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VICTOR HUGO CARVALHO ALEXANDRINO DA SILVA

Essays on International Macroeconomics and Finance

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Dissertation submitted in fulfillment of the requirements for the degree of Doctor in Economics at Insper Institute of Education and Research.
Concentration: Business Economics.
Field: Macro-Finance.

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Resumo

ALEXANDRINO DA SILVA, V. H. C. (2025) **Ensaios em Macroeconomia Internacional e Finanças**. Tese (Doutorado) - Insper, São Paulo 2025.

Esta dissertação é composta por três artigos acadêmicos que se aprofundam em tópicos fundamentais de política econômica: Intervenções cambiais e as transações em larga escala por parte de banco centrais, acesso ao mercado nos mercados de crédito internacional e calote de dívida soberana. Cada capítulo contribui com evidências empíricas para a literatura econômica. No Capítulo 1, apresentamos a introdução geral da tese. O Capítulo 2 investiga a influência de transações de larga escala no mercado de câmbio, usando como arcabouço os anúncios de transações cambiais do banco central na volatilidade e nos retornos de curto prazo no mercado cambial norueguês. Avançando para o Capítulo 3, o foco muda para o acesso ao mercado para economias de fronteira de baixo rendimento nos mercados de capitais internacionais, identificando fatores políticos essenciais que moldam a evolução do mercado de dívida. O Capítulo 4 apresenta um modelo quantitativo que exalta a importância da denominação da dívida nos mercados emergentes, ressaltando a dinâmica de inadimplência o os impactos da inflação. Os três capítulos elaborados aprofundam coletivamente a nossa compreensão da dinâmica da dívida soberana, do acesso ao mercado, das intervenções cambiais e do papel de agentes de de mercado, como um banco central, ao participar do mercado de câmbio. A pesquisa fornece contribuições importantes para a formulação de políticas, orientando agentes de mercado, bancos centrais e pesquisadores por meio dos resultados encontrados dentro dos três artigos.

Palavras-chaves: Transações em Larga Escala; Transações de Câmbio; Intervenções Cambiais; Volatilidade; Dados em Alta Frequência; Dívida Soberana; Calote Soberano; Emissão de Título Soberano; Portfolio de Dívida; Denominação de Dívida; Finanças Internacionais; Economias de Fronteira; Demanda de Crédito Externo

Abstract

ALEXANDRINO DA SILVA, V. H. C. (2025) **Essays on International Macroeconomics and Finance**. Doctoral Dissertation - Insper, São Paulo 2025.

This dissertation comprises three academic papers that discuss key policy topics in international macroeconomics and finance: Foreign exchange interventions, and large-scale transactions by central banks, market access in international credit markets and sovereign debt defaults. Each chapter contributes empirical evience to the economic literature. In Chapter 1, we provide a general introduction to the thesis. Chapter 2 investigates the influence of large-scale transactions in the foreign exchange market, using central bank foreign exchange (FX) announcements as a framework on volatility and short-term returns in the Norwegian foreign exchange market. Moving on to Chapter 3, the focus shifts to market access for low-income frontier economies in international capital markets, identifying key policy factors that shape debt market developments. Chapter 4 presents a quantitative model that highlights the importance of debt denomination in emerging markets, highlighting default dynamics and inflation impacts. The three chapters collectively deepen our understanding of the dynamics of sovereign debt, market access, foreign exchange interventions, and the role of market actors such as a central bank in participating in the foreign exchange market. The research provides important contributions to policymaking by guiding market actors, central banks, and researchers through the findings found within the three papers.

Keywords: Large-Scale Transactions; Foreign Exchange Transactions; Exchange Rate Interventions; Volatility; High Frequency Data; International Finance; Frontier Economies; External Credit Demand; Sovereign Debt; Sovereign Default; Sovereign Bond Issuance; Debt Portfolio; Debt Denomination;

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1 General Introduction

This work is composed by three research papers that explore the literature in international macroeconomics and finance, with subjects that explore the topics of sovereign default, market access in sovereign debt markets, and central banks' foreign exchange transactions.

Chapter 2 brings the research paper called *Central Bank FX Transactions Announcements: Implications for Short-Term Volatility and Returns*, that explores the role of foreign exchange (FX) interventions and their effects on economic policy. We investigate the implications of central bank FX transaction announcements on short-term volatility and returns in the Norwegian foreign exchange market, using monthly announcements from Norges Bank, which informs the market about its FX transactions involving the Norwegian currency.[1] Our empirical analysis reveals a significant association between central banks's announcements of large FX operations and short-term volatility and returns of domestic currencies, suggesting that central bank FX transactions as FX interventions can have substantial impacts on currency markets and may be important for policymakers when formulating foreign currency strategies. Moreover, we bring the notion that information shocks are also relevant in the short-term in affecting the currency when a Central Bank conducts a large FX operation, something that the current literature have not addressed so clearly.

Chapter 3 brings the research article entitled *Determinants of and Prospects of Market Access in Frontier Economies*, that also focuses on sovereign debt but centers on whether low-income countries, referred to as *frontier economies* in our work, have increased their market access to international debt markets. Our primary motivation comes from the observation that, in recent years, a growing number of low-income countries have begun issuing sovereign debt in international capital markets. After some motivation on trends from our panel data analysis of market access, we conclude that both

[1] Norges Bank denotes the Central Bank of Norway.

country-specific macroeconomic factors and external global variables are important in explaining frontier economies' increased access to capital markets. Additionally, we provide a prospective analysis by conducting forecast exercises to determine whether our data can predict future market access for frontier economies. We are able to demonstrate our model is able not only to analyze the determinants of market access but also to predict well the probability of a frontier economy issue sovereign debt, both when conducting an in-sample and an out-of-sample prediction.

Finally, Chapter 4 presents the research paper *Government Debt and Denomination: A Tale of Default, Inflation, and Capital Control*, a work that examines the role of nominal debt in emerging economies and how the portfolio structure of a sovereign economy may influence a benevolent government's ability to meet its obligations in sovereign credit markets. By utilizing a comprehensive panel database that includes both emerging and advanced economies, we characterize a quantitative model that incorporates sovereign debt and inflation. After calibrating and simulating the model, our results suggest that the decision to default may be influenced by the structure of debt portfolios: In times of heavy debt burdens, a sovereign may choose costly inflation, which affects its own citizens, in order to avoid rising spreads and an increased risk of default.

In general, the three chapters contribute to the literature on international macroeconomics and finance in terms of methodology, forecasting, and the interaction between policy actions from governments and central banks with market variables such as consumption, debt, inflation, exchange rates, among other economic fundamentals, both domestically and externally-driven. By bringing together these three articles, this thesis contributes to both the economics and finance literature.

This introduction constitutes Chapter 1 of this thesis. The next chapter, Chapter 2, includes the article *Government Debt and Denomination: A Tale of Default, Inflation, and Capital Control*, followed by Chapter 3, which presents the research paper *Determinants of and Prospects for Market Access in Frontier Economies*. Chapter 4 contains the study *Central Bank FX Transaction Announcements: Implications for Short-Term Volatility and Returns*, and finally, Chapter 5 concludes the thesis.

2 Central Bank FX Transactions Announcements: Implications for Short-Term Volatility and Returns

[1]

Abstract

This paper investigates the implications of central bank's FX transactions announcements on short-term volatility and returns in the Norwegian foreign exchange market. Our study focuses on the monthly announcements of the Norges Bank, the Central Bank of Norway, which informs the market about future FX transactions of the Norwegian currency conducted by the central bank. We make three key contributions: Firstly, we explore the concept of an information shock in large FX transactions by central banks, providing insight into its immediate effects on currency dynamics. Secondly, we emphasize the unique nature of Norges Bank's operations that despite being similar to central banks' FX interventions, could provide valuable insights about large FX operations in a country's currency dynamics as are assumed to be exogenous to the monetary policy framework. Third, we contribute to understanding the short-term costs and implications of central bank operations on exchange rates. Our empirical analysis reveals a statistically significant association between Norges Bank's announcements and short-term volatility and returns of the USD/NOK and EUR/NOK currency pairs. The results suggest that the announcements may increase short-term volatility, challenging the traditional view of central banks actions seeking to stabilize currencies. This study advances our understanding on central bank FX interventions and provides valuable insights for policymakers in formulating effective strategies for managing exchange rate dynamics.

Keywords: Foreign-Exchange Transactions, Foreign-Exchange Interventions, Information Shocks, Currency Returns, Volatility, High-Frequency Data

[1] This article was co-authored with Igor Ferreira Batista Martins (Insper and Örebro University), Antonio Daniel Caluz (Insper) and Bruno Cavani (Insper and University of Columbia).

2.1 Introduction

Central banks have increasingly employed foreign currency (FX) interventions to maintain economic stability and control exchange rates. While such interventions may yield long-term benefits, such as reducing volatility in flexible exchange rate regimes and smoothing exchange rate patterns in narrow-band regimes, their short-term costs remain under-explored. In particular, little is known about the short-term consequences of information shocks arising when central banks disclose FX operations. This gap is partly due to the difficulty in distinguishing information shocks from the interventions themselves.

This study addresses this gap by examining the short-term effects of Central Bank of Norway's monthly FX transactions announcements on the level and realized volatility of the Norwegian Krone (NOK).[2] Specifically, we investigate the immediate impact of these announcements using high-frequency intraday data, including 1-minute bid price quotations for USD/NOK and EUR/NOK, and simulate NOK 5-, 10-, and 30-minute returns and realized volatility. Although Norges Bank's FX transactions are not classical interventions, their effects on currency markets are similar. Thus, we treat these operations as FX interventions for the purposes of this paper.

Our contributions are threefold. First, we explore the concept of an information shock by disentangling the information and flow channels of Norges Bank's FX operations. Since the amount to be operated is announced in advance, we isolate the effects of the announcement itself, providing a clearer understanding of the exogenous information shock and its immediate impact on currency returns and volatility. This distinction offers new insights into the transmission mechanisms of FX interventions.

Second, we emphasize the unique nature of Norges Bank's actions compared to traditional FX interventions. Unlike interventions aimed at stabilizing domestic currencies or achieving specific price targets, Norges Bank's operations are part of a fiscal policy mechanism for managing Norway's petroleum revenues. This characteristic enhances the

[2] The Central Bank of Norway is commonly referred as Norges Bank.

exogeneity of the information shock, allowing us to examine the isolated effects of these announcements on returns and volatility, independent of monetary policy.

Third, our research contributes to the understanding of FX interventions' immediate effects on policy decisions. While most literature focuses on the medium- to long-term benefits of such interventions, we provide evidence on the near-term costs and implications. By analyzing the immediate effects of Norges Bank's announcements, our study offers valuable insights for policymakers designing strategies to regulate exchange rates and mitigate risks.

Our empirical results reveal a significant relationship between Norges Bank's FX announcements and both the returns and volatility of USD/NOK and EUR/NOK. The strongest effects are observed in 30-minute returns, particularly following large surprises relative to market expectations. The evidence also suggests that while market participants adjust quickly to new information, surprises in announcements still influence returns. Regarding volatility, both announcements and surprises are positively associated with increased uncertainty, indicating that FX interventions can elevate short-term market volatility, contrary to the usual goal of stabilizing currencies.

To our knowledge, this study is the first to examine the short-term effects of central banks' FX interventions using high-frequency intraday data, with a focus on information shocks rather than transaction flows. By uncovering these immediate implications, we advance the understanding of how such shocks influence currency markets.

To validate the robustness of our findings, we conducted additional analyses, varying the volatility equation's specifications and including seasonal components. Our results remain consistent, showing significant effects of announcements and surprises on both returns and volatility. Moreover, positive surprises—when announced FX purchases exceed market expectations—drive the observed effects, reinforcing the economic and statistical significance of our findings.

The remainder of this paper is structured as follows: Section 2.1.1 reviews the literature on central bank transactions and interventions, highlighting our contributions.

Section 2.1.2 details Norges Bank's mechanism, which generates an exogenous information shock. Section 2.2 describes the data and empirical model used to test our hypotheses. Sections 2.3 and 2.4 present the main results and robustness checks. Finally, Section 2.5 concludes the paper.

2.1.1 Literature Background

This article relates to the classic literature on central banks' FX interventions, which explores the various motivations for government or central bank intervention in the FX market. For example, Gabaix and Maggiori (2015) explain the empirical divergence between exchange rates and traditional macroeconomic fundamentals by examining balance sheet imbalances caused by capital flows, which affect exchange rate levels and volatility. Similarly, Hassan, Mertens and Zhang (2016) highlight how central bank currency manipulation can lower a country's risk premium on international markets, resulting in reduced risk-free interest rates, increased domestic capital accumulation, and higher wages. They also illustrate how powerful nations' currency manipulation affects global capital accumulation and interest rates. Chang (2018) emphasize the expanded role of the European Central Bank (ECB) in governing the Euro region, moving beyond traditional monetary policy to exert greater influence within the European Union.

Our work aligns with literature examining the costs and consequences of FX interventions. Identifying the precise impact of interventions in a complex macro-environment where numerous factors interact is challenging. To address this, we use high-frequency data on exchange rate fluctuations and public announcements from the Norwegian central bank about upcoming FX operations. This approach allows us to isolate the influence of market transactions by minimizing external factors, as is typical in high-frequency studies (Dominguez (2003), Pasquariello and Vega (2007), and Melvin, Menkhoff and Schmeling (2009)).

Our study thus aims to deepen economists' understanding of the short-term effects of foreign exchange transactions and the substantial trade impact of previous transaction announcements, shedding light on the potential hidden adverse short-term effects of central bank interventions. Specifically, we analyze a scenario where policymakers show a heightened receptiveness to using FX operations as a policy tool (Blanchard, Adler and Filho (2015), Ghosh, Ostry and Qureshi (2017), and Obstfeld, Ostry and Qureshi (2019)). Research suggests that central banks globally recognize FX interventions as an essential part of their toolkit (Mohanty and Berger (2013) and Frankel (2016)).

The effects of FX interventions on exchange rate levels and volatility have been extensively studied, including by Chamon, Garcia and Souza (2017), who analyzed the impact of daily FX futures sales in the Brazilian market following the Taper Tantrum episode using a synthetic control approach. Their findings indicate that the Central Bank of Brazil's FX interventions resulted in a statistically significant appreciation of the Brazilian Real. Our study aligns with this work by addressing the endogeneity problem commonly encountered in this literature. However, we advance the analysis by focusing on the effects of an information shock triggered by the announcement of large FX transactions, rather than the transactions themselves.

This paper also engages with research that explores alternative approaches to identifying intervention effects. Acknowledging the limitations of high-frequency data in assessing longer-term outcomes, some literature relies on lower-frequency data in event studies (Fatum and Hutchison (2003) and Fratzscher et al. (2019)), policy change analysis Kearns and Rigobon (2005), or counterfactual comparisons Fischer and Zurlinden (1999), Rossi and Pagano (2013). Despite potential endogeneity risks from confounding factors, these methods generally indicate that central bank actions are highly effective Dominguez, Hashimoto and Ito (2012). Our study adds to this literature by focusing on the information shock from a large central bank FX transaction and its impact on currency markets.

A key contribution of our study relates to the role of information shocks in FX interventions. While some papers acknowledge the importance of information in the macroeconomic effects of central bank interventions, most focus on its medium- to long-term implications. For example, Gründler, Mayer and Scharler (2023) find that information shocks from U.S. monetary policy announcements appreciate exchange rates over time, with effects that build slowly and persist. Menkhoff, Rieth and Stöhr (2021) also address information shocks in FX interventions, showing that the signaling channel dominates the portfolio channel in the medium run.

Candian, Leo and Gemmi (2023) contribute to this discourse by developing a macroeconomic model that formalizes the informational component of FX interventions and its implications for central bank policy and communication. However, these studies primarily focus on medium-term effects. In contrast, our work emphasizes information shocks as the main mechanism for exchange rate dynamics, providing robust evidence of both economically and statistically significant short-term effects on exchange rate levels and volatility.

Additionally, our study builds on relevant work by Lerbak, Tafjord and Øwre-Johnsen (2016), LUND and TAFJORD (2017), and Løberg (2018), who investigate the effects of the Central Bank of Norway's FX operations on the foreign exchange market. Løberg (2018) find both short- and long-term impacts of these operations on the NOK-EUR exchange rate, contrary to theoretical predictions. LUND and TAFJORD (2017) examine the Petroleum Buffer Portfolio (PBP) used by the central bank to manage FX transactions related to petroleum fund mechanisms and show how changes in the government's net cash flow from petroleum activities influence PBP movements. Lerbak, Tafjord and Øwre-Johnsen (2016) further clarify the petroleum fund mechanism's role, illustrating how it directs government revenue from petroleum toward expenditures and savings and highlighting changes in currency exchange needs over time due to shifts in government spending. Our study aims to contribute further insight into Norges Bank's specific operations related to managing Norway's petroleum revenues.

Finally, our research adds to the theoretical and empirical evidence on FX policy effects on economic outcomes. Building on the frameworks established by Gabaix and Maggiori (2015), Hassan, Mertens and Zhang (2016), Chang (2018), and others, we leverage high-frequency data to differentiate between intervention effects and announcement effects, with a particular focus on short-term volatility. We estimate the impact of these transactions on both returns and volatility using a straightforward empirical model. This complements alternative methodologies explored in the literature, such as lower-frequency studies and event analyses. By incorporating findings specific to the Norwegian context as studied by Lerbak, Tafjord and Øwre-Johnsen (2016), LUND and TAFJORD (2017), and Løberg (2018), our research provides a robust empirical analysis that broadens the understanding of these market operations and contributes to the ongoing discourse on economic policy and FX interventions.

2.1.2 Norway and the Petroleum Mechanism

Given Norway's significant oil income, the Norges Bank plays a crucial role in managing foreign exchange operations. As part of its FX policy, the Norwegian central bank regularly publishes updates on its foreign exchange transactions to control the government's non-oil budget deficit and maintain the value of the Norwegian Krone (NOK).

To align the NOK-FX exchange rate with economic fundamentals and policy goals, the central bank engages in trading on the foreign exchange market through its petroleum mechanism. These transactions impact both the government's net cash flow from petroleum activities and the non-oil budget deficit (Løberg (2018), LUND and TAFJORD (2017)). The amount of the non-oil budget deficit largely determines the government's net purchases of NOK, with Norges Bank executing the foreign exchange operations on behalf of the government. It is important to note that the government's net purchases of NOK are not influenced by revenues from petroleum activities or the breakdown of these revenues by currency Lerbak, Tafjord and Øwre-Johnsen (2016).

Figure 2.1 provides a diagram summarizing the Norges Bank transactions set-up. The diagram illustrates that government revenues derived from oil activities are used to finance budget deficits. A portion of these revenues is collected in foreign exchange, which is directed to the national pension fund, the Norwegian Government Pension Fund Global (GPFG). The other part of the government's resources is in NOK, obtained from taxes paid by petroleum companies exploring the Norwegian continental shelf and dividends from the state oil company (Equinor). The mechanism of Norges Bank's FX transactions operates as follows: When there is a surplus between oil revenues represented in NOK and the amount required to cover the government's non-oil budget deficit, this revenue is converted to EUR or USD for utilization in the GPFG, which is denominated in foreign currency. Conversely, if the government's revenues are insufficient to cover the domestic deficit, the government taps into the GPFG, converting foreign currency resources into NOK. In both cases, Norges Bank acts as an intermediary for these transactions on behalf of the government. Although these operations directly impact the value of USD/NOK and EUR/NOK exchange rates, their primary goal is to fulfill the government's revenue mechanism.

