Credit Ratings in Sovereign Bond Markets

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Abstract

How does credit market segmentation affect developing countries' default risk? This paper is about the market segmentation that results from sovereign credit ratings and highlights its disciplinary role in countries' borrowing. From emerging market panel data, I find that downgrades across the regulatory threshold are associated with a 30-basis-point higher spread. In order to account for this empirical finding, I build a quantitative sovereign default model with a credit rating and a segmented market structure generated by the rating. I calibrate the segmentation parameter to replicate the same downgrade coefficient observed in the data, and I find that this higher spread implies that the discount rate on junk bonds is 200 basis-point higher than comparable non-junk bonds discount rate. In my model, accumulating debt above a threshold triggers downgrades, and the sovereign bonds are priced by more impatient lenders, which imposes a high interest. As a result, the government finds it optimal to borrow less. This disciplinary behavior, in turn, lowers default risk and raises the overall bond price schedule in the calibration. I show that the segmentation makes the country worse off in the long run, but during the period of debt accumulation, the government can be better off in low-debt states. An analysis of an optimal rating rule suggests that a looser rating rule reduces the welfare gains.

Keywords: Credit rating; Market segmentation; Sovereign bonds; Default risk
JEL Classification Numbers: G24, G38, H63, F34

1 Introduction

Sovereign credit ratings are the assessment by credit rating agencies, for example, Moody's and Standard and Poors', of the likelihood of a government defaulting on its debt obligations.

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In recent decades, the demand for sovereign ratings has risen rapidly. In the early phase of the 20th century, Moody's rated roughly 50 bonds of central governments. These were mainly issued by developed countries, including the United States. The number has risen to more than 130 countries as of today. This growth is because sovereign ratings facilitate countries to access international capital markets: International investors, particularly United States investors, prefer rated government securities over unrated securities of similar default risk (Cantor and Packer (1995), Luitel and Vanpée (2018)). In recent decades, developing and low-income countries, for example, African countries, have newly had their sovereign bonds assessed for credit ratings. Developing countries pay considerable attention to sovereign ratings as a means of raising external funds from international capital markets (Cantor and Packer (1995)).

Another reason developing economies care about their credit ratings is because their rating change could trigger regulatory constraints on investing their bonds. Rating-based regulations on institutional investors are intended to prevent speculative investing under prudential measures. Those regulations originated from the Volcker Rule and the Dodd-Frank law in the United States [1] (see Duffie (2012), Bernstein (2019)), and the Basel II framework spread rating-based rules widely in advanced economies as well. The restrictions are often in the form of imposing the minimum level of rating for securities investment and holdings. A well-known notion for the minimum level is the speculative grade or junk: equal to or below BB+ under S&P and Fitch or Ba1 under Moody's. Therefore, when a developing country has its sovereign rating downgraded to junk, its sovereign bonds are subject to prudential regulations, and potential investors are limited to holding junk bonds due to regulatory concerns.

South Africa in 2020 provides anecdotal evidence of developing countries' concern about being junk-rated. In November 2022, Moody's and Fitch downgraded South Africa deeper into junk territory. South Africa's Minister of Finance said, "The decision by Fitch and Moody's ... is a painful one. ... Continuous rating downgrades will translate to unaffordable debt costs, deteriorating asset values ...."[2] According to JP Morgan estimates, the downgrade

[1] The Volcker Rule exempts the Unites States treasuries and federal agency bonds, but it does not exempt securities issued by foreign countries.

[2] https://www.reuters.com/article/us-safrica-ratings/painful-downgrades-will-raise-south-africas-borr

of South Africa could trigger the forced selling of up to $2.4 billion worth of South Africa's dollar-denominated Eurobonds.[3] Another piece of anecdotal evidence is Greece in 2010. As its debt crisis evolved, Greece was downgraded to junk by S&P and Moody's. According to Barclays Capital, a British universal bank, this downgrade is estimated to result in Greek government bonds worth $252 billion being excluded from its bond indexes. [4] [5]

This paper is about the regulatory usage of sovereign credit ratings, mainly the regulatory constraints in holding sovereign bonds with low ratings, which is what institutional investors are subject to. This paper investigates its consequence in capital market segmentation and how an open economy's sovereign ratings change the external credit supply that it faces. A country's downgrade to junk implies that it loses a set of investors subject to prudential regulations. A junk-rated country faces a different group of investors for raising funds from what an investment-grade country faces. This market segmentation by sovereign credit ratings affects developing countries more than developed countries, as developing countries occasionally experience downgrades to junk during recessions or political instability, whereas advanced economies are seldom rated as junk. [6]

Focusing on developing countries, this paper aims to understand the role of ratings in countries' credit access. Although sovereign ratings have significant implications, few studies have been conducted about their impacts on emerging markets. In fact, those few conclude that sovereign ratings can represent another systemic risk to emerging markets (Ferri et al. (1999)). This is problematic because the researchers did not consider the sovereign's ability to influence its ratings: the endogenous behavior of the sovereign. For example, Moody's

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[3]https://sports.yahoo.com/news/junk-rated-debt-could-cost-south-africa-more-071113410--sector.html?guccounter=1&guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlLmNvbS8&guce_referrer_sig=AQAAABUDy7jr94PK0m-au9_nJ8fWqfnF2DG-zWu3dBZsSsCT864flMtSS-bt14lHNZSqXCpwOn_-ThuNveGCc1ly2PSvK01khP2QzdGgjc0CAiTPbHYeLWq6kreMkhCTUdABrFm_Eh_C0v5oavsSB4LDScHXsL-xpEUMUGCVKhgEZda2

[4]https://www.wsj.com/articles/BL-MB-23516

[5]Investment decision by credit ratings is also present in internal rules of index funds. Investment-grade (rating equal to or above BBB- under S&P and Fitch or Baa3 under Moody's) bond indexes are forced to sell their junk bonds following internal guidelines. Dropping out major bond indices could trigger additional forced-sell by other investors.

[6]According to S&P sovereign rating, Sweden, the United Kingdom, Netherlands, and the United States have downgraded once during the entire rating history and it is from AAA (the highest rating level) to AA+ (the second highest rating level). Germany and Switzerland have been keeping their rating as AAA throughout their rating history. Singapore and Hong Kong constantly improved sovereign ratings and have kept their investment-grade status throughout their history. During the European debt crisis, only Portugal and Greece experienced downgrading to junk. Spain, Italy, and Ireland experienced multi-notch downgrades, but they never downgraded to junk.

upgraded Vietnam's rating as Vietnam's National Assembly conducted prudent debt management policies (including lowering the public debt ceiling).[7] Thus, it may be crucial to include the endogenous behavior of the sovereign when analyzing the role of credit ratings. By doing so, we can better understand developing countries' behavior facing segmented market structures. This paper fills the gap in the literature. There is limited research to connect the regulatory aspect of sovereign ratings and how emerging markets respond to it. To the best of my knowledge, this paper provides the first quantitative analysis of it.

Unlike the previous literature, this paper highlights the disciplinary role of sovereign ratings on countries' borrowing. Accumulating debt over a certain level may cause a downgrade to junk, and the markets charge a higher interest on the country's bonds. A government internalizes this consequences and may choose to reduce its debt level to avoid downgrades or to exit the junk territory. This disciplinary role lowers default risk and may allow the country to issue bonds at a better price. Incorporating the endogenous response of the sovereign is critical for this result to arise.

To this goal, I build a quantitative sovereign default model with credit ratings and a segmented market structure. In my model, the sovereign borrows from the international credit market to offset income shocks and to front-load its expenditure. It also chooses to default on its outstanding debt or not. The credit rating represents the country's default risk. But a rating also determines which set of creditors the government borrows from. When the country is high-rated (or investment-grade), it issues bond in a high-rating bond market and vice versa for the low-rated (or junk) bond market. Therefore, the segmented market structure generates different bond price schedules depending on the rating. I assume that those price schedules are different by the discount rate of the creditors, and the relative difference is the critical parameter to govern the degree of segmentation.

To discipline the segmentation parameter, I exploit an empirical statistic from an emerging market panel data. I use sovereign bond spreads and sovereign ratings data to capture the spread change when a country's rating changes from investment grade to junk. I find that countries experience an increase of a 30-basis-point in their yields when they are downgraded

[7] https://www.moodys.com/research/Moodys-upgrades-Vietnams-rating-to-Ba2-outlook-changed-to-stable--P 468174

to junk. This increase is compared to those countries with similar economic fundamentals but not experiencing a downgrade to junk. This higher spread is robust to other several specifications. I find that the increase in bond spread is higher for those countries that are downgraded to junk than those that are downgraded but not cross the regulatory threshold (downgraded within investment grade or junk grade). Those empirical findings are consistent with the regulatory usage of sovereign ratings.

By replicating this statistic, I calibrate the segmentation parameter represents a higher discount rate of the low-rated bond market than that of the high-rated one. This implies that a low-rated bond is charged a higher interest rate than a bond with a high rating. This discourages the government from accumulating its debt over the downgrade threshold. Although it prefers front-loaded expenditure, the government finds it optimal to reduce its debt level. Debt reduction as an optimal policy is apparent particularly when the economy is near a downgrade threshold. The debt issuance in a controlled manner makes the country resilient to negative output shocks, and therefore default happens less often. This lower level of default is embedded in the pricing schedule as lower default risk compensation. This is shown in the calibrated benchmark economy as opposed to the counterfactual economy without ratings. By targeting the economy to match the average of the panel data, the model simulation shows that the frequency of default, default risk, and average spread are lower in the benchmark than in the counterfactual.

