poverty economy, defaults would be much less likely to occur.

Since a higher proportion of poor households imply a higher level of inequality in the High-Poverty economy, we also compare the default risk of the High-Poverty economy to an analogous economy with the same level of inequality as the Benchmark economy and show that the additional default risk is primarily driven by the increase in the number of poor households as opposed to the increase in inequality that this creates. We also show that adjusting GDP in the High-Poverty economy to match the Benchmark economy does not eliminate the incremental default risk of the High-Poverty economy.

Why is the High-Poverty economy more likely to default? There are two factors that influence this. First note that the government of the High-Poverty economy would like to provide the same consumption stream to the poor as the government in the Benchmark economy (given the same endowment streams and social welfare weight of the poor) but has access to a smaller tax base due to the smaller number of non-poor households. Second, in the presence of the political constraint, the limited tax base can interact with high borrowing costs to create defaults that occur for political reasons. To understand this, note that non-poor households are willing to pay taxes as payments into a government run consumption insurance scheme whose effectiveness depends on the level of transfers promised by the government. If too large a fraction of tax receipts flow out of the economy as debt repayment, then the social safety net looks less attractive to the non-poor and they limit the level of taxes that the government can charge. In these situations, the government revenues in the High-Poverty economy take a double-hit – not only are the number of tax-payers smaller than in the Benchmark economy, the tax rate is also constrained politically. At low levels of debt, borrowing provides a means to keep transfers high relative to taxes but as the debt burden rises or as income falls, too large a fraction of tax receipts start to flow out of the social safety net towards debt repayment. As this dynamic worsens, non poor households will eventually be unwilling to participate in the tax-transfer scheme. Defaults at this juncture occur to keep the political constraint binding and we call these political defaults because the politically acceptable tax rate cannot support repayment of debt. We show that in our calibrated Benchmark economy, political defaults almost never occur while a large fraction of the higher default risk of the High-Poverty economy are due to political defaults. Of course both the Benchmark and High-Poverty economy also display standard defaults which occur when income is low and the marginal utility of the poor is high. Governments may then prefer to default rather than send precious resources abroad as debt repayment. Defaults in this situation are similar in spirit to the standard sovereign default models that follow Arellano (2008) and these are not the major source of the higher default risk of the High-Poverty economy. The High-Poverty economy is able to sustain a lower level of transfers relative to taxes and for any debt level, it hits that critical ratio when default becomes desirable at higher levels of income. Similarly, for any income level, the political constraint starts to bind at much lower levels of debt than in the Benchmark economy beyond which default is preferable.

Having shown that the model is capable of generating the correlation in question, we ask if it is capable of accounting for the patterns uncovered in our empirical work. To do this, we vary the proportion of poor households in the observed range in order to generate a number of artificial economies that differ from the Benchmark economy in only this aspect. Using simulations from these economies, an artificial panel dataset containing observations on poverty rates, debt to GDP ratios, log GDP deviations and spread levels can be created. We show, using regressions similar to those used in our empirical work that the conditional correlation between spreads and poverty rates is of a similar magnitude and sign as in the international data.

2.1.1 Related Literature

Our paper is related to recent work that links inequality to default risk and especially to Andreasen et al. (2019) who show that income inequality and regressive taxes make default more likely for a given level of debt, and tighter political constraints reinforce this effect. While our work shares an interest in the role that feasibility of fiscal policies play in determining default risk, not only is our focus on international differences in poverty rates, the specifics of the political constraint and fiscal policies are quite different. They have exogenously given taxes that depend on the income of the agent whereas our taxes are endogenous and may be positive or negative depending on income. Moreover we focus on a tax-transfer scheme that acts like a social safety net whereas they primarily focus on tax receipts to finance debt. For this reason, either everyone pays taxes or receives transfers from the government whereas in our model a fraction may pay taxes while the rest receive transfers. In Andreasen et al. (2019), the fiscal plan of the government must be approved by the population otherwise a default occurs. While this sounds similar to our political constraint there are important modelling differences which are driven by the context of the studies. When deciding whether to participate or not, households in our model compare the expected value of participating in the social safety net with the value of not participating, not with the value available to them in default (as happens in Andreasen et al. (2019)). Indeed, the tax-transfer scheme may continue to be implemented in default in our model whereas this is ruled out by assumption in theirs. We found it unreasonable to assume that there is no fiscal plan in operation while the government is in default in our context whereas it makes sense in theirs since taxes are only collected to repay debt. In our model, the government only proposes tax-transfer schemes that will be approved by households and sometimes these schemes involve defaults on existing debt. The strong assumptions regarding the effect of the political constraint is needed in their paper because the tax structure is set in stone and does not respond to the state of the economy. In contrast, ours responds each period and households evaluate their willingness to participate each period.

Our paper is also related to Jeon and Kabukcuoglu (2018) which explores how income inequality matters for government borrowing and default decisions[3]. The authors add time varying inequality shocks to a model with two types of households and impose a taxation regime that can be more or less progressive. They show that rising income inequality within a country increases the probability of default significantly. The idea is that during times of adverse inequality, the marginal utility of the poor is significantly higher than that of the rich and the government is tempted to default in order to try to equate the marginal utility of the two types. In contrast, the tax-transfer scheme in our model is endogenously determined and the amount of taxes that can be charged to the agents is limited by the political constraint discussed above. Moreover, we focus on variation in poverty rates across economies, not inequality shocks that change inequality over time. The implied differences in inequality between economies remain constant as a result. Deng (2021) also explores the role of income inequality on sovereign default risk with an emphasis on worker migration. The main channel through which inequality affects the spread is that the government of an economy with more inequality will use more progressive taxes for redistribution and to reduce consumption inequality. The progressive tax not only discourages labor supply but also induces emigration from the nation and shrinks the tax base, thus reducing government's ability to repay debt. At the same time higher inequality increases the temptation of the government to use defaults as a means to increase the progressivity of the tax base. She finds that income inequality and its interaction with migration explain about one-third of the average government spread. Our work differs in several ways from these studies in that we show that the proportion of poor agents in an economy has an independent role to play beyond inequality in determining the level of sovereign risk. While an increase in the proportion of poor households in an economy increases inequality, we show that the impact of this change on the terms of credit offered by international lenders and the debt choices of the government are robust to controlling for inequality. Moreover, we deliberately switch off any distortions caused by changing taxes either through labour supply distortions or through worker migration in order to highlight the interaction of the political constraint with the international cost of borrowing which lies at the heart of our mechanism.

Distributional incentives also play a role in domestic default risk and debt dynamics in D'Erasmo and Mendoza (2016) and D'Erasmo and Mendoza (2021) but the key heterogeneity among citizens is in their holding of government bonds so that defaults can cause a rearrangement of wealth among them and improve consumption dispersion. In contrast, we focus on income dispersion and especially

[3]Azzimonti et al. (2014) links higher income inequality to higher individual income risk which in turn leads to more public debt. Similarly, Arawatari and Ono (2017) show that higher income inequality causes politicians to reallocate fiscal pain to future generations by using debt to finance part of their government expenditure. Related work by Bi (2012) shows that the government's ability and willingness for debt-repayment depends on the fiscal limit which is determined by factors such as political uncertainty and size of the government.

the role of absolute poverty in determining default risk. In addition, unlike our model, government spending and taxes are exogenous (but transfers vary to satisfy the budget constraint) and there is no political constraint limiting the fiscal policy choices of the government. While our model does not have elections or political turnover, the presence of the political constraint which can induce political defaults links our work to the literature that studies the role that politics plays in defaults, fiscal policy and in sovereign debt dynamics. Some examples from this literature include Amador (2004), Chatterjee and Eyigungor (2019), Cotoc et al. (2021), Cuadra and Sapriza (2008), and Hatchondo and Martinez (2010). Our work is also related to sovereign default models with government spending and taxes that follow Cuadra et al. (2010). Bianchi et al. (2019) studies optimal fiscal policy in a New Keynesian model with unemployment where the government not only runs a tax and transfer scheme, it also offers unemployment insurance. Our work is also related to Alamgir et al. (2022) who find that cross-country differences in sovereign spreads are positively correlated with the average bribe rate in the country. The authors build a sovereign default model to generate a positive relationship between the average amount of diversion of public resources by bureaucrats and the average spread. Unlike this paper, the key mechanism for additional default risk is that defaults actually lower the diversion of government resources and allow the sovereign to increase the provision of public services. That study also differs in that all households in the economy are identical.

The remainder of the paper is structured as follows: Section 2 presents the empirical findings that motivate the theoretical analysis. Section 3 presents the model and section 4 describes the calibration of the model while Section 5 outlines the main quantitative implications. Section 6 concludes the paper. An appendix with data sources and computational algorithm is contained in Section 7.

2.2 Empirical motivation

In this section we show that the positive correlation between the sovereign spread of countries and the proportion of their population that lies below the poverty line discussed in the introduction is a robust feature of international data. We begin with a brief discussion of the main variables.

In our data the international poverty line is set at \$1.90 per day in 2011 purchasing power parity terms. This represents the mean of the national poverty lines found in the poorest 15 countries ranked by per capita consumption (World Bank, World Development Indicators). The poverty headcount ratio (our measure of national poverty) identifies the share of a country's population with income less than the poverty line. We use JP Morgan's Emerging Market Bond Index (EMBI) spreads which capture the difference between the yield of sovereign bonds of a country in basis points and the yield of US 10-year treasuries between the period 1995-2015. We start with all countries in the EMBI data and keep those for which at least five years of data is available. We also limit nations to those that have an average poverty headcount ratio that is greater than or equal to 1%. This leaves us with 37 middle and low income countries which are listed in the appendix in section

Table 2.1: Summary Statistics

Variable	Mean	Median	Std. dev	Minimum	Maximum	N
Spread	498.30	341.52	518.92	29.76	3926.79	552
Poverty headcount	10.99	8.43	10.89	1.16	59.33	37

2.6.

Table 3.1 displays some descriptive statistics for sovereign bond spread and poverty headcount ratio. The mean spread is about 498 basis points and ranges from a minimum of 29.76 to a maximum of 3926.79 basis points. For poverty, the mean is around 11 % while the lowest and highest values are 1.16 and 59.33 percentage points respectively.

In order to show that the positive correlation between poverty headcount ratios and sovereign spreads is robust to conditioning on other factors, we use the following empirical specification:

$$spread_{it} = \beta_0 + \beta_1 poverty_i + \Gamma' X_{it} + \Lambda' Z_i + \Psi' Y_t + u_{it}$$

where Y_t refers to a vector of global variables that are common to all countries but vary over time, Z_i refers to vector of country averages that do not change over time, while X_{it} refers to other control variables that vary over time and across countries. The vectors (Γ, Λ, Ψ) consist of coefficient estimates of the corresponding variables. We would like to emphasize that the goal of this specification is not to establish a causal link but rather to establish the robustness of the correlation in question. Data on macroeconomic control variables are collected from the World Development Indicators data set of the World Bank. The global variables, which include the ten year US treasury bill rate and the ten-year to one-year treasury yield curve, are taken from the Federal Bank of St Louis FRED database. We 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. We also include the log deviation of GDP per capita (in constant 2010 dollars) from trend as a measure of the state of the business cycle of the country as a conditioning factor since default risk has been shown to increase in recessions. Given the history of defaults in Latin American countries, we include a dummy variable that takes the value of 1 if a nation is part of that region and 0 otherwise. We will discuss additional variables as we add them below.

Our results are reported in Table 2.2 where column (i) presents the simplest specification with the poverty headcount ratio and a constant term as the only variables. Column (ii) adds the Latin American dummy and column (iii) further adds the current level of debt as a proportion of GDP and the log deviation from trend of real per capita GDP. Several studies have suggested that global factors play a role in determining spread levels and default risk (see Johri et al. (2022) for a sovereign default model of the impact of the level and volatility of the world interest rate on default risk as well as references to related empirical studies.) As a result we include year fixed effects in this

Table 2.2: Poverty and Spreads

	Dependent variable:						
	spread						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Poverty prop	3.40*	4.07**	3.16**	4.33***	3.09**	3.14**	3.14**
	(1.93)	(1.88)	(1.39)	(1.16)	(1.40)	(1.39)	(1.36)
LA dummy		85.23*	155.03***	189.44***	146.19***	143.53***	138.62***
		(45.00)	(44.53)	(51.77)	(44.97)	(44.95)	(46.10)
Debt/GDP			15.87***	16.67***	16.25***	16.01***	16.14***
			(1.81)	(1.99)	(1.87)	(1.93)	(1.76)
Log dev of output from trend			−27.26***	−27.16***	−27.00***	−26.28***	−23.50***
			(6.46)	(6.44)	(6.33)	(6.29)	(5.52)
Gini				−5.05			
				(3.27)			
Bribe rate %					19.98**	19.83**	19.94*
					(10.15)	(10.04)	(10.19)
GDP per capita rank					2.41	2.18	2.54
					(2.00)	(2.01)	(2.10)
Default						332.18	
						(292.14)	
10 year US Tbill							13.85
							(16.48)
US yield curve 10/1							38.99
							(25.90)
Constant	459.14***	419.23***	248.39	417.31**	158.23	169.62	−191.84*
	(28.48)	(29.75)	(151.96)	(202.57)	(163.38)	(164.55)	(109.89)
Year FE	No	No	Yes	Yes	Yes	Yes	No
Observations	552	552	472	465	472	472	472
R^2	0.01	0.01	0.43	0.43	0.43	0.43	0.39
Adjusted R^2	0.004	0.01	0.39	0.39	0.40	0.40	0.38
Residual Std. Error	517.82	516.69	418.45	417.91	417.60	416.70	424.09
F Statistic	3.34*	3.38**	13.80***	13.04***	12.94***	12.62***	36.84***

Standard errors are clustered at the country level, and reported in parentheses. ***,**,* represent significance level at 1%, 5% and 10% respectively.

and the following specifications. All three specifications indicate that there exists a positive and significant relationship between sovereign spreads and poverty rates. The results suggest that on average nations with poverty headcount ratios of 40 percent will display average sovereign spreads that are 120 to 160 basis points higher than nations with poverty headcount ratios of 10 percent. The control variables in column (iii) also exhibit their expected signs – higher debt burdens are associated with higher spreads, whereas higher than trend GDP is associated with lower spreads. The Latin American dummy is positive indicating that spreads are higher in that region relative to other emerging economies. The addition of year effects leaves the relationship of interest intact. We conclude that the positive correlation between poverty rates and spreads is robust to the inclusion of the usual conditioning factors.

Countries with more poor people have been shown to have a higher level of income inequality as well as weak institutions resulting in a higher incidence of corruption. These nations also tend to have lower GDP per capita. The existing literature on sovereign debt has discussed some of these as sources of default risk (see for example the role of the bribe rate of a nation in Alamgir et al. (2022) and the impact of inequality inDeng (2021) and Jeon and Kabukcuoglu (2018)). Alamgir et al. (2022) argue that when bureaucrats are known to divert funds from public projects, the government has an additional incentive to default relative to an economy without diversion since default may curtail diversion and increase the share of government services in times when revenue is below average. Jeon and Kabukcuoglu (2018) shows that periods of rising income inequality within a country increases the probability of default significantly. In light of this work, we explore if the poverty head-count ratio could be serving as a proxy for these other variables? Finally, since low per capita GDP and high poverty headcounts are likely to occur together we wish to control for this variable also. In the remaining specifications, we wish to see if the inclusion of these factors influences our results. In specifications (iv), we add the Gini coefficient as a measure of inequality while in column (v) we introduce the bribe rate and add the rank of initial year per capita GDP as an alternate measure of low income. As is evident from Table 2.2, the poverty headcount ratio continues to be positively correlated with spreads with little change in the magnitude of the relationship. While the bribe rate coefficient is positive and significantly different from zero in all specifications, neither inequality nor income level rank of nations appear to display a significant correlation with the spread[4]. In column (vi) we add a dummy variable which takes the value of 1 in the year that a nation defaults on its debt and 0 otherwise. The inclusion of this variable, which displays a large coefficient has little impact on the correlation of interest[5]. Finally, in column (vii), we replace the year fixed effects with two

[4]We have replaced the initial income rank of nations with their actual per-capital real GDP level in the initial period as well as in the final year of our sample with very similar results in specifications that are not shown here for brevity. Similarly we experimented with one-period lagged debt to GDP ratio with little impact

[5]We have also experimented with a crisis dummy in the spirit of Catão and Mano (2017) where we assign a value of 1 for countries that have ever experienced default, and zero otherwise. This captures the idea that countries which have defaulted in the past appear to experience higher spreads well into the future. This variable emerges as very strongly correlated with higher spreads but leaves the relationship of interest intact.

widely studied global factors – the yield on the ten year US treasury bill as well as the ten year to one year US treasury yield curve as a proxy for global risk. Neither factor is statistically significant though they display the anticipated signs.

Overall, in all specifications, the proportion of population lying below the poverty line is found to be positively correlated with sovereign spreads. Moreover, the results in Table 1 suggest that poverty rates have an additional marginal impact on country spreads beyond the fact that high poverty headcount ratios occur in nations with low per capita income and display high rates of income inequality. As such, we build a model in the next section where an economy with a higher proportion of poor people will display higher default risk.

2.3 Model

Consider a small open economy inhabited by a continuum of households of measure one and a government. At every point in time, there are two types of households: poor households comprise λ proportion of the population and non-poor households make up $1-\lambda$ proportion of the population. A non-poor household earns an income given by y while a poor household earns income given by $y_p = \alpha y$ with $\alpha \in (0,1)$. Here α represents the income gap between the average non-poor household and the poor household.

To be consistent with the quantitative sovereign default literature following Arellano (2008), preferences of both types of households follow the CRRA form:

$$u(\mathcal{C}) = \frac{\mathcal{C}^{1-\sigma} - 1}{1-\sigma}. \tag{2.1}$$

where $\mathcal{C} \in \{c, c^p\}$ represents the consumption of the poor c^p or the non-poor c.

A non-poor household pays non-distortionary taxes (transfers) at the rate τ which are set each period by government policy and consumes whatever remains from their endowment y :

$$c = y - \tau, \tag{2.2}$$

where the endowment process evolves stochastically according to the transition density $f(y', y)$. Similarly, the budget constraint of a poor household is:

$$c^p = y^p + \tau^p, \tag{2.3}$$

where the notation anticipates that a poor household will receive transfers though this is determined by the government in equilibrium each period and no restrictions are placed on the sign of τ^p. We note that the income gap of the two types of households is always held constant. This modeling choice deliberately distinguishes us from Jeon and Kabukcuoglu (2018) which studies the role of time varying inequality on default risk.

Households of either type do not save and make no dynamic decisions. We note that in this version of the model, we deliberately eschew distortionary taxation in order to focus on the relationship between the proportion of the poor in an economy and its default risk. Naturally, if higher distortionary taxes are required by the social safety net in an economy with more poor households then the ensuing reduction in labor supply could reduce revenue and be an additional source of default risk. This impact of income losses due to distortionary taxes on default risk has already been explored in the literature since Cuadra et al. (2010) and in several other contexts so we eliminate them to isolate our distinct mechanism (see Deng (2021) and Alessandria et al. (2020) for examples where the economy suffers from distortions due to both a decrease in labour supply as well as migration out of the economy).

Before turning to the government, we provide an expression for aggregate output or GDP as the weighted sum of household endowments:

$$Y = \lambda y^p + (1-\lambda)y = (\lambda\alpha + 1 - \lambda)y \tag{2.4}$$

and we note that aggregate output, Y_t is proportionate to the endowment of the non-poor, y_t. Since λ does not vary over time, aggregate output follows the endowment process, y_t.