Figure 2.1 – Norway Petroleum Revenue Mechanism

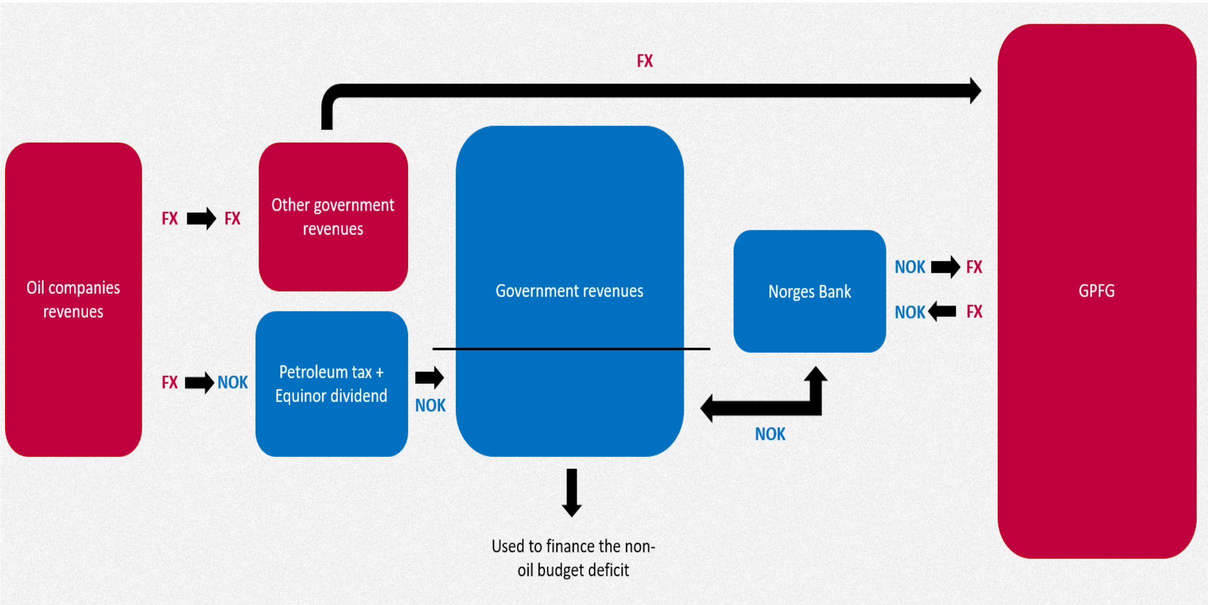
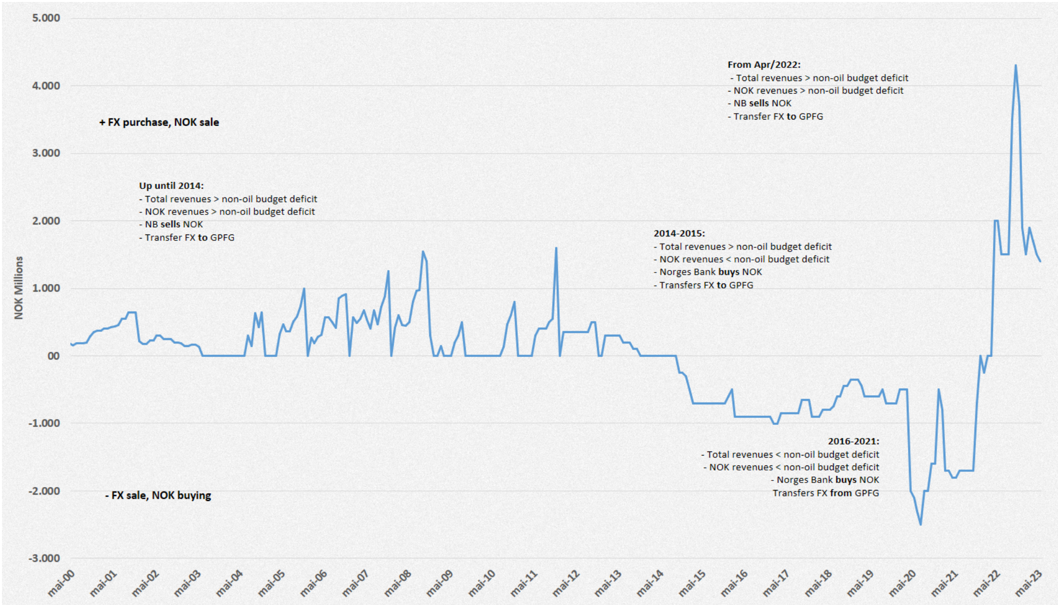


Figure 2.2 displays the amount of foreign currency (USD and EUR) purchased by Norges Bank to convert and allocate oil revenues to the Norwegian GPFG. Depending on global variables affecting the government's petroleum revenues, the central bank can either be a net buyer or seller of foreign currency, or it may not participate in the FX market at all. The announcements of FX transactions occur monthly, on the last working day of each month, when money needs to be transferred to or from the GPFG.[3]

Hence, when the amount of FX transactions is negative, Norges Bank buys NOK (or sells foreign currency), indicating that the non-oil budget deficit surpasses the government's collected resources. Conversely, when the amount is positive, the central bank

[3] At the time of writing (May 2023), Norges Bank is purchasing foreign currency as government revenues from petroleum activities exceed the domestic deficit.

Figure 2.2 – Norges Bank Daily FX Transactions on Behalf of the Government



conducts foreign exchange purchases (or sells NOK) to transfer the net cash flow from petroleum activities to the GPFG.

The announcement and implementation of these transactions can affect the NOK exchange rate in the short and long term. These FX purchases aim to control volatility in flexible exchange rate regimes Sarno and Taylor (2001) and stabilize the exchange rate over the long term, providing a smoother trajectory in nations with narrow-band regimes Fratzscher et al. (2019).

However, in the short term, the Norges Bank mechanism can lead to information shocks that impact the exchange rate when the central bank announces them at the end of each month. These shocks occur when the market updates its expectations based on the new information provided by the central bank, potentially resulting in changes in the level and realized volatility of the NOK immediately following the announcement.

Therefore, while the central bank's foreign exchange transactions are designed with medium- to long-term objectives, it is crucial to consider the immediate consequences of these information shocks on exchange rate volatility and levels. Understanding these impacts is essential for formulating effective monetary policy and managing potential risks associated with foreign exchange interventions.

2.2 Data and Empirical Model

2.2.1 Data

The paper analyzes the returns and realized volatility of the Norwegian Krone (NOK) at 5-minute, 10-minute, and 30-minute intervals. The data used consists of 1-minute bid price quotes for the USD/NOK and EUR/NOK currency pairs. The data covers the period from January 1, 2014, 00:00 GMT, to January 27, 2023, 23:59 GMT, resulting in 4,773,600 data points, with 1,440 observations per day over a span of 3,315 days. The USD/NOK and EUR/NOK exchange rates are traded 24 hours a day from Sunday 22:00 GMT to Friday 22:00 GMT and are obtained from Dukascopy Swiss Banking Group's Historical data feed.

The focus of the analysis is on the effects of Norges Bank's monthly announcements of foreign exchange transactions. The time stamps for the announcements are obtained from Bloomberg's Economic Calendar for Norway. These announcements occur on the last working day of each month when Norges Bank announces the amount of foreign exchange to be operated in the following month. The difference between the actual announcement and market expectations, as reflected in surveys, allows the identification of surprises. As explained in Section 2.1.2, these transactions are unrelated to FX control but rather pertain to the management of the government's petroleum revenue mechanism.

2.2.2 Empirical Models

Our empirical specification is based on two simple equations. Equation (2.1) and Equation (2.2) present the simplest version of our model. We address other possible features of interest on Section 2.3, when presenting the main results. Equation (2.1) models currency returns as a function of the indicator variable $I_{NBI,t-1}$ which assumes the value 1 if Norges Bank announces an FX transaction at time t -1 and a lagged return ret_{t-1}. We account for time-varying volatility by including σ_t which is proxied by the realized volatility of the asset. β_{NBI} connects Norges Bank's transactions and currency returns being the main coefficient of interest for Equation (2.1). Equation (2.2) captures persistent volatility via an AR(1) while allowing for Norges Bank's FX purchases to affect the volatility level as captured by the coefficient V_{NBI}.

$$ret_t = \alpha + \beta_{NBI} I_{NBI,t-1} + \beta_r ret_{t-1} + \sigma_t \varepsilon_t \text{ with } \varepsilon_t \sim N(0,1) \tag{2.1}$$

$$\log \sigma_t = \alpha_V + V_{NBI} I_{NBI,t-1} + \phi log \sigma_{t-1} + \nu \eta_t \text{ with } \eta_t \sim N(0,1) \tag{2.2}$$

Similarly, we estimate an equation to capture the effect of surprises on return and volatility of the target asset, as specified in equations (2.3) and (2.4). In both equations, $S_{NBI,t-1}$ represents the difference between what is announced by the central bank and market expectations proxied by the Bloomberg survey.

$$ret_t = \alpha + \beta_{NBI} S_{NBI,t-1} + \beta_r ret_{t-1} + \sigma_t \varepsilon_t \text{ with } \varepsilon_t \sim N(0,1) \tag{2.3}$$

$$\log \sigma_t = \alpha_V + V_{NBI} S_{NBI,t-1} + \phi log \sigma_{t-1} + \nu \eta_t \text{ with } \eta_t \sim N(0,1) \tag{2.4}$$

We must recover the $\{\alpha, \alpha_V, \beta_{NBI}, \beta_r, \alpha_V, V_{NBI}, \phi, \nu\}$ conditional on the observed returns and realized volatilities. We estimate simply by Ordinary Least Squares to obtain all desired parameters.

To assess the latent variable σ_t we use the realized volatility, as in Andersen et al. (2003), as a proxy.

$$RVar_{t,t+\tau} = \sum_{t}^{t+\tau} r_t^2 \text{ and } RVol_{t,t+\tau} = \sqrt{RVar_{t,t+\tau}} \tag{2.5}$$

We aggregate $r_{i,t}^2$ to produce 5, 10 and 30 minutes realized volatilities.

Table 2.1 presents the descriptive stats for the variables in equations (2.1) to (2.4).

Next section, we present the estimation results for the equations.

Table 2.1 – Descriptive Statistics

	5min	10min	30min
$E(ret_t)$	-3.573×10^{-07}	-1.324×10^{-06}	-5.520×10^{-06}
$sd(ret_t)$	4.508×10^{-04}	6.571×10^{-04}	1.14×10^{-03}
$E(logRV_t)$	-7.63	-6.86	-5.72
$sd(logRV_t)$	0.89	0.84	0.80

2.3 Results

This section presents the main results regarding the effect of Norges Bank's FX transactions announcement on different interest variables. Tables 2.2, 2.3 and 2.4 display the estimation results for the empirical model, accounting for three types of operations: announcements only, surprises relative to market expectations, and surprises larger than NOK 200 million, respectively.

The coefficient β_{NBI}, which represents the relationship between Norges Bank's transactions and currency returns, consistently demonstrates an impact on currency returns across all three scenarios and for all return intervals of 5, 10, and 30 minutes. In Table 2.2, we observe that in the presence of an announcement, the model predicts no significant impact on returns for the 5- and 15-minute intervals. The estimated impact is slightly larger for the 30-minute interval estimation, but with a low t-value, indicating that there is no significant impact of announcements alone on the currency return.

Table 2.2 – Annoucements only

5 minutes:					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-2.61×10^{-7}	3.27×10^{-5}	-2.80×10^{-2}	-2.78	0.63	0.63
(-0.67)	(0.89)	(-27.45)	(-385.67)	(9.43)	(677.33)
10 minutes					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-9.53×10^{-7}	-1.38×10^{-5}	-2.49×10^{-2}	-2.29	0.56	0.66
(-1.19)	(-0.26)	(-17.17)	(-259.18)	(9.21)	(519.20)
30 minutes					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-3.96×10^{-6}	-8.88×10^{-5}	-2.82×10^{-2}	-1.93	0.29	0.66
(-1.65)	(-0.96)	(-11.29)	(-150.40)	(4.96)	(297.96)

In Table 2.3, we focus on the effects of unexpected announcements, which deviate from specialists' predictions and are captured by the variable surprises. The estimated coefficients remain statistically significant when considering the 30-minute interval, but relatively smaller than those in the "Announcements only" scenario. Over a 5-minute interval, we find a β_{NBI} of 1.74×10^{-4}, marginally significant with a t-value of 1.60. For the 30-minute interval, the effect is larger, reaching 6.35×10^{-4}, and more significant with a t-value of 2.29. This result suggests that market participants might adjust more quickly in response to surprise FX transactions.

Table 2.3 – Surprises

5 minutes:					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-2.59×10^{-7}	1.74×10^{-4}	-2.80×10^{-2}	-2.78	1.31	0.64
(-0.67)	(1.60)	(-27.45)	(-385.61)	(6.51)	(677.39)
10 minutes					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-9.62×10^{-7}	2.36×10^{-4}	-2.48×10^{-2}	-2.29	1.15	0.66
(-1.21)	(1.48)	(-17.16)	(-259.10)	(6.31)	(519.25)
30 minutes					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-4.07×10^{-6}	6.35×10^{-4}	-2.83×10^{-2}	-1.93	0.83	0.66
(-1.69)	(2.29)	(-11.29)	(-150.36)	(4.84)	(298.08)

Moving on to the third set of estimation results presented in Table 2.4, we consider only large surprises, specifically those with a deviation larger than NOK 200 million. For this scenario, the model predicts a positive and statistically significant impact on returns. The estimated impact is larger for the 30-minute interval estimation, with a coefficient reaching 1.18×10^-3 and a t-value of 3.49, indicating significance.

The effect of Norges Bank's FX operations and surprises on realized volatility is also relevant. The estimated parameter V_{NBI}, which captures this effect, is always positive and significant. This result aligns with our hypothesis that announcements can bring short-term volatility to the currency return. We observe that, in the case of regular transactions and surprises larger than 200 million, the effect peaks at the 5-minute interval (1.46 with a t-value of 5.92, as shown in 2.2 and 2.4 and gradually decreases as the time interval widens. For surprises, the effect on volatility is lower, peaking at 1.31 (t-value 6.51) for the 5-minute interval and decreasing to 0.83 (t-value 4.84) for the 30-minute interval.

Table 2.4 – Surprises larger than 200MM

5 minutes:					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-2.62×10^{-7}	5.79×10^{-4}	-2.80×10^{-2}	-2.78	1.46	0.64
(-0.68)	(4.34)	(-27.45)	(-385.60)	(5.92)	(677.39)
10 minutes					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-9.67×10^{-7}	6.13×10^{-4}	-2.48×10^{-2}	-2.29	1.30	0.66
(-1.21)	(3.14)	(-17.16)	(-259.10)	(5.83)	(519.25)
30 minutes					
α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
-4.08×10^{-6}	1.18×10^{-3}	-2.83×10^{-2}	-1.93	1.18	0.66
(-1.69)	(3.49)	(-11.28)	(-150.37)	(5.56)	(298.09)

The coefficients β_r (effect of lagged return) and ϕ (autoregressive parameter for log volatility) also show a robust, significant, and negative relationship with returns and a positive relationship with volatility across all models.

In summary, the presented results suggest that Norges Bank's announcements have a significant impact on the currency, as measured by their effects on returns and realized volatility. These impacts become more pronounced with larger surprises.

2.4 Robustness Exercises

2.4.1 Robustness in the volatility equation

2.4.1.1 Adding lags in the volatility equation

Table A.1 in Appendix A.1.1 presents the estimation of the volatility equation with a different specification. Here, we focus on 5 minutes return and we show that the results for the impact of the FX transaction on the volatility are in line with the previous results, with positive and strongly significant results. The impact coefficients are .57 for the announcements only, 1.20 for surprises, and 1.37 for big surprises, with t-values of 9.01, 6.32, and 5.88, respectively. All 6 lags were significant in the volatility specification, but they do not change the direction of the impact coefficient. Hence, our results are robust to the specification of the equation.

2.4.1.2 Seasonal effects on volatility

Table A.2 in Appendix A.1.2 shows the results for the estimation of the volatility by adding a seasonal component to the equation. The addition of seasonality do not change the significance and direction of the impact of announcements, surprises, and big surprises in the volatility of the currency.

Overall, results are robust to the specification of the equation. However, there is similar data regarding the EUR-NOK exchange rate that allow us to test whether results are robust to the choice of the currency. Next section we provide the estimation of the main results for the EUR-NOK exchange rate

2.4.2 Results for EURNOK FX rate

In Appendix A.2 we present the robustness results for EUR-NOK exchange rate, following the exact estimations presented in the previous section. The estimation results, presented in Tables A.3, A.4, and A.5, provide similar results on the impacts of Norges Bank transactions in the context of EUR/NOK exchange rates. The results are similar, showing the robustness of the previous results

Table A.3 reports the estimation results for announcements only. Although the coefficient β_{NBI} consistently demonstrates a positive relationship with currency returns across all three intervals (5 minutes, 10 minutes, and 30 minutes), these coefficients are not statistically significant. However, when looking to the volatility equation, we observe a strong and positive association between the announcements and the currency returns, showing the increase in the short-term volatility generated by this policy transaction.

Similarly, Table A.4 presents the estimation results for the scenario of surprises. The coefficient β_{NBI} continues to exhibit a positive relationship with returns, but now with stronger significance in the return equation. For the 5-minute interval, the estimated coefficient is 2.85×10^{-4} (t-value: 1.84). For the volatility equation, we see a strong positive relationship between volatility and the surprises again.

Table A.5 restricts the results in table A.4 by using only surprises larger than

200MM. The presented results for the impact on return and volatility are both positive and statistically significant.

2.4.3 Anticipation Effects

In this subsection, we run our model computing the impact of the announcement on the previous return. To do this, we lag the dummy variable to investigate whether there is a significant impact by changing the variable to a period before, where there is no transaction.

As a result, we find no effect in both the mean and the volatility of the USDNOK return. The table results can be found in Appendix A.3.

2.4.4 Negative and Positive Surprises

Next, we present the effect for positive and negative surprises. Table A.7 and A.8 in Appendix A.4 present the results for surprises when the announcement/ is different from the predicted, showing distinct results when the transaction is more extensive than the predicted in the survey from when the operation is lower than the predicted.

Results indicate that positive surprises are driven the previous results for the mean return. However, the impact of the FX transaction is strongly significant for both negative and positive surprises.

The results for volatility are significant in all intervals and type of surprises. For the mean return, results are significant for Big Surprises in all intervals, and are strongly significant for all surprises in the 30-min return.

2.5 Conclusion

In conclusion, this study provides empirical insights into the short-term effects of FX transations generated by the Central Bank announcements, focusing on the impact of Norges Bank's actions on the USD/NOK and EUR/NOK currency exchange rates.

Through analysis of high-frequency data and distinguishing between interventions and their announcements, we uncover the implications of these operations on currency returns and volatility.

Our findings contribute to the existing literature in three ways. Firstly, by bringing the concept of an information shock to central bank interventions and isolating the impact of the announcement, we gain a clearer understanding of the exogenous information shock's immediate effects on currency dynamics. This enhances our understanding of the transmission mechanism of FX operations and their influence on exchange rate dynamics, providing robust empirical evidence within the Norwegian context and to the FX transactions literature.

Secondly, our framework is based on the unique nature of Norges Bank's announcements compared to typical FX interventions/transactions. The characteristic that these announcements precede the actual actions makes them arguably exogenous to other market activities, allowing us to examine their isolated effects on asset returns and volatility. Our study sheds light on how market participants quickly adjust to new information shocks, even before the actions take effect.

Thirdly, our research expands the scope of understanding the effects of FX operations on policy decisions. By examining the near-term costs and implications of Norges Bank's actions, we offer valuable insights that assist policymakers in formulating effective strategies for regulating exchange rates and mitigating risks.

The results of our analysis demonstrate that Norges Bank's actions have a significant impact on currency returns, with the estimated coefficients consistently indicating a positive relationship between announcements with surprises and currency returns, supporting theoretical expectations and highlighting the importance of operations in shaping short-term returns.

Furthermore, our study reveals a positive impact of central bank actions on currency volatility, a crucial aspect explored in this research. The estimated coefficients establish a statistically significant impact of announcements and surprises on realized volatility in all specifications.

In conclusion, this study enhances the understanding of the effects of central bank announcements and actions, shedding light on their impact on currency returns and volatility. The findings have implications for policymakers, market participants, and researchers seeking to comprehend the dynamics of foreign exchange markets and the consequences of central bank operations. By considering the unique characteristics of Norges Bank's interventions and the short-term implications of actions, our research provides valuable insights for formulating effective strategies and policies in the foreign exchange market, as well the role of information shock in the near-term effects of foreign exchange rates.