Next, I study whether developing countries can be better off with ratings and the segmented market than without it. I find that, under the calibration, the country is worse off with ratings when at the steady-state level of debt; however, the country can be better off at low levels of debt. There are opposite forces for this welfare implication. The welfare benefit arises from the disciplinary effect: the country can borrow at a higher price. On the other hand, borrowing less and abstaining from consumption reduces welfare. Another welfare cost is the high yield from impatient lenders when the country's rating is low. The calibrated sovereign is so impatient that the welfare cost quantitatively dominates the welfare benefit. However, I find that the segmentation can make the country better off in low-debt states. A counterfactual exercises about alternative segmentation rules suggests that loose rules generate negative welfare implications because they weaken the disciplinary effect and lower the welfare benefits of segmentation.

This paper is organized as follows: Section 2 goes over the literature review. Section 3 discusses the details and examples of the regulatory usage of sovereign ratings. Section 4 presents the empirical findings from emerging market data. Section 5 describes the model, and Section 6 shows the main quantitative results: the disciplinary effect of sovereign ratings and welfare implications. Lastly, Section 7 concludes the paper.

2 Related literature

This paper contributes to two related strands of literature. First, this paper is related to the quantitative sovereign default literature. Second, the paper is closely related to a broad set of empirical papers that analyze the impact of credit ratings on sovereigns, especially developing countries.

The sovereign default literature bases its theoretical framework developed in Eaton and Gersovitz (1981) and extended by Arellano (2008), Hatchondo and Martinez (2009), Chatterjee and Eyigungor (2012). The survey papers, Aguiar and Amador (2014), Aguiar and Amador (2021), documents the sovereign default literature in detail. The Eaton-Gersovitz model is about a government that faces income risk and borrows, using a defaultable but otherwise noncontingent bond. The risk-averse government borrows to smooth consumption, but its impatient preference generates front-loading consumption. The key feature of the model is that the government cannot commit to repay its debts. This class of model is able to match the countercyclical movement of interest rates in emerging markets, which is documented by Aguiar and Gopinath (2007), Neumeyer and Perri (2005).

Including long-term bond maturity allows the model to match higher debt levels and higher volatility of interest rates. Long-term bond maturity models have a computational challenge as discussed in Aguiar et al. (2020). Dvorkin et al. (2021) employs discrete choice methods to overcome the computational challenge, making the quantitative sovereign default model under long-term bonds tractable. I follow their methods and include extreme value shocks to handle the computational challenge.

There are ample empirical papers about sovereign credit ratings and their impact on sovereign bond spreads. Cantor and Packer (1996) estimate the weights of each sovereign's macroeconomic fundamentals in the determinants of sovereign credit ratings. Using cross-section data, they find that per-capital income, external debt, and inflation are crucial determinants of sovereign credit ratings. The paper shows that sovereign credit ratings summarize the country's macroeconomic fundamentals well and are highly correlated with sovereign bond spreads. Using event studies, the paper highlights that credit ratings can independently affect the market spreads and shows that the bond spread movements follow the announcement of the change in the country's credit ratings in the expected direction. The paper points out that spreads are affected more strongly by the rating announcement for non-investment grade, or junk grade, than investment grade bonds. Following the findings, I incorporate the regulatory usage of sovereign credit ratings to understand the distinction between investment grade and junk grade.

Hanusch et al. (2016), Drago and Gallo (2016) are the closest papers to the empirical evidence of this paper. Both papers focus on the regulatory usage of sovereign ratings. Hanusch et al. (2016) use panel regression to estimate the impact of downgrades from investment grade to junk. They estimate the impact on short-term borrowing using the Treasury T-bill, whereas this paper finds evidence on long-term borrowing which is consistent with the quantitative model. Drago and Gallo (2016) use an event study approach to provide evidence of the regulatory threshold. They find that the CDS spread reacts intensely to downgrades with crossing the threshold. Their papers compare the bond spread response to downgrades crossing the regulatory threshold and to downgrades without crossing the threshold. This paper takes a similar approach, and its findings are consistent with the literature. The contribution of this paper is building a quantitative model that can generate empirical findings, which enables us to do the welfare exercise and counterfactual policy experiments. To the best of my knowledge, this paper is the first quantitative paper to analyze the regulatory usage of sovereign ratings and its impact on developing countries.

3 Ratings and regulations on institutional lenders

As documented in Kiff et al. (2012), BIS (2009a), credit ratings are often used by authorities to classify securities in legislation, regulations, and supervisory policies. It affects the bond demand of institutional lenders and serves as a trigger in investment decisions under regulations. Those regulations are mostly motivated by prudential measures and have an intention of preventing institutional investors' portfolios from being exposed to high risks. Regarding credit ratings under regulation purposes, it refers to ratings released by credit rating agencies that are nationally recognized statistical rating organizations (NRSROs) under the United States Securities and Exchange Commission (the U.S. SEC).

Basel II is one of the prominent examples of the usage of credit ratings on regulations. Risk-based capital requirements under a standardized approach use credit ratings to map credit risks to risk weights or capital charges. Many advanced economies, for example, the European Union, Australia, Canada, Japan, and the United States, incorporate the Basel II framework into assessing the credit quality of securities in banking sectors. Limitations are set by central banks for acceptable collateral and margin requirements. For example, the European Central Bank (ECB) specifies the minimum rating level for the eligible collateral of commercial banks (ECB (2013)).

Not only the banking sector, but authorities also use credit ratings for regulatory purposes in the insurance sector. Mostly, the insurance company or pension funds are regulated to hold bonds with the minimum rating. In Japan, for example, estimating credit risks for insurance companies is done by calculating the solvency margin ratios, and credit ratings are used for the calculation. In the case of the United Kingdom, the Insurance Prudential Sourcebook relies on credit ratings for insurance capital resource requirements. In Canada, the Office of the Superintendent of Financial Institutions (OSFI) states, in its life insurer capital guideline, that "A company must consistently follow the latest ratings from a recognized, widely followed credit rating agency. Only where that rating agency does not rate a particular instrument, the rating of another recognized, widely followed credit rating agency may be used." The restriction is present under state legislation. For example, New York state insurance law mentions that an insurer may insure municipal obligation bonds that are not investment grade as long as at least 95 % of the insurer's aggregate liability is investment grade (see BIS (2009b)).

The stylized rating threshold of regulatory restrictions is whether a bond is an investment-grade or non-investment grade. Investment grade is above BBB- under the Standard and Poor's and Fitch rating system or Baa3 under Moody's system. Non-investment grade which is often called a junk grade is below BB+ under the Standard and Poor's and Fitch system or Ba1 under Moody's system. Regulatory restrictions imply that it is costly to hold non-investment grade (or junk grade) securities or that the potential holders of non-investment grade sovereign debt are limited. As documented in Rigobon (2002), upgrading to investment grade means that broader types of investors, for example, pension funds, and insurance companies, can hold sovereign bonds.

4 Empirical evidence

In this section, I present the empirical relationship between countries' credit ratings and their spread. Particularly, I investigate spread response as a country's credit rating changes across the regulatory threshold. Here, I use investment grade and junk grade as the regulatory threshold. The country's default risk affects both the bond spread and the credit rating, and in regression, I control for the country's default risk using its macroeconomic fundamentals. I show that the country experiencing downgrades across the regulatory threshold is associated with a statistically higher bond spread compared to the country with similar macroeconomic fundamentals but not experiencing the downgrade. I use the downgrade coefficient to calibrate the market segmentation parameter later in the calibration section. As a robust check, I compare the spread response to downgrades across the threshold to the spread response to the same degree of the downgrades but not crossing the threshold. I find a higher spread with downgrades across the threshold than downgrades not crossing the threshold.

Subsection 4.1 describes the emerging market panel data and data sources. Subsection 4.2 shows the main empirical findings.

4.1 Data description

The observation of interest is the bond market response to the regulatory constraints triggered by the change of credit rating. I use bond spreads as the measure of the bond market response. I exploit the JP Morgan's Emerging Market Bond Index (EMBI) spread in Global Economic Monitor (GEM) in the World Bank. The bond spreads are defined as the weighted averages of bond yield spread of the United States dollar-denominated external debts issued by sovereigns and sovereign entities and the spreads are over the United States government debt securities (see Comelli (2012)). Regarding the countries' credit ratings, I use Standard and Poor's sovereign credit ratings to measure a country's credit rating. [8] Under the Standard and Poor's (S&P) criteria, the regulatory threshold of interest is between BBB- and BB+. In other words, a country with S&P ratings above BBB- is investment-graded and the one with S&P ratings below BB+ is junk-graded.