2.3.1 The Government

The government maximizes a social welfare function where the utility of the poor and the non-poor households are weighted according to the parameters λ_{pol} and $1 - \lambda_{pol}$ respectively. These social welfare weights used by the government are not necessarily equal to the proportion of poor and non-poor households but govern the *desired* size of the social safety net that the government implements through its tax-transfer scheme. They can be viewed as the outcome of a social process outside the scope of the model or simply as capturing the average ideology of the nation which underpins the government's choice of social policy.

The government is the only agent in the economy who can borrow and lend in international credit markets and borrows from abroad by selling long-duration non-contingent bonds. As in Hatchondo and Martinez (2009), We assume that a bond issued in period t provides a perpetual stream of coupons that diminish at a constant rate δ.[6] That is, a bond issued in period t will pay $\kappa(1-\delta)^{(j-1)}$ units of tradable goods in period $t+j$ with $j \geq 2$. Let d denote the number of coupons due at the start of the current period, and d' denote the number of coupon claims due at the start of next period. The parameter κ determines the bond's coupon payment. Then the number of new bonds issued by the government is given by the following:

$$\iota = d' - (1-\delta)d$$

Consistent with the literature, we assume that the government lacks the ability to commit to repaying its debts. If the government does not default, it repays existing claims and can issue new debt, ι.

[6] See also Chatterjee and Eyigungor (2012) and Arellano and Ramanarayanan (2012).

If it defaults, it defaults on all existing claims and is excluded from credit markets for a stochastic number of periods. The bond price $q(d', y)$ takes default risk into account and will be discussed further below. The transfers made to the poor as part of the social safety net is the only domestic expenditure incurred by the government so its current period budget constraint is given by:

$$\lambda\tau^p + \kappa d = (1-\lambda)\tau + q(d', y)[d' - (1-\delta)d] \tag{2.5}$$

where the left hand side of the equation provides the uses of public funds while the right side provides the sources of public funds.

The government is limited in its ability to redistribute income using taxes by a political constraint which states that households must be willing to participate in the tax-transfer scheme. The idea here is that government's fiscal choices either face a referendum or the government takes into account that it must win elections which are lost if households are unhappy with the utility delivered by fiscal policy.

In order to motivate the non-poor to participate in a tax-transfer policy we offer two possible rationalizations. The first is the need for a social safety net to cover the possibility of an idiosyncratic household income shock. We assume that in every period there is a constant probability, p, that a household will draw a poverty income level receiving αy instead of y that period. In this situation, the tax-transfer scheme acts as an insurance device against the small probability of drawing a low income. We assume that the aggregate proportion of poor remains unchanged over time and government policy operates with the aggregate in mind. The other rationalization assumes that non-poor households care about the utility of poor households to a limited extent and p is the relative utility weight attached to the consumption of the poor while 1-p is attached to own utility. We can attribute this benevolence to feelings of justice, charity, equity etc. While a non-poor household is willing to give up some consumption to raise the consumption of poor households, a fiscal plan that gives too much away to the poor at the expense of the non-poor will have that plan rejected. Similarly a plan that gives the poor too little will also be viewed as unsatisfactory. Having said this, in our calibration of the model we will proceed with the first approach and obtain estimates of the transition probability from non-poor to poor households using South African data in order to tie down p.

Formally, government policy must satisfy the political support constraint:

$$W_\tau \geq W_0 \tag{2.6}$$

where W_τ is the utility in period t given the proposed fiscal plan (τ, τ^p), while W_0 is the utility without any fiscal program where all households consume their endowment (y, y^p).

$$W_\tau = pu(c^p) + (1-p)u(c) \tag{2.7}$$

$$W_0 = pu(y^p) + (1-p)u(y) \tag{2.8}$$

As explained earlier, p is the ex-ante transition probability from being a non-poor household to a poor household in which case W_τ may be thought of as the expected utility of the household under the tax-transfer scheme while W_0 is in its absence. This implementability constraint thus limits the amount of redistribution to the poor. It can, in certain states, also limit the ability of the government to collect sufficient taxes for repaying existing debt. As such, it can influence the government's decision to default or repay, which we discuss below.

We can think of the government's problem in two steps. Given the constraints discussed above, and the amount of resources available to the government from its debt policies, the government chooses the optimal fiscal policies (τ, τ^p) in response to the realization of the endowment shock y. The goal of the government in this step is to smooth consumption across households by minimizing the gap in socially-weighted marginal utilities of consumption between household types. The first-order condition from the government's optimization problem gives us:

$$U_c(c) = U_{c^p}(c^p)(\frac{\lambda_{pol}(1-\lambda)}{\lambda(1-\lambda_{pol})}) \tag{2.9}$$

Note that this equation ties down relative consumption of the two types, not the absolute consumption levels which also depend on debt policy discussed below.

Timing The timing in the model is as follows:

1. The output shock y is realized.
2. The government decides whether to repay its debt obligations or default and how much to borrow. Given the debt choices, the government proposes the optimal tax-transfer scheme. These decisions must ensure that equation (10), the political constraint (2.6) is satisfied.
3. Finally households consume with respect to their types.

2.3.2 Government value functions and recursive equilibrium

Each period, the government chooses between honoring its outstanding foreign claims or defaulting in order to maximize the weighted welfare of households. When the government defaults, it gets excluded from the credit market for a stochastic number of periods. Following default, the government may regain access to the international credit market with an exogenous probability θ, and it does so with no outstanding claims, $d = 0$. Default also entails direct costs such that output is lower during the periods the government is in autarky.[7] That is, each non-poor person's endowment is

$$y_{def} = h(y) \leq y \tag{2.10}$$

while each poor person's endowment is

$$y^p_{def} = \alpha h(y) \leq y^p \tag{2.11}$$

The value function when the government has access to the international credit market and owes d, given endowments (y, y^p) is given by $V^0(d, y)$. The government decides whether to default or repay its debts by comparing the value associated with paying back and remaining in the credit market $V^c(d, y)$ with the value associated with defaulting and going to temporary autarky $V^d(y)$. The problem can thus be expressed as:

$$V^0(d, y) = max[V^c(d, y), V^d(y)] \tag{2.12}$$

The value function when it does not default is given by:

$$V^c(d, y) = max[(1 - \lambda_{pol})u(c^*) + \lambda_{pol}u(c^{*p}) + \beta \int_{y'} V^0(d', y')f(y', y)dy'] \tag{2.13}$$

subject to

$\lambda\tau^p + \kappa d = (1 - \lambda)\tau + q(d', y)[d' - (1 - \delta)d]$
$c^* = y - \tau$
$c^{*p} = y^p + \tau^p$
$W_\tau \geq W_0$
$U_c(c) = U_{c^p}(c^p)(\frac{\lambda_{pol}(1-\lambda)}{\lambda(1-\lambda_{pol})})$

Similarly, when the government defaults on its debt, the value of default is given by:

$$V^d(y) = max[(1 - \lambda_{pol})u(c^*_{def}) + \lambda_{pol}u(c^{*p}_{def}) + \beta \int_{y'} [\theta V^0(0, y') + (1 - \theta)V^d(y')]f(y', y)dy'] \tag{2.14}$$

subject to

$(1 - \lambda)\tau - \lambda\tau^p = 0$
$c^*_{def} = y_{def} - \tau$
$c^{*p}_{def} = y^p_{def} + \tau^p$
$W_\tau \geq W_0$
$U_c(c_{def}) = U_{c^p}(c^p_{def})(\frac{\lambda_{pol}(1-\lambda)}{\lambda(1-\lambda_{pol})})$.

[7] Mendoza and Yue (2012) offer an endogenous interpretation of default costs that are related to domestic access to foreign goods.

where we assume that when the economy regains access to financial markets, it starts with zero debt.[8]

Later we will show that if repayment implies that equation (2.6) cannot be satisfied, the government will default in order to prevent too large a share of tax revenue from leaving the country, however the government may also default when the political constraint is satisfied. We also note that while it is not guaranteed in autarky that both 2.6 and 2.9 will be satisfied this is true for our parameterization.

The optimal default policy of the sovereign is thus characterized by:

$$D(d,y) = \begin{cases} 1 & V^d(y) \geq V^c(d,y) \\ 0 & otherwise \end{cases}$$

As such, given a level of claims d, the default set can be characterized as :$\mathcal{D}(d) = \{y \in Y : D(d,y) = 1\}$. Furthermore, given any set of claims and current realization of the income process y, the probability of default $\mathcal{P}$ can be inferred from the default set and the transition process for y.

International lenders

There exists a multitude of identical foreign lenders have access to borrowing or lending at the world interest rate r^* and participate in a perfectly competitive market to lend to the small open economy. The lenders possess complete information regarding the economy's endowment process, the distribution of poor households, as well as other parameters governing the economy and can observe y every period. They are risk neutral and they maximize their expected profits. With perfect competition in the credit market, a zero profit condition for the foreign creditor is satisfied. Hence the bond price is given by:

$$q(d',y) = E_{y'|y} \frac{(1-D(d',y'))(\kappa+(1-\delta)q')}{1+r^*}$$

Equilibrium

The recursive equilibrium for this economy is characterized by a set of policy functions for (i) consumption (c and c^p), (ii) international claims on the government d' and default rule D, (iii) government's fiscal choice τ and τ^p, and (iv) a bond price $q(d',y)$

such that:

1. Given the sovereign bond price $q(d',y)$ and the political constraint $W_\tau \geq W_0$, the government's policy set $\{d'(d,y),\ D(d,y),\ \tau(d,y),\ \tau^p(d,y)\}$ satisfies the government's optimization problem.

2. Given the government's policy set $\{d'(d,y),\ D(d,y),\ \tau(d,y),\ \tau^p(d,y)\}$, the household's consumption choices $c(d,y)$ and $c^p(d,y)$ satisfy the political constraint and the resource constraint.

[8] In contrast, Yue (2010) offers a model with partial debt recovery and renegotiation between lenders and borrowers.

3. The sovereign bond prices $q(d', y)$ reflect the government's default probabilities and are consistent with lender's expected zero profit condition and government's optimization problem.

2.4 Calibration

The model is numerically solved through value function iteration which requires parameter values to be assigned. We use annual data to calibrate to the South African economy over the period 1995-2015 and refer to this as the Benchmark model.

Table 2.3: Parameter values

Description	Parameter	Value	Target/Source
persistence	ρ	0.822	Estimation
sd of ε	σ_ϵ	0.016	Estimation
risk aversion	σ	2	Prior literature
world interest rate	r	0.04	Prior literature
re-entry probability	θ	0.154	Prior literature
poverty transition prob.	p	0.06	NIDS data
proportion of poor households	λ	0.245	NIDS Data
income share of poor households	α	0.16	NIDS Data
Coupon decay rate	δ	0.084	Avg duration of South African bonds
Bond coupon	κ	0.119	$(r^* + \delta)/(1 + r^*)$
political weight	λ_{pol}	0.067	Social expenditure/GDP
discount factor	β	0.927	Average debt/GDP
default cost	ψ_0	-0.698	Standard dev of spread
default cost	ψ_1	0.758	Average spread

We assume that the aggregate output follows an AR(1) process:

$$lnY_t = \rho lnY_{t-1} + \epsilon_t, \tag{2.15}$$

with $|\rho| < 1$ and $\epsilon_t \sim N(0, \sigma_\epsilon^2)$. In order to estimate ρ and σ_ϵ, we use logged and linearly de-trended GDP data for South Africa covering the period 1995-2015 which gives a value of 0.822 for ρ and 0.016 for σ_ϵ. Since the endowment process y follows aggregate output Y due to the assumption of fixed proportion of poor and non-poor households, we can use the estimated parameters above to calibrate the endowment process.

In order to estimate p, we employ South Africa's National Income Dynamics Study (NIDS). NIDS is a panel survey based on the livelihoods of households and individuals tracked over time. The study began in 2008 and continues to be carried out every two years with a nationally representative sample of over 28000 individuals in 7300 households across the country (Brophy et al. (2018)). The fact that the survey contains repeated households over time, allows us to study poverty transitions.

Our estimate of p is based on total household income derived from the NIDS data set for Wave 1 (2008), Wave 2 (2010), Wave 3 (2012), Wave 4 (2014-15), and Wave 5 (2017). We begin by calculating the per capita income of all households in all the waves using the survey weights to correct for non-response and systematic bias. In order to adjust for inflation, we use Statistics South Africa's headline CPI index to deflate the nominal income data to their real values. Next, using the upper bound national poverty lines relevant to each wave, we identify the poverty status of each household in the waves. Finally, the transition probabilities are calculated by counting the number of households that changed poverty status from wave to wave. We find that, on average, 12% of those who were non-poor in $Wave_i$, transitioned into poverty in $Wave_{i+1}$. This leads us to attach a value of 0.06 per year to p assuming a steady flow into poverty over the two year period.

We also use the NIDS data to tie down model parameters λ and α to the proportion of South African households that are poor and to their relative income respectively. The value of λ in the data is found to be 0.245 which is the mean proportion of households who lie below the poverty line in wave 1 through 5 of the NIDS dataset. Similarly, we calculate the income gap between the non-poor and poor households, α, using the data on per capita income of households and the national poverty line. Specifically, we express the national poverty lines of each wave as percentage of the average income per capita of the non-poor households in the corresponding wave which generate a value of 0.16 for α. This simplifying assumption ignores that some households may be below the poverty line, not on it, so that the average income of the poor may be less than that implied by the poverty line. On the other hand, there may be non-monetary grants for these households which are incompletely accounted for in NIDS so we opted for a flawed but clearly stated measure of α.

Following the standard values used in the real business cycle literature for small open economies as well as in the quantitative sovereign default literature, we use a relative risk aversion coefficient of 2, and a world interest rate of 4 percent annually. The probability of re-entry after default into international credit market is set to 0.154, such that the government remains in financial autarky for a period of approximately 6.5 years on average following a default event, consistent with Chatterjee and Eyigungor (2012). We set $\delta = 0.084$ and use it with the average yield to produce an average bond duration of 7.25 years in the simulation which is consistent with the average average bond duration for South Africa as reported in Bai et al. (2017).[9]

We calibrate the welfare weight of the poor in the government's social welfare function λ_{pol}, so that our model can match the transfers to GDP ratio in South African data. According to the Government Finance Statistics, IMF, public social expenditure comprises approximately 8.1% of GDP in South Africa over the period 1995-2015. This target is achieved by setting the socio-political welfare weight λ_{pol} equal to 0.067. Finally, we are left with three parameters to assign values to: the discount factor β and default cost parameters ψ_0 and ψ_1. We calibrate these parameters to jointly target the following moments from the data:(i) a mean external debt-to-GDP ratio of 25.1%; (ii) a mean sovereign spread of 2.3%, and (iii) a standard deviation of 1.0% for the spread. All

[9]We use the Macaulay duration of bond formula $D = \frac{1+r}{r+\delta}$ where r refers to the average yield generated by the bond.

Table 2.4: Targeted and non-targeted moments

	Data	Model
Targeted moments		
Mean spread (%)	2.3	2.3
Mean debt/GDP (%)	25.1	25.2
Standard deviation of spread	1.0	1.0
Mean transfer/GDP (%)	8.1	8.1
Non-targeted moments		
corr(spread, GDP)	-0.4332	-0.8289
corr(tb/y, GDP)	-0.4104	-0.8624
corr(spread, tb/y	0.3566	0.8523

the data counterparts correspond to the average values in South Africa over the period 1995-2015 extracted from the World Development Indicators dataset of the World Bank and the JP Morgan's EMBI Global Index.[10]

Table 3.4 displays these targeted moments along with some moments that were not targeted in the calibration. In order to calculate these moments, we simulate the model by generating 500 sample paths of 1500 periods each, and then discard the first 500 periods to eliminate the influence of initial guesses. Moments are then calculated from the detrended series of the remaining data after excluding the default episodes. [11] The calibrated model comes close to the targeted values. The model also does quite well in generating the expected cyclical properties found in the literature. As observed in the data, both spreads and trade balance/GDP are countercyclical, and spreads are positively correlated with trade balance to GDP.

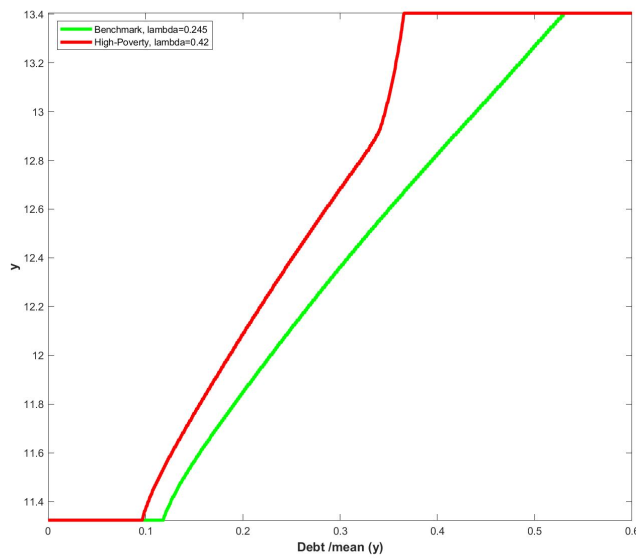
2.5 Results

In this section we will use variants of the Benchmark model economy to understand the economic forces that may lie behind the observed positive correlation between poverty head-count ratios and spreads. To begin, we modify the Benchmark economy by setting $\lambda = 0.42$ while keeping all other parameters unchanged. We will refer to this economy as the High-Poverty economy. Figure 2.2 depicts the default regions associated with these two economies where the endowment level is shown on the vertical axis and the level of debt normalized by mean y is on the horizontal axis. The green line refers to the Benchmark economy, while the red line refers to the High-Poverty economy. Each line divides the space into two regions such that the government of that economy will default in the represented states under the respective curve. The main message of the paper is immediately

[10]We thank César Sosa-Padilla for sharing sovereign spread data with us.

[11]We detrend the log of income, consumption and trade balance using the Hodrick-Prescott filter with a smoothing parameter of 100.

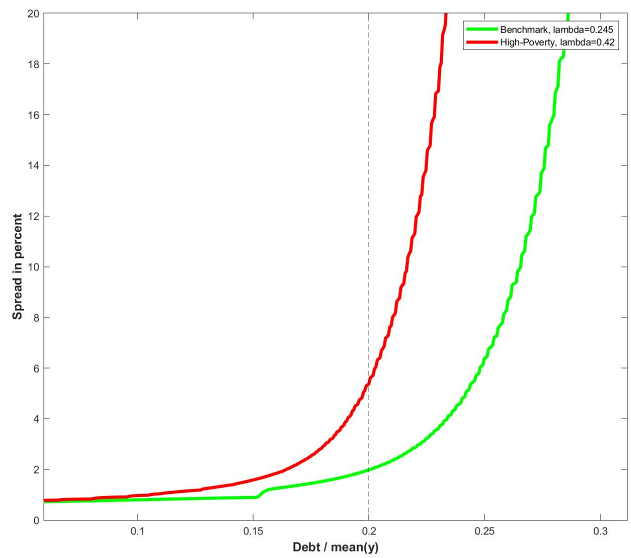
Figure 2.2: Default regions



apparent from Figure 2.2 – the High-Poverty economy's default set is larger and will be associated with higher default risk. Moreover, focusing for the moment on the green line only, for any level of debt/mean(y) above 0.11, a sufficiently low realization of income leads to default. As the level of debt rises from that point, the rising green line implies that the income level that is needed to avoid default also rises. Moreover, while not shown, the government will default at even the highest income level when debt/mean(y) is sufficiently high. Finally, note that at a sufficiently low level of debt, the government will not default at even the lowest income levels. These properties of the default region of an economy are quite standard in the quantitative sovereign default literature. Turning to the red line, we see that the High-Poverty economy can support a much lower amount of debt without defaulting at even the highest income level. On the other hand, the level of debt at which default can be avoided at the lowest income level is smaller than the Benchmark economy. Above that level (where the red line intersects the horizontal axis), the red line is always above the green line indicating that identical debt levels would require higher y levels for the High-Poverty economy to avoid default compared to the Benchmark economy.