3 Determinants of and Prospects of Market Access in Frontier Economies

[1]

Abstract

In recent years, there has been an increase in low-income countries' access to international capital markets, especially after the Global Financial Crisis. This paper investigates what country-specific macroeconomic fundamentals–and/or external variables—-have contributed to the surge in external bond issuance by these countries, also called 'frontier economies'. Using data on public and publicly guaranteed external bond issuance, outstanding bond stock, as well as sovereign spreads, we employ panel data analysis to examine factors related to the increase in issuance by these economies as well as the reduction in their spreads over time. Our empirical study shows that both country-specific fundamentals (such as public debt, current account balance, level of reserves, quality of institutions) and external variables (such as US growth and the VIX index) play a role in explaining the increased amount of issuance and the decline in spreads of frontier economies' sovereign bonds. The impact of some of these variables on issuance appears to reflect a country's need to issue bonds for external financing ('the supply side' of bond issuance), while others appear to correlate more through their impact on investors' appetite for a country's debt ('the demand side'). In addition, the impact of country-specific variables can also be affected by external factors such as global risk appetite. Our model is able to forecast properly market access in both an in-sample analysis and out-of-sample framework. Our analysis of key factors that have contributed to increased market access for frontier economies over the past decade provides important information to gauge the prospects for their continued market access, and for other low-income countries to join this group by tapping international markets for the first time.

Keywords: Sovereign Bond Issuance; Frontier markets; Bond spreads, Forecasting.

[1] This article was co-authored with Diva Singh (IMF) and Luisa Antoun de Almeida (IMF), and a preliminary version of it was published as an IMF working paper. Available at (SILVA; ALMEIDA; SINGH, 2021).

3.1 Introduction

In recent years, we have seen a new group of low-income economies increasingly issue sovereign debt in international capital markets. These countries typically occupy the higher end of the income spectrum for low-income countries (LICs) and are referred to in this paper as *frontier economies.*[2] Not only has the amount of issuance by individual frontier economies been increasing, but the number of these countries that have been able to access international sovereign markets has also seen a notable spike, especially in the last ten years.

What is more, the continuous decline in frontier economies' EMBI spreads in recent years suggests that they have not only broken into the international capital markets arena but appear to be welcome participants in it.[3] Since sovereign spreads against benchmark US Treasury rates can be seen as a real-time gauge of country risk, the compression of frontier economies' spreads suggests a reduction in the perceived risk of investing in these countries, or conversely, an increase in investors' appetite for their government debt.

This paper attempts to analyze the drivers of these trends. In particular, we study whether domestic macroeconomic fundamentals or external factors, such as global market volatility, US growth and interest rates, have been the main impetus for frontier economies' increased market access and declining spreads in the post-Global Financial Crisis decade. We also seek to answer whether bond issuance by frontier economies has been driven more by their rising financing needs (the supply-side) or by investors' appetite for their bonds (the demand side).

Our main results show that both country-specific macroeconomic factors and external variables are relevant in explaining frontier economies' increased access to international capital markets. However, the results vary depending on how market access is defined. For example, when we define market access as the outstanding stock of frontier economies' external bond debt, a proxy for the cumulative volume of issuance, this ap-

[2] We define frontier economies in this paper as LICs that have had market access from the period 1990-2019. See Section 3.3.

[3] JP Morgan's Emerging Market Bond Index Global (EMBIG).

pears to be related to both investors' demand for bonds and frontier economies' financing needs. But when we look instead at the probability of bond issuance in a given year as a gauge for market access, this seems to depend more critically on investors' demand for a country's debt at that juncture. Finally, if we take sovereign spreads as an indicator of market access—being an indicator of country risk that reflect the cost of issuance—these respond to both domestic and external factors that impact investors' risk appetite.

Additionally, we consider how our findings on the determinants of frontier economies' market access could inform a forward-looking assessment of their prospective market access. We begin by providing an in-sample analysis of the accuracy of our models in predicting market access. We then extend this to out-of-sample predictions, applying the standard "horse-race" approach to forecasting models to evaluate the predictive power of our analysis. We compare the alternative models using several metrics of forecast performance, including metrics that take into account that the predictions are on zero-one events. In our analysis, using simply the Linear Probability Model (LPM) we can predict better out-of-sample events in relation to probit, logit, and conditional logit. We also profit from the literature on model combination to test whether combining the different forecast can improve the prediction performance. Our results show that the model combination has results that are comparable with the LPM, depending on the metrics. In addition, we show what are the countries in which each model (LPM and model combination) perform worst. We show that the models mistakes are different depending on the approach, although quantitatively both models perform equal in the hit-rate, We find that in both exercises that our models are able to predict well market access in frontier economies.

Our analysis makes several contributions to the literature on developing economies' market access, most notably by focusing on frontier economies rather than conventional emerging markets. By examining whether domestic macroeconomic fundamentals or external factors, such as global liquidity and risk aversion, have been more critical to the increased market access of frontier economies over the past decade, we provide insights into the role of policies in shaping the evolution of their debt markets. The use of three distinct proxies for market access further enriches our analysis, enabling us to explore different dimensions of market access. Additionally, through a forward-looking forecasting exercise, we identify the key variables that influence frontier economies' ability to secure market access. Such an assessment could be useful not only for frontier economy authorities to gauge financing prospects, but also for multilateral institutions such as the IMF in determining whether a LIC (that may or may not have issued sovereign bonds in the past) has access to international capital markets at a given juncture – a key factor for some of the IMF's LIC lending operations.[4]

This paper is divided into six sections. This Section 3.1 consists to the Introduction. Section 3.2 summarizes the literature related to this work. Section 3.3 presents our dataset and key definitions. In Section 3.4, we depict some stylized facts to illustrate the evolution of frontier economies' access to international capital markets. Finally, Section 3.5 presents our empirical strategy and main results, along with some robustness checks, and Section 3.6 concludes the paper.

3.2 Literature Review

This paper draws on and contributes to at least two important strands of the literature. First, it contributes to the literature investigating the drivers of market access, both from the perspective of domestic macroeconomic factors and external variables. Second, it adds to the literature on the accuracy of prediction models based on quantitative measures, an important exercise for applying these models to assess market access prospects and predict various types of financial crises.

3.2.1 Drivers of Market Access

This paper builds on an extensive literature on the drivers of international market access among emerging markets and extends the analysis to cover the recent surge in bond issuance by frontier economies. The first challenge that our paper seeks to overcome is finding an accurate measure of market access that accounts for its multiple dimensions,

[4] See Box I, at Appendix B.1.

such as price, quantity, and frequency. Previous studies, such as Guscina, Malik and Papaioannou (2017), provide different definitions of market access and the loss thereof. IMF (2020) considers a low-income country to have sustainable and durable access to international capital markets if it has issued international bonds in three out of the past five consecutive years in a cumulative amount of at least 50 percent of its IMF quota. Guscina, Malik and Papaioannou (2017) find that, among other factors, a significant deterioration in sovereign spreads, nonresident holdings of public debt, rollover rates, sovereign credit ratings, and government cash balances are all leading indicators for loss of market access. Our paper takes profit from these works, but also provides three different definitions of market access, which make us able to analyze the problem in different lens to the same problem.

The literature typically identifies two main drivers of emerging markets' access to international capital markets. On the one hand, 'pull' factors are country-specific characteristics that may spark or thwart investors' interest. These factors include macroeconomic fundamentals such as fiscal performance, external sustainability, income level, growth, private sector development, quality of governance and institutional characteristics. On the other hand, 'push' factors are exogenous external variables, such as global market volatility and the US policy rate, which may impact investors' risk appetite and borrowing decisions.

Most papers (Comelli (2012); Gelos, Sahay and Sandleris (2011); Presbitero et al. (2015)) find that both, country-specific macro fundamentals as well as external factors, influence the capacity of emerging markets to tap international capital markets. Studies, such as Presbitero et al. (2015) and Min et al. (2003), show that countries with stronger fiscal and external balances, sound institutions, and solid liquidity and solvency positions are more likely to access international capital markets. In addition, Comelli (2012) and Fratzscher (2012) report that the impact of domestic fundamentals on market access depends on external factors. Comelli (2012) find that the impact of domestic fundamentals is diminished at times of high global market volatility relative to more stable periods. In a similar vein, Fratzscher (2012) shows that while push factors were the main drivers of capital flows during the GFC, country-specific determinants have become more important in defining the post-GFC sovereign borrowing dynamics. Interestingly, Gelos, Sahay and Sandleris (2011) document that not only is the probability of market access not influenced by the frequency of defaults but also that a default, if resolved quickly, does not necessarily reduce the probability of tapping markets.

As LICs' access to international capital markets is a relatively recent phenomenon, analysis of this trend is more limited and often coincides with discussions on international investment diversification. Mecagni et al. (2014) examine the increase in international bond issuance by African frontier economies, exploring the role of issuance in financing structural investment in these economies on the one hand, and the portfolio diversification opportunity presented to international investors on the other. On the latter, they conclude that maintaining a sound fiscal environment is paramount to attract investor demand. Similarly, Haque, Bogoev and Smith (2017) find that maintaining a strong growth performance and a favorable sovereign rating increase LICs' chances to access international capital markets. They also caution that LICs with access to capital markets must implement policies to prevent excessive borrowing and ensure sound debt management (as investors in search for yield may ignore weakening fundamentals until too late). Berger, Pukthuanthong and Yang (2011) provide empirical evidence that frontier markets' exchange-traded funds have low integration with the world and thereby offer investors an important diversification tool.

Finally, several previous papers study whether receiving financial support from international financial institutions (IFIs), such as the World Bank and IMF, can help catalyze funding from other sources, including international capital markets. The conclusions vary. While Gelos, Sahay and Sandleris (2011) find no catalytic effect from IMF-supported programs, Presbitero et al. (2015) find that IMF support is associated with a higher likelihood of an emerging market issuing an international bond. Somewhat distinctly, Corsetti, Guimaraes and Roubini (2006) use a theoretical game theory model to show that financial support from IFIs can help prevent a destructive bank run in LICs and that these effects are stronger the larger the size of the support.

3.2.2 Modeling and Predicting Market Access, Sovereign Debt, and Currency Crises

This paper also contributes to another strand of the literature that investigates the forecasting performance of regression models used to predict and track market access, debt crises, and currency crises. The evaluation of these models typically combines in-sample fit measures with out-of-sample forecasting accuracy, focusing on metrics related to international debt and exchange markets. This literature often compares competing models using forecasting performance metrics, an approach addressed in the present study.

Fuertes and Kalotychou (2004) emphasize the importance of controlling for temporal and geographical heterogeneity when predicting sovereign default risk, using a combination of econometric estimation methods and out-of-sample error measures. The authors identify global macroeconomic uncertainty, U.S. monetary policy, and investor risk aversion as key predictors of defaults, and compare models using metrics that aggregate the percentage of out-of-sample false positives and false negatives to select the best forecasting model.

Similarly, Savona and Vezzoli (2015) propose a decision tree methodology for predicting sovereign debt crises, comparing their models with benchmarks. They show that incorporating multiple risk signals improves out-of-sample predictive accuracy through tests such as the Diebold-Mariano test. The authors find that signal-based models outperform traditional models like logit and stepwise logit. Their model selection criteria are based on a cost function for Type I and II errors, both in-sample and out-of-sample. The econometric results indicate that illiquidity (short-term debt to reserves ratio), insolvency (reserve growth), and contagion risk are the primary predictors of debt crises.

More related to our study, in the context of the loss of access to sovereign debt markets, Zigraiova, Erce and Jiang (2020) analyze episodes of market access loss in the eurozone's sovereign debt markets. They highlight the role of market conditions, fiscal stance, and the macroeconomic cycle as important predictors of these episodes. The authors aggregate these factors into indicators to predict deteriorating market conditions, but find that these indicators perform poorly in out-of-sample forecasts. Multivariate regression models, however, outperform in out-of-sample predictions based on metrics that also include Type I and Type II errors.

Finally, Alaminos et al. (2021) use machine learning models to predict sovereign debt and currency crises, comparing their predictive performance with traditional statistical techniques. Using a global sample from various regions, including Africa, Latin America, and Europe, they show that models like fuzzy decision trees, AdaBoost, extreme gradient boosting, and deep neural networks outperform traditional methods in terms of accuracy. Their model comparison is based on the traditional root mean square error (RMSE) criterion, which demonstrates the superiority of computational models for out-of-sample predictions compared to simpler logit models.

In Section 3.5.2, we will present model comparison measures based on the cited literature, which will be applied to the results to select models using both in-sample metrics (for modeling the determinants of sovereign debt market access) and out-of-sample metrics (for predicting market access prospects).

3.3 Data

Our panel dataset consists of annual data for 18 frontier economies from 1990 to 2019. Frontier economies are defined as LICs that fulfill the following two criteria: i) income criterion: countries that are Poverty Reduction and Growth Trust (PRGT) - the IMF support arrangement for LICs - and/or International Development Association (IDA) eligible - the World Bank Group support arrangement for LICs - excluding economies that are only eligible because of their small economy status, and ii) market access criterion: countries that have issued public and publicly guaranteed (PPG) external bonds at least once between 1990 and 2019.[5] External bond debt according to the World Bank's International Debt Statistics (IDS) definition consists of bonds held by nonresident creditors,

[5] The eligibility criteria for PRGT funding used in this paper are detailed in IMF (2020). The IDA operational cuttoff was $\$1,185$ in fiscal year 2021, used by the time of this writing. The operational threshold is revised on an annual basis every July.

which can be denominated in both foreign and domestic currency. The final list of countries includes 15 countries that are both PRGT and IDA eligible and 3 economies that are only IDA eligible, most of which (11 out of 18) are African countries. Table 3.1 summarizes our sample.

Table 3.1 – Frontier Economies

Countries	Eligibility
Cameroon	PRGT and IDA
Cote d'Ivoire	
Ethiopia	
Ghana	
Guinea	
Honduras	
Kenya	
Lao PDR	
Mozambique	
Moldova	
Papua New Guinea	
Rwanda	
Senegal	
Taijikistan	
Zambia	
Mongolia	IDA
Nigeria	
Pakistan	

The analysis uses three different proxies for market access: i) the outstanding PPG bond stock to GDP ratio; ii) the probability of issuance, a binary variable that is equal to 1 if a frontier economy has issued PPG bonds in a given year and equal to 0 if not; and iii) EMBI spreads.

These different measures capture different dimensions of the concept of market access: For example, if a country can issue the quantity it wants to at a time when it needs to and at a cost that it can absorb, we can say that it enjoys market access; but all of these elements may not be satisfied at the same time. Thus, the three gauges of market access complement each other. The outstanding bond stock to GDP ratio is a proxy for the cumulative volume of issuance and contains information about the magnitude of issuance relative to the size of the economy. On the other hand, the probability of issuance variable captures the timing of issuance, independently of its size. When issuance is not observed in this model, however, we cannot explain whether this is because the country did not need financing or because it did not find investors' demand for its bonds. Finally, EMBI spreads contain information on investors' risk assessment of a country and the cost to the country of issuing debt; in particular, whether it is financially viable to issue.

EMBI spreads are only available for 12 countries in our sample that have more developed bond markets. Data on bond stocks and issuance comes from the World Bank Group's International Debt Statistics (IDS). We have chosen IDS as our source of bond issuance data as it provides complete standardized annual information on bond stocks and issuance and also has observations on LICs. Table 4.1 summarizes our dependent variables with their respective descriptions and sources.

Table 3.2 – Measures of Market Access

Variable	Description	Source
PPG Bond Stock	Outstanding PPG bond stock as percent of GDP	WBG International Debt Statistics (IDS)
Probability of Issuance	A binary variable that is equal to 1 if a frontier country issued PPG bonds in a given year and equal to 0 otherwise	WBG International Debt Statistics (IDS)
EMBIG spreads	EMBIG Index	Bloomberg

Table 3.3 describes our set of pull and push explanatory variables. The majority of our country-specific data (pull factors) was collected from the IMF's World Economic Outlook (WEO, October 2020) and includes GDP per capita, GDP growth, fiscal balance, current account balance, reserve assets, government debt, external debt, terms of trade, inflation, and credit to the private sector. In addition, the quality of institutions is proxied by the World Bank's rule of law index from the World Governance Indicators (WGI) database. The indicator is in percentile rank, where 0 is the lowest bound and 100 is the highest rank, meaning better institutions. We also include a dummy for IMF financial support as a country-specific variable, which equals 1 if a country has an IMF financial arrangement in place in a given year, and 0 if not. On the other side, external push factors include the US GDP growth rate, the US policy rate, 10-year Treasury bond yields and the VIX index.[6] The US growth rate, policy rate, and 10-year bond yields should capture

[6] We include upper credit tranche PRGT and General Resources Account (GRA) arrangements as some of the countries in our sample are blenders (as described in Appendix B.1), and others were not PRGT-eligible for the entire time period.

investors' chase for yield behavior. The CBOE volatility index (VIX) proxies volatility and risk aversion in global financial markets.

Table 3.3 – Push and Pull Factors

Pull factors (country-specific characteristics)

Variable	Unit	Source
GDP per capita	Thousands US Dollars	IMF WEO
GDP growth	Percent	IMF WEO
Fiscal Balance	Percent of GDP	IMF WEO
Current Account	Percent of GDP	IMF WEO
Reserve Assets	Months of Imports	IMF WEO
Government Debt	Percent of GDP	IMF WEO
External Debt	Percent of GDP	IMF WEO
Terms of Trade	US Dollars	IMF WEO
Inflation	Percent	IMF WEO
Private Credit Lending	Percent of GDP	WBG WDI
Institutions (Rule of Law)	Percentile rank (0 lowest, 100 highest)	WBG WGI
IMF Support IMF PRGT-ECF Support IMF PRGT-SCF Support	Dummy variable (1 if it received the support in a given year, in a given year, 0 otherwise)	IMF Finance Department Database

Push factors (global external characteristics)

Variable	Unit	Source
US policy interest rate	Percent	Bloomberg
US Bond 10yr yield	Percent	Bloomberg
US growth	Percent	IMF World Economic Outlook (WEO)
CBOE VIX Index	Index	Bloomberg

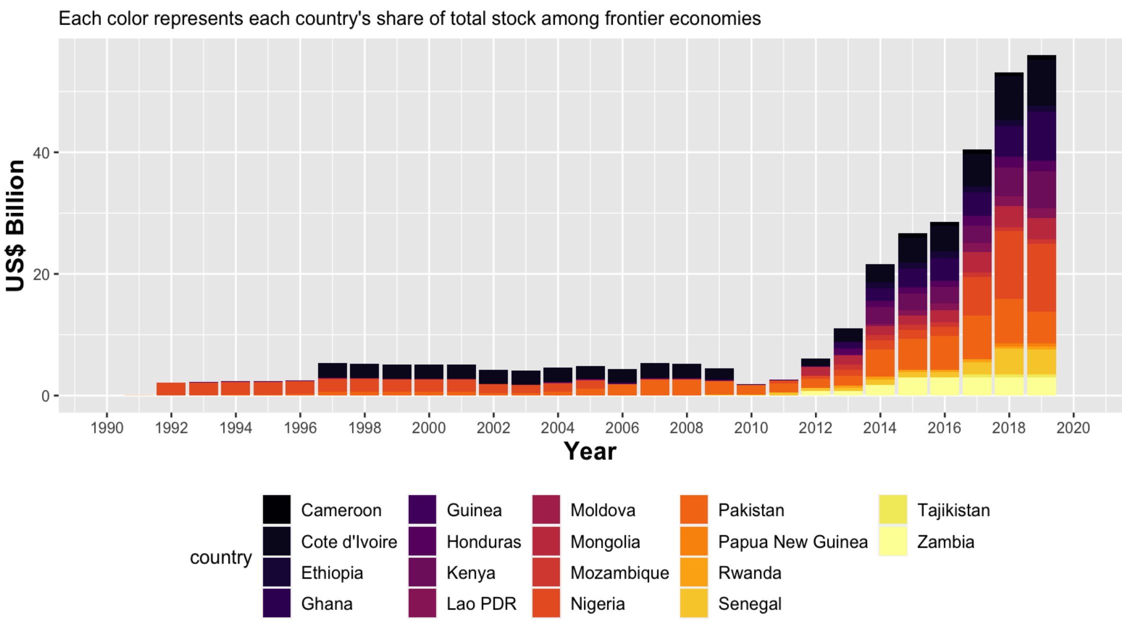
Finally, we would like to acknowledge some of the challenges we faced on the data front. First, since we are dealing with frontier economies that have only begun to access international markets in recent years, our dataset misses some observations for spreads and interest rates. We are also hostage to idiosyncrasies of the past decade. For example, as we will discuss in the next section, in our baseline identification strategy, we use US growth in place of the US policy rate as an explanatory variable since US interest rates have remained stable at historical lows since 2009. Second, since we are working with a relatively short timeframe, this could lead to goodness-of-fit issues in our main regressions.