I choose a set of countries that have experienced being both investment-graded and junk-graded throughout the sample period. The sample period is from January 1998 to December 2019. The 12 countries in the sample are Azerbaijan, Brazil, Bulgaria, Colombia, Croatia, Hungary, Mexico, Namibia, Panama, Peru, the Philippines, and South Africa. Bond spread and rating are calculated monthly. For each country's economic fundamentals, I use real GDP growth in percentage and gross debt to GDP ratio in percentage. The data is from World Economic Outlook (WEO) in the IMF, and it is calculated yearly.

Table 1 shows the summary statistics of bond spreads by ratings. The observation is monthly, and the number of total observations is 2,610. The sample is centered around the regulatory threshold, between BBB- and BB+. A low level of ratings indicates the low credibility of creditors. As expected, a lower rating is associated with a higher bond spread. Moreover, bond spreads become more volatile as the ratings get lower.

Table 2 shows how a country's credit rating changes in the following month. A downgrade is defined as an event where a country's rating changes to a lower level than the rating level

[8] The Standard and Poor's is one of the major credit rating agencies authorized as an NRSRO. It is fairly documented by the literature that the ratings of different credit rating agencies rarely differ much (see Ferri et al. (1999)). El-Shagi and von Schweinitz (2018) documented empirically that the mean absolute difference to the average rating level is 0.5 notches. It means ratings across agencies are far less than one notch apart on average. Therefore, the empirical findings would not change much by using credit ratings of different agencies, for example, Moody's and Fitch.

	rating	mean	median	s.d.	min	max	freq.	obs.
Investment grade	A-	50	53	0.24	13	124	0.02	-
	BBB+	187	168	0.95	55	668	0.13	-
	BBB	183	172	0.83	43	696	0.20	-
	BBB-	263	226	1.14	45	924	0.20	-
Junk	BB+	331	312	1.46	103	937	0.16	-
	BB	357	315	1.68	97	985	0.16	-
	BB-	444	393	2.48	137	1,370	0.07	-
	B+	884	751	3.64	430	2,057	0.02	-
	B	782	803	1.94	506	1,365	0.01	-
	total	294	234	2.08	13	2,057	1.00	2,610

Table 1: Summary statistics of bond spreads by ratings (bps)

	freq.	obs.
no change	0.97	2,776
downgrade	0.01	31
upgrade	0.02	49

Table 2: Monthly rating changes

of the previous month. An upgrade is defined in a similar fashion. Every rating change in the sample is by one notch.[9] As shown in the table, countries' ratings are persistent, and a country's credit rating has a 97% likelihood of not changing in the next month. The literature has documented that countries' ratings tend to be persistent. rating (See El-Shagi and von Schweinitz (2018)).

[9]In the real world when a country is under distressing crisis, credit rating agencies change the rating more than one notch or change multiple times in a month. For example, during Russia's invasion of Ukraine, Moody's downgraded Russia's rating from Baa3 to B3 by 6 notches on March 3, 2022, and Moody's downgraded Russia again from B3 to Ca by 4 notches on March 7, 2022. During Asia's financial crisis in the 1990s, S&P downgraded South Korea from A- to BBB- by 3 notches on December 11, 1997, and downgraded again from BBB- to B+ by 4 notches on December 22, 1997. Ferri et al. (1999) document that credit rating agencies downgraded countries during the Asian crisis more than the economic fundamentals would justify. This paper abstracts from the rating changes beyond the fundamental change, and the sample dataset embeds rating changes by one notch at most.

4.2 The empirical results

After constructing the sample, I investigate how the bond market responds when a country's rating triggers regulatory constraints. Bond spreads are the market response of interest. The event where regulatory restrictions are triggered is defined as when a country's rating changes from investment grade to junk (from BBB- to BB+ under S&P rating system). I include GDP growth and gross debt-to-GDP ratio as control variables to control a country's underlying economic fundamentals that affect both spreads and sovereign ratings. Unlike ratings and spreads in monthly frequency, economic fundamental variables are yearly. To capture the movement of the fundamentals within a year, I include the country's lagged spread (the spread of the previous month) as another control variable.

I conduct the following panel fixed effect regression:

$$spread_{it} = \beta_0 + \beta_1 DowntoJunk_{it} + \Gamma X_{it} + \alpha_i + \delta_t + \epsilon_{it} \tag{1}$$

$spread_{it}$ is country i's bond spread at time t, $DowntoJunk_{it}$ is a dummy variable which equals to one if the country i's rating is investment grade at time $t-1$ and junk at time t and equals to zero otherwise. X_{it} is a set of control variables including the country's economic fundamentals and lagged spread. I include country-fixed effect α_i and time-fixed effect δ_t in monthly frequency. The coefficient of interest is the downgrade dummy coefficient β_1 estimate.

The regression result is summarized in Table 3. The coefficient of $DowntoJunk$ is positive and statistically significant, implying that a country's rating change across the regulatory threshold is associated with higher bond spread. The bond spread is, on average, higher by as much as 30 bps when the country downgrades from investment grade to junk compared to the spread of a country with similar fundamentals but not experiencing the downgrade to junk. This finding is consistent with the literature, for example, Hanusch et al. (2016). They also find the positive and significant spread response as a country downgrades to sub-investment grade. Unlike those who use a short-term bond (60-day Treasury bill) spread, I use a long-term bond spread, which is consistent with the specification of the quantitative model in Section 5 and 6.

	(1)
	spread
DowntoJunk	29.64***
	(11.47)
lag_spread	0.969***
	(0.005)
gdp	-0.312
	(0.308)
grossdebt	0.146**
	(0.057)
Observations	2528
R^2	0.981
Country FE	Y
Time FE	Y

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 3: Regression with downgrade to junk dummy

The positive estimates are robust to other specifications. I include other downgrade dummies in the regression and compare the coefficients across the dummies. *withinJunk* and *withinInvst* variables represent similar downgrades to $DowntoJunk_{it}$ in the benchmark regression because those are downgrades by the same degree (downgrades by one notch). However, *withinJunk* variables capture downgrades within junk: downgrade events either from BB+ to BB or from BB to BB-. Similarly, *withinInvst* variables denote downgrades within investment grade: downgrade events either from BBB+ to BBB or from BBB to BBB-. Both downgrade dummies are still near investment-grade and junk threshold (between BBB- and BB+), but the downgrades do not lead to triggering regulatory constraints. This specification aims to isolate the effect of crossing the threshold by comparing other downgrades.

	(1)
	spread
withininvst	17.10*
	(9.572)
DowntoJunk	30.14***
	(11.46)
withinjunk	18.63*
	(10.09)
lag_spread	0.969***
	(0.005)
gdp	-0.249
	(0.309)
grossdebt	0.141**
	(0.057)
Observations	2528
R^2	0.981
Country FE	Y
Time FE	Y

Standard errors in parentheses

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

Table 4: Regression with different downgrade dummies

Formally, the regression with different downgrade dummies is as follows:

$$spread_{it} = \beta_0 + \beta_1 DowntoJunk_{it} + \beta_2 withinJunk_{it} + \beta_3 withinInvst_{it} + \Gamma X_{it} + \alpha_i + \delta_t + \epsilon_{it} \quad (2)$$

where $withinJunk_{it} = 1$ when a country i's rating is either BBB+ at time $t-1$ and BBB at time t or BBB at time $t-1$ and BBB- at time t. $withinInvst_{it} = 1$ when a country i's rating is either BB+ at time $t-1$ and BB at time t or BB at time $t-1$ and BB- at time t. The variable of interest is β_1 estimate relative to β_2 and β_3 estimates.

Table 4 depicts the regression results. Downgrades crossing the threshold, *DowntoJunk*, are associated with higher spreads than downgrades not crossing the threshold, *withinJunk* and $withinInvst$, which implies that the threshold between investment-grade and junk particularly matters and could be related to the regulatory concerns. In general, downgrade events are negative news about the economy, and a positive sign of downgrade coefficients is expected. However, the magnitude of the coefficient estimates is different whether the country's rating crosses the regulatory threshold or not. Furthermore, the downgrades crossing the threshold are statistically more significant than downgrades not crossing the threshold.

This result with different downgrade dummies is consistent with the literature. Using the CDS spreads of European countries, Drago and Gallo (2016) find that crossover downgrades have a significantly greater impact than non-crossover downgrades. They conclude that downgrades leading to a country's rating category change imply intense reactions from investors due to regulatory constraints. The contribution of this paper is using a broader set of countries than limiting the analysis to European countries to show the evidence of the regulatory aspect of sovereign ratings.

In the Appendix, I show additional tables related to the regressions and the regression result of a different specification.

5 The model

Motivated by the challenges developing countries facing the global credit market, I build a dynamic small open-economy model. The model has credit ratings and a global credit market segmented by credit ratings, and an impatient sovereign which borrows in long-term loans and strategically defaults, as in Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012).

5.1 Model Environment

Time is discrete and infinite $t \in \{0, 1, ..., \infty\}$. The economy consists of a country, a global credit market, and the country's credit rating. The sovereign maximizes its expected and discounted lifetime utility. Its utility comes from consumption each period under budget constraints. The sovereign faces a stochastic output process and has an outstanding debt. The country can choose to default on its outstanding debt. If so, the country is exempted from all debts, but the default is costly. Under no default, the country pays debt services and rolls over its debt by raising bond revenue. Which credit market the sovereign raises the revenue from depends on which credit rating the sovereign is assigned. Credit rating indicates the country's credibility and is assigned every period based on the country's default risk next period. Not only does it indicate how likely the country will default next period, but it is also meaningful for determining from which market the sovereign can raise bond revenue. The model has multiple credit markets with a representative lender for each. The representative lender of each market is different and therefore has a different bond price schedule. I focus on Markov equilibrium and from now on, I describe the model in a recursive fashion.