The implications of the larger default region of the High-Poverty economy are reinforced using Figure 2.3 which shows the menu of debt (normalized by mean(y)) and interest rate spreads on offer to the two economies at mean endowment levels. Note that the interest rate spread is calculated as the interest rate currently paid by an economy minus the world interest rate so that when there is very little debt in either economy, the spread is small. Since debt is long-lasting, lenders take into account the possibility of future indebtedness levels and future default possibilities so the spread may not be exactly zero even with little currently owed by the government. From the bottom left of the figure, as we move rightward, the spread in either economy is increasing in the chosen amount of

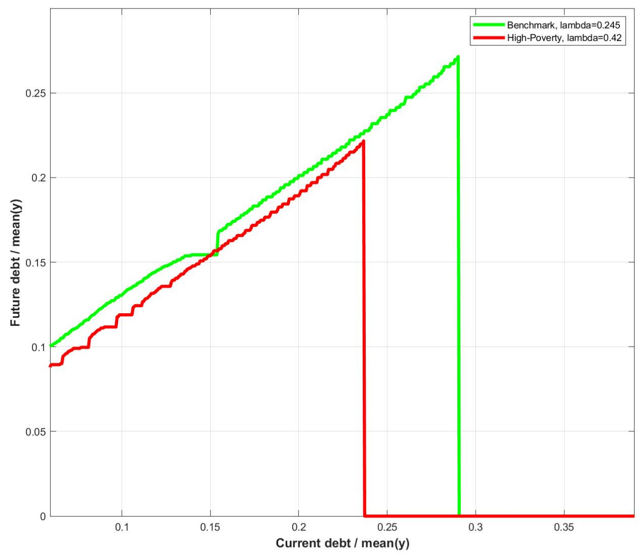
Figure 2.3: Spread-debt menu at mean(y)



debt, which is consistent with the default regions discussed above. At any given level of normalized debt in Figure 2.3, the red line lies above the green line, implying that the High-Poverty economy will pay higher spreads than the Benchmark economy. We can also see that the debt limits are endogenously imposed by the equilibrium menus (since the spread rises to extreme levels at debt levels approaching this limit), and that this limit (the nearly vertical regions of the lines) is much lower for the High-Poverty economy. Figure 2.3 shows the much harsher terms of credit available to the High-Poverty economy compared to the Benchmark economy at the average debt/mean(y) level of 0.2 (see vertical line) – the spread is 5.4 percent vs. 1.9 percent. As a result, the government of the High-Poverty economy will choose lower equilibrium debt levels than the Benchmark economy and this can be seen in Figure 2.4 which plots the current obligations due relative to mean y on the horizontal axis and the corresponding choice of next period obligations on the vertical axis while the endowment is held at the mean. At high debt levels, first the economies start to lower debt below current levels and eventually the almost vertical lines indicate the point at which no debt is sustainable due to extremely high default risk and hence high spreads. This happens at lower debt levels for the High-Poverty economy.

Since the High-Poverty economy faces worse borrowing terms, it will choose lower debt levels and therefore potentially lower equilibrium spreads. In order to see if the equilibrium behavior of the model is consistent with the empirical correlations discussed earlier which were conditioned on debt levels, we run a simple regression of spread on the proportion of the population in poverty, debt to y and log deviation of y from its mean using model-simulated data. The simulated data is generated from the Benchmark economy with a λ of 0.245 as well as twenty-four other economies with different values of λ, ranging from 0.11 to 0.59. For each economy we simulate 500 sample

Figure 2.4: Debt choice



paths with 1500 periods each, and then drop the periods in default. As is evident from Table 2.5, the estimated coefficient on the proportion of poor households is positive and statistically significant at 1% level of significance after controlling for the level of debt to y and log deviations in y. This is consistent with our empirical results presented in Table 2.2. We have reproduced the most directly relevant empirical result in column 2 for comparison ease.

In order to understand why economies with a higher proportion of poor households are more likely to default, we examine the properties of the equilibrium tax-transfer scheme. Recall that fiscal policy serves as an insurance device in the event that a non-poor household draws a poverty level income shock. The effectiveness of the insurance scheme depends on the value of the transfers received by the poor relative to the taxes paid by the non-poor. To augment transfers, the government can also borrow from international lenders, however, when indebtedness is high relative to income, the terms of credit will worsen and this can lead to situations where a large fraction of taxes flow out of the country to repay international lenders. A weakening ability to fund the consumption of poor makes defaults look attractive to the government when this occurs. Moreover, it makes the tax-transfer scheme less attractive as an insurance scheme to the non-poor and this brings the political constraint into play. We will discuss these in turn.

Figure 2.5 plots the transfer to tax ratio (measured as total transfers made relative to total tax collected) for both economies, holding y at the mean level. The green line in the figure refers to the Benchmark economy while the red line represents the High-Poverty economy. The dotted lines show what the transfer to tax ratio would have been if the two economies always chose to repay regardless of the optimal decision. Note that when it is optimal to repay, the solid and dashed lines overlap but when the government prefers to default, the solid line diverges from the dashed line. We first

Table 2.5: Poverty and Spread: simulations vs. international data

	Dependent variable: spread	
	Model	Data
poverty prop	5.69***	3.17**
	(0.02)	(1.32)
LA dummy	NA	149.80***
		(42.94)
debt/GDP	21.76***	15.82***
	(0.09)	(1.69)
log dev of output from mean	−33.00***	−25.01***
	(0.07)	(5.59)
constant	−276.18***	11.71
	(1.99)	(44.74)

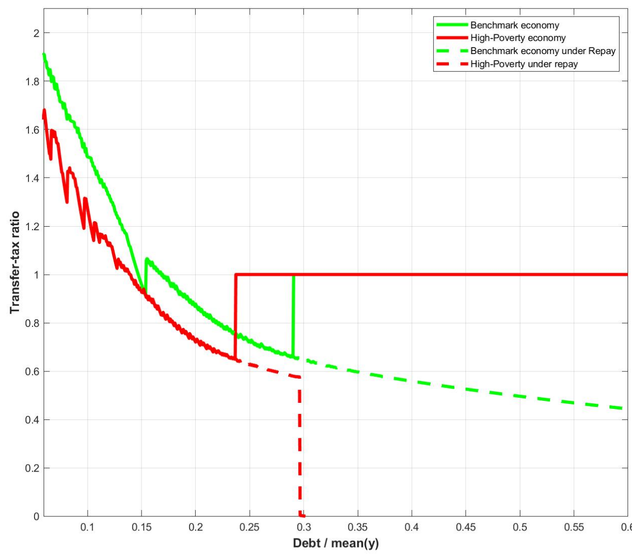
Note: Standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

note that the Benchmark economy can usually support a higher level of transfers relative to taxes collected than the High-Poverty economy. This occurs because of the more favourable credit terms available to it. In addition, it can be seen that at lower levels of debt, the transfer to tax ratio is well above 1 for both the economies. This implies that the excess transfer payments above the tax revenue collected are financed by borrowing from international lenders. As the debt to endowment ratio increases or as the aggregate income in the economy falls (not shown), the transfer to tax ratio falls below unity. In each economy, there comes a level of the transfer to tax ratio at which the government prefers to default rather than repay its obligations because repayment takes too large a share of tax revenue away from transfers. This event can be seen in the vertical jump in the transfer to tax ratio and the opening of a gap between the solid and dotted lines. The horizontal section of the transfer-tax ratio line at unity is associated with autarky since the government cannot borrow having just defaulted on its debts. We note that the Benchmark economy defaults at a higher transfer to tax ratio than the High-Poverty economy. We also note that the jump in the red line is larger than in the green line which signifies a greater gain in transfers relative to taxes by defaulting for the High-Poverty economy.[12]

The model can generate two types of defaults. The typical default seen in the Benchmark

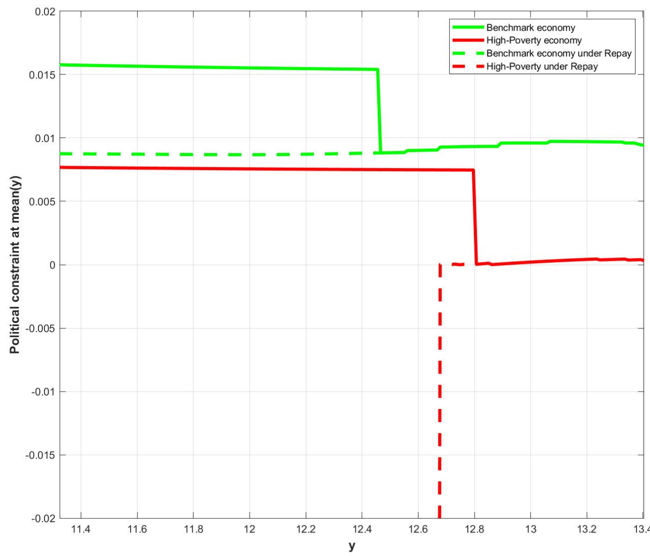
[12]We have cut the vertical axis at zero in order to focus on the economically relevant region. This is why the negative part of the dashed red line is not visible.

Figure 2.5: Transfer to tax ratio at mean(y)



economy occurs because governments wish to maintain the consumption levels of poor households relative to non poor households through transfers. When credit terms take a turn for the worse, taxes start to fund too little of transfers and the government chooses what may be called non-political or regular defaults in order to free up fiscal space. In addition, the economy can display a political default. This occurs when the political constraint is violated under repayment but not violated under default. In order to understand this type of default we display the behaviour of the political constraint in the two economies in Figure 2.6 at a debt to mean(y) of 32% for different values of y. The political constraint is formulated by taking the difference between the ex-ante expected utility of a household with and without the tax-transfer policy in operation. Households are in favor of the tax-transfer policy as long as this difference is positive. Going from right to left, the endowment level falls and the political constraint falls as well in both economies. The green political constraint graph for the Benchmark economy in Figure 2.6 is always positive, implying that the fiscal policies implemented by the government are politically feasible. In contrast, the red graph hits zero when the endowment level is around 12.8 roughly. This triggers a political default in the High-Poverty economy. The default allows the government to raise transfers relative to taxes so that the non poor are once again willing to participate in the scheme. We can also see a non-political default occur in the Benchmark economy at slightly lower endowment levels. Once again, the dashed lines in the figure display the constraint if the government was to repay at all endowment levels so that a divergence between the solid and dashed lines indicates a situation of default. Moreover, it is worth noting that for the High-Poverty economy, the red dotted line is negative indicating that if the government chose to repay rather than defaulting, that would violate the political constraint. In contrast, for the Benchmark economy, the dotted line is still positive below the endowment level at

Figure 2.6: Political constraint at debt/mean(y)=32%



which default occurs, implying that the political constraint would still be satisfied if the government chose to repay. So, default in the Benchmark economy occurs because the government wishes to maintain the consumption levels of its citizens.

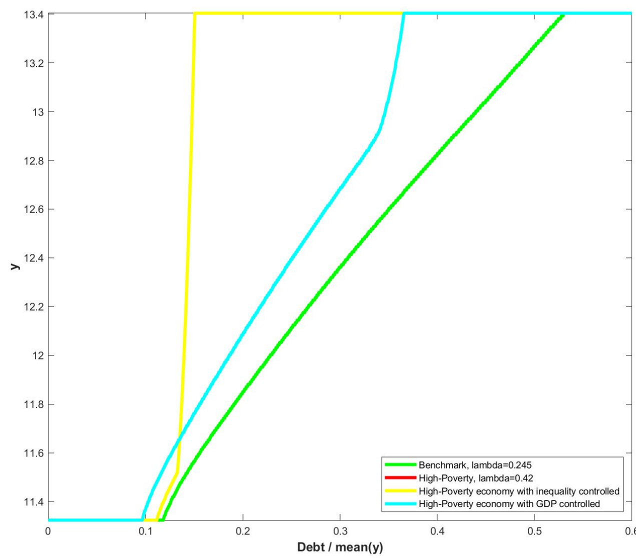
2.5.1 Controlling for GDP and inequality

The increase in the proportion of poor households in the High-Poverty economy has two additional implications relative to the Benchmark economy. First, inequality as measured by the mean value of the Gini coefficient rises from 0.1956 in the Benchmark economy to 0.3162 in the High-Poverty economy. Second, overall GDP is reduced from an average value of 7.97 in the Benchmark economy to 6.48 in the High-Poverty economy. In order to show that the main underlying factor increasing the default risk of the High-Poverty economy is the rise in the proportion of poor households as opposed to changes in inequality or GDP, we will control for these effects next.

We control for inequality by raising α until the Gini coefficient is restored to the value in the Benchmark economy. Note that in this economy there are more poor people but they are not as poor as in the Benchmark economy. Similarly, we control for the fall in GDP in the High-Poverty economy by simultaneously increasing the income of all households, (by raising mean(y), so that mean GDP remains unchanged from its value in the Benchmark economy.

Figure 2.7 plots the default regions for the Benchmark and High-Poverty economy along with the economies where either GDP or Gini are held fixed when λ is increased. The cyan line for the GDP fixed economy sits exactly on top of the red line for the High-Poverty economy showing that the default risk of the two economies is identical. The default region of the Inequality fixed economy,

Figure 2.7: Default regions



shown by the yellow line is larger than that of the High-Poverty economy which suggests that the pure impact of the change in λ is even larger than when inequality is allowed to change.[13] We also note that the income of poor households in the Inequality fixed economy is higher than in either the Benchmark economy or the High-Poverty economy. This weakens the desire of the non-poor to participate in the tax-transfer scheme making the political constraint tighter. As a result, political defaults become more likely which result in a larger default region.

2.5.2 The role of poverty parameters

In this subsection we will briefly discuss the impact of varying two key parameters related to poverty: p and α. The former, governs how likely it is for a non-poor household to become poor in any given period, while the latter governs the income of poor relative to non-poor households. In Figure 2.8, we display the default region of the Benchmark economy as well as the Low-p economy. The only difference between the two is that the probability of becoming poor is half of the Benchmark economy (0.03 vs. 0.06) in the Low-p economy. A glance at the figure immediately reveals that the Low-p economy has a much larger default region. This occurs because the political constraint is much more binding in the Low-p economy, leading to political defaults in states where none would occur in the Benchmark economy. An example of this can be seen in Figure 2.9 where the solid purple line hits zero while the green line (Benchmark economy) does not. This increased prevalence

[13] We conjecture that one reason that inequality seems to reduce default risk in our quantitative results is because the tax-transfer system does not impose output losses on the economy. The effect of distortionary taxes on default risk in the presence of inequality is already explored in Jeon and Kabukcuoglu (2018) and has been turned off in our work.

of political defaults is easy to understand. A lower p implies that an income shock is less likely to push a household into poverty and this makes the insurance scheme provided by tax payments less attractive than in the Benchmark economy. Of course, the higher default probability raises borrowing costs which makes it even more likely that transfers will be low relative to taxes and this worsens the desirability of the tax-transfer scheme.

Turning attention to the impact of changing α, we draw the readers attention to Figure 2.7 again. A comparison of the default region of the High-Poverty economy (cyan and red overlap) to the default region of the inequality fixed economy (yellow) displays the pure impact of raising α while keeping λ at the level of the High-Poverty economy. It is clear from this comparison that an increase in α makes political defaults more likely because poverty is no longer as 'bad' as in the High-Poverty economy since the income gap is lower. As a result, non-poor households will demand a higher transfer to tax ratio in order to participate in the insurance scheme.

2.5.3 Welfare

The worse borrowing terms faced by the High-Poverty economy come with welfare losses relative to the Benchmark economy. Figure 2.10 reveals that the transfers received by poor households in the High-Poverty economy (red line) are much lower than in the Benchmark economy (green line). Figure 2.11 shows how this translates into large consumption differences for the poor in the two economies while Figure 2.12 plots the welfare calculated using the social weights used by the government (see equation 2.12). Recall that these weights are held constant in both economies. All three figures plot the respective variables for different debt levels while holding y fixed at it's mean level.

2.5.4 Decomposing the effect of credit terms

As we saw earlier, the High-Poverty economy suffers from heightened default risk both due to the worse fiscal situation in the country due to higher poverty and the greater risk of political defaults. This additional default risk leads to worse credit terms as exemplified by Figure 2.3. In order to decompose the additional default risk into the economy specific local factors and the impact of the external borrowing terms which respond to these factors, we solve for the equilibrium choices of the government in the High-Poverty economy using the spread menu of the Benchmark economy. We will refer to this economy as the Counterfactual economy. Any resulting change in the default region in the counterfactual economy relative to the High-Poverty economy will isolate the effect of the worse credit terms on inducing additional default risk. Similarly comparing the counterfactual economy to the Benchmark economy will display the pure impact of λ. We can think of the Counterfactual economy as a situation where a poor nation is offered concessional borrowing terms by an international aid agency.