3.4 Stylized Facts

This section presents some stylized facts on how market access has evolved in frontier economies in recent years. Four key trends stand out. First, frontier economies started to issue bonds in international capital markets after 1990, but the issuance really took off after 2009. Second, after the GFC, the proportion of bond issuance became more evenly distributed among our sample of frontier economies. Third, the increase in bond issuance after 2009 coincided with a decreasing trend in global financial market volatility.[7] Lastly, frontier economies' sovereign spreads have narrowed during the period covered in our sample.

Frontier economies' outstanding stock of external PPG bond debt—a proxy for the cumulative volume of PPG external bond issuance—increased substantially between 1990 and 2019, particularly after the GFC (Figure 3.1). While the total amount of frontier economies' outstanding external PPG bonds stood at USD 4.5 billion at end-2009, this increased to USD 55.9 billion by end-2019.[8]

Figure 3.1 – Outstanding PPG Bond Stock in Frontier Economies - 1990 to 2019

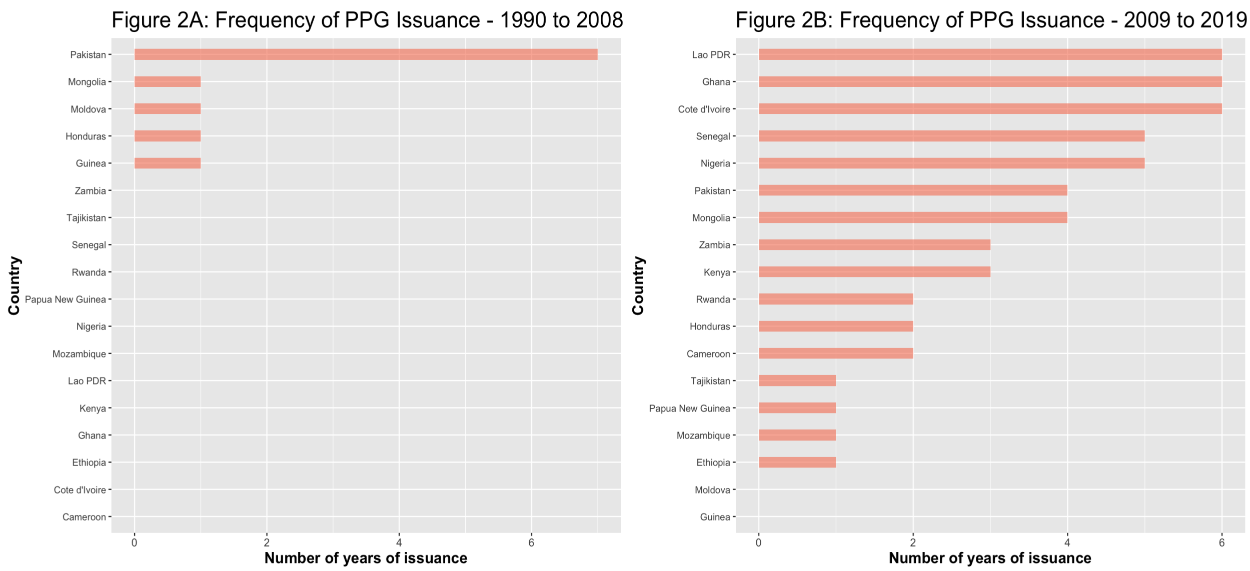


[7] US S&P500 volatility, measured by the Chicago Board Options Exchange Volatility Index (CBOE VIX).

[8] These numbers pertain to the 18 frontier economies included in our sample.

Not only did the volume of issuance increase in the post-GFC period, but there was also an increase in the frequency and the number of issuing countries in our sample (Figure 3.2). From 1990-2008, there were only 11 international bond issuances by five frontier economies (Pakistan, Moldova, Honduras, Guinea and Mongolia). By contrast, in the decade following 2008, 16 out of 18 frontier economies in our sample were able to tap international capital markets, with 52 bonds issued over this period (Moldova and Guinea were the only exceptions). A median country did not issue in any year during 1990-2008, while issuing in two to three years during 2009-2019. Five countries in our sample (Laos, Senegal, Nigeria, Ghana, and Cote d'Ivoire) issued in at least half of the years between 2009-2019, and African economies accounted for about two-thirds of the issuance over this period. It is worth noting that the lower amount of issuance in 1990-2008 may partly owe to the fact that many countries in our sample were participating in the Heavily Indebted Poor Countries (HIPC) debt relief initiative (launched in 1996) under which they were precluded from issuing market debt until they reached the completion point of the process. By 2009, all but two HIPC countries in our sample had already reached the HIPC completion point.[9]

Figure 3.2 – Frequency of PPG Issuance by Frontier Economies



The increase in frontier economies' outstanding PPG bond stock from 2009 also coincided with a decrease in global financial market volatility. Figure 3.3 shows the evo-

9 Guinea and Cote d'Ivoire reached the HIPC completion point in 2012.

lution of the bond stock in our sample from 2009 to 2019 plotted together with the VIX Index, which represents volatility in global financial markets: it is clear that the increasing slope of the bond stock has corresponded with a decreasing slope for the VIX. This suggests that during calm periods in global financial markets, foreign investors may be less risk averse and therefore more willing to invest in frontier economies.

Figure 3.3 – Outstanding PPG Bond Stock vs VIX - 2009 to 2019

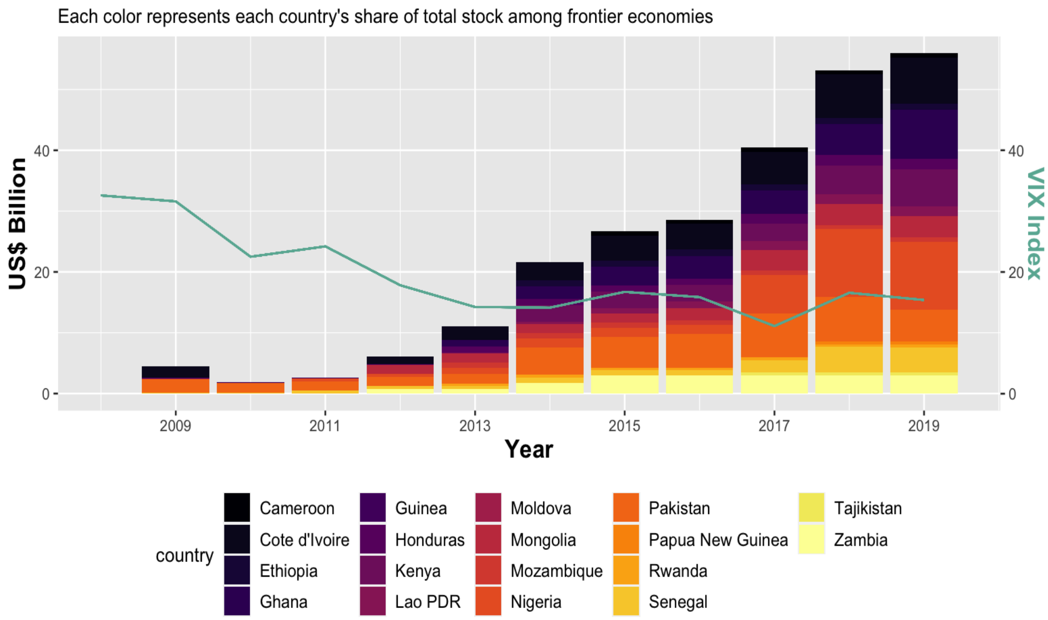
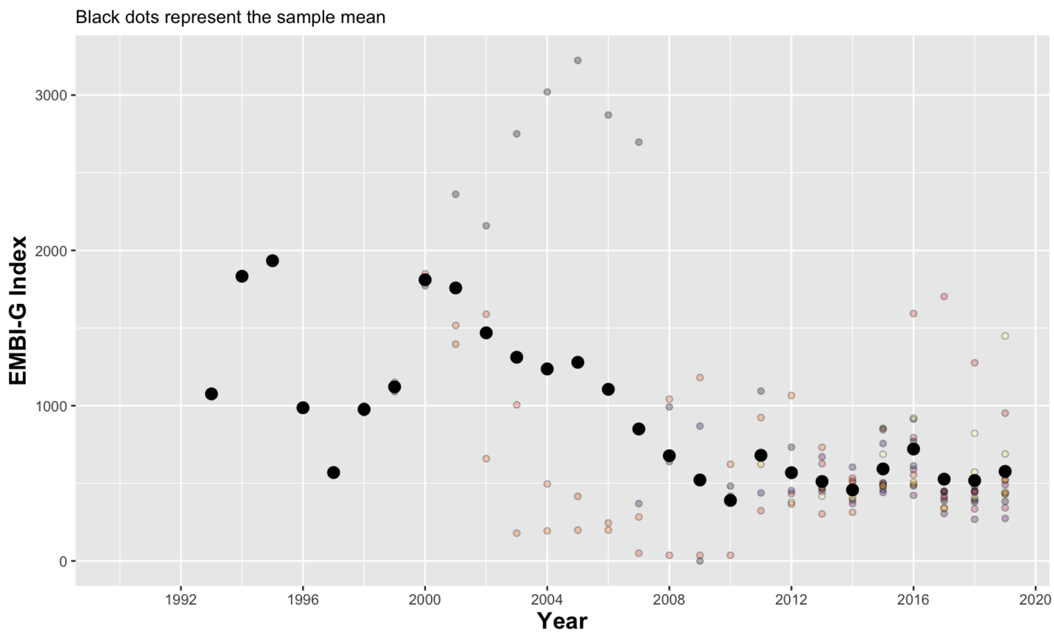


Figure 3.4 – Evolution of EMBIG in Frontier Economies



Finally, sovereign spreads to US benchmark Treasuries are a key variable when assessing market access, as they reflect investors' risk assessment of a country and the relative cost of issuing. Figure 3.4 shows the path of sovereign spreads in our sample using J.P. Morgan's Emerging Market Bond Index Global (EMBI) that tracks the sovereign rates of emerging market countries relative to the US benchmark yield. Black dots represent the average of our panel for a given year, while small colored dots are each country in our total sample. During the period covered, EMBI spreads have shown a decreasing slope among our pre-selected frontier economies, departing from an average of 1,000-2,000 basis points (bps) in the 1990s to around 500 bps after 2009. Since bond yields have an inverse relationship with bond prices, the decrease in spreads indicates an increase in frontier economies' bond prices, which in turn suggests higher demand for their bonds over this period.[10] The period 2009-19 was also characterized by low yields in advanced economies amid unprecedented amounts of quantitative easing, prompting investors' search for yield in emerging and frontier economies.

To sum up, our stylized facts show that over the past decade, we have not only seen an increase in PPG bond issuance by frontier economies but also a decrease in their sovereign spreads. Both trends indicate an increase in foreign investors' appetite for frontier economy debt over this period, which has facilitated their increased participation in international capital markets.

3.5 Empirical Analysis

The empirical section is divided into two parts. In Section 3.5.1, we use data on frontier economies' external bond issuance and spreads to examine factors that may have contributed to their increased market access in recent years. Our goal is to identify a shortlist of factors or patterns that seem most relevant for assessing their continued or prospective market access. In Section 3.5.2, we evaluate the predictive power of our probability of issuance model by testing how accurately it would have predicted actual

[10] We note that while the number of frontier economies included in the EMBIG index has increased over time, not all economies in our sample are part of the EMBIG index.

issuance over the past decade in countries that have issued bonds at least twice since 1990. We do this in two ways: First, we compare real issuance with fitted values from our probability of issuance model (in-sample prediction). Second, we restrict the sample to estimate issuance for the most recent years of our complete sample (out-of-sample prediction). We then conduct a traditional horse-race analysis of different models to assess the best fit and compare the real odds of market access with the main forecasts.

We use three models in our analysis of the determinants of market access in frontier economies. The first model assesses the linear relationship between the outstanding PPG external bond stock and our set of explanatory variables described above:

$$PPG\ Bond_{i,t} = \beta_0 + \beta_1 Pull_{i,T} + \beta_2 Push_T + \alpha_i^{iss} + \delta_t^{iss} + \varepsilon_{i,t}^{iss} \tag{3.1}$$

Where $PPG\ Bond_{i,t}$ is the outstanding PPG bond stock as a percentage of GDP for each country i and year t. $Pull_{i,T}$ is a set of pull variables for each country i and year $T = \{t-1, t\}$, while $Push_T$ is a vector of exogenous push factors for each $T = \{t-1, t\}$. α_i^{iss} represents potential country fixed effects and δ_t^{iss} potential time fixed effects. $\varepsilon_{i,t}^{iss}$ is the error term for each country i and year t. We run four identifications for this first regression: a pooled OLS model, a country fixed effects regression, a time fixed effects identification, and finally, an identification that controls for both country and time fixed effects.

Our second model uses the probability of issuance as its dependent variable. The binary variable $Issuance_{i,t}$ is equal to 1 when a given frontier economy i has issued PPG bonds in a given year t, and equal to 0 otherwise. Given this definition, we first run three nonlinear identifications - a random effects probit, a random effects logit, and a conditional logit estimation. As the Hausman test rejects the null hypothesis that the country-specific errors are not correlated with the regressor, we also run a linear probability model (LPM) with the same variables, but now accounting for country and time fixed effects. We consider the following model specification:

$$Prob(Issuance_{i,t}) = \beta_0 + \beta_1 Pull_{i,T} + \beta_2 Push_T + \varepsilon_{i,t}^{Prob} \tag{3.2}$$

Here, $Prob(Issuance_{i,t})$ is the probability of PPG bond issuance. We keep the same push and pull variables from Equation 3.1 and $\varepsilon_{i,t}^{Prob}$ is the error term. It is worth noting that when an issuance is not observed in this model, it could be a result of a country not having the *need* to issue or having the need but not finding *demand* for its bonds. As noted in Presbitero et al. (2015), given that frontier economies typically require a large amount of external financing for their investment needs, it is unlikely that there is a lack of need for external financing. However, some economies may opt out of international capital markets due to the availability of grants and concessional loans, or for political reasons. In the absence of a clear identification strategy, the results of this model do not imply causality but rather a correlation.

Our third and final model uses EMBIG spreads as the dependent variable, a proxy for access to international capital markets:

$$EMBIG_{i,t} = \beta_0 + \beta_1 Pull_{i,T} + \beta_2 Push_T + \alpha_i^{EMBIG} + \delta_t^{EMBIG} + \varepsilon_{i,t}^{EMBIG} \tag{3.3}$$

with $EMBIG_{i,t}$ being the EMBIG Index representing sovereign spreads for each country i and year t. $Pull_{i,T}$ and $Push_T$ are the same vectors of pull and push variables as in Equations 3.1 and 3.2. Also, α_i^{EMBIG} and δ_t^{EMBIG} are potential country and time fixed effects as in our first model, with $\varepsilon_{i,t}^{EMBIG}$ being the error term. Similar to Equation 3.1, we look at four different identifications: a pooled OLS model, a country fixed effects regression, a time fixed effects regression, an a country and time fixed effects regression. Country fixed effects capture time-invariant unobservable country characteristics that may affect countries' propensity to access international capital markets, while time fixed effects capture time-variant global factors common to all countries that may affect their propensity to access international capital markets.

The analyses focus on the period 2009-2019, as it was during this period that international bond issuance by frontier economies started to be observed with more frequency. In order to avoid endogeneity to the extent possible, we have chosen to use lagged explanatory variables, with the exception of the VIX index and EMBI variables that we consider to be fast-moving, as well as the dummy variable for IMF Support. Finally, due to limited data availability, the study uses a dynamic panel data estimation in a case where T< N, with variables for 18 countries observed over 2009-19. In this sense, the estimation faces a short T problem that renders the fixed effects estimator biased (the Nickell bias). This bias could potentially be addressed by using the Generalized Method of Moments (GMM) estimation method.[11]

3.5.1 Determinants of Market Access

Tables B.3, B.4, B.5 and B.6 show the regression results for the three models described above, with the stock of external PPG bonds, probability of issuance, and sovereign spreads serving as proxies for market access, respectively. Given that each of these captures a different element of market access (quantity, timing, price), it is not surprising that the results for pull and push factors' impact on market access vary across the models.

For our first model with outstanding bond stock as the dependent variable (Table B.3), the estimated coefficients for most explanatory variables move in the direction we would expect. However, the magnitude and statistical significance of the results varies depending on whether or not we include EMBI spreads as an explanatory variable since data on EMBI spreads is not available for all countries in our sample and therefore their inclusion reduces the sample size. With respect to domestic or 'pull variables', in general, we would expect a larger outstanding bond stock in frontier economies to be associated with sound macroeconomic fundamentals, as these would be more likely to attract higher

[11] As a robustness check, we conducted the analysis for the PPG bond stock regressions using GMM and an Arellano-Bond estimator, but obtained similar results, in terms of both significance and magnitude, to those reported in this paper. Further work on this subject could employ GMM for the probability of issuance and EMBI regressions.

demand from international investors. In line with this, our results show that a larger outstanding PPG bond stock is positively associated with GDP per capita, GDP growth, private sector credit (a proxy for domestic financial sector development), and rule of law (a proxy for better institutions and governance), and negatively associated with inflation. Results for other macroeconomic fundamentals, while initially less intuitive, make sense when viewed through the lens of countries' financing needs (the bond supply side) rather than investors' demand: a larger PPG bond stock is associated with a lower level of reserves and a higher public debt to GDP ratio, both of which signify higher financing needs for the issuing country. Two variables that do not show statistically significant results are the current account and the IMF support dummy, both of which may owe to a degree of collinearity with other explanatory variables.

The impact of push variables also appears to be relevant to the stock of outstanding PPG bonds. Our analysis suggests that a larger PPG bond stock is associated with lower global market volatility as measured by the VIX index, and with lower EMBI spreads. This is in line with our priors as we would typically expect volatility and spreads to have an inverse relationship with investors' risk appetite and thus to dampen the demand for frontier economy bonds. Finally, US growth, included in our analysis as a proxy for US interest rates to capture investors' chase for yield behavior, shows insignificant results across all specifications, which once again could be a result of collinearity.

Results for our second model, using the probability of issuance as a proxy for market access, are presented in Tables B.4 and B.5. This model is not concerned with the volume of bond debt issued by a country but rather the timing of issuance, and allows us to examine whether explanatory variables are positively or negatively associated with bond issuance in any given year. As in our first model, the effects of pull and push variables can be divided into factors associated with the 'demand side' and 'supply side' of frontier economies' bond issuance. The results are similar to those of our first model, but with some interesting exceptions. Taking first our nonlinear specifications (Table B.4), we find that the probability of issuance is positively associated with GDP per capita and the rule of law, while being inversely associated with global market volatility and EMBI spreads.

In contrast to our first model, however, government debt shows an inverse relationship with the probability of issuance, suggesting that when it comes to the timing of issuance, the financing needs/supply side of the story would be secondary to attracting investor demand through the stronger fundamentals associated with lower public debt to GDP.