5.2 Timing

The timing of the game is as follows.

1. Output y realizes with inherited debt b.
2. The country chooses to default on the debt or repay.
3. Conditional on repaying, the country chooses a new debt level b'.
4. Credit rating r is assigned.
5. Bonds are traded in the global credit market, and the country raises bond revenue.

5.3 Country

The state of the economy is output, y, and the outstanding debt, b. Output is stochastic and exogenous. I assume it follows an AR(1) process with persistence ρ and volatility η. I estimate the process from the emerging market panel data in the empirical section. Consistent with the previous literature, as in Neumeyer and Perri (2005) and Aguiar and Gopinath (2007), the estimated parameter features the emerging market's volatile output. The debt is in face value and in a long-term and defaultable bond. Following Hatchondo and Martinez (2009) and Chatterjee and Eyigungor (2012), I assume bonds issued in every period decay at the same rate of λ with coupon payment κ. With this specification, a unit of bond issued today is a contract that promises to pay debt service, $\lambda + (1 - \lambda)\kappa$, and contract ownership of the remaining portion, $(1 - \lambda)$, only if the country does not default. With long-term bonds with a constant decay, the relevant variable to keep track of is the stock of the debt that the country is owed.

At the beginning of each period, the country chooses to default on its debt or repay it. If the default is chosen, the country is exempted from its debt obligation, but the default is costly in two ways: 1) it generates direct output cost, which is captured by $def(y)$, and 2) the sovereign is excluded from the global credit market and cannot borrow any credits for some period of time. If repaying is chosen, the country pays the total debt service which is proportional to the stock of outstanding debt and raises a bond revenue. Consumption takes place within the budget of exogenous output and bond revenue after serving debt service. The country is risk-averse and wants to insure itself from output shock by issuing a bond. The sovereign's problem is described as follows.

The country, at the beginning of each period, chooses to repay or not. $V(y, b)$ is the value at state (y, b), $V^R(y, b)$ is the value under reply and $V^D(y)$ is the value under default.

$$V(y, b) = \max\left\{V^R(y, b), V^D(y)\right\}$$

Under default, the country is free from debt obligation, but suffers direct output cost and is excluded from the credit market. It cannot borrow anymore, but in the next period with some probability, it can re-enter the credit market starting from zero debt. θ governs how likely it is that the country can re-enter the credit market under default status.

$$V^D(y) = u(def(y)) + \beta E_{y'|y}\left\{\theta V(y', 0) + (1 - \theta)V^D(y')\right\}$$

Under repayment, the country pays the debt service, coupon payments, and the principles of matured debt, and chooses the stock of debt tomorrow, b'. By doing so, the country raises bond revenue on the newly issued debt, $b' - (1 - \lambda)b$, under bond price q. The bond price is evaluated by how likely it is that the country repays tomorrow, and it depends on tomorrow's stock of debt b'. The innovation of this paper is that bond price also depends on the country's credit rating. Credit rating matters because it determines in which market it sells its bond. When a country is in high rating, it sells its bond in a high-rating bond market, whereas when it is in low rating, it faces the bond price schedule of a low-rating bond market. How the two credit markets are different is explained in the market segmentation section. $u(.)$ is the country's flow utility function under risk aversion preference. β is the country's discount factor. Following the literature, the country is impatient relative to the global credit markets. Given this, I assume the country always wants to borrow, not save, in the global credit market, and assume $b \geq 0$. The country chooses its optimal debt issuance to smooth its consumption under the budget constraint, equation (1).

$$V^R(y,b) = \max_{c,b' \geq 0} u(c) + \beta E_{y'|y}\{V(y',b')\}$$

$$s.t. \quad c + \big(\lambda + (1-\lambda)z\big)b = y + q(b', r(b',y))\big(b' - (1-\lambda)b\big) \tag{3}$$

5.4 Credit rating

In each period, the country's credit rating, r, is assigned. Credit rating takes value among a finite set as in the real world.[10] For simplicity, I assume that credit ratings are between two levels: $r \in \{h, l\}$. Investment-graded bonds in the real world are high-rated bonds, and junk bonds in the real world are low-rated bonds in the model. Incorporating the fact that holding junk bonds is subject to regulatory limitations unlike holding investment-graded bonds, I assume that high-rated bonds are traded in a different credit market from where low-rated bonds are traded. I will explain more in the market segmentation section. I assume there is no incomplete or imperfect information in the economy.[11]

As in the real world where credit rating implies the credibility of the country's debt obligation, in the model credit rating implies the country's default risk. If the country is likely to default in the next period, a low rating is assigned, and vice versa. I assume the assignment of credit rating is under the exogenous rule, which is characterized by rating

[10] Credit rating agencies, like Moody's and S&P, issue sovereign credit ratings with the highest AAA+ and the lowest D. There are 20 different levels of credit ratings.

[11] There are literature studies on sovereign credit ratings under the global game framework. See Carlson and Hale (2006), Holden et al. (2012), Holden et al. (2018)

rule parameter $\bar{p}$. This parameter serves as a threshold between high and low ratings: if the country's default risk is higher than $\bar{p}$, the country's bond is a low-rated bond and vice versa. It is important to remember that credit rating is assigned after the country's debt issuance choice. Therefore, the country takes into account that its debt choice affects how its bonds are rated.

The recursive way in which credit rating is assigned is followed. For each state s, given sovereign's debt choice b',

$$R(b'(s), s) = l \quad if \quad E_{s'|s}\big(D'(s', b'(s))\big) > \bar{p} \tag{4}$$

$$R(b'(s), s) = h \quad if \quad E_{s'|s}\big(D'(s', b'(s))\big) \leq \bar{p} \tag{5}$$

$R(b'(s), s)$ is the rating policy function under the rule $\bar{p}$.

5.5 Global credit market

There are two credit markets; one for high-rated bonds and the other for low-rated bonds. Each market is perfectly competitive and is composed of a continuum of lenders. Lenders in each market are homogeneous, and therefore, each market has a representative lender. Both representative lenders are risk-neutral and have a deep pocket. I assume that the representative lender of the high-rated bonds markets purchases and holds the high-rated bonds and they cannot purchase and hold the low-rated bonds, and vice versa.[12]

Each lender maximizes the expected profit of the country's risky bonds. In each period, the representative lender purchases bonds at the market price. The payoff of the bonds is conditional on the country's repayment next period and consists of debt services and the market value of the remaining bonds next period.[13] In equilibrium, bond price schedules of

[12] I do not allow lenders to choose which rated bonds to hold but take it as exogenous. This enables the model to be solved in a tractable way, especially the pricing schedules.

[13] When the country is either upgraded or downgraded next period, the current bondholder can no longer hold the bonds and has to sell the holding bonds to the secondary market. When the country keeps its rating, the current bondholder can sell the bonds or resell them to the secondary market. I assume both primary and secondary markets are perfectly competitive, and the secondary market has no liquidity friction. Therefore, primary and secondary markets share the same market price schedule, and I can recursively express bond prices with a single price schedule.

high- and low-rated bonds satisfy zero expected profit for each lender.

The two lenders are different in terms of the discount factors: $\frac{1}{R_h}$ for the high-rated bond market lender and $\frac{1}{R_l}$ for the low-rated bond market lender. I normalize R_h to a risk-free rate, and R_l captures how different the two lenders are in terms of patience.

It is reasonable to assume that $R_l > R_h$, which means the lender in the low-rated bond market is more impatient than the high-rated bond market lender. Because hedge funds usually seek high-return investment through short-selling and speculative investment practices, their outside investment options are higher than those of commercial banks and pension funds. Therefore, sovereign bonds that are junk-rated need to compensate enough for hedge funds to find investing in junk bonds is as profitable as investing in high-yield outside options. Investing in junk bonds involves regulatory costs that financial institutions have to bear, for example, higher capital requirements and not being counted as eligible collateral by the central banks. Pricing of junk bonds incorporates the compensation for those costs. It also captures the different risk tolerance between traditional financial institutions and hedge funds. I calibrate R_l by matching the regression coefficient of the downgrade dummy variable using model simulated data to the counterpart data moment using emerging market panel data and show that the calibrated R_l is lower than R_h as expected.