Figure 2.13 presents the default regions associated with the three economies: the Benchmark

Figure 2.8: Default regions with varying p

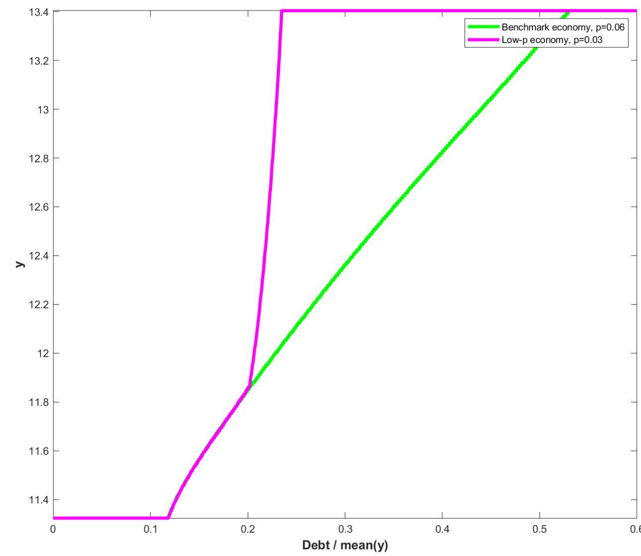


Figure 2.9: Political constraint with varying p

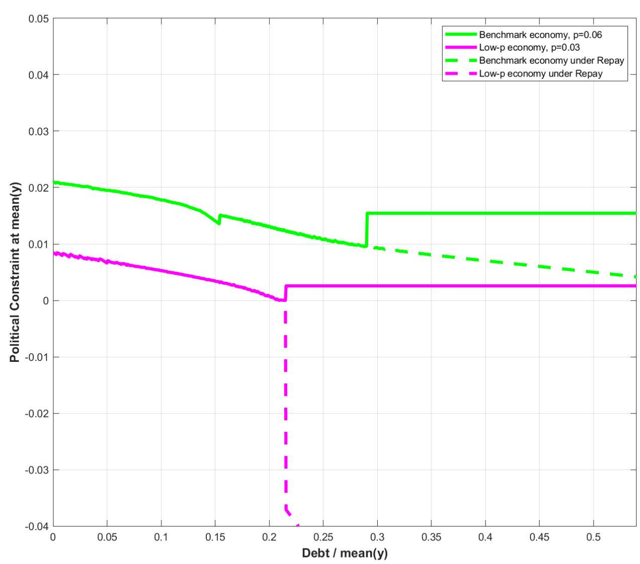


Figure 2.10: Transfers to poor households

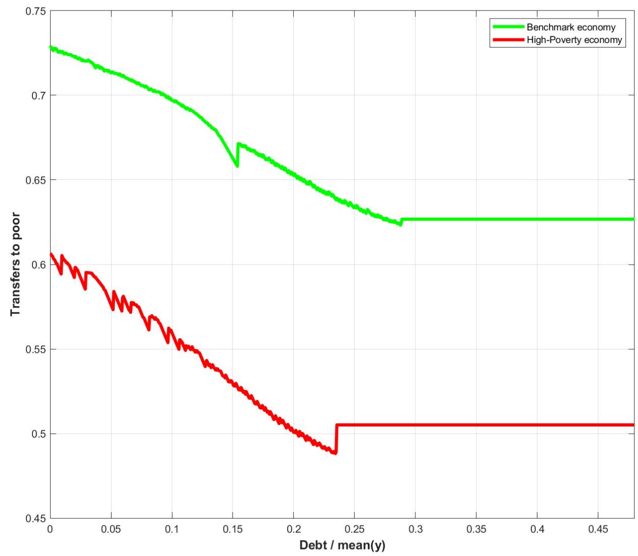


Figure 2.11: Consumption of poor households

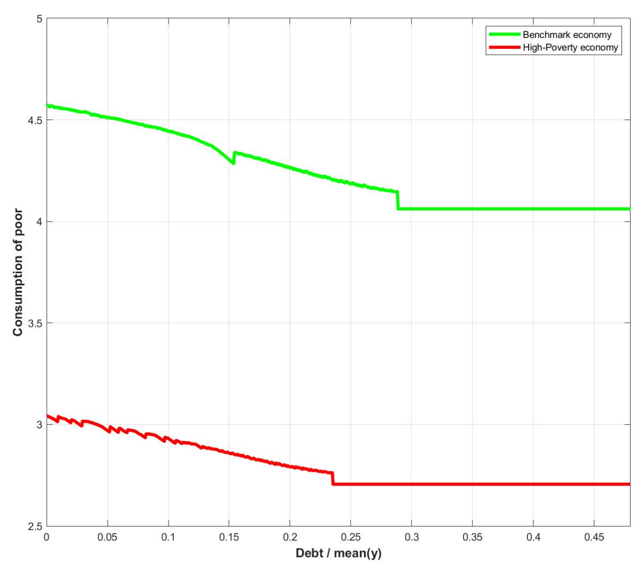


Figure 2.12: Welfare at average GDP

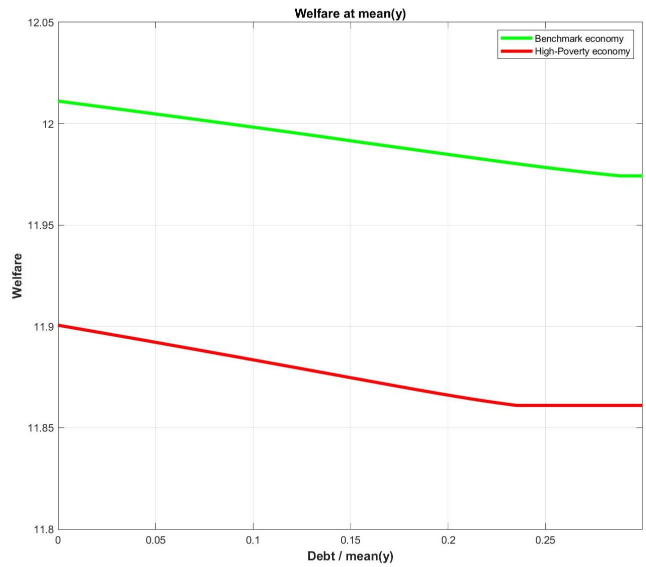


Figure 2.13: Default regions of High-Poverty economy: decomposition

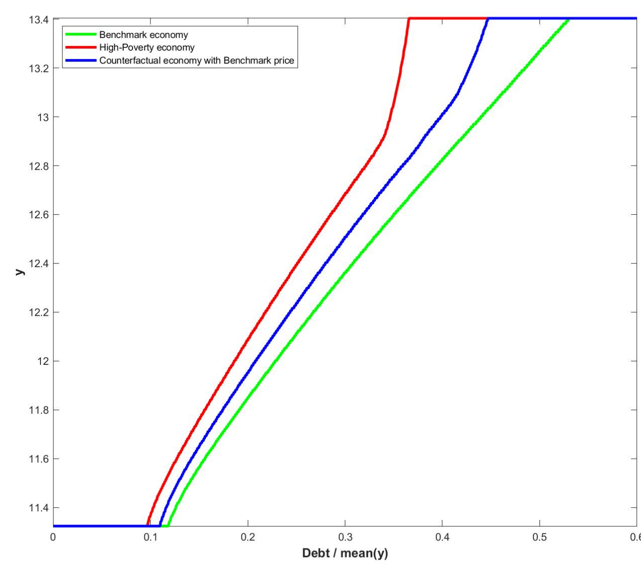
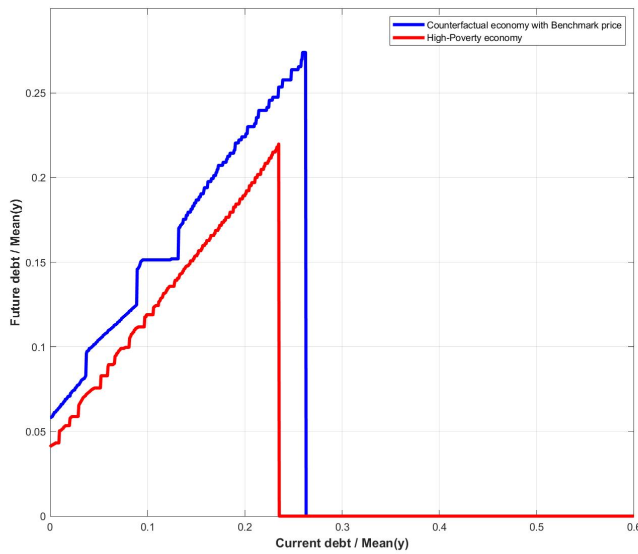


Figure 2.14: Debt choices



economy, the original High-Poverty economy and the High-Poverty economy projected with Benchmark economy's bond prices, ie. the Counterfactual economy. It is evident from the figure that the income level needed to avoid default at any given level of debt is significantly lower for the counterfactual economy than the actual High-Poverty economy. This gives rise to a smaller default region for the counterfactual economy. The resulting decrease in default risk for the Counterfactual economy can be attributed to the improvement in borrowing terms.

Figure 2.14 shows another immediate implication of the worse borrowing terms faced by the High-Poverty economy. Again it is evident that the harsher credit terms faced by the original High-Poverty economy forced them to choose a lower level of debt for any current debt level than the counterfactual economy. Indeed the endogenous debt limit above which debt is no longer sustainable is also much higher for the counterfactual economy than the High-Poverty economy.

2.6 Conclusions

International data suggests that there is a positive correlation between the proportion of extremely poor households in an economy and the average level around which its sovereign spread fluctuates. Even after controlling for a number of country specific and time varying factors, we find that a country with 40% of their population below the poverty line is associated with average spreads that are more than 120 basis points higher than a country with only 10% of population below the poverty line. We build a sovereign default model with poor and non-poor households and a government that wishes to run a social safety net using a tax-transfer scheme. The government must ensure that proposed taxes on the non-poor leave these households willing to participate in the insurance against income shocks provided by the scheme. While international borrowing allows the government to limit taxes relative to transfers when debt is low relative to aggregate income, when either debt is high or income is low, too high a proportion of tax revenue may need to flow out of the country to repay debt leading to two types of default. Regular or non-political defaults occur when the political constraint is satisfied but the government chooses to default in order to free up fiscal space to achieve the desired consumption levels of the two types of households. Political defaults occur when the government realizes that the unconstrained optimal tax-transfer levels it wants to achieve with repayment of debt would be unacceptable to households. As a result it chooses to default. The tightness of the political constraint is an equilibrium function of the proportion of poor households in an economy, their income relative to the non-poor as well as the probability of transitioning into poverty. The higher the proportion of poor, or the lower the risk of poverty, the more default risk in the economy. Moreover, the smaller the gap between poor and non-poor, the more likely political defaults are to occur since the insurance provided seems less valuable in the face of an income shock. Variants of the model generate quantitatively similar correlations between the proportion of poor households and spreads as seen in international data.

The higher default risk associated with a higher proportion of poor households implies much worse credit terms from international lenders. This has important implications for the economies in question – they pay higher interest rates and carry less debt which, in turn, leads to lower transfers and consumption for the poor and lower overall welfare. We decompose the additional default risk associated with the High-Poverty economy into two parts. The first is intrinsic to the higher poverty while the second is a consequence of the interaction of the worse borrowing terms with fiscal policy and the political constraint. If the High-Poverty economy could borrow from an international aid agency at the same terms as the Benchmark economy, external borrowing would be much higher and defaults would be much less likely to occur.

Appendix

Data sources and variable definitions

Income and poverty dynamics of South Africa

We make use of the Household income variable in the public-release dataset of the National Income Dynamics Study (NIDS). NIDS is a panel survey based on the livelihoods of households and individuals over time. The study began in 2008 and continues to be carried out every two years with a nationally representative sample of over 28000 individuals in 7300 households across the country. Our estimation is based on all existing waves which covers survey periods ranging from 2008 to 2017. The household income variable as reported in the NIDS is an aggregation of all income sources received by households on a monthly basis, net of taxes.

Other macroeconomic variables

1. Spread: We obtained spread data from Cesar Sosa-Padilla. It is extracted from JP Morgan's EMBI Global Index which consists of weekly observations ranging from the first week of 1995 to May 29, 2015 for 53 countries. We converted them to annual frequency and computed annual averages for each country.

2. Poverty: As a measure of poverty, we use the average poverty head count ratio at 1.90 dollars a day which identifies the share of a country's population with income less than the poverty line.

3. Bribe rate: This represents the 'value of gift expected to secure a government contract' taken from the World Bank Enterprise Survey.

4. GDP: Extracted from the World Bank's World Development Indicator database.

5. Debt-to-GDP ratio: We use total external debt stocks (current US$) extracted from the World Bank's Global Development Finance database divided by GDP (current US$) to compute the debt-to-gdp ratio.

6. 10-year US Tbill and US yield curve: Taken from the Federal Bank of St. Louis FRED database.

7. Gini coefficient: The Standardized World Income Inequality database.

8. Default events: Taken from the online appendix of Catão and Mano (2017)

9. Social benefit/GDP: This represents the public social expenditure as a percentage of GDP, extracted from the Government Financial Statistics, IMF.

List of countries included in the Empirical analysis

Computational algorithm

We solve the benevolent government's problem using value function iteration. The aggregate output shock Y follows an AR(1) process and is discretized using 201 equally spaced grid points following Tauchen's method. Similarly, a discretized state space for debt d consisting of 1000 equally spaced grid points is used. Upon realization of output shock Y, the government updates the repayment value and default value , and decides whether to repay or default and how much to borrow d'. Next, the government chooses an optimal tax-transfer scheme τ, τ^p given that the political constraint is satisfied. Any fiscal tax-transfer and debt policy that violates the political constraint is discarded from the value function iteration process by assigning a sufficiently low value to consumption.

The model is solved using the following algorithm:

1. Create grids and discretize the state space for debt d with 1000 grid points, and for output y with 201 grid points.

2. Start with a guess for the bond price schedule $q^o(d, y)$ for all d' and y.

3. Given the bond price schedule, solve for the debt choice d' using value function iteration. The optimal choice for consumption of the two household types $c(d, y)$ and $c^p(d, y)$ follow from the government's budget constraint and the optimality condition 2.9. The taxes and transfers $\tau(d, y)$ and $\tau^p(d, y)$ are then determined from the household budget constraints.

4. Check that these optimal choices c, c^p, d satisfy the political constraint; if not, reject this d'

5. Update the repayment value $V^c(d, y)$ and default value $V^d(d, y)$ for each iteration.

6. Based on the updated value function, update the defaulting decision, bond price schedule $q(d', y)$ and the optimal value function of the government $V^0(d, y)$.

7. Iterate on the value function until the distance between the updated value function and the one from last iteration for a given $q^0(d, y)$.

8. Finally compute new bond price schedule $q^1(d, y)$ based on the default sets and repayment sets and keep on iterating until the distance between $q^1(d, y)$ and $q^0(d, y)$ convergences to the tolerance level.

Table 2.6: List of countries included in the Empirical analysis with their corresponding poverty rates

Country	Poverty prop	Country	Poverty prop
Argentina	5.03	Kazakhstan	2.03
Belarus	2.07	Lithuania	1.39
Belize	14.35	Mexico	7.84
Brazil	8.43	Morocco	4.20
Bulgaria	2.33	Namibia	23.30
Chile	2.14	Nigeria	59.33
China	16.06	Pakistan	14.34
Colombia	11.09	Panama	8.83
Cote d'Ivoire	26.64	Peru	11.09
Dominican Republic	4.21	Philippines	11.37
Ecuador	9.81	Russian Federation	1.16
Egypt	3.31	Serbia	6.15
El Salvador	9.81	South Africa	24.73
Gabon	8.00	Sri Lanka	5.42
Georgia	11.13	Tunisia	4.68
Ghana	23.60	Turkey	1.17
Indonesia	22.02	Venezuela	15.19
Iraq	1.60	Vietnam	17.44
Jamaica	2.60		

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Chapter 3

The Bribe Rate and Long Run Differences in Sovereign Borrowing Costs

[1]

3.1 Introduction

Emerging nations are well known to be plagued with corrupt officials who divert resources from government projects for their own use. The World Bank Enterprise Survey collects data from several countries on the value of “gifts" that must be given to officials as a percent of the value of a public contract in order to win that contract. We will refer to the average value of this percentage as the bribe rate of that country. Interestingly, the bribe rate shows remarkable variation across nations, from a low of 0.1 percent to a high of 9 percent.

Emerging economies also pay widely differing interest rates on their sovereign debt when these rates are averaged over many years. Figure 3.1 reports the average spread of sovereign bonds for various nations contained in the EMBI Global Index over U.S. ten year treasuries averaged between 1995 and 2015. Across nations, once fluctuations are averaged out, we see dramatic variation in the sovereign spread level. This has important welfare implications for the citizens of these emerging nations because higher interest costs limit the ability of their governments to use international markets to provide government goods and services, especially when domestic sources of revenue fall.

We begin by showing that countries with high bribe rates are also countries with high spreads. Theory suggests that since higher debt levels relative to domestic revenue sources come with higher default risk, international lenders will offer loan terms in which higher indebtedness and interest rates go together. As a result, we must condition our correlation between spreads and bribe rates with the external debt of each nation as a percentage of government revenue. We find that a nation with a bribe rate that is one percent higher, tends to pays roughly 33 basis points more in interest

[1] This chapter builds on the preliminary work by Johri and Cotoc (2021)

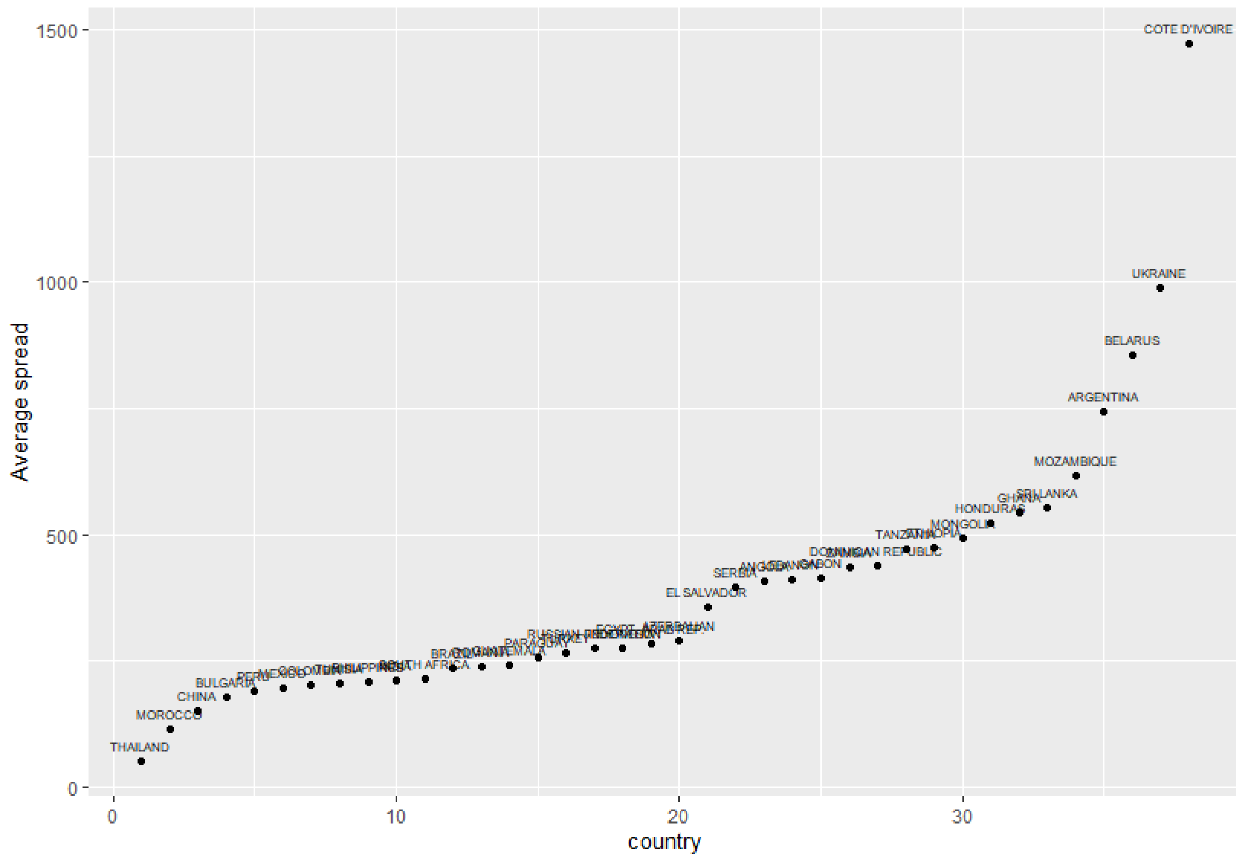


Figure 3.1: **Average sovereign spreads in basis points: 1995-2015**

costs, holding indebtedness constant. In the next section we will show that this positive conditional correlation is remarkably insensitive to the inclusion of various other domestic and global factors, including the level of government indebtedness as well as detrended government revenue.

Before discussing the model used to explain this correlation, it may be worth emphasizing a few things about our empirical choices. Other studies have shown that spreads are positively correlated with corruption perception measures but a problem with these measures is that they do not quantify the extent of stealing from the public purse. Moreover, they do not help to distinguish between various possible types of corruption, some of which may be more or less relevant for the government budget. After all, international lenders are unlikely to care about corruption unless it affects default risk through the budget. A high corruption index could reflect pervasive tax evasion or it could reflect diversion of resources from public projects (as is the case with the bribe rate) but it could also reflect other forms of corruption which do not directly affect the government budget constraint.[2] In order to calibrate our model, therefore, we found the bribe rate to be quite useful (relative to generalized perception of corruption indexes) because it allows us to measure bureaucratic diversion from government spending. In our empirical work we can control for unmeasured objects such as

[2]Bribes paid to turn a blind eye to illegal activity is one example of many.

tax evasion by working with actual revenue collected by the government as opposed to GDP which is more conventionally used in spread regressions. As a result, the correlation between spreads and bribe rates uncovered in our work cannot be explained away by tax leakages that reduce the ability of the government to repay its debt. For consistency with the empirical work, we also switch off any sources of revenue distortion in the model either due to tax evasion, or reduction in the tax base but we expect that if this were allowed it would generate even stronger results.