The results of our linear probability model (Table B.5) confirm the importance of sound fundamentals, indicating a positive association between the probability of issuance and GDP per capita, the rule of law, and the current account, while once again showing a negative association with volatility. In line with our first model, they also show an inverse relationship between the probability of issuance and reserves, likely reflecting that higher reserves at any given point in time would reduce the need to issue externally. In contrast to our first model, however, credit to the private sector exhibits an inverse relationship with the probability of issuance in our LPM results, suggesting that the financing needs channel is at play: higher private sector credit to GDP is indicative of a more developed domestic financial market, which in turn may reduce a country's need to issue externally at a given point in time. The economic significance of these coefficients is also non-negligible. For instance: a 10 percent increase in GDP per capita is associated with a 2 percentage point higher likelihood of issuing a bond (column 3); an increase in reserves by 1 month of imports is associated with a 12 percentage point decrease in the likelihood of issuing a bond (column 2); and a two-point increase in the VIX index, which is among the 75th percentile of changes in the last 20 years, is associated with a decrease of 5 percentage points in the likelihood of issuing a bond (column 1). It is important to keep in mind that the probability of bond issuance is also influenced by the availability of other sources of financing, such as grants and bilateral loans, which are not included in the model but are partly captured by time fixed effects.

Finally, the results for our third model using EMBI spreads as a proxy for market access are reported in Table B.6. As opposed to the previous two specifications, we do not differentiate between supply and demand side factors when interpreting these results. EMBI spreads are themselves a real-time gauge or reflection of the 'cost' of frontier markets' risk and thus 'price in' investors' appetite for frontier markets' bonds—with lower spreads indicating lower perceived risk, and thus a lower cost of issuing. As we would expect, narrower EMBI spreads are related to sounder macroeconomic fundamentals, reflected in higher GDP per capita, higher GDP growth, a higher current account balance, higher reserves, lower public debt, and lower inflation. Narrower spreads are also associated with the presence of an IMF program, which makes sense in the context of frontier economies where IMF programs are often structural in nature and not necessarily triggered by shocks or full-fledged BOP crises. With respect to external 'push factors,' our results depict that higher frontier economies' EMBI spreads are associated with higher global volatility as measured through the VIX, and with higher US interest rates as proxied through higher US growth, both of which we would expect. Finally, the results show a statistically insignificant result for the rule of law, which is somewhat surprising given the positive and significant results we have seen for this variable in our other models. Private credit to GDP also shows an odd positive association with EMBI spreads, although the result is not highly significant from a statistical perspective.

3.5.2 Prospective Market Access

Assessing countries' prospective access to international debt markets primarily relates to assessing investors' appetite for holding their bonds. In the context of frontier economies, which are the newest entrants to the global sovereign debt arena, having successfully issued an external bond once may not necessarily signify perennial access to international markets, particularly when political or economic circumstances in the issuing country change. So how do we gauge whether a frontier economy would find demand for its bonds in international capital markets in the future if the need arose? The analysis on the determinants of market access in the previous subsection provides valuable information on factors affecting investors' demand for frontier economies' bonds. The analysis also demonstrates that EMBI spreads themselves represent a useful embodiment of the risk associated with investing in a country's bonds as well as global risk appetite, with narrower spreads reflecting lower risk and thereby potentially greater demand that would allow the placement of bonds at financially viable yields. The first two models of our determinants of market access analysis used countries' outstanding stock of bonds relative to GDP, and the probability of issuing a bond in a given year as dependent variables representing market access. In this section, we examine how well our probability of issuance model captures market access by first testing how accurately it would have predicted actual issuance over the past eleven years (2009-2019) for countries in our sample, and then conducting an out-of-sample forecasting exercise to assess whether the model can track market access in frontier economies.

3.5.2.1 In-sample Probability Prediction

We begin by predicting the in-sample probability that a frontier economy has issued PPG bonds in a given year by computing the fitted values for both our nonlinear and linear probability models. We then analyze how each model performs by calculating the percentage of "correct predictions" when measured against the observed issuances in actual data. In testing our models this way, from our original sample of 18 frontier economies, we only keep 12 that have issued PPG bonds at least twice during the period from 1990 to 2019, with at least one issuance occurring between 2009-19, in order to ensure that our models' predictive power is only being gauged on countries that already have the apparatus in place to issue bonds. Figure 3.5 shows the number of issuances by these 12 economies in 2009-19.[12]

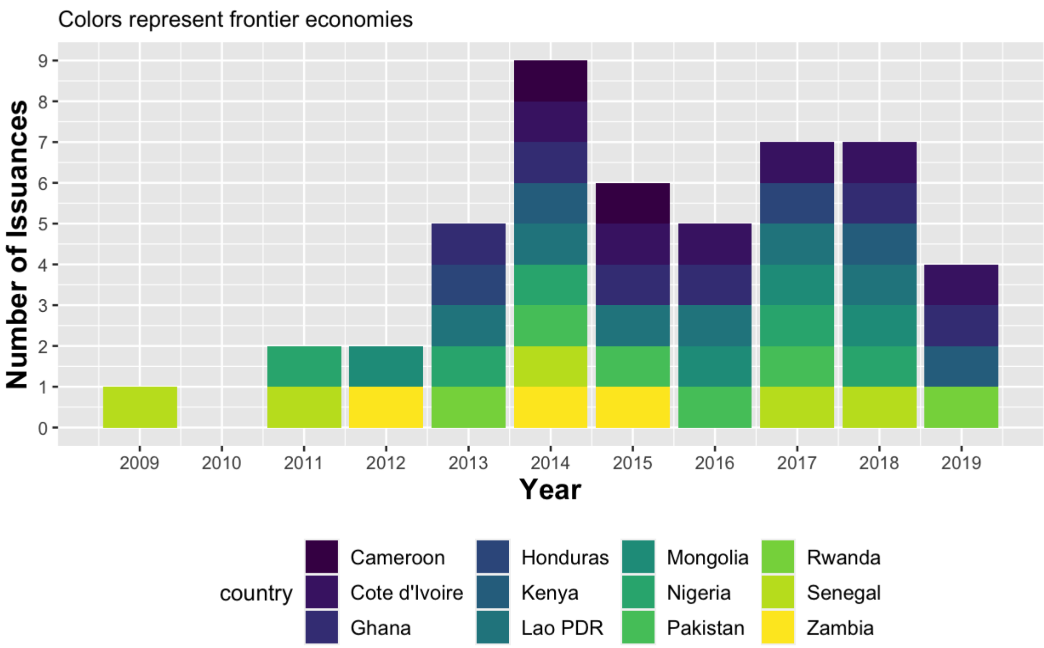
We use the following methodology to calculate the effectiveness of our models. Model predictions are considered to be *correct* if: (i) the fitted probability of issuance prediction for a given year and country is greater than or equal to 0.5 and this country has actually issued PPG bonds in that year, or (ii) the fitted probability of issuance prediction for a given year and country is lower than 0.5 and this country has actually not issued in that year. Given this definition, we define the indicator *percentage of correct predictions* as:

[12] Cameroon, Cote d'Ivoire, Ghana, Honduras, Kenya, Lao PDR, Mongolia, Nigeria, Pakistan, Rwanda, Senegal and Zambia.

$$\% \; Correct \; Predictions = \frac{Amount \; of \; Correct \; Predictions}{Amount \; of \; Total \; Predictions}$$

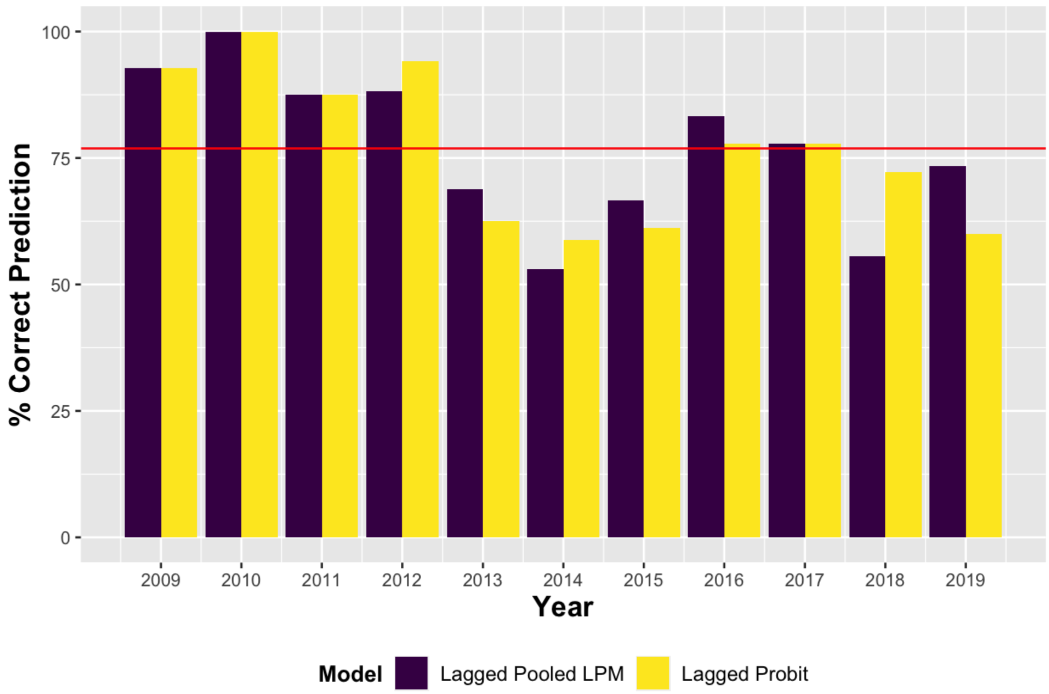
Figure 3.6 shows the evolution of *correct predictions* for the two best-performing models out of our various nonlinear and linear specifications: the pooled LPM and Probit model. The two models show an average percentage of *correct predictions* between 2009-19 of about 75 percent.

Figure 3.5 – Number of issuances by year and country



The fitted values predicted by our pooled LPM and Probit models together with actual issuances for each country are shown in Figure 3.7. If we focus more narrowly on the years 2013-19, as 90 percent of total issuances between 2009-19 occurred during these years, we find that while both models seem to capture the correct overall trend for most countries, for some countries such as Honduras, Kenya and Nigeria, the link between the model predictions and actual data is not easily discernible. Indeed, the average percentage of *correct predictions* for the models falls to about 67.8 percent for this sub-period. Moreover, while we include the most obvious pull and push factors in our models, neither

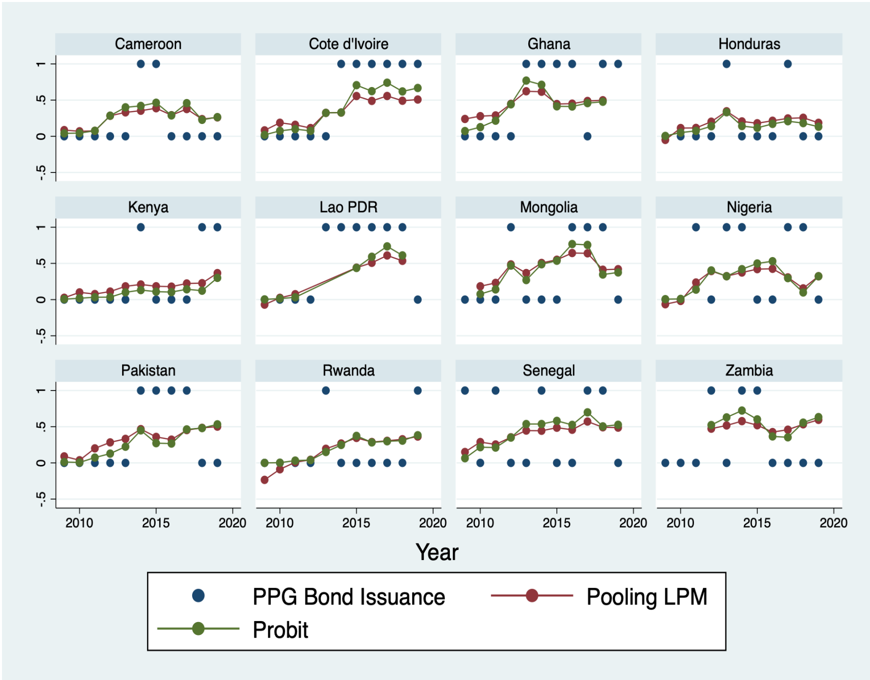
Figure 3.6 – Percentage of Correct Predictions of PPG Issuance



model accounts for political events or other country-specific shocks, or cyclical events such as commodity price shocks. This clearly impacts the predictive power of the models: for example, 2014 was the year of lowest *correct predictions* for both models (Figure 3.6); this was also the year of maximum number of issuances between 2009-19 (Figure 3.5) and marked the end of the so-called "commodity price boom" with a major reversal in commodity prices, a shock that was not captured by the models. Indeed, when we run the models with the Bloomberg Commodities Index included as an explanatory variable, this materially improves the percentage of *correct predictions* in 2014. Nonetheless, if the models were to be used to help assess prospective market access for a particular frontier economy at a particular point in time, it would be possible to control for some of these shocks.

In summary, the results of our analysis on factors affecting frontier economies' market access vary depending on which measure of market access we choose. However, there are still several general conclusions that hold true. First, both pull and push factors seem to be relevant for frontier economies' recent surge in access to international capital markets. Second, the impact of some domestic 'pull' factors can be more related to the

Figure 3.7 – In-sample Probability of Issuance Predictions



demand side, capturing investors' appetite for frontier economies' debt, or to the supply of bonds, reflecting frontier economies' financing needs, depending on which aspect of market access our dependent variable represents. The outstanding stock of bond debt, for instance, seems to relate to both investors' demand for bonds and frontier economies' financing needs as it reflects the overall volume of issuance over time, while the probability of issuance and EMBI spreads—reflecting the timing and cost of issuance, respectively—not surprisingly seem to be more influenced by investors' demand. The credit to the private sector variable displays a particularly interesting result, with a positive association to the outstanding bond stock on the one hand, and an inverse association to the probability of issuance on the other. While seemingly contradictory, both results are intuitive as a deeper, more developed domestic financial sector would be more likely to *attract* a larger stock of external bonds, while at the same time potentially reducing the *need* to issue externally at a point in time given domestic financing options. Appendix B.1.2 summarizes how our results for frontier economies compare to the results of previous studies on emerging markets.

Finally, we test the predictive power of our probability of issuance model by examining how accurately the model would have predicted actual issuance over the past eleven years (2009-2019) for a subset of countries in our sample that issued bonds at least twice in the 1990-2019 period, with at least one of those issuances occurring in 2009-19. Our results indicate that the Probit and pooled LPM specifications work best. While their average percentage of *correct predictions* during the 2013-19 period (when most issuances occurred) is 67.8 percent, the sample size and timeframe are still too small and short to come to a definitive conclusion. Nonetheless, these models could certainly provide a useful input to an assessment of a frontier economy's prospective market access.

3.5.2.2 Out-of-Sample Methods for Forecast Evaluation

In this section, we present an out-of-sample performance measures for the forecast exercises using the proposed models, based on existing literature. It is important to provide not only traditional out-of-sample measures but also those suited for classification/probability models, such as the logit and linear probability models.

The first three measures proposed are adapted from Fuertes and Kalotychou (2004) and Savona and Vezzoli (2015). First, we use the Hit Rate, measuring the percentage of correct forecasts.[13] Moreover, the authors also use the Quadratic Probability Score of Brier (1950), which is similar to a scaled Mean Squared Errors but with binary outcome. Moreover, we present the Logarithm Probability Score (LPS), that does not penalize symmetrically wrong and right forecasts. From Zigraiova, Erce and Jiang (2020) we profit from the type I error, which is the rate of false negative in the data. Finally, the traditional RMSE is also presented, which is the usual measure when we have many competing models, as in Alaminos et al. (2021).

- Hit Rate::

$$HR = \frac{1}{N}\sum_{i=1}^{N}\Big[y_i I\{\hat{P}_i - \tau \geq 0\} + (1-y_i)(1 - I\{\hat{P}_i - \tau \geq 0\}\Big]), \quad HR \in [0,1]$$

  Where N is the total number of observations; y_i is the actual outcome; τ is the threshold for classifying whether the event occurs or not, and here we set .5; and

[13] In Fuertes and Kalotychou (2004) they define the Hit Rate as the opposite, the percentage of incorrect forecast. Here, we focus on the correct predictions based on a threshold for the probability. Something similar we did in Section 3.5.2.1.

$I\{\cdot\}$ is the indicator function, which equals 1 if the condition inside is true, and 0 otherwise. Notice that here the higher is the HR, the better is the forecast evaluation.

- Quadratic Probability Score:

$$QPS = \frac{1}{N}\sum_{i=1}^{N} 2(\hat{P}_i - y_i)^2, \quad QPS \in [0, 2]$$

Where $\hat{P}_i$ is the predicted probability; and y_i is the actual binary outcome.

- Logarithmic Probability Score (LPS):

$$LPS = -\frac{1}{N}\sum_{i=1}^{N} \left[y_i \ln(\hat{P}_i) + (1 - y_i)\ln(1 - \hat{P}_i)\right], \quad LPS \in [0, \infty)$$

Which is a non-symmetric penalty function. Notice that when $y_i \neq \hat{P}_i$ the value is positive and unbounded.

- Missed Event Rate (Type I Error):

$$Type\, I = \frac{\text{False Positive}}{\text{Total Number of Events}}$$

This metric calculates the rate of events where the model predicts no issuance incorrectly.

- Root Mean Squared Error (RMSE):

$$RMSE = \sqrt{\frac{1}{N}\sum_{t=1}^{N}(y_t - \hat{y}_t)^2}$$

Where y_t is the observed value and $\hat{y}_t$ is the predicted value.

- Absolute Mean Squared Error (AMSE):

$$AMSE = \frac{1}{N}\sum_{t=1}^{N}|y_t - \hat{y}_t|$$

Where y_t is the observed value and $\hat{y}_t$ is the predicted value.

Some of the measures are similar, but together they can help to evaluate the better models to predict and understand the prospects on issuance events.

3.5.2.3 Out-of-sample Evaluation

Table 3.4 presents the out-of-sample forecast performance of the four proposed models, comparing two variations of the Logit model (Logit Random-Effects and Conditional Logit) with the Random-Effects Probit (Probit RE) and the Linear Probability Model (LPM). We use the metrics outlined earlier: Hit Rate, Type-I error rate, RMSE, Absolute Mean Squared Error (AMSE), Logarithmic Probability Score (LPS), and Quadratic Probability Score (QPS).

Table 3.4 – Metric Table: Out-of-sample Performance for Probability of Issuance

	Model	Hit_Rate	Type_I_Error	RMSE	AMSE	LPS	QPS
1	Logit RE	0.730	0.270	0.520	0.270	3.112	0.270
2	Probit RE	0.622	0.081	0.554	0.388	1.663	0.307
3	Conditional Logit	0.730	0.270	0.521	0.278	3.077	0.271
4	LPM	0.730	0.081	0.452	0.433	0.596	0.204

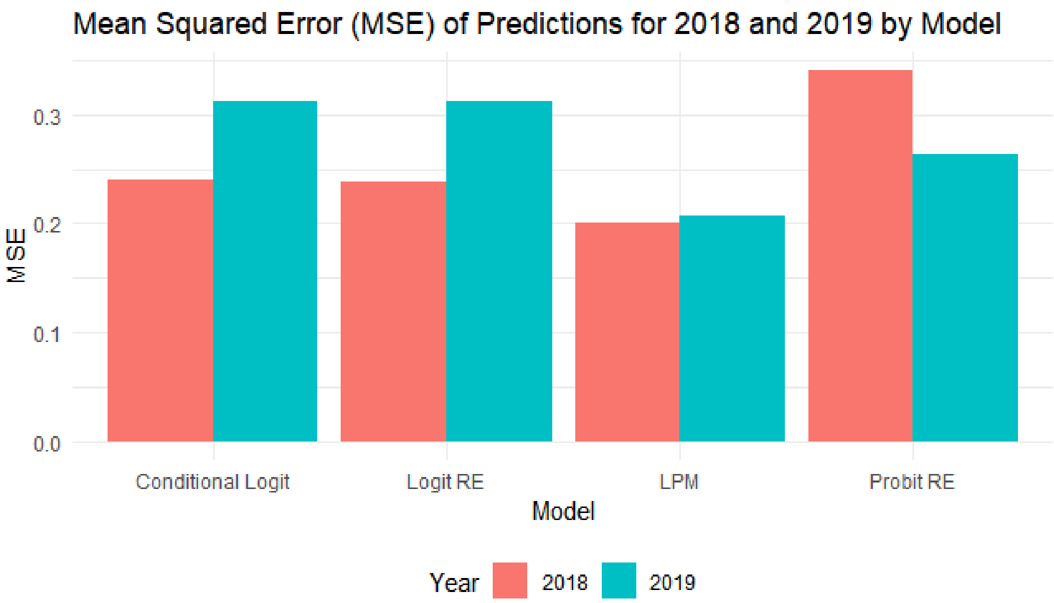
In summary, we observe that three models perform equally well in terms of the Hit Rate, and two models have the same Type-I error rate, with the Probit RE and LPM being the top models. In terms of RMSE, LPS, and QPS, the LPM performs best. Overall, the Linear Probability Model dominates most metrics, followed by the RE Probit model.