The recursive pricing equations for each market are as follows. For each state, and given the country's choice of b', the pricing schedule for high-rated bonds is

$$\begin{aligned} q(b', s, r(b', s) =& h) \\ &= \frac{1}{R_h} E_{s'|s}\Big[(1 - D'(b', s'))\big(\lambda + (1-\lambda)\kappa \\ &+ (1-\lambda) q'(b''(b', s'), s', r'(b''(b', s'), s'))\big)\Big] \end{aligned}$$

The pricing schedule for low-rated bonds is

$$\begin{aligned} q(b', s, r(b', s) = & l) \\ & = \frac{1}{R_l} E_{s'|s} \Big[(1 - D'(b', s'))\big(\lambda + (1-\lambda)\kappa \\ & + (1-\lambda) q'(b''(b', s'), s', r'(b''(b', s'), s'))\big) \Big] \end{aligned}$$

It is important to notice that both pricing schedules are similar except for the discount factor. Regarding the pricing of the bond today, not only does its expected payoff tomorrow matter, but also the bond's rating, thus to whom it is sold. Furthermore, today's bond price incorporates tomorrow's expected remaining value of the bond, which depends on tomorrow's credit rating. Assuming the lender in the low-rated bond market is impatient, the more likely it is that the country's bond will be rated lower tomorrow, the lower the value of the remaining bond tomorrow. This expectation is embedded in today's bond pricing. Today's bond could be low-priced even though it is a high-rated bond today, if it has a high chance of being downgraded tomorrow.

Another important feature of the model is the endogenous response of the country and the response embedded in the pricing equation. The equilibrium pricing schedule and the country's policy function are determined as fixed points. The country internalizes how its borrowing decision affects its credit rating and therefore the pricing schedule that it faces. The impatient country has a temptation to front-load consumption, and a long-term bond structure generates high borrowing incentives for the country. The opposite tension of high borrowing is present in the model. It is not only the fact that the bond is devalued by the default risk but also the fact that borrowing over a certain threshold (so that the country is downgraded to a low rating) triggers another bond devaluation by impatient lenders in the low-rated bond market, and the country internalizes the devaluation.

5.6 Markov equilibrium

I define the Markov equilibrium of the economy as follows. Given the exogenous rating rule $\bar{p}$, the Markov equilibrium consists of the country's value functions $V(b,s)$, $V^D(y)$, $V^R(b,s)$, the country's policy functions $B(b,s), D(b,s)$, rating policy function $R(b',s)$ and bond pricing schedule $q(b',s)$ where

1. Given the rating policy function and the bond pricing schedule, the country's value functions and policy functions satisfy the country's bellman equations and maximization problems.

2. Given the country's policy functions, the rating policy function is consistent with the rating rule $\bar{p}$.

3. Given rating policy functions and the country's policy functions, the bond pricing schedule satisfies zero expected discounted profit conditions.

6 Calibration

Parameters of the economy are chosen either from outside of the model or by matching moments. The model targets the average across countries in the panel data. The model is a yearly model.

6.1 Functional forms

The flow utility function is the constant relative risk aversion (CRRA) utility on consumption.

$$u(c) = \frac{c^{1-\sigma} - 1}{1-\sigma}$$

The default cost is in the unit of output. As discussed in Arellano (2008) and Chatterjee and Eyigungor (2012), it is non-linear in output.

$$def(y) = max\{0, d_0 + d_1 y\}$$

parameters	description	value	source
σ	risk aversion	2	literature
ρ	output persistence	0.844	the panel data
η	output volatility	0.034	the panel data
R_h	high rating market	1.027	risk-free rate
λ	bond structure	0.1	10-years maturity
$\bar{p}$	rating rule	0.0064	Moody's rating rule

Table 5: Parameters calibrated outside of the model

6.2 Parameters calibrated outside of the model

Table 5 shows the list of parameters that I calibrate outside of the model. The country's risk aversion σ is taken as the standard value in the literature. Stochastic output is assumed to follow an AR(1) process, and I estimate the process from the emerging market panel data. For each country, I linearly detrend real GDP growth and estimate AR(1) process from the cyclical components. I take the sample mean on estimated output process weighted by data observations.[14] The estimated value for persistence and volatility on output are $\rho = 0.84$ and $\eta = 0.03$ for each.

I normalize the discount rate of the high-rated bond market to the risk-free rate. I take a long-term government bond for Germany as a benchmark safe asset of the risk-free rate. The risk-free rate is estimated as the average of 10-year German bond yield from FRED in 1998-2019 which is the same time period of the panel data. The bond maturity parameter λ is set to resemble the 10-year maturity bond structure.

The rating rule parameter $\bar{p}$ is taken from idealized cumulative expected default rates [15] released by Moody's (2018), one of the major credit rating agencies. These rates suggest the benchmark expected default rates where a rated-counterparty will fail to perform its debt obligation (Moody's (2022)). The rates are available for each rating level, and the rates in the 1-year horizon are used for the estimation. Since $\bar{p}$ captures the threshold of credit ratings under regulatory purposes, I take the mean of expected default rates of the Baa3

[14] The dataset is not balanced, and some counties, for example Azerbaijan and Namibia, have fewer observations on spreads.

[15] The word "idealized" may imply a potential discrepancy between the expected default rate by the time the credit rating agency assigns a rating to the entity and the default rate afterwards. The default risk estimate using historical ratings path could be different from the initial design of each rating category.

parameter	description	value	moments	target	model
R_l	low rating market	1.047	downgrade coefficient	29.64	29.98
β	country's impatience	0.918	mean b/y	47.1 %	25.5 %
$d0$	default cost	-0.217	mean spread	294 bps	293 bps
$d1$	default cost	0.254	s.d. spread	1.80	1.37

Table 6: Parameters calibrated inside of the model

rating and the Ba1 rating. The estimated value of $\bar{p}$ is 0.64%. It means that country is low-rated if it is expected to default at a higher rate than 0.64% next period in the model.

6.3 Calibrated parameters

The rest of the parameter values are jointly calibrated by matching moments under simulation. The key parameter is the discount rate of the low rating market R_l which governs the degree of market segmentation. As R_l is highly distinct from R_h, two markets are different to a greater degree. It implies that the credit market is greatly segmented. I calibrate the segmentation parameter to target the downgrade coefficient. To be specific, I run the same regression using the model simulation with the one in the empirical section. In the model simulation, the downgrade dummy variable captures downgrades from $r = h$ last period to $r = l$ in the current period. I use the same control for model simulation regression: output level y, debt-to-output ratio b/y, and last period spread. I do not control for country-fixed effect and time-fixed effect in the model simulation because it is a single-country model and because there is no exogenous time-varying risk-free rate. [16]

Following the literature, the country's discount factor β and default cost parameters d_0, d_1 are calibrated to match mean debt-to-output ratio, mean spread level, and the standard deviation of spread. The data moments are calculated as the sample average across countries in the panel data. In the end, I calibrate segmentation parameter R_l, country's impatience β, and default cost d_0, d_1 jointly to match the four moments.

[16] The reason for including time-fixed effect in the data is to control exogenous time-varying risk premium and to capture the fundamental change that the macro-fundamental control could not capture. Note that the spread data is in monthly frequency and the macro-fundamental variable data is in yearly frequency. In the model simulation, the current spread perfectly captures the fundamental change between last period and current period.

Table 6 show the calibrated values for four parameters and the targeted moment fit. The model has a limitation in matching the mean debt-to-output ratio. It is because high enough R_l relative to β is necessary for generating the downgrade coefficient, but that R_l discourages the sovereign from accumulating the debt in the model simulation. On the other hand, low enough β relative to R_l weakens the segmentation effect, and the downgrade coefficient is not generated under the model simulation. Including the variance of taste shock in the calibration is a potential modification for a better match.[17]

7 Quantitative results

I describe some features of the Markov equilibrium in the calibrated model. To understand the role of sovereign ratings, I compare the benchmark to the counterfactual economy with no ratings and market segmentation. No segmentation implies a single credit market and a single bond price schedule. The single pricing schedule is assumed to be discounted at the risk-free rate, the discount rate of the high-rated bond market in the benchmark. I demonstrate the disciplinary role of ratings and the implied segmentation.

7.1 The equilibrium bond pricing schedule

Figure 1 depicts the equilibrium bond spread schedule as a function of the debt choice b'. The schedule is evaluated at the mean y level, and the b' level in the horizontal axis is relative to the mean y level. The junk cutoff indicates that the country's rating is high with a higher b' level than the cutoff, and a lower b' level than the cutoff produces the low rating for the country. The spread schedule is upward-sloping: the higher b' level increases the equilibrium spread. A high level of debt choice today means a high level of outstanding debt tomorrow, raising the sovereign's incentive to default tomorrow. That increased default risk is compensated as a higher interest rate (or a lower bond price) in today's bond pricing. The upward-sloping pricing schedule is present in both the benchmark and the counterfactual.

[17] Following Dvorkin et al. (2021), I employ extreme value shock to tackle computational issues solving a sovereign default model with long-term bond. Taste shock-related parameters are directly taken from the literature for now, but potentially I can include those parameters in the joint calibration. For the literature to include taste shocks in the calibration, see Arce (2021).