In order to explain the correlation between bribe rates and spreads, we build a sovereign default model with long-term external debt where the government is constrained to use corrupt bureaucrats to deliver public goods and services. In our quantitative sovereign default model, both international lenders and the sovereign government are aware that despite monitoring, a time-varying fraction of the resources allocated to public spending will be diverted by bureaucrats creating a wedge between public spending and the level of public services actually available in the economy. In choosing their optimal debt levels and default policy, governments of different economies take the optimal diversion policy of bureaucrats into account. This diversion policy depends on the efficiency with which bureaucrats can be monitored which varies across economies and underpins the positive correlation between default risk and bureaucratic diversion levels. We tie down the monitoring efficiency level to the Rule of Law index and estimate the diversion policy function using our assembled emerging economy data that combines fiscal information with the bribe rate and the Rule of Law index and use the estimated parameters to calibrate our quantitative model. The estimates imply that the amount of diversion is increasing in the size of government resources and decreasing in the Rule of Law index.

We use the model to show that artificial economies with low monitoring efficiency display high diversion as well as high default risk and spreads. Running the same regression on our artificial data as the international data, we find that spreads are positively associated with the bribe (gift) rate and with debt levels. These results emerge because defaults come with the *additional benefit* of reducing bureaucratic diversion and this benefit is shown to be inversely related to monitoring efficiency. Note that the usual mechanism found in sovereign default models is also present here - defaults provide the government with fiscal room to provide services since foreign obligations are not met. The model also implies that economies with better monitoring efficiency will borrow more than their counterparts with lower efficiency. We show that this is also a feature of our international data.

Next, we show that if the bureaucratic diversion policy did not display pro-cyclicality (with respect to incoming government resources) and instead was solely a function of monitoring efficiency of the nation then only a constant amount of resources would be diverted from government spending. As a result, the incremental benefit of default in the form of lower diversion would be eliminated and the model would be unable to deliver the empirical correlation between spreads and bribe rates ie., economies that differ in diversion levels would have roughly the same equilibrium default frequency and spread. This exercise is important because it shines light on a common prior about the model –

default risk is higher in economies with more corruption because the government has fewer resources. So the bigger the diversion, the higher the default risk. While technically correct, this effect is too small to account for significant variation in spreads across countries. The larger quantitative effect built into our model is more subtle. Default risk increases if the value of defaulting relative to the value of repaying debt goes up. As explained above, this relative value is a function of the diversion policy of bureaucrats. Since diversion falls in default, the wedge between government expenditure and government services is reduced, making default more attractive. If the same amount of resources were diverted in default as under repayment, this additional gain from default would be absent and variation in monitoring efficiency would have little impact on spreads.

3.1.1 Related literature.

Due to the importance of long term differences in the spreads faced by emerging economies, some recent work tries to understand the economic forces that lie behind the phenomenon. Cotoc et al. (2021) link international variation in spreads to the propensity of countries to elect left wing policy makers over right wing policy makers while Alamgir and Johri (2022) show that the proportion of the population in absolute poverty can influence default risk when it interacts with political constraints on the ability of the government to transfer resources to the poor. In this paper, we contribute to this developing literature by exploring the relationship between the level of bureaucratic diversion of government resources in a country with its average sovereign spread level.

Our model is related to several papers that incorporate spending on public goods and services into quantitative sovereign default models, especially Chatterjee and Eyigungor (2019) and Cuadra et al. (2010). Building on Cuadra et al. (2010), Hatchondo et al. (2015) study fiscal policy in a sovereign default model with long run debt and focus on the effects of policies that limit the level of debt or the sovereign interest rate. In the absence of any such fiscal rules, they find the model delivers procyclical fiscal policy like Cuadra et al. (2010). Bianchi et al. (2019) add New-Keynesian features and study the question of the optimal cyclicality of fiscal policy in the presence of default risk. On the one hand, expansionary policy can ease the recession, on the other defaults are more likely, overall leading to a preference for procyclical fiscal policy.

The main goal of our study is to explain the link between bribe rates and spreads rather than discuss fiscal policy per se. Even so, our model also delivers procyclical government spending. Moreover, government revenue is an exogenous process in our work which is theoretically equivalent to a fixed tax rate in an economy with exogenous income shocks. This is similar to Arellano and Bai (2017), where the tax rate cannot be changed but the level of debt and government spending can be changed. Unlike our model, the sovereign chooses both the tax rate and the level of public spending in the papers above. Asonuma and Joo (2019) incorporate different forms of public expenditure while also keeping the tax rate fixed and show that the model can deliver declines in public investment during restructurings which is a feature of the data. The models differ in several respects from our work, especially that government revenue in our model is exogenous whereas in their model it depends on the interaction of given tax rates and endogenous income and consumption. None of these papers involve bureaucratic diversion of public resources. Unlike these papers, Chatterjee and Eyigungor (2019) incorporates politicians who divert public funds when in office. The amount of funds diverted are exogenously fixed whereas they are endogenously determined in equilibrium in our model. Indeed we show that they vary pro-cyclically over time and fall in default and that this property is crucial for generating the positive correlation between spreads and diversion. Their study focuses on political turnover and links the exogenous growth regime to the re-election probability of politicians. Cotoc et al. (2018) incorporate political competition between left-wing and right-wing parties into a sovereign default model. The parties differ in the elasticity of their re-election probability with respect to fiscal policy. The model implies that left-wing sovereigns pay higher spreads on average and display more counter-cyclical spreads than right-wing sovereigns which are features of the data. This occurs because the left has a stronger desire to default in bad times in order to prevent government spending and political support from falling too much. Scholl and Tong (2020) develop a sovereign default model where private agents avoid taxes by producing in the underground economy. In a debt crisis, the higher interest costs force the government to raise tax rates encouraging the underground economy which drives down tax revenue and makes default more likely. In contrast, our model focuses on the relationship between monitoring efficiency, bureaucratic diversion of public funds and default risk with particular attention to long run international differences in sovereign spreads induced by these institutional differences. Finally, our work is linked to the quantitative sovereign default literature more generally that follows early work by Arellano (2008) and Aguiar and Gopinath (2006).

Layout. The rest of the article proceeds as follows. Section 3.2 presents our empirical findings. Section 3.3 introduces our benchmark model of sovereign borrowing and default with bureaucratic diversion of public resources. Section 3.4 discusses the calibration of the model, and section 3.5 studies the main results and quantitative implications of the theory as well as shows the robustness of the framework to changing some assumptions. Section 3.6 concludes. An appendix provides information about the data, computation methods, and further robustness exercises for both the empirical work and the model.

3.2 Empirical findings

In this section we show that the bribe rate (average rate of “gifts" that must be given in order to secure a government contract) of a country is positively correlated with the sovereign spread of that country, and that this correlation is robust to a number of conditioning factors.

The bribe rate is very useful for our work because it provides direct information on international differences in the diversion of funds from public contracts. It is based on an Enterprise Survey question which asks firms about the percentage of contract value expected as a gift in order to

Table 3.1: Summary Statistics

Variable	Mean	Median	Std. dev	Minimum	Maximum	N
Spread	473.67	313.27	580.05	51.28	3926.79	377
Bribe rate	1.92	1.10	2.39	0.1	8.95	38

secure a government contract. We will interpret it as a bribe that leads to diversion of public funds from the contract. Since the survey is only done in a few years that are not the same for each country, we take a country average and use it as a country specific value in our regressions. We use annual averages of JP Morgan's Emerging Market Bond Index (EMBI) sovereign yield spreads which is the difference between the yield of sovereign bonds of a country in basis points and the yield of US 10-year treasuries from 1995-2015. Beginning with all countries and years in the EMBI data, we keep those for which at least five years of data as well as the bribe rate is available. This leaves us with 38 countries that are listed in the Appendix.

Table 3.1 displays some descriptive statistics for the average bribe rate in these 38 countries and for sovereign bond spreads that vary across time and across the 38 countries.[3] Sovereign spreads ranges from 51 to 3927 basis points with an average of 474 basis points. The bribe rate ranges from 0.1 to 8.95 percentage points with a mean value of 1.92. [4]

There exists a vast empirical literature exploring the correlates of sovereign spreads. Some early studies include Edwards (1984) and Cline and Barnes (1997) where a nation's spread is correlated with the nation's GDP and exports. Cantor and Packer (1996) as well as Eichengreen and Mody (1998) find that they are correlated with domestic economic conditions when measured using the credit rating channel. Following the literature, we use the following empirical specification:

$$Spread_{it} = \beta_0 + \beta_1 s_i + \Gamma Z_{it} + \Lambda F_t + u_{it}, \tag{3.1}$$

where s_i refers to the average bribe rate of country i. In addition, Z_{it} refers a vector of controls that vary over time and between countries which are discussed below in more detail while F_t refers to global variables that vary over time but are the same for all countries or to year dummy variables. (Γ, λ) are vectors of relevant coefficients that vary from specification to specification. It is important to emphasize that our goal is not to establish a causal link, rather it is to test the robustness of the correlation between bribe rates and spreads to the usual conditioning factors. We include the debt to revenue ratio as a conditioning factor since theory as well as previous studies suggest that more

[3]We also have limited data on high income countries. Of the 34 nations classified by the World Bank as OECD High-income, the Enterprise Survey only sampled 11. Of these, three report a bribe rate of zero. This leaves us with only 8 countries namely Chile, Czech republic, Hungary, Latvia, Lithuania, Poland, Slovak Republic and Slovenia. Fortunately we can calculate the average EMBI spread for all these nations. To see if these high income countries display similar patterns as emerging economies, we calculate the correlation between the average bribe rate and the average EMBI spread. It takes a value of 0.43.

[4]A detailed characterization of the bribe for each of the 38 countries is presented in the Appendix

indebtedness relative to available resources should be correlated with higher spreads on average. Similarly, we control for the log deviation of government revenue from trend as a measure of the business cycle state because countries are expected to exhibit higher default risk during recessions. These data are obtained from the World Development Indicators data set of the World Bank. Details regarding how the data was constructed can be found in an appendix. These variable can be found in all of our specifications discussed below. As we add additional variables, we will discuss them in turn.

We report the results of four specifications in Table 3.2 Specification (i) in column (i) uses annual data on the external debt to revenue ratio, the log deviations of revenue from trend as controls and includes year fixed effects. Following Johri et al. (2022) and a long literature studying the role of global factors, specification (ii) in column (ii) adds the ten year US treasury bill rate and the ten year to one year treasury yield curve as global conditioning factors in addition to the previous specification while removing year fixed effects. These variables are obtained from the Federal Bank of St. Luis FRED database. In column (iii), specification (iii) controls for other domestic economic conditions such as volatility of GDP (which is a country specific fixed value), net exports/GDP and reserves/GDP to the variables in specification (i). Column (iv) adds the incidence of previous default events to the existing variables in specification (iii). This is consistent with Catao and Mano (2017) which concludes that countries which have defaulted in the past appear to experience higher spreads in the future.[5]

It is evident from all four specifications that the bribe rate is positively associated with spreads, displaying a coefficient that ranges from 20 - 34. The control variable coefficients display the expected signs: the debt to revenue ratio is positively associated with spreads while the deviation of revenue from trend is negatively associated with spreads. The estimated coefficients are always significantly different from zero at conventional levels of significance. The addition of global variables in specification (ii) has little impact on the estimated relationship between spreads and bribe rates while controlling for GDP volatility, net export/GDP, reserves/GDP and default events also keep the positive relationship intact, with only a small change in the estimated coefficient on the bribe rate.

We draw two conclusions from these results. First, the data suggests that some of the observed differences in the borrowing costs of different national governments are correlated with the rate at which funds can be diverted from government projects. Second, this positive relationship is not driven solely by greater average indebtedness in nations with more corrupt bureaucracies as well as a host of other factors that have been shown to be important as correlates of spreads in the

[5]The empirical literature emphasizing the role of global factors in influencing sovereign spreads is too vast to cover here so we refer readers to the citations in Johri et al. (2022). These authors build a sovereign default model where country risk responds to variation in both the level and volatility of the world interest rate and provide evidence that emerging economy sovereign spreads respond to US treasury yields. The importance of global factors has been reinforced using a variety of empirical methods and proxies for global risk over varying time periods and countries in related work. We mention Akinci (2013) as an example using a very different methodology (structural VAR on a panel of emerging nations) with similar implications.

Table 3.2: Bribe Rate and Spread

	Dependent variable:			
	Spread			
	(1)	(2)	(3)	(4)
Bribe rate %	33.85**	34.24**	19.77**	20.19**
	(14.21)	(13.93)	(8.65)	(8.56)
External Debt/ Revenue	2.96***	2.93***	2.99***	2.93***
	(0.49)	(0.48)	(0.30)	(0.29)
Log Revenue dev from trend	−8.68***	−7.80**	−7.16**	−6.29**
	(3.37)	(3.32)	(2.28)	(2.28)
10 year US Tbill		30.19		
		(21.47)		
US yield curve 10/1		35.55		
		(34.59)		
GDP volatility			5.31***	5.19***
			(2.15)	(2.13)
Net export/GDP			8.66**	8.30**
			(2.36)	(2.34)
Reserves/GDP			−6.48***	−6.32***
			(1.26)	(1.25)
Default events				764.76***
				(298.39)
Constant	325.10*	−113.76	293.52	294.36
	(170.81)	(125.52)	(281.32)	(279.01)
Year FE	Yes	No	Yes	Yes
R^2	0.38	0.36	0.36	0.37
Adjusted R^2	0.34	0.35	0.35	0.36
Residual Std. Error	472.32	468.63	394.13	390.33
F Statistic	9.31***	41.01***	33.09***	30.05***

Standard errors are clustered at the country level, and reported in parentheses. ***,**,* represent significance level at 1%, 5% and 10% respectively.

literature. At face value, these results imply that a nation with an average bribe rate of 6% faces an average borrowing cost that is 100-170 basis points higher than a nation with a 1% bribe rate, ceteris paribus, thus highlighting the considerable potential significance of this channel for the ability of emerging economies to borrow on international markets. Obviously these results do not imply causation – indeed we will explore the source of this positive relationship more fully in the sections that follow using our quantitative model.

Since it is rare to see the bribe rate being used in international studies and because the empirical literature on the impact of corruption on economies usually works with the corruption perception index (see Ciocchini et al. (2003) for a link to sovereign spreads and Wei (2000) to foreign direct investment) from Transparency International, we repeated the same regressions with this measure.[6] As expected, both the corruption perception index and debt to GDP ratio display positive (and statistically significant) associations with spreads.[7] We nonetheless prefer to focus our work on the bribe rate because it provides a quantification of the amount of stealing from the provision of public services rather than tax evasion which is notoriously hard to measure and also because we can later use it to tie down the parameters of our quantitative model.

Since economies with high bribe rates are also likely to be economies with poor quality institutions which may in turn affect default risk, in the Appendix we show the robustness of our results by introducing other institutional quality measures one by one. As shown in Table .1 in the Appendix, we control for four indices contained in the World Governance Indicators dataset: Political Stability, Regulatory Quality, Government Effectiveness and Voice and Accountability. In this context, it is appropriate to mention existing work showing that higher government effectiveness lowers default risk in both emerging and advanced economies. In particular see the work of Fournier and Bétin (2018) as well as Jeanneret (2018) who also provides a theoretical structure relating government effectiveness to revenue collection. As discussed in the Introduction, leakages from tax revenue would add to our mechanism which does not operate through that channel.

3.3 The Model Environment

The economy is made up of a sovereign government, a bureaucrat and international lenders. Our focus is on the problem of an infinitely lived sovereign government operating in a small open economy that wishes to deliver public goods and services to the economy using an exogenously given stochastic stream of government revenue y, while also having the ability to borrow from foreign lenders using long-term debt[8]. The sovereign cannot commit to repay its debt so that risk neutral lenders will

[6]Other survey measures of corruption such as the ICRG have also been used extensively (see Fredriksson and Svensson (2003) and Svensson (2000)) in the economics literature and have been shown to be highly correlated with the corruption perception index. Some studies, such as Alquist et al. (2019) provide sensitivity to various measures and find the results are robust to changing the index.

[7]Result available from authors.

[8]This simplification is equivalent to a more standard set up in the quantitative sovereign default literature where consumers in the economy receive an endowment and the sovereign government can collect taxes at a

charge an interest rate at a level above the risk-free world interest rate in order to be compensated for the probability of default, as is standard in models that follow Eaton and Gersovitz (1981) and especially the quantitative implementations that build on Arellano (2008) and Aguiar and Gopinath (2006). The actual provision of government goods and services requires the use of a bureaucrat who is a self-interested agent with the ability to divert public funds for private use (see discussion in Acemoglu and Verdier (2000))[9].

In what follows we use recursive notation, where *un-primed* variables (e.g. x) represent current values, while *primed* variables (e.g. x') represent next-period values. Time is discrete and goes on forever: $t = 0, 1, 2, \ldots$.

3.3.1 The Government

The sovereign is infinitely lived and derives utility from the provision of public goods and services (g) which is reminiscent of the set up in Chatterjee and Eyigungor (2019), however, unlike the setup in that paper, the sovereign obtains utility from the actual goods and services provided by the government rather than the total government expenditure which includes the amounts diverted by bureaucrats. The per-period utility function is given by:

$$u(g) = \frac{g^{1-\xi}}{1-\xi} \tag{3.2}$$

The government borrows from a large number of international lenders by issuing 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.[10] Specifically, 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 evolution of debt can be written as follows:

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

where b refers to the number of coupons due at the beginning of the current period, ν to the number of long-term bonds issued in the current period, and b' to the number of coupons due at the beginning of next period and κ is a parameter that controls the size of the per-bond coupon payment. This payment structure enables encapsulation of all future international obligations derived from past debt issuances into a one-dimensional state variable: the obligations maturing in the current period.

The flow budget constraint of the government is:

fixed rate. We note that information on tax rates are notoriously imprecise and hard to obtain for emerging nations so we prefer to use readily available data for total revenue collections when we calibrate our model. To be consistent, we model it as an exogenous process here. As a result, we will be able to show that two economies with identical revenue streams will display different default risk

[9] We ignore heterogeneity among bureaucrats here since it is unnecessary for the mechanism.

[10] Arellano and Ramanarayanan (2012) and Hatchondo et al. (2016) allow for issuance of both short-term and long-term debt, while studying optimal maturity.

$$g + s = \begin{cases} y + [b' - (1-\delta)b]\, q(b', y) - \kappa b, & \text{if debt repaid} \\ y_a, & \text{if defaulted} \end{cases} \tag{3.3}$$

where $y_a \leq y \, \forall y$ captures exogenous default costs and s is the amount diverted from public coffers by corrupt officials using bribes.[11] Here y refers to domestic sources of revenue available to the government which is assumed to have compact support $\mathcal{Y}$ and to follow a Markov process with transition function $\mu(y', y)$. q is the price at which sovereign bonds can be sold. Note that total spending by the government on public goods equals $g + s$ but only g units add to utility, while s goes to the bureaucrat.