Notice, however, that Table 3.4 shows the performance aggregating all predictions from 2018 and 2019. In Figure 3.8, we present the forecast performance, summarized by the MSE, splitting the prediction for 2018 and 2019. We can see a dominance from the LPM in relation to others, including the RE probit.

Finally, to statistically confirm the superior performance of the LPM over the RE Probit, we conducted a Diebold-Mariano (DM) test, which compares the predictive accuracy of two models. The results show that the LPM significantly outperforms the RE Probit model in predicting issuance events (p-value $< 5\%$).

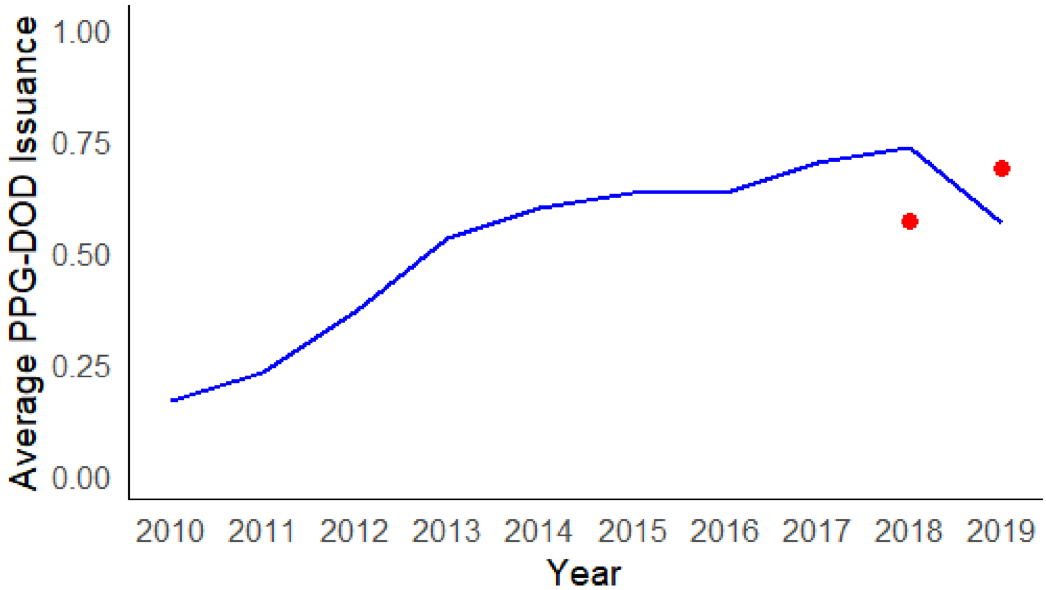
- DM Statistics $= -1.912$
- p-value $= 0.02763$
- H_a: the loss function is lower for the LPM in relation to the RE Probit

Figure 3.8 – Out-of-sample MSEs from Models' Forecast



In Figure 3.9, we present the average number of issuance predictions from the LPM (red line) alongside the actual values (blue line). The results are satisfactory, as the continuous probability model predicts 0-1 values effectively.

Figure 3.9 – Actual (Average) and Forecast Issuance Events for the LPM



Therefore, we have provided a prospective analysis of market-access by evaluating both in-sample and out-of-sample predictions from our probability of issuance model. Our results show robustness in both types of analysis, with satisfactory fit across various metrics, indicating that these models can effectively forecast issuance events in frontier economies.

Now, we can present where this model is performing better or worse. To do this, in Table 3.5, we present the list of countries, with the accuracy of the LPM to both 2018 and 2019, reporting whether the predictions are right or wrong.

Table 3.5 – LPM Accuracy by Country and Year

	Country	Accuracy_2018	Accuracy_2019
1	Bangladesh	Yes	Yes
2	Benin	No	No
3	Bhutan	Yes	
4	Cabo Verde	Yes	Yes
5	Cameroon	Yes	
6	Congo, Rep.	Yes	
7	Cote d'Ivoire	Yes	Yes
8	Ghana	Yes	Yes
9	Honduras	No	No
10	Kenya	Yes	Yes
11	Maldives	Yes	No
12	Mongolia	No	Yes
13	Mozambique	Yes	Yes
14	Nigeria	Yes	Yes
15	Pakistan	Yes	Yes
16	Papua New Guinea	No	Yes
17	Rwanda	No	
18	Senegal	No	No
19	Tajikistan	Yes	Yes
20	Uganda	Yes	Yes
21	Zambia	Yes	

The results show 27 hits in the out-of-sample prediction. Moreover we can see that for Benin, Honduras, and Senegal, predictions for the two out-of-sample observations are wrong. Thus, the model should be used carefully for prediction exercises in specific countries.

Other possible method to provide prospective analysis is a combination of models. In the next section we present a weighted forecast combination exercise to evaluate whether the forecasts can beat the preferred model.

3.5.2.4 Model combination

The use of model combinations in forecasting has gained attention in the economics literature (BAJARI et al., 2015) and, more broadly, in business applications (BATCHELOR; DUA, 1995). The core idea is that combining forecasts from different models can reduce prediction variance and, depending on the accuracy of individual forecasts, enhance overall predictive performance.

In this section, we present the results of a combined forecast based on inverse variance-weighted predictions. The weights assigned to each model are:

- Logit: .2560
- Probit: .1848
- Conditional Logit: .2498
- LPM: .3094

First, with this model we provide the out-of-sample forecast performance metrics in Table 3.6:

Table 3.6 – Accuracy Metrics for Combined Model

	Model	Hit_Rate	Type_I_Error	RMSE	AMSE	LPS	QPS
1	Combined Model	0.730	0.270	0.422	0.344	0.528	0.356

The combined model demonstrates the best performance in terms of root mean squared error (RMSE) and logarithmic probability score (LPS) when compared to the individual models. Additionally, it ties with three other models for the highest hit rate, indicating strong predictive accuracy. However, it also shares the worst performance in terms of Type-I errors.

To further assess its predictive capability, we replicate the accuracy table presented earlier, broken down by country and year, to analyze where the combined model performs better in forecasting market access prospects.

Table 3.7 summarizes the hits for the combined forecast. While the overall results are quantitatively similar to those of the LPM, there are notable differences in specific cases. For instance, the combined model incorrectly forecasts both Cabo Verde and Uganda, where the LPM had different outcomes. This highlights that, despite having the same total number of errors, the distribution of these errors varies across countries, reflecting heterogeneous prediction performance.

Table 3.7 – Combined Model Accuracy by Country and Year

	Country	Year_2018	Year_2019
1	Bangladesh	No	No
2	Benin	No	No
3	Bhutan	No	
4	Cabo Verde	No	No
5	Cameroon	Yes	
6	Congo, Rep.	Yes	
7	Cote d'Ivoire	Yes	Yes
8	Ghana	Yes	Yes
9	Honduras	Yes	Yes
10	Kenya	Yes	Yes
11	Maldives	Yes	No
12	Mongolia	Yes	Yes
13	Mozambique	Yes	Yes
14	Nigeria	Yes	Yes
15	Pakistan	Yes	Yes
16	Papua New Guinea	Yes	Yes
17	Rwanda	Yes	
18	Senegal	Yes	Yes
19	Tajikistan	Yes	Yes
20	Uganda	No	No
21	Zambia	Yes	

3.5.3 Robustness Analysis

In this section, we present several robustness exercises to test the consistency of our findings. First, we start detailing a random forest model to test the predictive power of machine learning techniques. Moreover, we test alternative measures for key variables such as US interest rates, and the influence of global factors as commodity prices and the institutional quality during financial turmoil.

3.5.3.1 A Random Forest Exercise

The Random Forest model is a widely used machine learning technique for classification issues, and it is based on the construction of multiple decision trees during training. Thus, it allows to combine predictors with a classification algorithm in order to obtain out-of-sample forecasts. This can result in a higher accuracy and reduced overfitting compared to individual models.

In the present analysis, the Random Forest model outperformed all other evaluated models across all metrics, as shown in Table 3.8. It achieved a hit rate of 89.2%, significantly higher than the rates observed for the linear probability model, logit, and probit models. Furthermore, the Random Forest model demonstrated the lowest values for error-based metrics, including an RMSE of 0.319 and an AMSE of 0.284, indicating a closer alignment between the predicted and actual outcomes. Probabilistic metrics, such as the logarithmic probability score (LPS) and quadratic probability score (QPS), also confirmed the superiority of the Random Forest model by penalizing deviations less than the alternative methods.

Table 3.8 – Random Forest Metrics

	Model	Hit_Rate	Type_I_Error	RMSE	AMSE	LPS	QPS
1	Random Forest	0.892	0.073	0.319	0.284	0.358	0.204

The robustness of the Random Forest model is further evidenced by its performance in predicting individual cases, as depicted in Table 3.9. For 2018 and 2019, the model correctly predicted 19 and 14 cases, respectively, yielding a total of 33 accurate predictions across both years, higher than the LPM and the model combination.

In sum, the results highlight that for prediction issues, machine learning techniques can improve the out-of-sample forecast, however, is still harder to identify the importance and significance of each predictor in this task, while the other presented models allow us to compute marginal effects and other objects some ML models can not.

Table 3.9 – Accuracy Table for Random Forest by Country and Year (Adjusted)

	Country	Year_2018	Year_2019
1	Bangladesh	Yes	Yes
2	Benin	No	No
3	Bhutan	Yes	
4	Cabo Verde	Yes	Yes
5	Cameroon	Yes	
6	Congo, Rep.	Yes	
7	Cote d'Ivoire	Yes	Yes
8	Ghana	Yes	Yes
9	Honduras	Yes	Yes
10	Kenya	Yes	Yes
11	Maldives	Yes	No
12	Mongolia	Yes	Yes
13	Mozambique	Yes	Yes
14	Nigeria	Yes	Yes
15	Pakistan	Yes	Yes
16	Papua New Guinea	No	Yes
17	Rwanda	Yes	
18	Senegal	Yes	Yes
19	Tajikistan	Yes	Yes
20	Uganda	Yes	Yes
21	Zambia	Yes	

3.5.4 Predictors' Contribution:

To further interpret the predictions of our estimated models and understand the relative importance of each explanatory variable to forecasting the probability of sovereign bond issuance, we compute Shapley values for each observation in the training dataset. Shapley values, derived from cooperative game theory, is commonly used in machine leaerning applications to provide a simple measure of each predictor's contribution to the final prediction. We denote it as ϕ_j, representing a measure of the contribution of each explanatory variable to an individual model prediction. They are computed as the weighted average of all possible marginal contributions that a variable j makes when added to different subsets of covariates, which can be numerically constructed for both linear and non-linear models[14].

Figure 3.10 presents the mean Shapley values across four parametric estimation

14 For detais, see Janzing, Minorics and Blöbaum (2020).

strategies: the random-effects logit (RE Logit), random-effects probit (RE Probit), conditional logit (CLogit), and the linear probability model (LPM). Each bar in the plots corresponds to the average marginal contribution of a given variable to the predicted probability of sovereign bond issuance, holding all others constant.

In panel 3.10a, we observe that `gov_debt_to_gdp` and `log_gdp_pc` have the highest average positive contributions in the RE Logit model, suggesting that countries with higher debt levels and higher per capita income are more likely to access international debt markets. Conversely, in panel 3.10b, the RE Probit model attributes greater importance to external push factors, particularly `vix_us` and `log_gdp_pc`, which aligns with the hypothesis that global financial conditions critically shape market access for frontier economies.

Panel 3.10c, which depicts the conditional logit results, reveals that within-country changes in `log_gdp_pc` and `rule_of_law` are the strongest drivers of issuance. This reflects the fact that, conditional on country fixed effects, structural improvements in institutional quality and income are strongly associated with sovereign bond issuance events. Finally, the LPM results shown in panel 3.10d largely mirror those from the non-linear models, though the magnitudes are more evenly distributed across predictors.

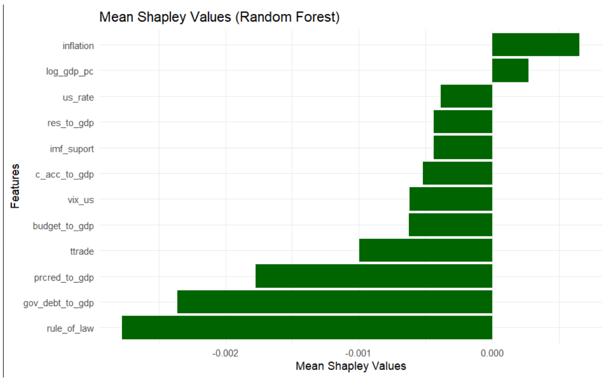
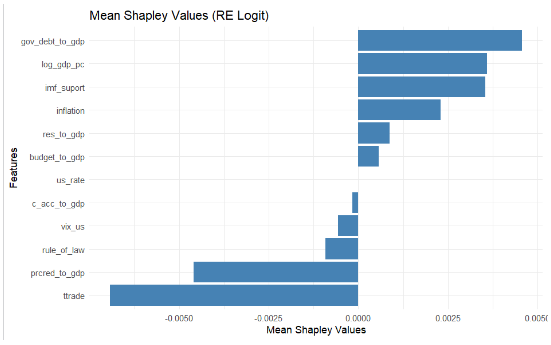
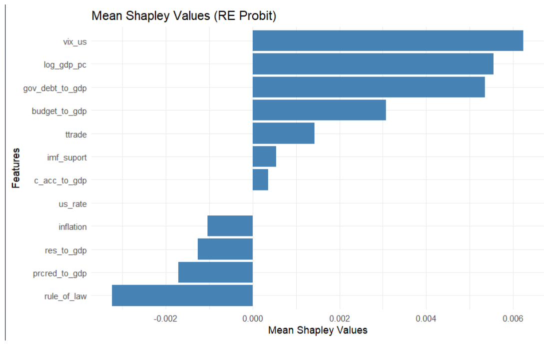


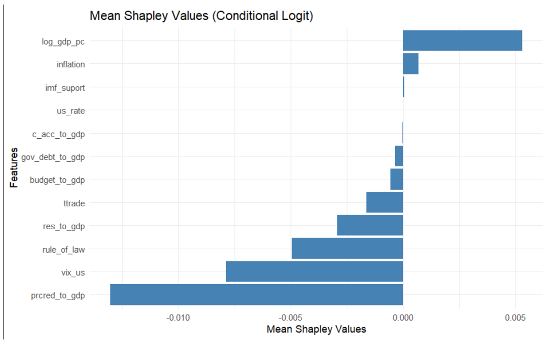
Figure 3.11 – Mean Shapley Value - Random Forest



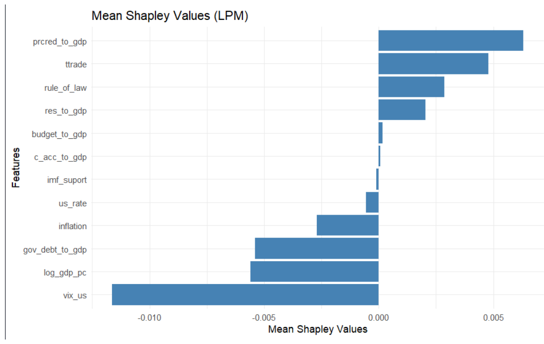
(a) RE Logit



(b) RE Probit



(c) Conditional Logit



(d) LPM

Figure 3.10 – Mean Shapley Values across Estimation Methods

In addition to parametric models, we preset Shapley values for the Random Forest classification model. Figure 3.11 reports the mean Shapley values obtained from the Random Forest model. As we see, `vix_us` and `prcred_to_gdp` emerge as important features in the model. This suggests that global risk aversion and access to domestic credit are key determinants of market access behavior.

Overall, these results demonstrate that both macroeconomic fundamentals and external conditions shape the likelihood of international debt issuance. Moreover, the consistency of key predictors across models reinforces the robustness of the estimated relationships.

3.5.4.1 US 10-year bond yield as a proxy for US interest rates

In our main regressions, we opted for using US growth instead of the US policy rate or 10-year bond yield in order to assess whether the 'investors' chase for yield' theory holds true (on the assumption that US growth and interest rates are positively correlated). The reason for this was two-fold: in the period under analysis (2009-2019) US reference rates have been at historically low levels, and US growth also reflects the benefits of investing in the US. It is important to note, however, that the US neutral rate of interest has been declining and this may affect the relationship between the neutral rate and US growth (although we would not expect it to change the direction of the relationship). Moreover, the link between short- and long-term rates has been non-monotonic over the years, with the yield curve even inverting periodically. Appendix B.4 shows that if we replace US growth by US 10-year yields, the latter is only significant for our first model with outstanding bond stock as the dependent variable, and exhibits a negative sign, indicating that higher US bond yields are associated with a lower bond stock in frontier economies. This is an intuitive result, consistent with the argument that higher interest rates in the US would reduce investors' incentive to chase higher yields in riskier frontier economies.

3.5.4.2 Different IMF concessional (PRGT) facilities

In our main regressions, only our third model with EMBI spreads as the dependent variable displayed statistically significant results for the IMF Support dummy variable, indicating an inverse relationship between IMF support and spreads. However, the IMF Support variable in our main regressions does not differentiate between different types of PRGT financing arrangements. This robustness check investigates whether we get different results if we replace the IMF financial support dummy by an Extended Credit Facility (ECF) dummy and a Standby Credit Facility (SCF) dummy. The ECF is a medium-to-long-term arrangement that caters to protracted and structural BoP problems in LICs, while the SCF is a facility for LICs with actual or potential short-term BoP problems (typically caused by a shock). For each arrangement, we build a dummy that is equal to 1 if a frontier economy has received ECF/SCF support in a given year and equal to zero otherwise. Appendix B.4 shows that both SCF and ECF financing are related to a lower probability of issuance, which is plausible since IMF financing would likely preclude the need to issue bonds. In addition, the SCF is related to a lower outstanding bond stock. And finally, in line with our main results, ECF support is associated with lower EMBI spreads.

3.5.4.3 Country fundamentals in times of global turmoil

Our results indicate that global market volatility is negatively correlated with frontier economies' market access, while sound macroeconomic fundamentals show a positive correlation with access. In order to check whether stronger country-specific macroeconomic fundamentals can improve the likelihood of issuance at times of global turmoil, i.e., whether investors still differentiate across countries based on fundamentals at such times, we add an interaction between the VIX index and the rule of law to our regression specifications. The results in Appendix B.4 show that this is not the case; i.e., good institutions matter less for market access amidst global financial turmoil. This implies that solid macroeconomic fundamentals do not necessarily help frontier economies to access international capital markets in times of global crises, as investors' risk appetite is typically very low and there is a flight to safety.

3.5.4.4 Commodity prices

Several countries in our sample are rich in natural resources, with commodities accounting for a significant share of their exports. Furthermore, when testing the predictive power of our probability models, we found that including the Bloomberg Commodities Index (BCOM) as an independent variable materially improved the percentage of correct predictions for the probability of issuance in 2014, a year when commodity-exporting economies were affected by a major negative reversal in commodity prices. A robustness check to investigate the impact of commodity prices on our results therefore seems warranted. Appendix B.4 shows that our main results are largely robust to inclusion of the BCOM Index (in level terms). The index shows a significant and inverse correlation with market access as measured by the PPG bond stock, but a positive correlation with the probability of issuance in our nonlinear model, suggesting that it impacts the former from the financing needs or supply side, and the latter from the demand side.