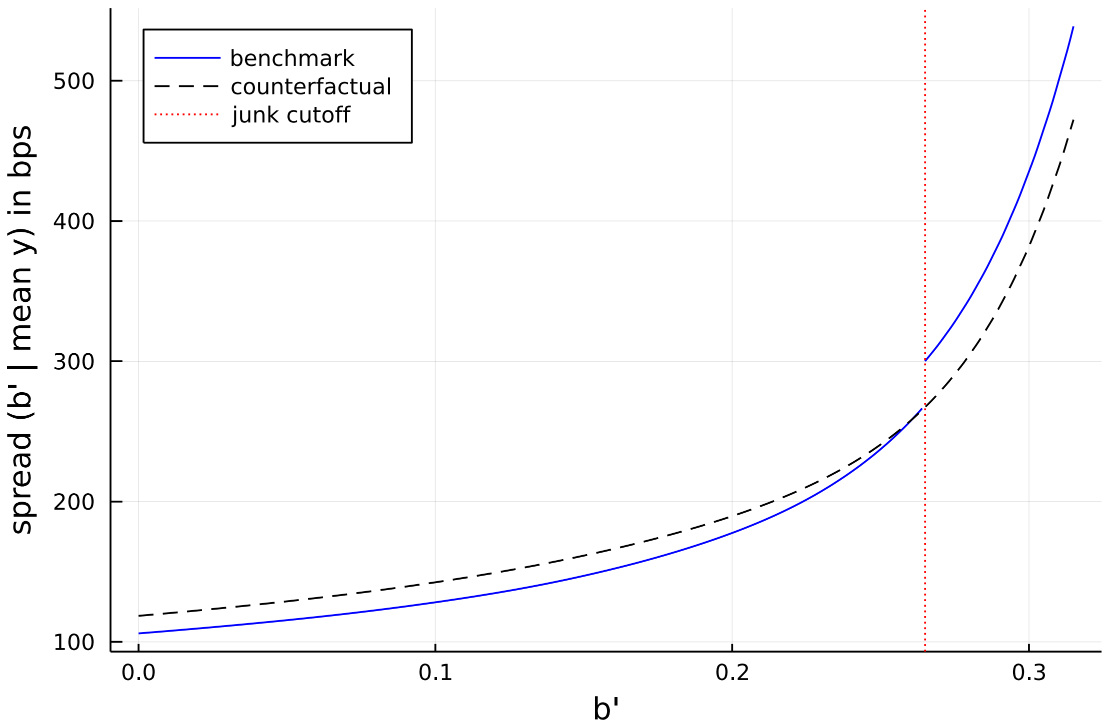

Figure 1: The equilibrium bond pricing schedule

Unlike the counterfactual, the first distinctive feature of the benchmark is discontinuity. This discontinuity comes from the segmentation. As the debt choice b' increases over the cutoff, the country's default probability increases over the rating rule, $\bar{p}$, and the country's rating changes from high to low. As the country's rating changes from high to low, the lender who prices the bond switches from the patient lenders (the lenders in the high-rated bond market) to the impatient lenders (the lenders in the low-rated bond market). This switch means a discrete change in the discount rate of the equilibrium pricing equation. The default risk compensation grows smoothly as the default risk increases around the cutoff, shown in the counterfactual. Therefore, the discrete increase in the spread is not from default risk compensation but from the switch to a different credit market. This discrete increase in the interest rate is the driving force of generating the disciplined borrowing behavior of the sovereign.

Another feature in the pricing schedule is the anticipation effect. Note that the bond structure in the model is long-bond, and the bond price includes the future value of the remaining bond. If the country downgrades to a low rating tomorrow, the market value of bonds tomorrow will be low-valued by the impatient lenders. Even though the sovereign's rating is high today and patient lenders price the bond with a low yield, the bond price could be noticeably low when there is a high probability of downgrades tomorrow. The expectation of future downgrades forces the devaluation of bonds in the current period. This devaluation is visualized when b is lower than the cutoff but substantially high enough: the spread increases faster as b' rises closer to the cutoff. This more rapid growth in the spread (or faster devaluation of the bonds) is not because the default risk evolves faster under the benchmark[18] but because downgrades in the next period are more likely to be anticipated.

Combining the first and the second features tells us how the discontinuity is determined endogenously. The discontinuity is higher as the R_l parameter is larger than R_h (or as two credit markets differ significantly). On the other hand, the greater the anticipation effect is, the lower the discontinuity is. The country's borrowing incentives govern the anticipation effect and how likely the downgrade will happen tomorrow under the exogenous output shock. The country's impatience and default cost parameters are relevant for the borrowing incentives. The downgrade coefficient is to capture this discontinuity under the simulation. To identify R_l in the model simulation, I need to consider the interaction of this discontinuity with other parameters, which provides a rationale for the joint calibration.

The last feature to highlight is the lower spread in the benchmark under a low enough level of b'. As long as b' is low and downgrades are less likely to happen tomorrow, the sovereign can borrow cheaply. This cheap borrowing is from the disciplined borrowing behavior and lower probability of default, which is explained in detail in the following subsections.

7.2 Optimal policy of the sovereign

Figure 2 describes the optimal policy of the sovereign under the calibration. The borrowing policy is plotted as a function of the outstanding debt level b evaluated at the mean y level. The level of the horizontal axis is normalized by the mean y level. The function is weakly increasing in b, which means the sovereign finds it optimal to choose high b' when

[18] The growth rate of default probability with b' around the cutoff under the benchmark is almost equivalent to the one under the counterfactual.

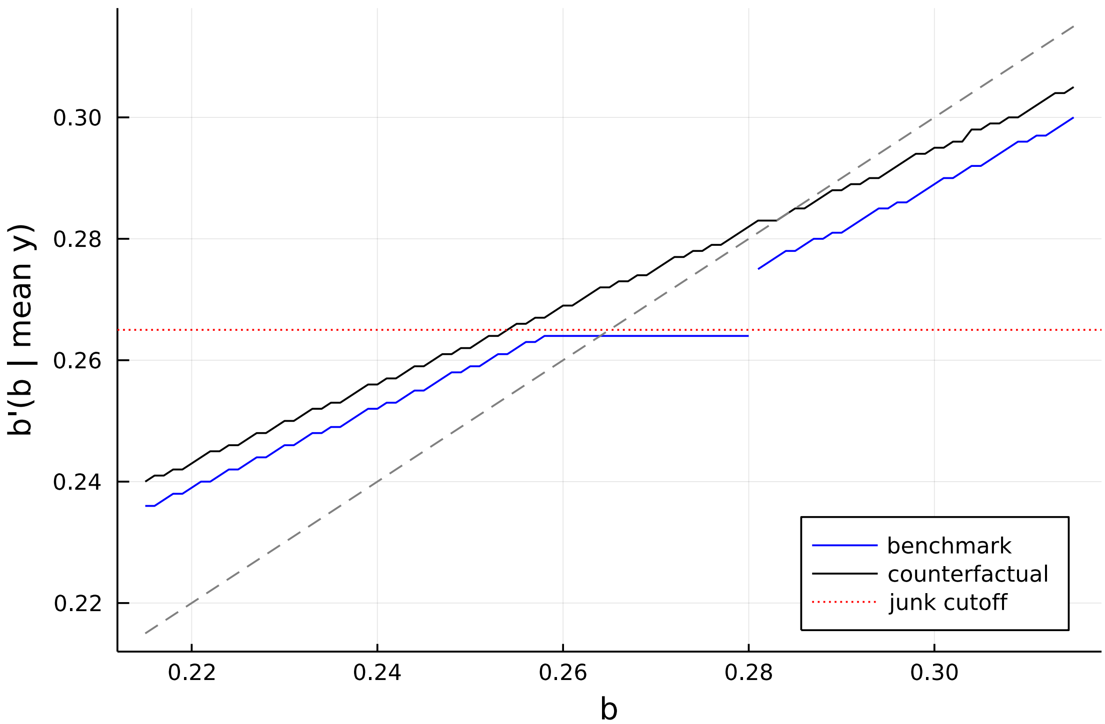

Figure 2: Sovereign's borrowing policy

it is inherited with a high level of the stock of debt b. It is because the sovereign rolls over the inherited debt and, conditional on repayment, consumption from which the sovereign gains flow utility reduces with the higher outstanding debt. The junk cutoff denotes that at the given y if the government chooses b' level above the threshold, its rating is low today. Therefore, the government faces the impatient lenders of the low-rated bond market for raising revenue.

The distinguishing feature under the benchmark is that the sovereign stops borrowing near the cutoff. To be more precise, the country reduces the debt stock to a level right below the cutoff. It internalizes the consequence of borrowing over the cutoff. The government finds it optimal to keep its high rating and avoid the high yield from the impatient lenders. However, stopping borrowing means less consumption and less flow utility today. With a high enough outstanding debt level, the country has no choice but to cross the threshold and is rated as low. But still, the government chooses less debt stock than it would have chosen in the counterfactual because the country can exit the low-rating territory shortly by gradually reducing debt stock.

Not only when the state is near the cutoff, but less borrowing is also present throughout the entire debt state b, including when the country's rating is high and is far from the cutoff[19]. This less borrowing can be interpreted as a precautionary behavior of risk-averse agents in the incomplete market (Aiyagari (1994)). A sufficient negative output shock could lead to downgrades, and the country pays the high yield as a consequence. Due to an incomplete market structure, the government cannot hedge from this output shock and the following rating downgrades. Instead, the risk-averse government chooses to borrow less out of the precautionary motive, even when the state is far away from the cutoff and the probability of downgrade, which comes from the sufficient negative output shock, is low. This motive becomes more apparent as the probability of downgrades rises: as the state is closer to the cutoff, the government chooses to borrow much less. Less borrowing in the entire debt region lowers the default probability, and the pricing schedule embraces it. Therefore, the sovereign can borrow at a lower spread under a high rating than it would have had in the counterfactual, as shown in Figure 1.