3.3.2 Bureaucrats

The government is constrained to use bureaucrats in order to provide public goods but cannot fully prevent them from diverting resources for their own use. Instead it partially monitors its accounts and recovers diverted funds at zero cost when misappropriation is discovered. For notational simplicity, we assume that one risk-neutral bureaucrat manages the government's resources, x. Let s refer to the amount of government resources that the bureaucrat wishes to appropriate. Since the government can only partially audit its projects and recover some funds diverted by the bureaucrat, we can express the expected return from stealing for the bureaucrat as

$$Es = (1 - p(.))s \tag{3.4}$$

where $p(.)$ encapsulates the proportion of misappropriated funds that are recovered through monitoring. The proportion $p(.)$ combines the probability of being caught stealing funds and the fraction of funds that can be recovered.[12]

The efficiency of the audit in detecting misappropriation of funds, successful implementation of legal proceedings and the partial or full recovery of the stolen amount is determined by the quality of institutions in the country which are taken as given in an economy. We will encapsulate all these aspects into the term monitoring efficiency m henceforth. Clearly p will depend on monitoring efficiency. A nation with well functioning courts and police, a strong and independent media with high quality journalists, and a general regard for the rule of law will make it harder for corrupt officials

[11] In order to understand how bribes and diverted funds may be related, consider the following example. From public accounts, we can observe how much was paid by the government to the private sector for a contract to build a bridge, say \$100. We know a certain amount was paid as a "bribe" by the private sector firm to the bureaucrat in order to obtain this contract, but this amount does not show up in the accounts. Assuming free entry for private firms wishing to win the bridge contract, profits will be driven to zero. As a result, revenue will equal costs for the firm, so that 100 equals bribe plus true costs of building the bridge. Similarly, in the aggregate, the private sector would never spend more on all government contracts plus the aggregate bribes paid than the amount paid by the government which aggregates up to g plus s.

[12] A more notationally heavy formulation would have a continuum of identical bureaucrats, some of whom would be monitored and caught with little effect on the results. Then p is the probability of being caught diverting government funds assuming those detected to have diverted funds must return them.

to divert public funds than a nation without institutions of the same quality. In addition, following both the corruption literature and the monitoring literature and economic intuition, the probability of being caught misappropriating funds is increasing in the amount stolen by the bureaucrat. This is consistent with early work by Barreto (2000) and Blackburn et al. (2006).[13] Finally, we assume that p, is decreasing in the size of incoming government resources, x. The idea here is that it is easier to divert a given amount from a project, without detection, if it is a smaller percentage of the total amount. Similarly, any attempts to manipulate accounting statements are less likely to be noticed the more accounting items that have to be tracked (see Greenwood et al. (2013) for a quantitative application in an emerging economy context). The obvious implication is that the magnitude of misappropriated government funds will tend to increase with the size of the budget. We provide empirical support for this assumption by calculating the correlation coefficient between the diversion level and total government resources for each country in our data and find the median value to be 0.51. This idea can also be seen in operation in Acemoglu and Verdier (2000) and Alesina et al. (2008) where the equilibrium amount of diversion is increasing in GDP.[14] We note that later, in the calibration section, we will take these properties of p to the international data.

The bureaucrat will chose the optimal level of diversion to maximize their expected return, taking monitoring efficiency of the government into account. Thus the optimal diversion level can be implicitly expressed as:

$$s^* = P(m, x) \tag{3.5}$$

where x is defined as the sum of incoming resources from internal and external sources:

$$x = \begin{cases} y + [b' - (1-\delta)b]\, q(b', y), & \text{if debt was repaid} \\ y_a, & \text{in default} \end{cases} \tag{3.6}$$

. While the government knows the diversion policy of the bureaucrat s^*, as well as the total amount of incoming resources x, they must monitor at zero cost in order to recover funds as well as to limit diversion. In the benchmark version of the model presented here, there are no additional costs of monitoring but this can be easily incorporated with little change in results as we show in section 3.5.3. The richer specification in which the government can spend resources on improving monitoring efficiency suffers from the difficulty of finding suitable international data on these expenditures for calibration of the model. As a result, we opt for the simpler benchmark model with a more reliable calibration. Further robustness to model assumptions is provided in the Appendix where we also show that the model can capture the positive relationship between bureaucratic diversion and

[13] Blackburn et al. (2006) assume that some bureaucrats may not be corrupt and that the cost of stealing from the government is a function of both the amount stolen by one official and the total number of corrupt officials. For simplicity, we ignore this distinction here.

[14] The context of Alesina et al. (2008) is different – the incumbent government takes rents for itself and these rents are limited by the public by threatening to vote in another government if their utility falls below a threshold. The maximum amount of rents that can be taken is increasing in the revenue available.

default risk when x only depends on domestic revenue, y. As discussed above, the sovereign realizes that bureaucratic diversion will occur in equilibrium and takes $s^*(m, x)$ as given when choosing government spending, debt levels and whether to default or not. We turn to these decisions next.

3.3.3 Debt and Default

Each period, conditional on being in good financial standing, the sovereign chooses whether to honor its outstanding foreign debt or default. Default involves temporary exclusion from international financial markets and depressed revenue levels but opens up fiscal room for government spending since debt is not repaid. In addition to this standard motivation for default, the present model provides an additional benefit to the sovereign government. As we will see later, bureaucratic diversion falls in default, and this makes defaults more attractive than in the absence of diversion.

For a given level of monitoring efficiency m, let $V(b, y)$ denote the government's value function when it has access to credit markets. It begins the period with a level of debt obligations b, and a realized value of y. Let $V^R(b, y)$ represent the value associated with the government's decision to repay its debt, and $V^D(y)$ the value function when it decides to default. The decision problem can be expressed as follows:

$$V(b, y) = \max\{V^R(b, y), V^D(y)\}. \tag{3.7}$$

When the government repays, its value function is given by:

$$V^R(b, y) = \max_{b'} \left\{ u(g) + \beta \int_{y'} V(b', y')\mu(y', y)dy' \right\}, \tag{3.8}$$

subject to its budget constraint :

$$g + s = y + \left[b' - (1 - \delta)b\right] q(b', y) - \kappa b. \tag{3.9}$$

and the optimal diversion policy of the bureaucrat s^*.

When the government defaults on its debt obligations, the problem is:

$$V^D(y) = \max_{g} \left\{ u(g) + \beta \left(\theta \int_{y'} V(0, y')\mu(y', y)dy' + (1 - \theta) \int_{y'} V^D(y')\mu(y', y)dy' \right) \right\} \tag{3.10}$$

subject to

$$g + s = y_a,$$

and the optimal diversion policy s^* of the bureaucrat.

Equation 3.10 reflects the stochastic exclusion from international credit markets that follows default. It can regain access to markets with probability θ but starts with zero debt, which is captured by the value function $V(0, y')$. Alternatively, the economy may remain in autarky with probability $1 - \theta$.

Following Chatterjee and Eyigungor (2012), the revenue loss caused due to default is specified as follows:

$$y_a = y - max\{0, \psi_o y + \psi_1 y^2\}, \psi_1 \geq 0$$

As discussed in Chatterjee and Eyigungor (2012), this specification allows for an asymmetry in default costs, implying higher losses in high-revenue periods.

The default policy of the sovereign is characterized by:

$$d(b, y) = \begin{cases} 0 & \text{if } V^R(b, y) \geq V^D(y) \\ 1 & \text{otherwise.} \end{cases} \tag{3.11}$$

Let $\mathcal{D}(b)$ represent the set of revenue realizations for which the sovereign finds it optimal to default, given a debt level b and diversion level s:

$$\mathcal{D}(b) = \{y \in \mathcal{Y} : d(b, y) = 1\},$$

hence, the next-period default probability of the sovereign is

$$\lambda(b', y) = \int_{\mathcal{D}(b)} \mu(y', y) dy' .$$

3.3.4 Foreign Lenders

Foreign lenders are risk neutral and can borrow funds at the risk free rate r_f. Lenders have perfect information about the revenue process of the small open economy and observe the monitoring efficiency, m, and understand the behavior of bureaucrats. Bonds are priced in a competitive market inhabited by a large number of identical lenders, which implies that bond prices are pinned down by a zero expected profit condition yielding:

$$q(b', y) = E_{y'|y} \frac{(1 - d(b', y'))(\kappa + (1 - \delta) q(b'', y'))}{1 + r_f} \tag{3.12}$$

where $d(b', y')$ and $q(b'', y')$ represent the government's default decision and equilibrium bond price in the next period.

3.3.5 Recursive equilibrium definition

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

1. *a set of value functions* V, V^R, *and* V^D,

2. *a default policy rule* d *and a borrowing policy rule* b' *for the sovereign government,*

3. *policy rules for* s, *the amount of resources diverted by the bureaucrat for own use and* g, *for public services,*

4. *a bond price function* q,

such that:

(a) *given the default and borrowing policy functions of the government and diversion and government spending rules of the bureaucrat,* V, V^R, *and* V^D *satisfy equations* (3.7), (3.8) *and* (3.10) *when the government can trade bonds at* q;

(b) *given the default and borrowing policy functions, and the diversion policy of the bureaucrat, the bond price function* q *is given by equation* (3.12);

(c) *the default and borrowing policy functions* d *and* b' *solve the dynamic programming problem defined by equations* (3.7), (3.8), (3.10) *and* (3.11) *when the government can trade bonds at* q *and given the diversion policy rule* s

(d) *given the default and borrowing policy rules and the bond price function, the diversion policy rule solves the bureaucrat's problem.*

3.4 Calibration

We solve the model numerically using value function iteration[15]. A period in the model is one year. Some of our parameters are taken from the literature. We will discuss these first. We assume a coefficient of relative risk aversion of 2, and set the risk-free rate to 4% annually, which are the standard values used in the quantitative sovereign default literature. The probability of reentry into international debt markets was set to 15.4%, so that the government remains in exclusion for a period of 6.5 years following a default episode, on average, consistent with Chatterjee and Eyigungor (2012). We set $\delta = 0.168$ which produces an average duration of approximately 4.5 years, similar to what is found in the past literature (Hatchondo and Martinez (2009), Cruces et al. (2002)).

Turning to the estimates of the revenue process, we proceed as follows. From our list of nations, we choose those nations for which revenue data is available from 1995-2015 without any missing years. The data is logged and linearly de-trended for each country and ρ and σ are then calculated using an auto-regression of order one. We take the mean of these country values for each parameter and report it in Table 3.3. The tax revenue data for each country is constructed by multiplying tax revenue as a percentage of GDP with GDP per capita in constant terms, both of which are obtained from the Word Development Indicators database.

[15]Further details of our procedure can be found in the Appendix.

Table 3.3: Parameter values.

y autocorr.	ρ	0.637	Estimation
SD of ϵ	σ	0.062	Estimation
Borrower's risk aversion	ξ	2	Prior literature
Risk-free rate	r^*	0.04	Prior literature
Duration of defaults	θ	0.154	Prior literature
Coupon decay rate	δ	0.168	prior literature
Bond coupon	κ	0.2	$(r^*+\delta)/(1+r^*)$
Diversion parameter	γ	1.06	Estimation
Diversion parameter	ϵ	5.2	Estimation
Average monitoring efficiency	m	2.13	Mean value of index
Discount factor	β	0.86	Calibration
Default cost parameter	ψ_0	-0.388	Calibration
Default cost parameter	ψ_1	0.484	Calibration

In order to calibrate the parameters (γ, ϵ) that appear in the optimal diversion policy rule of the bureaucrat, we run the following non-linear cross-country regression. We regress the average diversion level, s_i, on our measure of monitoring efficiency, m_i, and on x_i, which measures the resources flowing into government coffers, where the subscript i refers to the country index. In order to implement this, we assume the following functional form for p:

$$p(m,s,x) = \frac{m^{\epsilon}}{(\gamma+1)x} s^{\gamma}, \gamma > 1. \tag{3.13}$$

The optimal diversion level in country i is then given by :

$$s_i^* = \left(\frac{x_i}{m_i^{\epsilon}}\right)^{\frac{1}{\gamma}} \tag{3.14}$$

so that bureaucratic diversion rises in equilibrium with government resources whereas it falls as monitoring efficiency rises.

Our monitoring efficiency measure is based on the Rule of Law index taken from the World Governance Indicators (WGI) database (details in the Appendix). Since the index is scaled from -2.5 to +2.5 points, we rescale it to always take positive values. As a result we add 2.5 to the value for each country. Since the index is available for more than one year, we take the country average as our measure of monitoring efficiency. The average value of m varies from a low of 0.8 to a high of 3.84 though the range in the non-averaged data is greater. We calibrate the benchmark economy to the average value in our data set which is 2.13.

The WGI dataset contains six indicators – Voice and Accountability, Political Stability and Absence of Violence, Government Effectiveness, Regulatory Quality, Rule of Law and Control of

Corruption. Of these six indicators, only the last two appear to be relevant as a proxy for m. The definitions provided in WGI documentation states that the “Rule of law captures perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence." As such, this appears to be a good proxy for the efficiency of monitoring bureaucratic diversion of resources. In contrast, “Control of corruption captures perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as “capture" of the state by elites and private interests." Based on this we conclude that the Control of Corruption index measures the extent of corruption in a society as opposed to monitoring efficiency. Since we already have the bribe rate as our measure of diversion, a perceptions based measure of overall corruption is neither necessary nor desirable as a right hand side variable in 3.14. Moreover, the corruption index conflates state capture by elites and private interests which may be more relevant for policy choices as opposed to direct diversion of state resources by bureaucrats. Overall, while it is apparent that none of the available monitoring efficiency measures are perfect for our purposes, the Rule of Law index comes closest to what we have in mind. Indeed the estimates reported below show that the Rule of Law is correlated with the bribe rate.[16]

Estimates of γ, and ϵ are obtained using a non linear cross country regression based on equation (3.14). All variables are average values for each country from 1995 to 2015. Our estimate of $\epsilon = 5.2$ with a t-value of 9.26 while our estimate of $\frac{1}{\gamma} = 0.941$ (t-value of 89.28) which implies that $\gamma = 1.06$ approximately.

We jointly calibrate β and the default cost parameters ψ_0 and ψ_1 so that the benchmark model can match the debt to government revenue and the mean and standard deviation of spread using the average values found in our dataset. The target for the spread is 3.9 percent, while the target for debt to revenue ratio is 36%. This number is calculated by first obtaining the average ratio of debt to revenue for all countries in our data set. Next, since, on average, the haircut imposed on creditors in the post-1980 defaults is about 37% (Cruces and Trebesch, 2013), we approximate unsecured debt using this proportion. The standard deviation of the spread is targeted at 1.5 % which is the average value in our data. To achieve these targets, we set $\beta = 0.86$, $\psi_0 = -0.388$, and $\psi_1 = 0.484$.

In order to get a sense of the ability of the calibrated model to deliver the key co-movement properties associated with sovereign spreads and fiscal policy as discussed in the literature, we report some non-targeted measures of volatility and co-movement in Table 3.4 as well as the targetted moments discussed above. Since our model makes predictions for the co-movement of resource diversion with these fiscal variables, we also report these moments. The first column in Table 3.4 reports the observed value of the moments in our panel data. We calculate these moments for each country separately in our dataset when information was available for the entire time period from 1995-2015 and then report the median value. Nations with missing observations during this

[16] We also note that if we use the Control of Corruption index instead of the Rule of Law index, we get very similar estimates of γ, and ϵ.

Table 3.4: Targeted and non-targeted moments

	Data	Benchmark Model
Targeted moments		
Mean spread (%)	3.9	3.9
Mean debt/revenue (%)	36	36
Standard deviation of spread	1.5	1.5
Non-targeted moments (median values)		
Average diversion (%)	2.01	2.30
Std dev of govt. spending	0.06	0.06
Std dev of diversion	0.06	0.05
Corr(spread, govt. spending)	-0.47	-0.94
Corr(spread, revenue)	-0.32	-0.92
Corr(revenue, govt. spending)	0.51	0.99
Corr(spread, diversion)	-0.47	-0.94
Corr(diversion, govt. revenue)	0.51	0.99

period were dropped. For example, we calculate the average bribe rate for each country and then report the median value (2.1 percent) in column 1. The corresponding moments from the simulated benchmark model, reported in column two, are calculated by simulating the benchmark model across 500 sample paths for 1500 periods each and then discarding the first 500 periods from each sample as burn-in and excluding the default periods. Government spending and revenue are logged and linearly de-trended prior to calculating the moments. The model does quite well in capturing the volatility of diversion. The average diversion generated by the model is also close to that found in the data. The model also delivers key features of emerging economy business cycles – spreads are negatively correlated with government spending and revenue. Moreover, government spending and revenue are positively correlated. Diversion is positively correlated with government revenue and negatively correlated with spread. The signs of these correlations are in keeping with their empirical counterparts but the magnitudes of the moments from the model are higher.

3.5 Results

3.5.1 The impact of monitoring efficiency on emerging economies

In this subsection, we discuss the behaviour of debt and default choices, government spending and bureaucratic diversion of government funds. We show how variation in monitoring efficiency affects these decisions and discuss the mechanism underlying the results.

Figure 3.2 displays the default regions associated with two economies. The green line refers to

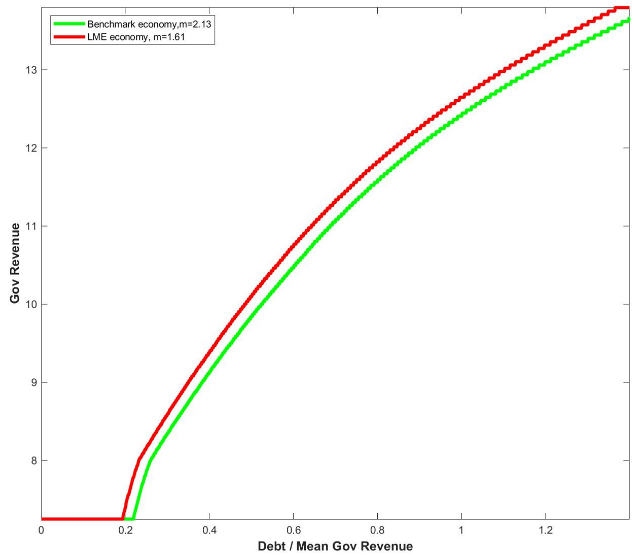


Figure 3.2: Default Regions

the Benchmark calibrated economy while the red line refers to an economy with a lower monitoring efficiency (m=1.6). This level of m in the model economy, generates an average bribe rate equal to 9%, which is the highest value seen in our international dataset. We will refer to these economies in what follows as the Benchmark economy and the LME (low monitoring efficiency) economy. Each line divides the space into two regions with default occurring below and to the right of the line. The vertical axis measures government revenue while the horizontal axis reports debt obligations relative to mean revenue. For any given level of debt, lower realizations of government revenue lead to default in each economy. As debt rises, the revenue level that is needed to avoid default also rises. These features of the default region are consistent with the quantitative sovereign default literature. It is clear that the default region is larger for the LME economy and that default is therefore more likely to occur at almost all debt levels in the LME economy. At very low levels of debt, neither economy will default, even when revenue levels are low.