3.6 Conclusion

This paper investigates factors that may have contributed to the increased access to international capital markets enjoyed by a group of higher-income LICs that we call frontier economies over the past decade. Using data on external bond issuance and sovereign spreads, we find that both domestic macroeconomic fundamentals as well as external conditions have played a role in frontier economies' increased access to capital markets. However, results vary depending on the measure of market access used for our dependent variables, and the channel through which explanatory variables affect our dependent variables.

While some domestic fundamentals or 'pull factors', such as the level of reserves, operate more through their impact on frontier economies' external financing needs (the bond supply side), others, such as GDP per capita, GDP growth, the current account, and rule of law are primarily relevant through their impact on investors' demand for frontier economies' bonds. In particular, the outstanding external bond stock, a proxy for total volume of issuance over time, relates to both investors' demand for bonds and frontier economies' financing needs, while the probability of issuance and EMBI spreads—reflecting the timing and cost of issuance, respectively—respond more to investors' demand for bonds. The level of development of frontier economies' domestic financial markets, proxied through private credit-to-GDP, plays an interesting role in our analysis: on the one hand, this variable positively correlates to market access over time, reflecting countries' higher capacity to issue internationally and lower repayment risks; on the other, deeper domestic financial markets help preclude the need to issue externally at a given point in time on account of greater domestic financing options.

With respect to external factors, higher global market volatility, which typically coincides with lower global risk appetite, is associated with lower bond stocks and probability of issuance, and higher EMBI spreads, as would be expected. As for US interest rates, proxied through US growth, while we find only indirect evidence for a 'chase for yield' argument through a positive association with EMBI spreads in our main regressions, we find firmer evidence in our robustness analysis, when we replace US growth with US 10-year yields, suggesting that higher bond yields in advanced economies tend to reduce investors' interest in riskier frontier markets. Finally, the results of our robustness analysis suggest that the importance of domestic macroeconomic fundamentals in frontier economies recedes at times of global financial turmoil as investors' risk appetite falls and there is a flight to safety.

The results of our analysis provide valuable insights into frontier economies' increased market access and offer a useful framework for assessing their future access to international markets. To test this, we first evaluate the predictive power of our probability of issuance model by examining how accurately it would have predicted actual issuance over the past eleven years (2009-2019) for a subset of countries in our sample. We find that the Probit and pooled LPM models perform best, achieving an average *correct prediction* rate of approximately 77 percent during this period. Next, we conduct an out-of-sample prediction analysis, employing a standard horse-race approach to assess the best model for forecasting market access. Our findings show that the LPM performs the best across various accuracy metrics. These results offer valuable insights into the prospective analysis of market access for frontier economies. While a longer time frame and larger sample would be needed for a more definitive assessment, our model can serve as an additional tool for evaluating frontier economies' future market access, which is an important consideration in frameworks such as the IMF's concessional lending operations. This analysis also contributes to the broader literature on sovereign market access.

This paper makes several key contributions to the literature on frontier economies' access to international capital markets. First, it extends existing research by focusing specifically on frontier economies—low-income countries (LICs) that have gained access to international debt markets in recent years—rather than conventional emerging markets. This focus allows for a deeper understanding of the drivers behind their market access, including both domestic macroeconomic fundamentals and external factors such as global market volatility and US economic conditions. Second, by examining three different proxies for market access—outstanding bond stock, probability of issuance, and EMBI spreads—the paper provides a comprehensive analysis of the various dimensions of market access, highlighting how different variables influence market access at different points in time. Third, it contributes to the development of forecasting models for market access, using both in-sample and out-of-sample prediction exercises to assess the effectiveness of a probability of issuance model. This analysis not only demonstrates the predictive power of the model but also provides valuable insights into prospective market access for frontier economies. Finally, the paper adds to the literature by exploring the role of IMF financial support and the impact of global financial conditions on frontier economies' market access, offering new perspectives on how external factors shape the sovereign debt dynamics of these countries.

Looking ahead, future research should extend the analysis by incorporating more recent data, including the impact of the COVID-19 pandemic on frontier economies' market access. Additionally, exploring causality in our analysis would be a valuable next step. Machine learning techniques, such as the causal forest algorithm proposed by Athey and Imbens (2015) and Davis and Heller (2017), could help establish causal relationships rather than mere correlations among the variables. Finally, while access to international markets provides significant benefits for frontier economies, it also entails risks—such as exchange rate risks—that must be carefully managed. The vulnerabilities exposed by the COVID-19 pandemic underscore the importance of managing these risks to ensure debt sustainability in frontier economies and emerging markets.

4 Government Debt and Denomination: A Tale of Default, Inflation

Abstract

As explored by recent literature, a sovereign country may hold mixed debt portfolios. Data shows that debt denomination plays a central role in this subject, with most of emerging markets portfolio composed by a dominant share of nominal and local currency debt. With this motivation, this paper has the task to study the dynamics of debt denomination in sovereign default models, by exploring the trade-off between inflation and sovereign default when assuming that sovereign bonds are partially denominated in nominal terms. Using a complete panel database of sovereign default for emerging markets, we first characterize some main trends in debt denomination and inflation between our group of countries. Then, we propose a quantitative model on sovereign default that explores mixed portfolios. We find that, when a country issues only external and nominal (local currency) debt bonds, there are incentives to inflate the economy in order to free up resources for consumption. Moreover, after simulating our economy for a certain number of periods, the majority of variable moments matches with empirical data: Default is counter-cyclical, as the real exchange rate and inflation, while debt issuance shows positive correlation with output.

Keywords: Sovereign Default; Sovereign Holdings; Debt Denomination; Inflation; International Finance.

4.1 Introduction

Emerging markets can hold debt portfolios in various forms, and the denomination of debt has been a topic of extensive debate in economics for many years. For instance, Eichengreen and Hausmann (1999) introduced the concept of "original sin", arguing that emerging markets often lack the ability to borrow in their local currency, resulting in dependence on foreign financial conditions. When a country's currency is vulnerable, governments may face significant challenges in servicing their debt. Despite progress in addressing the limitations of original sin, discussions on debt denomination remain relevant, particularly in relation to its interactions with economic variables in the literature on sovereign debt.

Recent data highlight that emerging economies are increasingly diversifying their debt portfolios, including a growing emphasis on domestic and nominal debt. According to the Bank for International Settlements (BIS), as presented byBogdanova et al. (2021), the amount of local currency debt has been rising alongside an expansion in domestic investors' holdings of government debt. This shift suggests that sovereign debt frameworks are evolving, enabling borrowers to rely more on local currency-denominated debt.

However, questions remain about why countries choose to borrow in different forms, rather than relying solely on commonly external or price-indexed debt in this literature. One potential explanation lies in the flexibility nominal debt provides. When borrowers can issue bonds in nominal terms, inflation becomes a potential policy tool. In such cases, governments may prioritize inflation over default, especially when they have access to monetary policy as a means to mitigate debt burdens. This raises the question: what is the optimal government response when faced with a trade-off between inflation and default? This paper aims to further explore the mechanisms driving this decision.

To address these questions, we begin with an empirical analysis using a comprehensive panel database on debt denomination in emerging markets. Our analysis reveals a main key trend that merging markets have increased the average external share of nominal debt holdings over the last decade.

Building on this empirical motivation, we propose a quantitative model that incorporates sovereign debt and inflation, focusing on the role of mixed government debt portfolios. Our findings suggest that when countries have the option to issue nominal (local-currency) debt instead of real (foreign-currency) debt, there are incentives to inflate the economy to free up resources for consumption. This policy choice serves as an alternative to sovereign default: In times of debt distress, governments may resort to costly inflation — impacting domestic stakeholders — to avoid rising default risks and increased borrowing costs.

This study contributes to the growing literature on sovereign debt by emphasizing the critical role of debt denomination in the trade-off between default and inflation: Our results show that when there is a possibility to incur with inflation, the country presents a lower probability of default. This issue is particularly salient during periods of increased government debt. For example, the COVID-19 crisis led to a substantial increase in government debt issuance, renewing interest in debt management strategies. As highlighted in the International Monetary Fund (IMF) report by Breuer, Cohen and Thor (2020), debt managers have considered various actions to adapt to the unprecedented challenges posed by the pandemic. Examining both sovereign bonds and the options for managing debt burdens is essential for understanding fiscal limits in emerging economies. As nominal debt continues to play a significant role in sovereign portfolios, studying its impact on default decisions is key to understanding the dynamics of bond markets in emerging economies.

This introduction corresponds to Section 4.1. Section 4.2 presents the theoretical literature related to our topic. Section 4.3 describes the data used in this study and characterizes emerging markets' debt portfolios, providing motivation for our approach. Section 4.4 develops a theoretical quantitative model of sovereign default that explores the role of debt denomination in the trade-off between inflation and default. Section 4.5 details the model calibration process and parameter selection. Section 4.6 discusses the main findings, including key policy functions and model simulations aligned with empirical observations. Finally, Section 4.7 concludes the study.

4.2 Literature Review

The concept of sovereign default was first modeled by Eaton and Gersovitz (1981), who introduced a framework addressing default dynamics, incorporating both government and corporate sectors. Their model established the basis for understanding default risk and its economic implications. We take profit from the basic structure presented by them in order to characterize the basic dynamics of equilibrium of sovereign default models. Subsequent advances include the contributions of Aguiar and Gopinath (2006) and Arellano (2008), who developed models that incorporated default risk in small open economies with incomplete markets and lack of commitment. Together, their work established a standard quantitative framework for analyzing default risk and debt sustainability. Although these studies focus exclusively on real debt issuance, we extend their framework to include local-currency-denominated debt, exploring how this addition reshapes the default trade-off and equilibria.

Reinhart and Rogoff (2011a) and Reinhart and Rogoff (2011b) emphasized the importance of domestic debt in default risk, using a historical database to show how local debt influences repayment probabilities. While our analysis does not explicitly examine debt ownership, it builds on their findings by exploring the role of debt structure in the trade-off between inflation and default. Similarly, Broner et al. (2014) highlighted the role of domestic creditors during times of sovereign distress. Their model demonstrated that domestic creditors often expect higher returns on sovereign debt during turbulent periods, a finding that underscores the importance of considering creditor preferences in default risk analysis. Our paper incorporates these insights to better understand how the debt structure influences sovereign decisions.

The contractionary effects of default were explored by Mallucci (2015), who presented a general equilibrium model with both external and domestic debt. Their work emphasized the spillover effects of default on domestic investors, a theme we extended by analyzing how debt denomination interacts with default mechanisms and inflation dynamics. Further developments in the literature include Erce and Mallucci (2018) and Paczos and Shakhnov (2019), who investigated the implications of different default strategies and their economic consequences. The former examined how domestic versus external defaults affect various sectors, while the latter showed how domestic debt can smooth tax wedges and foreign debt can stabilize output shocks. Both studies used DSGE models with endogenous default risk, building on the theoretical foundation provided by Mendoza and Yue (2012).[1] Our paper incorporates these insights to study how debt composition shapes sovereign policy choices.

On the subject of debt denomination, Sunder-Plassmann (2020) challenged conventional assumptions by showing that higher nominal debt does not necessarily lead to increased inflation. This finding is particularly relevant for our analysis, as we investigate the interplay between debt denomination, inflation, and default risk. Other studies, including Engel and Park (2018), Ottonello and Perez (2019), and Sabbadini et al. (2018), examined the pricing of sovereign bonds in nominal terms, revealing the presence of an inflation component in bond valuations. These findings inform our exploration of how debt denomination influences inflation and default dynamics. We extend their work by introducing the comparison of inflation costs in order to assess how it could influence the probability of default.

Du, Pflueger and Schreger (2020) further examined the relationship between inflation and default, highlighting the emergence of counter-cyclical inflation when risk-averse lenders hold nominal debt. This interaction is central to our study, as it sheds light on the trade-offs faced by sovereign borrowers. The relationship between inflation and debt crises has also been explored by Gumus (2013), who introduced nominal debt in a two-sector model with outright default. They found that higher nominal debt reduces the counter-cyclicality of interest rates. Similarly, Röttger et al. (2015) and Na et al. (2018) extended this framework to include exchange rate policies, showing that defaults are often accompanied by significant currency devaluations. These mechanisms are also relevant to the analysis presented in this paper.

Finally, Arellano, Bai and Mihalache (2020) investigated the interaction between

[1] DSGE: Dynamic Stochastic General Equilibrium

monetary policy and external defaultable debt, showing how default risk amplifies monetary frictions. Their findings provide valuable insights into the relationship between monetary policy, debt sustainability, and default risk, which we incorporate into our analysis of inflation volatility and policy choices.

In summary, this review highlights key contributions to the understanding of sovereign default, debt denomination, inflation dynamics, and their interplay with monetary policy. By building on these works, our study extends the literature by examining how debt denomination shapes the trade-offs between inflation and default, offering new insights into sovereign borrowing decisions and economic outcomes. We are able to show how costly inflation differentiates the dynamics and incentives of default depending on whether the government relies on nominal local-currency or real foreign-currency debt.

4.3 Empirical Analysis

Our empirical motivation is divided in two. First, Section 4.3.1 presents our panel that brings data on debt structure, denomination, together with macro fundamentals, either from domestic and external variables. Second, in Section 4.3.2, we present key trends that motivate our study from these data, focusing our analysis on debt denomination in emerging economies.

4.3.1 Data

In order to show some trends on debt denomination, we first provide a visual analysis of emerging economies with respect to debt portfolio allocation. We extend the data from Silva et al. (2021), that contains panel data information on both domestic and external variables and also data for debt of 45 countries from 2004 to 2019. 22 of these countries are defined in this paper as *Emerging Markets (EM)*, while the remaining are defined as *Advanced Markets (AM)*.[2] The database was partially constructed using Arslanalp and Tsuda (2014a) and Arslanalp and Tsuda (2014b) work on debt demand.

[2] The criteria considered to define AM and EM was taken from Arslanalp and Tsuda (2014b) and (ARSLANALP; TSUDA, 2014a). The list of countries are described by Table C.1 in Appendix C.1.1.

The panel contains information on countries' creditors holdings on sovereign debt, divided by local and foreign currency, along with information on bond structure and indebtedness.

With respect to the debt structure characterization, we will use in this empirical motivation the approach proposed by Sunder-Plassmann (2020). As we are going to detail in Section 4.3.2, it assumed that a fraction δ of debt is held by domestic residents, while a share of $1-\delta$ of debt issuance is bought by external investors. Moreover, a fraction $1-\alpha$ and $1-\kappa$ of domestic and external bonds, respectively, are denominated nominal terms. In this paper, we consider nominal and local currency as synonyms, following the standard literature. That is, if $\alpha = 1$, debt bonds are total indexed to domestic prices, where a claim of b units of money repays exactly b units of consumption in the next period. The calculation methodology of δ, α and κ is detailed in Appendix C.1.2.

Finally, we also collected data on domestic fundamentals from the IMF's World Economic Outlook (WEO) and IMF's International Financial Statistics (IFS).[3]

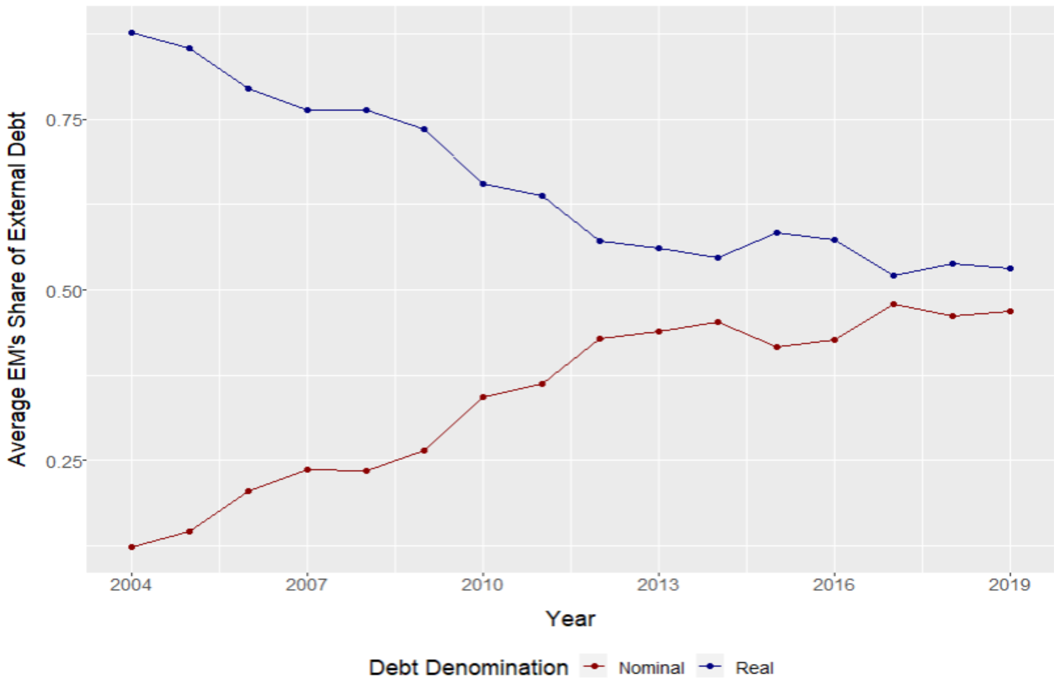
4.3.2 Trends on Debt Denomination in Emerging Economies

Using the data and bond structure outlined above, we examine the main variables from our country panel, focusing on debt denomination. The main empirical observation that motivates this study is the increasing average share of nominal external debt among emerging markets. Figure 4.1 illustrates the evolution of nominal external debt shares for emerging markets in our database. It reveals that the wedge between nominal and real debt denomination is narrowing. Since 2004, emerging economies have allocated an increasing proportion of their external debt portfolios to local currency-denominated debt, which represented nearly half of their external debt by 2019.[4]

These trends indicate that debt denomination plays a crucial role in sovereign debt structure, correlating with domestic fundamentals such as inflation and indebtedness. In the next section, we develop a quantitative model to analyze these dynamics more rigorously and explore the trade-off between indebtedness and inflation. Our approach

[3] Data collected in April 2021.
[4] See Appendix C.1.2 for detailed methodology on debt denomination calculations.

Figure 4.1 – External Debt Denomination for Emerging Markets



builds on standard sovereign default models while introducing two key policy options for governments: outright default or inflationary erosion of debt.

4.4 Model

In order to characterize and quantify the trade-off between inflation and default, we develop a quantitative model to better understand how the government optimally choose between repay their obligations or inflate the economy. The model has as benchmark the framework developed by Eaton and Gersovitz (1981), Aguiar and Gopinath (2006) and Arellano (2008), along with the contributions from Ottonello and Perez (2019) and Sabbadini et al. (2018), in which is proposed a small open economy with debt issuance accounting for the possibility of nominal debt.

We model a small open economy with government bonds as the main fiscal instrument and no commitment to repay. Since we do not account for debt ownership in this paper, we assume here that only external investors are able to purchase government debt. We then write two versions of the model in order to explore the role of nominal debt in our framework. Firstly, we characterize the *Foreign Currency Economy (FC Economy)*, which corresponds to the traditional real bond default model, as defined in Arellano (2008), when real bonds are inflation-linked and denominated in foreign currency. Secondly, in order to include inflation in our set-up, we build a version of the model when government bonds are assumed to be nominal, that is, the sovereign can only issue external government bonds that are local currency denominated. We call this set-up as the *Local Currency Economy (LC Economy)*. With respect to bond pricing, in both economies, external creditors are assumed to take as given bond prices established by risk-neutral bond pricing. In our model, the small open economy is subject to a stochastic endowment of tradable goods and an *ex-ante* amount of non-tradable goods every period. There is a lack of commitment, thus, in every period, the government chooses whether to repay or default on its obligations for each of the environments. Output costs from default are standard: A temporary exclusion from the government borrowing capital market and an output cost. In the *LC Economy*, there is a trade-off between default and inflation: In each period, the benevolent government decides its debt standings and the amount of the inflation rate, which is costly for the households. This does not happen for the *FC Economy*, since governments bonds are assumed to be real. Finally, it is assumed that there is no possibility of partial default for the both versions of our model.