7.3 Simulation

Table 7 compares the model simulation result to that of the counterfactual economy. To make the comparison sensible, I feed the same time series of stochastic variables, the output series and the re-entry shock upon default. After chopping the first 100 periods of each simulation, I imposed the same initial debt level of the benchmark simulation on the counterfactual simulation. Each simulation is over 1,000 periods, and the listed moments are calculated as the sample average over 100 simulations. Percentage change denotes the percentage change of the moment under the benchmark relative to the counterfactual. The period when the country is under the default status is not included in calculating the moments.

As documented before, a lower mean debt level relative to output in the benchmark is expected under the simulation. Regarding the average spread, disciplined borrowing lowers the incentive to default at a given output level and could result in a lower spread, especially

[19]The entire debt state refers to a set of debt state $[0, \bar{b}]$ where the default probability reaches to 1 under $\bar{b}$ given y as the mean level. In this region, the optimal borrowing in the benchmark is strictly lower than that in the counterfactual.

	benchmark	counterfactual	% change
mean default risk	1.83 %	2.60 %	- 30 %
junk freq.	37 %	51 %	- 27 %
annual default freq.	1.7 %	2.5 %	- 32 %
mean debt/y	25.5 %	26.9 %	- 5 %
mean spread	293 bps	313 bps	- 6 %
s.d. spread	1.37	1.45	- 6 %

Table 7: Model simulation results

when the country's rating is high. On the other hand, the presence of impatient lenders could contribute to a higher spread on average when low ratings happen frequently. Under the calibration, the country's rating is often high in the simulation, and the average spread of the benchmark economy is lower than without ratings.

Another important finding is that the country's default risk reduces with the segmentation, and fewer defaults happen on the equilibrium path. This quantitative result is consistent with lower spread volatility and mean spread. High default risk contributes to the high spread volatility because bond spread surges exponentially under the high level of default risk. On the other hand, frequent downgrades could contribute to higher spread volatility. This is because the spread surges discretely with switching to impatient lenders. The fact that spread volatility is reduced by a small magnitude compared to a significant reduction in default risk shows those opposing forces. In the end, the first force quantitatively dominates the latter force, and spread volatility is lower under the benchmark.

A relatively significant reduction in default risk compared to the decrease in mean debt level suggests a distinctive role of the segmentation. The segmentation restricts the country from staying at a positive default risk state. This restriction prevents the default risk from evolving. This is also shown in the optimal borrowing policy. The debt reduction is more apparent near the cutoff or low-rating territory. It is the region where default risk is strictly positive and the economy is vulnerable to adverse output shocks.

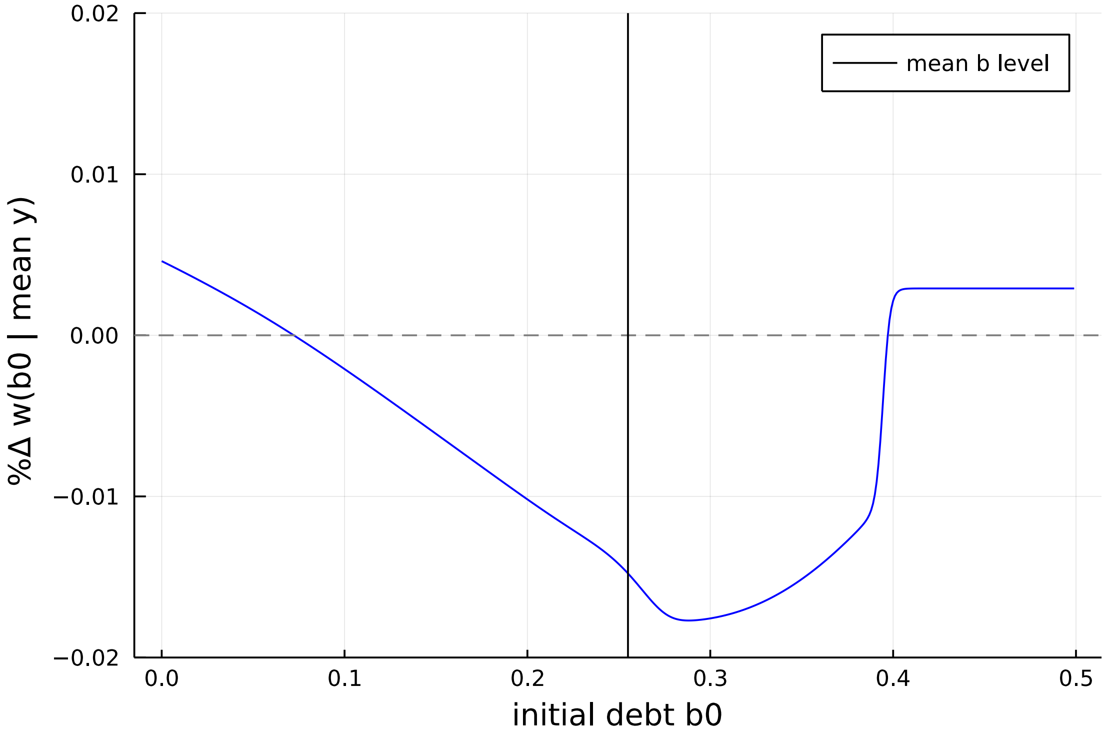

Figure 3: Change in welfare with the segmentation

7.4 The welfare implication of the segmentation

Figure 3 outlines the percentage change in welfare under the benchmark compared to the counterfactual. The difference is evaluated at the mean y level, and the plot is across the initial debt level b_0. The positive number means the segmentation generates welfare gain for the sovereign.

The change in welfare is a decreasing function under the low level of the initial debt. It is because the welfare benefit from the segmentation decreases with the high debt level, whereas the welfare cost rises with the high debt level. Those opposite forces are crucial to understanding the welfare implication of the segmentation. Disciplined behavior lowers the country's default risk and allows the government to borrow credit at a better price, which is a potential source of welfare benefit. This benefit is maximized when the debt state is far from the junk cutoff at a given y level. As the debt state is closer to the cutoff, the anticipated bond devaluation counteracts the disciplinary effect, and the welfare benefit diminishes. Although the sovereign currently maintains a high rating, there is a decent chance that the country will downgrade to junk next period when the debt state is close enough to the cutoff.

On the other hand, the primary source of welfare cost is less consumption from reducing debt issuance. In this model, the country's welfare is derived from the flow utility from consumption. As the debt state is closer to the cutoff at a given y level, the government actively shrinks the bond issuance, and the welfare cost from less consumption amplifies. Not only is reducing debt stock painful to the country, but the high yield from the impatient lenders is also a crucial source of welfare cost. Adverse output shocks trigger downgrades to low ratings, and the sovereign pays high yields to impatient lenders in addition to a high default risk compensation. This is not ideal from the perspective of risk sharing: the sovereign may want to hedge from low-income shock.

The graph shows how each opposite force aggregates quantitatively and when the segmentation improves the country's welfare. First, the segmentation delivers welfare loss to the sovereign in the long run. The percentage change in welfare under the mean debt level is negative under the calibration. The calibrated sovereign is so impatient that it accumulates debt sufficiently close to the cutoff. The anticipated devaluation counterbalances the welfare benefit from the segmentation, at the same time the country suffers from controlled borrowing as it is near the cutoff. Moreover, the government is exposed to a decent chance of downgrades next period (coming from low-income shocks). In the end, the welfare cost quantitatively dominates the welfare benefit, and the welfare loss, in the long run, is as much as around -0.015% under the calibration.

However, the country gains welfare from the segmentation in the transition, especially with the low debt stock. As long as the country is far from the cutoff, downgrades rarely happen, and the government does not need to reduce the issuance aggressively. The benefit of borrowing credit at a better price is maximized without anticipated depreciation. Quantitatively, the country's welfare is enhanced by the segmentation by roughly 0.005% 0.005%. Also, the welfare gain happens under the default region. The debt region over the level of 0.4 visually shows it. In this model, the country in default status returns to the credit market with zero debt, where the welfare benefit is maximized.