Since lenders evaluate the probability of default when pricing the debt of each economy, it is not at all surprising that they offer worse terms to the economy that is more likely to default, ie., the LME economy. Figure 3.3 displays the menu of debt and interest rate spreads on offer to the two economies. A number of properties of the sovereign default model are immediately apparent from Figure 3.3. First, for any economy, the interest spread that must be paid over and above the world interest rate is increasing in the amount of debt chosen by the sovereign. Second, the maximum amount of debt is limited from above due to the sharply rising interest costs available from international lenders. Third, the vertical distance between the red line and the green line measures how much higher borrowing costs are for the LME economy at any given debt level. For instance, at the mean debt/revenue level of the benchmark economy shown by the dotted vertical

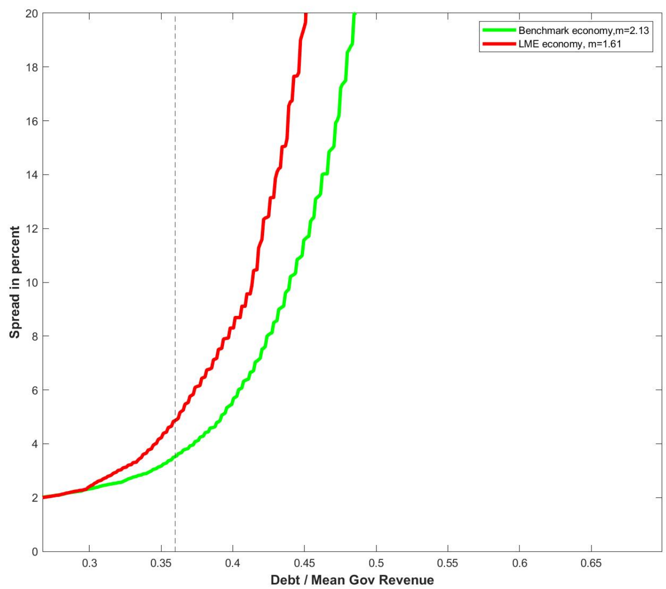


Figure 3.3: Spread Menus at Average Revenue

line in 3.3, the LME economy faces a spread of 4.9 percent while the benchmark economy is offered approximately 3.5 percent. Fourth, the endogenous debt limit imposed by the equilibrium menus is tighter for the LME economy.

Figure 3.4 displays the amount of debt chosen by the sovereigns of the two economies at various current debt levels conditional upon revenue being at its mean level. The worse terms on offer to the LME economy seen in Figure 3.3 leads to its sovereign choosing lower debt levels. The endogenous debt limit is also clearly visible as the vertical region of the debt choices with this level lower for the LME economy.

The relationship between debt levels and monitoring efficiency is also a feature of international data. Figure 3.5 presents a scatter plot of the average external debt to revenue ratio of various nations against their average Rule of Law index. The line of best fit from regressing the debt to revenue ratio on the rule of law index is also shown and clearly demonstrates the positive relationship between the two variables of interest. The regression coefficient implies that a unit increase in the index is associated with an additional 9 percent of debt to revenue on average.[17]

Figure 3.6 explores the net amount of government services g provided by the government as a ratio of total government spending $g + s$. The horizontal axis displays government revenue levels while debt is held constant at its mean value in the Benchmark economy. It is clear that the LME economy has fewer government services available to it as a proportion of government spending than in the Benchmark economy at all levels of revenue. Note too, that the benefit of defaulting is apparent in the sudden rise of the $\frac{g}{g+s}$ curve following default, relative to that at the marginally

[17]The estimated coefficient is 9.15 with a t-statistic of 10.4.

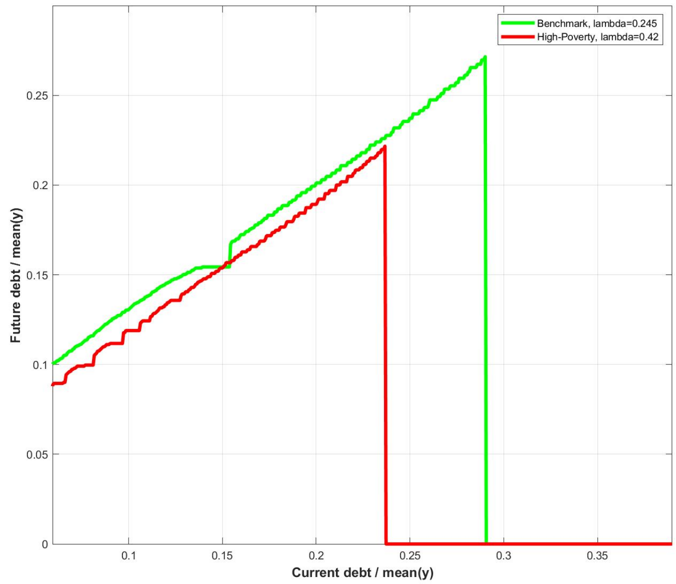


Figure 3.4: Debt Choices at Average Revenue

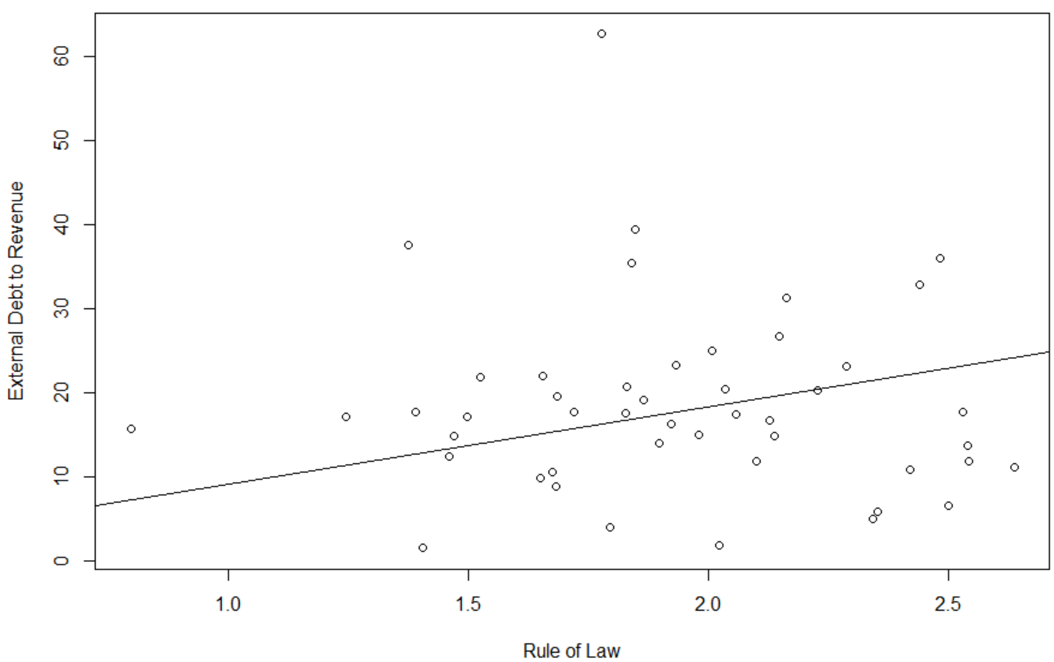


Figure 3.5: Average Debt and Rule of Law

higher revenue level when debt is repaid. It is also clear that the gain in the proportion of net public services from defaulting is much higher in the LME economy than in the benchmark economy. This higher benefit from defaulting as measured by the increase in $\frac{g}{g+s}$ ratio in the LME economy induces it to default at a higher revenue level and hence makes default more likely in the LME economy compared to the benchmark economy.

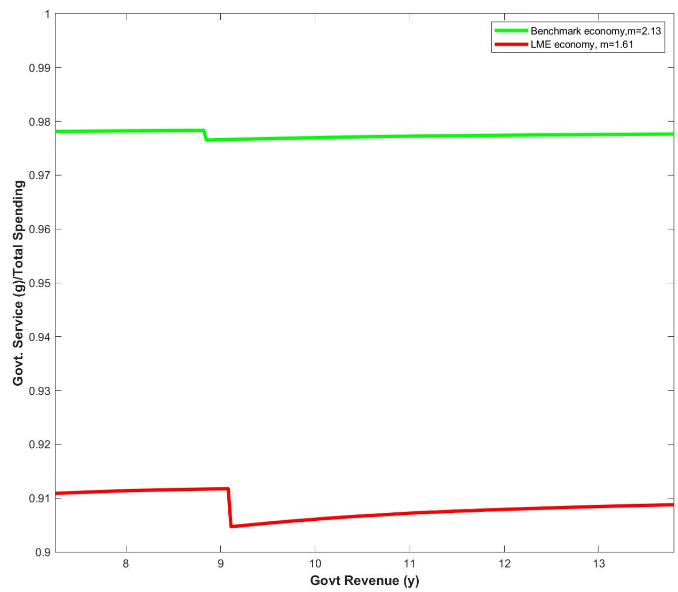


Figure 3.6: Government Service / Total Spending at Mean Debt

Figure 3.7 presents the amount of diversion, s, undertaken by the bureaucrat as government revenue varies and debt is held constant at its mean. As is evident from the figure, holding debt at its mean level, diversion of public resources increases in good times as government revenue rises. This occurs because of the expansion of the budget given existing debt obligations. This expansion can be funded, not only because there is more revenue available, but also because it is possible to take on more debt since good times are associated with lower spreads. Equation 3.14 implies that diverting funds is easier as the government budget expands, so the bureaucrat takes advantage of the good times and we observe pro-cyclical diversion in both economies. We also note that diversion falls sharply in default. Compared to the Benchmark economy, the diversion level is higher in the LME economy as expected. Moreover, as revenue expands, diversion rises faster in the LME economy than in the Benchmark economy. In other words, bureaucratic diversion is more pro-cyclical in the LME economy. Finally, note that diversion of resources drops more in default in the LME economy compared to the Benchmark economy. This difference in the behaviour of the bureaucrat is the mirror image of the behaviour of government services shown above and it explains why defaults are more likely in the LME economy. Bureaucratic diversion of public resources is a dead-weight loss to the sovereign which must be tolerated as a part of doing business. A benefit of default is that this dead-weight loss is lowered while bearing the revenue loss caused by the default decision. Note that since the revenue loss from default is the same in both economies, it is clear that there is a bigger net gain in economies where monitoring efficiency is low than where it is high. Obviously, the usual forces found in sovereign default models where default frees up fiscal room are also in operation here. These are well understood so we do not repeat these points here.

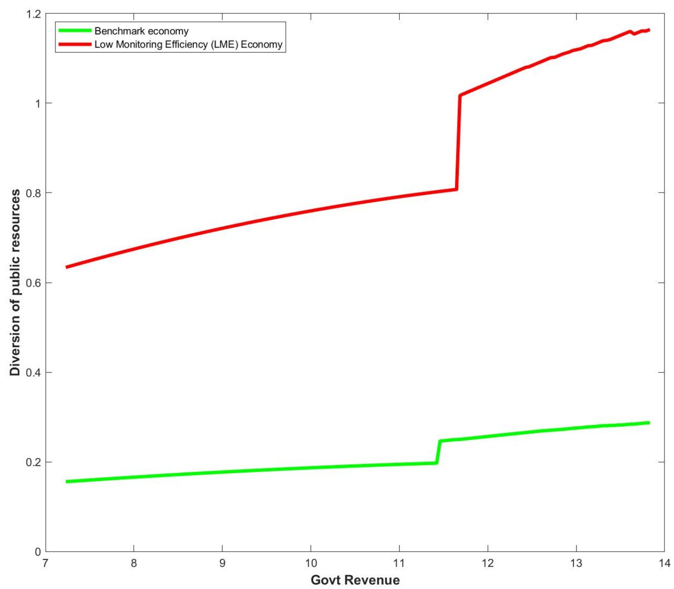


Figure 3.7: Bureaucratic Diversion at Mean Debt

These results suggest that the model may be consistent with the positive co-movement between countries with high bribe rates and those with high sovereign spreads found in the empirical section – model economies with lower monitoring efficiency display higher average bureaucratic diversion and also higher spreads since default is more desirable. We use our model in the next section to generate artificial data that can be compared to our actual international data. Since the choice of debt is an important covariate of spreads, we need to control for it like we did in the empirical section. We therefore proceed to run identical regressions on the simulated data and the emerging economy data. We discuss this next.

3.5.2 Comparing the model to the data

In order to compare the model's ability to generate the positive correlation found in section 3.2, we generate simulated data from 38 nations that vary only in monitoring efficiency m, while all other parameters are kept at their benchmark values. We vary m in the range from 1.25 to 2.64 to match the values of m exactly in our international dataset. We simulate each economy along 500 sample paths with 1500 periods each and then remove the first 500 observations from each sample as burn-in. Next, from the remaining data, we extract 500 samples with 21 periods before default in order to make it comparable to the empirical results. We then regress spread on the diversion rate, external debt to revenue ratio and a constant and report the results in column 3 in Table 3.5. Table 3.5 also reports the analogous regression coefficients from the data.

Table 3.5: 38 nations that differ in m only

Dependent variable: Spread	Data	Simulation
constant	34.5	-872.1***
	(38.9)	(1.93)
Average Bribe rate %	33.9***	12.5***
	(9.3)	(0.03)
External Debt/ Revenue	3.1***	33.6***
	(0.2)	(0.05)

Standard errors are reported in parentheses. *p<0.1; **p<0.05; ***p<0.01

Like the actual international data, the simulated model-generated data produces a positive correlation between spread and diversion rate once we control for indebtedness. The model based coefficient is smaller than that found in the data. In contrast, the coefficient of the debt to revenue ratio is bigger than in the data, though also of the correct sign. Our model suggests that a nation that has 5% higher diversion rates will face spreads that are 62.5 basis points higher on average, holding other things constant. The corresponding rise in spread is 173 basis points in the emerging economy data set which suggests that the calibrated model can account for approximately 37 percent of the observed co-movement between spreads and bribe rates purely from changes in m. We note that the model economies only vary in m, whereas there are other sources of difference in the emerging economy dataset. Moreover, we exclude any reduction in the ability of governments to repay debt due to loss of revenue due to tax evasion or loss of tax base. Clearly these additional sources of default risk would complement the results presented here.

Since the change in m is the underlying factor that drives the spread-diversion relationship in the model economies, we explore this link in our emerging economies data by running the following regression of spread on the rule of law index after controlling for the level of debt to revenue and log deviations of revenue from trend.

$$Spread_{it} = constant + \alpha_1 m_i + \alpha_2 debt/rev_{it} + \alpha_3 log\_dev\_rev_{it} + u_{it}, \tag{3.15}$$

We find an estimated α_1 coefficient of -402.8 with a t-statistic of 6.02, suggesting that higher values of the Rule of law index is also highly correlated with lower spreads, providing some validation of the main model mechanism.

We also report two non-targeted cross-sectional moments in Table 3.6. In row 1 we report the correlation of the average diversion level with government spending as a proportion of GDP and in row 2 with monitoring efficiency as measured by the Rule of Law index. In column two we report the corresponding correlations obtained from our simulated data discussed above. In the simulated data and in the international data, nations with higher monitoring efficiency display lower diversion levels. In addition, economies with higher diversion levels display higher amounts of government spending on average.

Table 3.6: Non-targeted moments capturing cross-sectional variations

	Data	Benchmark Model
Corr(diversion, govt. spending/gdp)	0.2034	0.8950
Corr(diversion, monitoring efficiency)	-0.1154	-0.8201

3.5.3 A model with government spending on monitoring efficiency enhancement

In this subsection we extend our benchmark model to allow the government to incur detection costs that enhance their monitoring effectiveness. Except for the changes noted below, the model and calibration is the same as in the benchmark economy. With detection costs, the flow budget constraint of the government is:

$$g + s + d^g = \begin{cases} y + [b' - (1-\delta)b]\, q(b', y) - \kappa b, & \text{if debt repaid} \\ y_a, & \text{if defaulted} \end{cases} \tag{3.16}$$

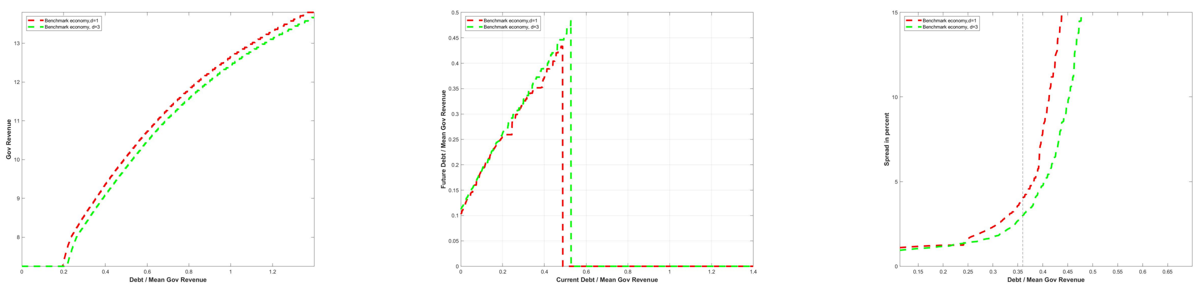
where d^g refers to the quantity of resources that the government spends in order to detect diversion. We correspondingly modify the functional form for p as follows:

$$p(m, s, x, d^g) = \frac{d^g m^\epsilon}{(\gamma+1)x} s^\gamma, \gamma > 1. \tag{3.17}$$

The optimal diversion level will then be modified to :

$$s_i^* = \left(\frac{x_i}{d_i^g m_i^\epsilon}\right)^{\frac{1}{\gamma}} \tag{3.18}$$

A glance at equation 3.18 reveals that a value of $d^g = 1$ in this model implies a monitoring effectiveness that is equivalent to the effectiveness in the benchmark model. As a result, we choose that as our starting value for d^g. In order to understand the effect of increasing government expenditure on detection on our results, we assign a higher value $d^g = 3$, holding all other parameters at their benchmark values. This higher value of monitoring effectiveness is equivalent to the highest value of m^ϵ observed in our data. In Figure 3.8, the red dotted line represents the benchmark calibrated economy with $d^g = 1$ while the green dotted line refers to the benchmark economy with $d^g = 3$. The figure clearly illustrates that the government can influence default risk, debt choices and spread menus by spending a higher amount on detection. Moreover, it shows that enhancing the Benchmark model with costly government detection expenditure leaves the main result intact: economies with higher monitoring efficiency generate lower spreads and lower diversion, in keeping with the main correlation reported in the empirical section.



(a) Default Regions (b) Debt choices (c) Spread Menus

Figure 3.8: Debt and Default choices with government detection costs

3.5.4 Acyclical diversion model

In this subsection we contrast the results of our Benchmark model with a specialized version where the amount of resources diverted by the bureaucrat only depends on monitoring efficiency. All other parts of the model remain the same. In other words, we rewrite the optimal diversion policy of the bureaucrat in equation 3.14 as $s^* = m^{-\frac{\epsilon}{\gamma}}$, so that s is a constant over time in each model economy. In Figure 3.9, we plot the spread - debt menu on offer to the two model economies as before. The green line refers to the modified version of the Benchmark economy (m=2.13) while the red line to the modified version of the LME economy (m=1.6). As is apparent from a glance, there is very little difference in the menus. The LME economy faces slightly higher spreads at the same debt level but this effect is too small to account for observed differences in the data. The two governments select very slightly different levels of debt and government spending because the bureaucrat in the LME economy diverts more resources for their use than in the Benchmark economy. As a result, total spending (and debt levels) must be adjusted to achieve the optimal levels of g. This result highlights the importance of the interaction of the cyclicality of revenue with the amount of resource diversion in generating a linkage between the bribe rate and default risk seen in the data. This is further emphasized by the alternate version of the model with cyclical s that only depends on domestic revenue which is presented in the Appendix.

3.6 Conclusions

International data suggests that nations differ in the average level around which their sovereign bond spreads fluctuate and these differences in levels persist for decades. This suggests that international debt markets assign idiosyncratic default risk that varies from country to country. In this paper we show that this idiosyncratic difference is linked to the average bribe rate in the country. The bribe rate measures the percentage of a government project value that must be given as a “gift" in order to secure a contract for the project. We find that a one percent increase in the bribe rate is associated with a 34 basis point rise in sovereign spreads using an international panel of time-series data covering 38 countries during the period 1995-2015. This correlation between the bribe rate and the spread level conditions on a number of domestic and global factors including the level of indebtedness of nations. Since the bribe rate ranges from 0.1 percent to 9 percent across these 38 countries, there is potential for it being associated with substantial international differences in sovereign spreads, which in turn will have large implications for welfare.