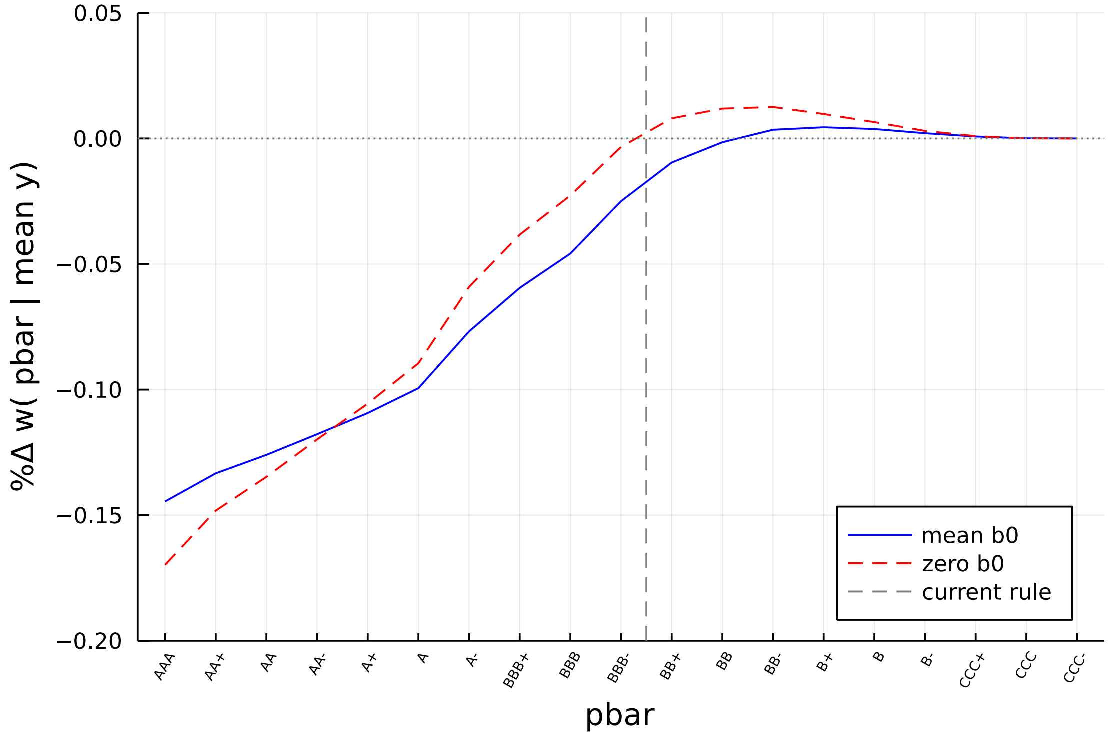

Figure 4: Change in welfare under the counterfactual segmentation

7.5 The counterfactual exercise: different segmentation rules

Figure 4 illustrates the result of the counterfactual exercise: how the country's welfare changes with a different segmentation rule. The benchmark rule is segmenting the credit market between BBB-/Baa3 and BB+/Ba1, the distinction between investment-grade and junk. The figure shows the percentage change in welfare with different rules normalized by welfare under the counterfactual. I assume that the counterfactual segmentation rule is characterized by a different pbar, the horizontal axis. I map the counterfactual pbar level to the rating level according to Moody's rating rule, which I use in calibration. I assume the same discount rate for each segmented market as in the benchmark. The welfare change is evaluated under the mean y level with a different initial debt level: starting the economy with zero or the mean debt level in the benchmark.

The result suggests that the current rule is reasonable, whereas the optimal segmentation rule is a bit looser than that. Under the calibration, between BB-/Ba3 and B+/B1 is the optimal rule, and the country is better off even with a mean debt level. The sovereign is significantly impatient under the calibration, and a bit of loosening of the rule can somewhat reduce the welfare cost. However, if the rule is loosened too much, it delivers negative welfare implications because it weakens disciplinary motives and diminishes the welfare benefit from the segmentation. On the other hand, tight segmentation rules aggravate the country's welfare.

8 Conclusion

From the regulatory usage of sovereign credit ratings, this paper highlights the disciplinary role of ratings on governments' overborrowing. I build a model of a country's borrowing, default, credit rating, and the consequent credit market segmentation. I incorporate the endogenous response of the government. This delivers a different implication of sovereign ratings in the international credit market, which the previous literature has neglected. I calibrate the segmentation parameter using the spread response to countries' downgrade to junk observed in the data. The consequence of downgrades to junk gives sovereigns incentives to manage their credit ratings and discourages them from borrowing over the threshold. Under the calibration, downgrades to junk imply that the impatient lenders of junk bond markets charge a high yield to the sovereign. This consequence of downgrades and the country's ability to manage its ratings are the driving forces of disciplined borrowing behavior.

This disciplined behavior lowers the country's default risk and allows it to borrow at a better price, which is a potential source of welfare benefit. The welfare cost of ratings and implied segmentation is from the anticipated devaluation of bonds before downgrades and controlled borrowing when the country is near the threshold. Under the calibration, the cost dominates the benefit, and the segmentation by sovereign ratings results in welfare loss to the impatient country in the long run. However, the government gains from the segmentation during the transition, especially when the debt stock is low.

This welfare analysis suggests the importance of moderate segmentation in the international capital market. The finding suggests a rationale for the current segmentation rule. The paper proposes that loose segmentation policies weaken disciplinary motives and deliver negative welfare implications to developing countries. Imposing an adequate punishment as a form of market segmentation could alleviate commitment issues and give developing countries better credit access.

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Appendices

A Additional tables for empirical evidence

Table A1: additional table for the regression (1)

	(1)	(2)	(3)	(4)	(5)
	spread	spread	spread	spread	spread
DowntoJunk	141.4*	33.58*	37.72**	37.42**	29.64***
	(78.73)	(18.02)	(16.85)	(16.90)	(11.47)
lag_spread		0.973***	0.976***	0.973***	0.969***
		(0.004)	(0.005)	(0.005)	(0.005)
gdp			0.879***	1.132***	-0.312
			(0.325)	(0.379)	(0.308)
grossdebt			0.0627	0.124	0.146**
			(0.052)	(0.079)	(0.057)
Observations	2610	2597	2528	2528	2528
R^2	0.001	0.948	0.949	0.949	0.981
Country FE	N	N	N	Y	Y
Time FE	N	N	N	N	Y

Note:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses. In all specification, the dependent variable is EMBI+ sovereign bond spread. DowntoJunk is a dummy variable which equals to 1 when a country's S&P sovereign rating is above or equal to BBB- in period $t-1$, and below or equal to BB+ in period t. Lag spread is a 1-month lag variable. gdp is real gdp growth rate, and grossdebt is public debt to gdp ratio. The data is montly frequency across 12 countries.

Table A2: additional table for the regression (2)

	(1) spread	(2) spread	(3) spread	(4) spread	(5) spread
withininvst	174.7***	18.71	19.57	20.00	17.10*
	(65.84)	(15.07)	(14.06)	(14.10)	(9.572)
DowntoJunk	142.2*	33.84*	38.46**	38.12**	30.14***
	(78.65)	(17.99)	(16.82)	(16.86)	(11.46)
withinjunk	26.52	47.11***	50.75***	51.30***	18.63*
	(69.39)	(15.87)	(14.82)	(14.85)	(10.09)
lag_spread		0.973***	0.976***	0.974***	0.969***
		(0.004)	(0.005)	(0.005)	(0.005)
gdp			0.977***	1.247***	-0.249
			(0.325)	(0.379)	(0.309)
grossdebt			0.0583	0.120	0.141**
			(0.052)	(0.079)	(0.057)
Observations	2610	2597	2528	2528	2528
R^2	0.004	0.948	0.950	0.950	0.981
Country FE	N	N	N	Y	Y
Time FE	N	N	N	N	Y

Note:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses. In all specification, the dependent variable is EMBI+ sovereign bond spread. DowntoJunk is a dummy variable which equals to 1 when a country's S&P sovereign rating is above or equal to BBB- in period $t-1$, and below or equal to BB+ in period t. Lag spread is a 1-month lag variable. gdp is real gdp growth rate, and grossdebt is public debt to gdp ratio. The data is montly frequency across 12 countries.

Table A3: regression result with a different specification

	(1) spread	(2) spread	(3) spread	(4) spread	(5) spread
DowntoBBB	29.91	74.07***	77.26***	78.10***	17.74
	(104.0)	(23.78)	(22.15)	(22.20)	(15.13)
DowntoBBB-	23.81	25.55	29.52	29.85	19.38
	(93.06)	(21.27)	(19.85)	(19.89)	(13.52)
DowntoJunk	142.2*	33.83*	38.43**	38.07**	30.26***
	(78.68)	(17.99)	(16.81)	(16.85)	(11.47)
DowntoBB	174.9**	24.40	25.86	26.47	24.20**
	(78.68)	(18.00)	(16.78)	(16.82)	(11.43)
DowntoBB-	174.1	5.412	4.734	4.642	0.513
	(120.1)	(27.46)	(25.57)	(25.64)	(17.45)
lag_spread		0.973***	0.976***	0.974***	0.969***
		(0.004)	(0.005)	(0.005)	(0.005)
gdp			0.974***	1.240***	-0.245
			(0.325)	(0.379)	(0.309)
grossdebt			0.0605	0.123	0.142**
			(0.052)	(0.079)	(0.057)
Observations	2610	2597	2528	2528	2528
R^2	0.004	0.948	0.950	0.950	0.981
Country FE	N	N	N	Y	Y
Time FE	N	N	N	N	Y

Note:* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors in parentheses. In all specification, the dependent variable is EMBI+ sovereign bond spread. DowntoJunk is a dummy variable which equals to 1 when a country's S&P sovereign rating is above or equal to BBB- in period $t-1$, and below or equal to BB+ in period t. DowntoBBB is a dummy variable which equals to 1 when a country's rating is BBB+ at period $t-1$ and BBB at period t. Other dummy variables, DowntoBBB-, DowntoBB, and DowntoBB-, are constructed similarly (BBB in period $t-1$ and BBB- in period t, BB+ in period $t-1$ and BB in period t, and BB in period $t-1$ and BB- in period t, respectively). Lag spread is a 1-month lag variable. gdp is real gdp growth rate, and grossdebt is public debt to gdp ratio. The data is montly frequency across 12 countries.