In order to understand why higher spreads and higher bribe rates go together, we build a sovereign default model of a small open economy in which the government wishes to provide public goods and services but is constrained to utilize corrupt bureaucrats to manage the budget and implement public projects. Our formulation implies that bureaucratic diversion of public resources is increasing in the size of incoming government resources and decreasing in the quality of institutions that govern the ability to monitor and punish corrupt officials. We obtain estimates of this diversion policy by measuring monitoring efficiency through the Rule of law index from the World Governance Indicators database and measuring the diversion of public resources through the bribe rate. We find that the amount of diversion is decreasing in monitoring efficiency and increasing in the resources flowing into the government accounts.

We calibrate the model to international data and embed the estimates of the diversion policy into the model parameters. Our Benchmark model delivers the key cyclical properties of sovereign spreads and government spending emphasized in the sovereign default literature. The spread falls in good times when revenue increases while government spending increases. The model also delivers bureaucratic diversion levels which are consistent with the mean value in our data. Moreover the volatility of spreads, diversion and of government spending are in line with the data.

Having established that the Benchmark model accounts well for these key properties, we explore the impact of varying monitoring efficiency on diversion levels and spreads. The model implies a positive relationship between the average amount of diversion of public resources and the average spread. Running the same regression on the simulated data as we did on the international data, we obtain similar results. Specifically, conditioning on debt to revenue ratio, a one percent increase in the bribe rate is associated with a 34 basis point increase in spread in the data while the model reports a 12 basis point increase. The key insight driving the higher default risk for nations with lower monitoring efficiency is that the diversion policy is increasing in the amount of resources flowing into the budget. In the absence of diversion, when revenue is low, a government may choose to default to prevent too many funds from flowing to international lenders. In our model, the government also realizes that bureaucratic diversion will fall in default. The lower the monitoring efficiency of a nation, the larger is the fall in diversion, the more attractive default becomes. As a result the default region is bigger for nations with worse monitoring efficiency, and so they tend to face higher spreads and are forced to take on less debt in order to control their borrowing costs.

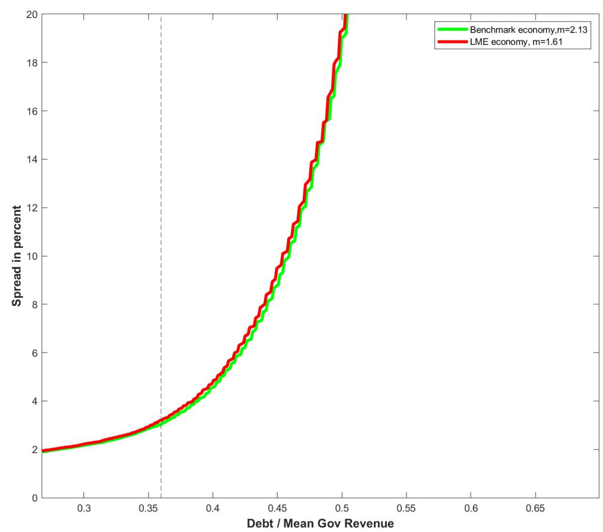


Figure 3.9: Spread Menus under Acyclical Diversion

Appendix

Data definition and sources

A1. List of countries with their corresponding Bribe rates

A2. Construction of Country Averages Data

We amalgamate data from 4 different sources in order to build the dataset of country averages. The main source on corruption data is The World Bank Enterprise Survey. We downloaded this dataset from https://www.enterprisesurveys.org/ and we selected the variable "Value of gift expected to secure a government contract (% of contract value)". There are one to three observations for each of the 139 countries in this dataset. These observations are for different years, anywhere from 2006 to 2018.

The source on monitoring efficiency data is The World Governance Indicators. This dataset was downloaded from http://info.worldbank.org/governance/wgi/ and we selected the "Rule of Law" variable. There are several annual observations for each of the 214 countries in this dataset for the following years: 1996, 1998, 2000, and 2002 to 2016.

Spread data comes from J.P. Morgan's EMBI Global Index and consists of weekly observations ranging from the first week in 1995 to May 29, 2015. There are a total of 67 countries in this dataset. In order to convert to annual frequency, we computed annual averages for each country.

We gathered data on domestic macroeconomic variables from The World Development Indicators dataset of the World Bank, which can be downloaded from the following website.

https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.MKTP.CD&country=#.

We downloaded data on 217 countries for years 1995 to 2015. We chose these years in order to be consistent with the aforementioned EMBI dataset. The following series were collected: "GDP (current US$) - NY.GDP.MKTP.CD", "GDP (constant US$) - NY.GDP.MKTP.KD", "GDP growth (annual %) - NY.GDP.MKTP.KD.ZG", "External debt stocks, public and publicly guaranteed (PPG) (DOD, current US$) - DT.DOD.DPPG.CD", "Revenue, excluding grants (% of GDP) - GC.REV.XGRT.GD.ZS", and "General government final consumption expenditure (% of GDP) - NE.CON.GOVT.ZS".

We took country averages of all observations between 1995 and 2015 for each of the series.

The following data transformations were performed to obtain the series used in the paper. We computed "External debt to GDP" by dividing "External debt stocks, public and publicly guaranteed (PPG) (DOD, current US$)" by "GDP (current US$)". "General government final consumption expenditure" was computed by multiplying "General government final consumption expenditure (% of GDP)" by "GDP (constant US$)". The country average of "General government final consumption expenditure" was multiplied by the country average "Value of gift expected to secure a government contract (% of contract value)" in order to compute the average "Diversion level" by country. The "Rule of Law" variable from The World Governance Indicators ranges from -2.5 to +2.5. We rescaled

Table .1: List of countries with their corresponding Bribe rates

Country	Bribe rate	Country	Bribe rate
Angola	6.6	Lebanon	0.2
Argentina	1.1	Mexico	2.45
Azerbaijan	0.55	Mongolia	2.35
Belarus	0.55	Morocco	0.2
Brazil	0.4	Mozambique	1.7
Bulgaria	0.3	Paraguay	1.83
China	0.2	Peru	1.2
Colombia	1.5	Philippines	8.35
Cote d'Ivoire	2.6	Romania	0.8
Dominican Republic	0.5	Russia	3.25
Egypt	0.25	Serbia	0.6
El Savador	1.13	South Africa	1.7
Ethiopia	0.35	Sri Lanka	0.4
Gabon	1.4	Tanzania	3.25
Ghana	5.25	Thailand	1.1
Guatemala	0.9	Tunisia	0.4
Hondurus	0.87	Turkey	1.45
India	0.1	Ukraine	8.95
Indonesia	2.35	Zambia	2.15

this variable by adding 2.5 to the average value of each country to ensure that it is always positive. "Total Resources" was computed by adding "External debt to GDP" to "Revenue, excluding grants (% of GDP)" and multiplying everything by "GDP". "External debt to tax revenue" is computed by dividing " External debt to GDP " by " Revenue, excluding grants (% of GDP)".

A3. Construction of Annual Dataset

This dataset used four sources, three of which were already described in the previous section: The World Bank Enterprise Survey, J.P. Morgan's EMBI Global Index, and The World Development Indicators. Aside from the series mentioned in the Country Averages Dataset, we also used the following series: "GDP per capita (constant 2010 US$) - NY.GDP.PCAP.KD", "Exports of goods and services (% of GDP) - NE.EXP.GNFS.ZS", "Total reserves (includes gold, current US$) - FI.RES.TOTL.CD", and "Imports of goods and services (% of GDP) - NE.IMP.GNFS.ZS".

The fourth source is the Federal Bank of St Louis. We downloaded the series "10-Year treasury constant maturity rate - GS10" and "1-Year treasury constant maturity rate - GS1" from https://fred.stlouisfed.org/ for years 1995 to 2015. In order to convert to annual frequency, we computed annual averages.

The following data transformations were performed. "Log Y deviations from trend" was computed by logging "GDP per capita (constant 2010 US$)" and then removing the linear trend. The "10-Year yield curve" series was computed by subtracting the "1-Year treasury constant maturity rate" from the "10-Year treasury constant maturity rate" and then taking the annual average. We computed "Reserves to GDP" by diving "Total reserves (includes gold, current US$)" by "GDP (current US$)". "Detrended tax revenue" was computed by multiplying "Revenue, excluding grants (% of GDP)" by "GDP per capita (constant 2010 US$)", taking logs and then removing the linear trend. "Net exports to revenue" was computed by subtracting "Imports of goods and services (% of GDP)" from "Exports of goods and services (% of GDP)" and dividing it by "Revenue, excluding grants (% of GDP)".

Additional empirical results: Controlling for other institutional factors

In order to disentangle the effect of corruption from other institutional factors, we extend column 2 of our spread regression in Table 3.2 by introducing other institutional measures one by one. As shown in Table .1, we control for all four dimensions of governance contained in the WGI dataset and bribe rate appears to be positive and statistically significant in all four specifications. This implies that the positive correlation between spread and bribe rate presented in the empirical analysis is robust to inclusion of other institutional factors.

Table .1: Bribe and Spread with control for other institutional factors

*Dependent variable:*spread	(1)	(2)	(3)	(4)
Bribe rate %	34.61**	23.53**	16.86*	42.88***
	(14.01)	(11.74)	(12.47)	(13.05)
External Debt/Revenue	2.92***	2.33***	2.30***	3.39***
	(0.48)	(0.50)	(0.42)	(0.48)
Log dev of Revenue from trend	−7.78**	−8.98***	−8.95***	−6.94**
	(3.32)	(3.34)	(3.29)	(3.21)
10 year US Tbill	31.99	72.36***	61.53***	26.32
	(21.65)	(20.02)	(20.92)	(20.74)
US yield curve 10/1	36.04	47.55	45.98	35.79
	(34.26)	(31.62)	(31.75)	(33.68)
Voice and accountability	−20.66			
	(39.81)			
Government effectiveness		−426.08***		
		(72.62)		
Regulatory quality			−463.61***	
			(53.31)	
Political stability				216.97***
				(45.65)
Constant	−77.25	694.32***	960.60***	−694.85***
	(159.03)	(213.95)	(159.74)	(195.82)
Observations	377	377	377	377
Adjusted R^2	0.35	0.41	0.44	0.39
F Statistic	34.15***	44.74***	50.90***	40.75***

Standard errors are clustered at the country level, and reported in parentheses. ***,**,* represent significance level at 1%, 5% and 10% respectively.

An alternate specification of x

In this subsection we present a variant of our model where incoming resources x depend only on domestic revenue y, such that equation 3.6 can be rewritten as:

$$x = \begin{cases} y, & \text{if debt was repaid} \\ y_a, & \text{in default} \end{cases} \tag{.1}$$

.

All other parts of the model remain unchanged. An obvious implication of this new x is that the amount diversion of the bureaucrat is now more pro-cyclical than before as the diversion policy varies almost proportionately with y. Figure .1 presents the default regions and Figure .2 shows the menu of debt and interest rate spreads for the two economies as before. As is evident from the graphs, the positive relationship between bureaucratic diversion and default risk is still preserved in this version of the model where the optimal bureaucratic diversion policy is a function of domestic revenue y and m only. This implies that our findings are robust to changes in the specifications of the diversion function.

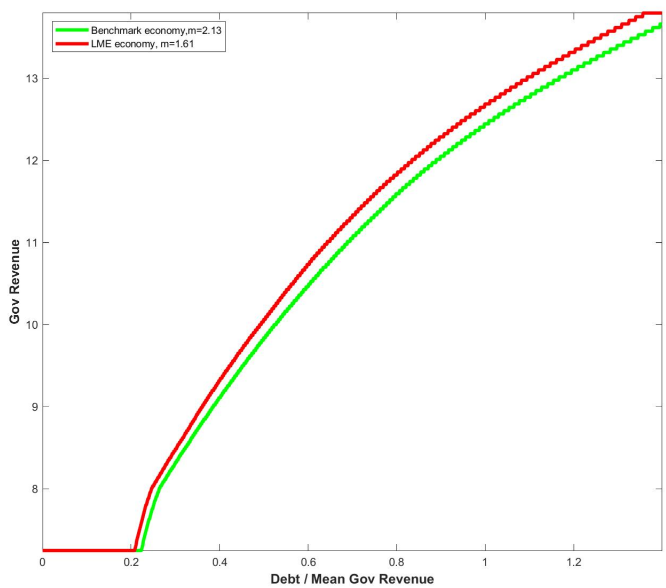


Figure .1: Default Regions with $x = y$

Solution Algorithm

The government problem is solved numerically using value function iteration. The stochastic stream of government revenue y follows an AR(1) process and is discretized using 201 equally spaced grid points using Tauchen's method. For government bond b, we construct a grid with 1200 equally

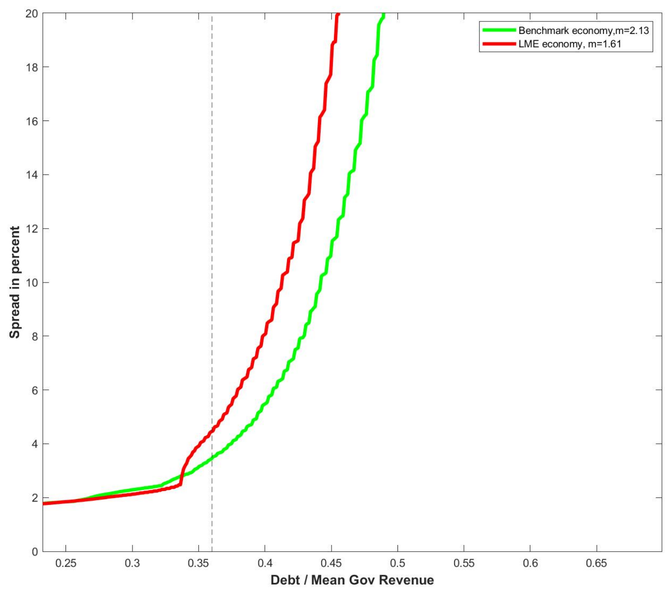


Figure .2: Spread Menus with $x = y$

spaced grid points. Given the realized revenue shock y and taking the optimal diversion policy of the bureaucrat s^* as given, the government updates its repayment value and default value and chooses government spending g, debt levels $b^{'}$ and whether to default or not.

A more detailed description of the algorithm is as follows:

1. Create equispaced grids and discretize the state spaces for revenue y with 201 grid points and for debt b with 1200 grid points.

2. Start with some guesses for the parameters to be calibrated: β, ψ_0 and ψ_1 and also start with some initial value for the bond price $q^0(b, y)$ for all $b^{'}$ and y.

3. Given the bureaucrat's optimal diversion policy $s^*(m, x)$, and the bond price schedule, solve for debt choice $b^{'}$ and government spending g.

4. Update the repayment value $V^c(b, y)$ and default value $V^d(b, y)$ for each iteration, and update the defaulting decision, bond price schedule $q(b', y)$ and the optimal value function of the government $V^0(b, y)$ based on the new value functions.

5. Iterate on the value function until the distance between the updated value function and the one from last iteration for a given $q^0(b, y)$.

6. Compute new bond price schedule $q^1(b, y)$ corresponding to the updated default sets and repayment sets and keep on iterating until the distance between $q^1(b, y)$ and $q^0(b, y)$ convergences.

7. Finally simulate the model on 500 sample paths for 1500 sample paths each, and compute key moments from 21 periods before default in each sample. If the model generated moments match the data moments, we stop, otherwise modify the parameters and repeat from step 2.

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Conclusion

Sovereign default continues to be a focal point for policymakers and academics, given its significant implications for global financial stability and national welfare. The COVID-19 pandemic and Russia's war on Ukraine have had significant economic and financial consequences for low-income countries. The war has not only destabilized Europe but also disrupted global food and energy security, significantly affecting regions like the Middle East and Africa, which were already reeling from the pandemic. As a result, several nations, including Argentina, Russia, Lebanon, Sri Lanka, Venezuela, and Zambia, have defaulted on their sovereign debt, with many more facing severe debt distress. This thesis delves into the multifaceted dynamics of sovereign default, particularly in the context of emerging economies. By examining the influences of global factors like oil price volatility, domestic economic conditions such as poverty, and institutional challenges including bureaucratic corruption, this research provides a comprehensive understanding of the determinants of sovereign default risk.

The first chapter of my thesis is primarily inspired by the recent surge in sovereign default events. In this paper, I incorporate time-varying volatility in global oil prices into a standard sovereign default model with long-term debt. My findings reveal that the response of sovereign spreads in response to changes in the oil price level is three times higher during periods characterized by high volatility compared to periods when volatility is low. It is 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. To highlight the importance of incorporating time-dependent fluctuations in oil price volatility, I compare a benchmark calibrated model (the "full model") with two alternative models: the "intermediate model," where oil price volatility is fixed at its mean while the level fluctuates, and the "basic economy," where both oil price level and volatility are fixed at their averages. This analysis demonstrates that the benchmark economy, which uses a stochastic volatility framework, produces higher spreads, greater spread variability, and a higher default rate for an equivalent average debt/GDP ratio. Finally, this paper emphasizes the need to incorporate volatility shocks into sovereign default models by analyzing the welfare effects of transitioning from an economy with oil price uncertainty to one without it. Ignoring this aspect of oil price data would lead to an underestimation of the impact of oil price shocks on sovereign default risk.

The second chapter shifts focus slightly to examine sovereign spread differences across countries through a country-specific factor: poverty. We first establish that national poverty head-count ratios and sovereign spreads are positively correlated, controlling for country differences in debt, inequality, per-capita GDP, and institutional quality. We then develop a sovereign default model featuring households at average income levels and those at the poverty line. The government taxes average income households to transfer consumption to the poor and repay debt. A political constraint ensures that all households participate in the social safety net program, limiting the government's fiscal choices. This model, calibrated with South African data on household income dynamics, the poverty line, and aggregate social transfer rates, reveals that increasing the proportion of poor households elevates default risk. The interaction of borrowing terms with the social safety net and the political constraint leads to higher default risk, consistent with empirical data.

The third chapter introduces another country-specific factor: corruption (measured by the bribe rate), to explain sovereign default risk. To understand the correlation between higher spreads and higher bribe rates, we construct a sovereign default model of a small open economy where the government, constrained by the need to use corrupt bureaucrats, aims to provide public goods and services. Our model suggests that bureaucratic diversion of public resources increases with incoming government resources and decreases with improved institutional quality that monitors and punishes corruption. By measuring monitoring efficiency through the Rule of Law index from the World Governance Indicators database and diversion through the bribe rate, we find that the extent of resource diversion decreases with higher monitoring efficiency and increases with greater government resources.

The insights from this thesis have significant policy implications. Understanding the heightened sensitivity of sovereign spreads to oil price volatility can help policymakers in oil-importing countries develop better risk management strategies and macroeconomic policies that account for global oil market fluctuations. Additionally, the findings on poverty and sovereign risk emphasize the need for policies that enhance social safety nets to reduce default risk and improve credit terms. The analysis of bureaucratic corruption highlights the importance of strengthening institutional frameworks and monitoring mechanisms to curb corruption and its detrimental effects on sovereign borrowing costs. For policymakers, these insights are invaluable for designing strategies that mitigate default risk and enhance economic stability. As emerging economies continue to navigate the challenges of globalization and domestic vulnerabilities, a nuanced understanding of sovereign default dynamics will remain essential for fostering sustainable development and financial resilience.