In the next subsections, we describe the debt structure that this economy faces off, the decision problems from the agents, and the optimal policy that characterizes the quantitative model proposed in this paper.

4.4.1 Debt structure

While in the *FC Economy* the government debt b^* is assumed to be real (inflation-linked debt), in the *LC Economy*, debt denomination is explored as the following: Local currency debt issued by the government is assumed to be nominal. That is, an amount of sovereign bonds b purchased by an arbitrary agent represents a claim of b local currency units tomorrow. This claim is worth $\frac{b}{P_t}$ units of consumption today, but only $\frac{b}{P_{t+1}}$ when repaid tomorrow, where P_t and P_{t+1} are the aggregate domestic price levels in the two subsequent periods. Thus, when inflation, represented as $\pi_{t+1} = \frac{P_{t+1}}{P_t}$, is positive, the real value of this nominal debt will be eroded. The goal is to understand how the trade-off between inflation and indebtedness behaves, along with the main statistical moments of the economy.

4.4.2 Decision problems

4.4.2.1 Households

For both versions of our model, the economy has a representative agent that maximizes the discounted expected lifetime utility from aggregate consumption C_t and inflation π_t:

$$U = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \Big(\frac{C_t^{1-\sigma}}{1-\sigma} - l(\pi_t) \Big) \tag{4.1}$$

Where $l : \mathbb{R}_+ \to \mathbb{R}$ denotes a differentiable, convex inflation disutility function that captures distortionary costs from the inflation rate:

$$l(\pi_t) = \frac{\gamma}{2} \pi_t^2 \tag{4.2}$$

Aggregate consumption is composed by tradable and non-tradable goods such that

$$C_t(c_{T,t}, c_{N,t}) = c_{T,t}^{\omega} c_{N,t}^{1-\omega} \tag{4.3}$$

The government issues only external debt, which is purchased by external creditors. Households are assumed to be hand-to-mouth. The economy has an endowment of tradable goods $y_{T,t}$ and non-tradable goods $y_{N,t}$.

The aggregate price level P_t is the solution of the following minimization problem, as proposed by Ottonello and Perez (2019):

$$P_t \equiv \min_{c_{T,t}, c_{N,t}} p_{T,t} c_{T,t} + p_{N,t} c_{N,t} \ \text{ s.t. } C_t(p_{T,t}, p_{N,t}) = 1 \tag{4.4}$$

Thus, we define the *household problem* as the decision to choose state-contingent plans $\{C_t, c_{T,t}, c_{N,t}\}_{t=0}^{\infty}$ that maximize (4.1), subject to the inflation loss function (4.2), the aggregate consumption plan (4.3) and the aggregate price level problem (4.4), given the sequence of prices $\{p_{T,t}, p_{N,t}\}_{t=0}^{\infty}$, and the set of endowments $\{y_{T,t}, y_{N,t}\}_{t=0}^{\infty}$.

4.4.2.2 Government

The benevolent government maximizes households' utility by choosing the level of inflation and issuing sovereign bonds. It finances exogenous expenditures g by collecting bond revenues from external borrowing $B_{t+1} = \{b^*_{t+1}, b_{t+1}\}$, where b^*_{t+1} and b_{t+1} correspond to the case of the *FC Economy* or *LC Economy*, respectively, constrained to the government budget constraint:

$$g = Q_t B_{t+1} - B_t \tag{4.5}$$

Where $Q_t = \{q^*_t, q_t\}$ is the set of bond prices for each version of our model: q^*_t the bond price in the *FC Economy* and q_t the bond price in the *LC Economy*.

4.4.2.3 External investors

External debt is assumed to be bought by risk-neutral international investors in a competitive market in both set-ups of our model. They are assumed to be risk-neutral and to have access to a risk-free with return r^*. They are subject to the default decision in $t+1$ from the government d_{t+1}, which is equal to 1 in case of a bad credit standing and equals 0 if the government decides to repay its debt. The standard *FC Economy* bond pricing follows the trade-off between a risky real debt and the risk-free bond subject to a probability of default, given by:

$$q_t^*(y_T, b_{t+1}^*) = \mathbb{E}_t\left[\frac{1-d_{t+1}}{1+r^*}\right] \tag{4.6}$$

In the *LC Economy*, since we assume that all external bond is issued in local currency terms, the bond pricing relation depends on the depreciation of the nominal exchange (e_t) rate, because foreign investors are interested in the return measured in foreign currency.[5] Similar to the *FC* case, they price the bond's payoff in order to maximize expected profits, which a price q_t given by

$$q_t(y_T, b_t, b_{t+1}) = \mathbb{E}_t\left[\frac{1-d_{t+1}}{1+r^*}\frac{e_t}{e_{t+1}}\right] \tag{4.7}$$

4.4.3 Market clearing

Only the endowment of tradable goods $y_{T,t}$ is subject to a stochastic process. It follows an auto-regressive dynamics such that

$$\ln y_{T,t} = \rho \ln y_{T,t} + \epsilon_t,\ \ \epsilon_t \sim N(0, \sigma_\epsilon^2) \tag{4.8}$$

In the case of non-tradables, we follow Ottonello and Perez (2019) and assume that, in equilibrium, the market of non-tradables clear:

5 We define the rate of depreciation between the current period t and the next period $t+1$ as $\frac{e_t}{e_{t+1}}$.

$$c_{N,t} = y_{N,t} = 1 \tag{4.9}$$

Given that the law of one price holds in this economy, is assumed that first, the international price level is normalized to one, that is, $p^* = 1$. Therefore, the price of tradable goods can be written as a function of the nominal exchange rate e_t:

$$p_{T,t} = p^* e_t = e_t \tag{4.10}$$

Once established this last equilibrium, we can re-write the aggregate price level problem in (4.4) as

$$P_t \equiv \min_{c_{T,t}, c_{N,t}} e_t c_{T,t} + p_{N,t} c_{N,t} \text{ s.t. } C_t(p_{T,t}, p_{N,t}) = 1 \tag{4.11}$$

Which gives the following solution for aggregate price:

$$P_t = e_t \frac{1}{\omega} \left(\frac{c_{T,t}}{c_{N,t}} \right)^{1-\omega} \tag{4.12}$$

In its turn, the inflation rate in the current period can be written as

$$\pi_t = \frac{P_t}{P_{t-1}} \tag{4.13}$$

Thus, given market clearing conditions (4.8) - (4.13) and the government budget constraint (4.5), we can write both resources constraints as the following: For the *FC Economy*, it is simply canonical resource constraint from sovereign default models. While for the *LC Economy* resource constraint it can be written as a function of the stream of stochastic tradable endowment $y_{T,t}$ aggregate price level P_t and the ratio of consumptions $\frac{c_{T,t}}{c_{N,t}}$ as the following:[6]

$$c_{T,t} = y_{T,t} + q_t^* b_{t+1}^* - b_t^* \tag{4.14}$$

$$c_{T,t} = y_{T,t} + \frac{1}{P_t}\frac{1}{\omega}\left(\frac{c_{T,t}}{c_{N,t}}\right)^{1-\omega}(q_t b_{t+1} - b_t) \tag{4.15}$$

4.4.4 Equilibrium

Finally, once the market clears, we can now define the competitive equilibrium in the small open economy:

Definition 1 (Competitive Equilibrium)**.** *Given initial debt position* $B_0 = \{b_0^*, b_0\}$ *for each of the versions of our model, an initial aggregate price level* P_0*, a state-contingent sequence of endowments* $\{y_{T,t}, y_{N,t}\}_{t=0}^{\infty}$*, and government inflation policy* $\{\pi_t\}$*, a competitive equilibrium is a state-contingent sequence of allocations* $\{c_{T,t}, c_{N,t}\}_{t=0}^{\infty}$ *and prices* $\{Q_t, e_t, P_t\}_{t=0}^{\infty}$*, where* $Q_t = \{q_t^*, q_t\}$ *such that*

1. *Government choices solve household's problem given equilibrium prices;*

[6] Note that our resource constraint relies on a dimensionality problem. In order to deal with this, we work with a detrended economy by reducing the dimension through recursive form. More details in Appendix C.2.1.

2. *Government budget constraint is satisfied;*

3. *Government bonds are priced as (4.6) and (4.7) for each of FC and LC economies;*

4. *The market of non-tradable goods clears following (4.9).*

4.4.5 Optimal policy problem

The government is assumed to be benevolent, but lacks commitment to its policies. That is why there are incentives to borrow once new debt issuance is non-distortionary. Therefore, in the case of *LC Economy*, this lack of commitment brings incentives to erode the real value of outstanding debt through inflation or default. In each period the sovereign must decide the credit standing d_{t+1} for the total debt decision and inflation π_t, assuming that monetary policy is credible and there is no partial default.

4.4.5.1 Sovereign default

In the case the country defaults on its obligations, following the standard literature, it faces a negative productivity shock in the stochastic tradable endowment and is temporarily excluded from borrowing capital markets. The output cost comes from Arellano (2008): Defaults are associated with disruptions to the real side of the economy, while the exclusion punishment after a default comes from the historical in data that, after a debt burden and a subsequent default, no debt issuance is observed following debt crises. Therefore, tradable consumption and output after a sovereign default is given by

$$c_{T,t} = y_{T,t}^{def} = (1 - \psi)y_{T,t} \tag{4.16}$$

With $\psi \in (0, 1) \in \mathbb{R}$ being the default cost parameter. In its turn, each period after a default, there is a probability of $\theta \in (0, 1)$ that the economy will regain access to international credit markets.

4.4.5.2 Recursive equilibrium

We finally can define the set of aggregate states in our economy as $s = \{y_T, b^*\}$ or $s = \{y_T, b, P_{-1}\}$, for each of set-ups, and write the government problem in a recursive form. If the sovereign is in good credit standing, it has the choice of whether to remain current or default by solving:

$$V(s) = \max_{d \in \{0,1\}} (1-d)V^R(s) + dV^D(y_T) \tag{4.17}$$

Where $V^R(s)$ is the value of repaying, when the government chooses allocations $\{B'(s), c_T(s), \pi(s)\}$ subject to (4.15) that solves

$$V^R(s) = \max_{B', c_T, \pi} \Big\{ u\Big(C(c_T, y_N)\Big) - l(\pi) \Big\} + \beta \mathbb{E}_{y_T} \Big[V(s') \Big] \tag{4.18}$$

In case of default, the value of being in autarky is given by

$$V^D(y_T) = u\Big(C(y_T^{def}, y_N) - l(\pi)\Big) + \beta \mathbb{E}_{y_T} \Big[\theta V^R(y_T, 0) + (1-\theta) V^D(y_T') \Big] \tag{4.19}$$

It is assumed that the government re-enters with zero debt to borrowing markets and that the optimal inflation rate for the case of *FC Economy* and for the *LC Economy* while in autarky is zero. This last assumption goes in line with the mechanism we are looking for: In a economy denominated in local currency debt, once defaulted, the government has no incentives to incur in costly inflation, since there is no nominal debt to dilute. This illustrates the trade-off we intend to explore: In times of debt burden, the government may choose between costly inflation or costly default. Finally, we can define the Markov Perfect Equilibrium in our economy:

Definition 2 (Markov Perfect Equilibrium)**.** *A Markov perfect equilibrium of the economy, given the aggregate states for each of denominations* $s = \{y_T, b^*\}$ *or* $s = \{y_T, b, P_{-1}\}$*, are a set of policy functions* $\{d(s), c_T(s), B'(s), \pi(s)\}$*, value functions* $\{V(s), V^R(s), V^D(s)\}$ *and bond price* $\{Q(s)\}$ *such that*

1. *Policies* $\{c_T(s), B'(s), \pi(s)\}$ *solve the planner's problem represented by (4.17).*
2. *The bond price* $Q(s)$ *coincides with (4.6) and (4.7) for each of FC and LC economies.*

4.5 Calibration

After defining the model highlights, we can now calibrate our small open economy with Brazilian data in order to simulate the transition dynamics and verify if our mechanism reflects the observed in the data. We choose Brazil for two reasons: First, it is an economy with a significant share of local-currency government debt in its portfolio. As shown in Section 4.3.2, during our covered period, Brazil, being a large emerging market, has been dominated by most of the nominal debt holdings. And second, even not showing from 2004 to 2019 any default event, Brazil is an important emerging economy who adopts an inflation target regime. Therefore, the option to inflate the economy is possible when assuming a credible monetary policy.

To solve the model numerically, we follow the standard literature and assume functional form for the exogenous process and assign parameter values. Table 4.1 presents the numerical values assigned to all the model parameters. With respect to the preferences values, we follow Arellano (2008) with the canonical coefficient of risk aversion σ. For the tradable share of good ω and the inflation cost γ, we use the values estimated by Ottonello and Perez (2019). The default cost ψ and the stochastic discount factor β come from the annual frequency estimated by Sabbadini et al. (2018), which also replicates Brazilian moments and is close to what is observed in emerging economies. With respect to the rest of the values, except for the non-tradable endowment y_N, which is normalized by one, we use data from our panel described in Section 4.3.1. For the international risk free rate r^*, we take the average US nominal interest rate between 2004 and 2019, the time covered by our data. The re-entry probability is taken from Gelos, Sahay and Sandleris (2011). Such value is standard in the literature as it simplifies the default exclusion duration to 2 years. And finally, with respect to the exogenous process for tradable output, we do an estimation using the cyclical component of the Brazilian GDP between 2004 and 2019.[7]

Table 4.1 – Calibration parameters

Parameter		Value	Description / Target
Preferences			
Risk aversion	σ	2.00	(ARELLANO, 2008)
Tradable share in utility	ω	0.59	(OTTONELLO; PEREZ, 2019)
Discount factor	β	0.77	(SABBADINI et al., 2018)
Inflation cost	γ	1.30	(OTTONELLO; PEREZ, 2019)
Endowments and Interest Rate			
Risk free interest rate	r^*	1.45%	Average US nominal interest rate (2004-2019)
Non-tradable endowment	y_N	1.00	Normalization
Tradable output persistence	ρ	0.71	Estimation, Brazilian data (2004-2019)
Tradable output volatility	σ_ϵ	0.025	Estimation, Brazilian data (2004-2019)
Re-entry probability	θ	0.50	(GELOS; SAHAY; SANDLERIS, 2011)
Default tradable output cost	ψ	0.89	(SABBADINI et al., 2018)

4.6 Results

4.6.1 Policy Functions

We solve the model by value function iteration.[8] We first interpret the policy functions for the credit standings, debt issuance, real exchange rate and inflation for both *FC* and *LC* economies, which are summarized in Figures 4.2 and 4.3.

The horizontal axis in each panel represent the current debt level. As common in the literature, we observe three distinct realizations of the endowment: A low, median and high output case. The transition paths provide interesting information. First, in both versions of debt denomination, as indicated in Panel A, our economies are able to hold a higher amount of debt before not paying its obligations as higher the output. That is, default is more likely in turbulent times: The threshold for current debt when there is a low

[7] The cyclical component was obtained from the HP filtered Brazilian GDP in our covered period. Also, we use quarterly data for the calibration.
[8] The algorithm for solving the model is described in Appendix C.2.2.

Figure 4.2 – Policy Functions for *FC Economy*

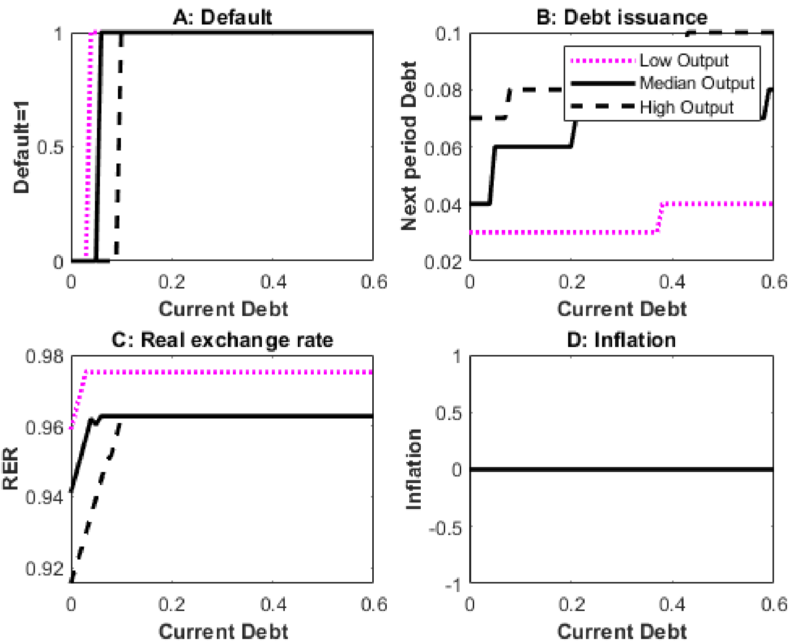
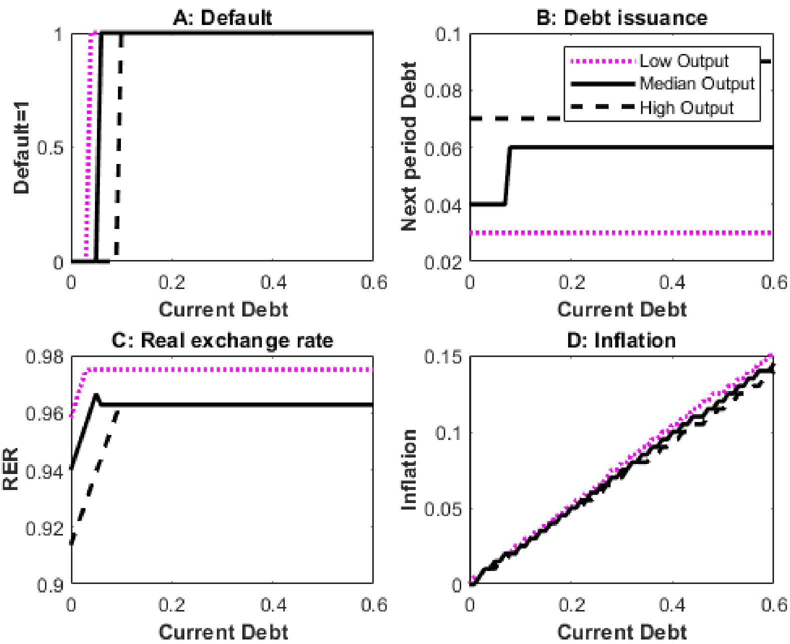


Figure 4.3 – Policy Functions for *LC Economy*



output endowment is lower than the case of median and high endowment shocks. Second, this rationale holds for new debt issuances, as shown in Panel B: While in realizations with lower output the endowment of next period debt is constant, high output economies issue larger amounts of bonds as the current debt increases. However, our simulation for the *LC Economy* shows a lower tolerance for debt issuance in lower output realizations. It seems that when debt is assumed to be denominated in local-currency terms, the capacity of new issuances is more sensible to the activity endowment. Moreover, debt accumulation is higher for the case of *FC Economy* in comparison to the *LC* Economy.

Panel C in both *FC* and *LC* economies show the simulated path for the real exchange rate (RER) for different levels of outstanding debt. It suggests that there is a positive correlation between the RER and the current debt until the level of default, independently to the debt nomination. This result goes in line with Ottonello and Perez (2019), which argues that exchange rates are affected by debt choice, suggesting that RER in emerging economies are counter-cyclical, with exchange rates widening as the current debt increases.

Finally, Panel D plots the inflation choice if the sovereign honors its obligations.[9] Here is where the main difference between our *FC* and *LC* economies appears: When debt is defined in real terms, there is no inflation in our economy, since bonds are denominated in foreign currency. But, in the case of our *LC* set-up, inflation appears to be positively related with the amount of debt. It explores the main mechanism we want to asses: The inflation option. The increasing path of prices as the current debt increases suggests that there is more incentive to inflate when debt is high. Additionally, for higher levels of current debt, inflation is higher when we are at a low-output endowment shock. One understanding for this behavior is that inflation can act as a counter-cyclical mechanism to free up resources for consumption only from a certain threshold of outstanding debt, and slightly acyclical before that point.

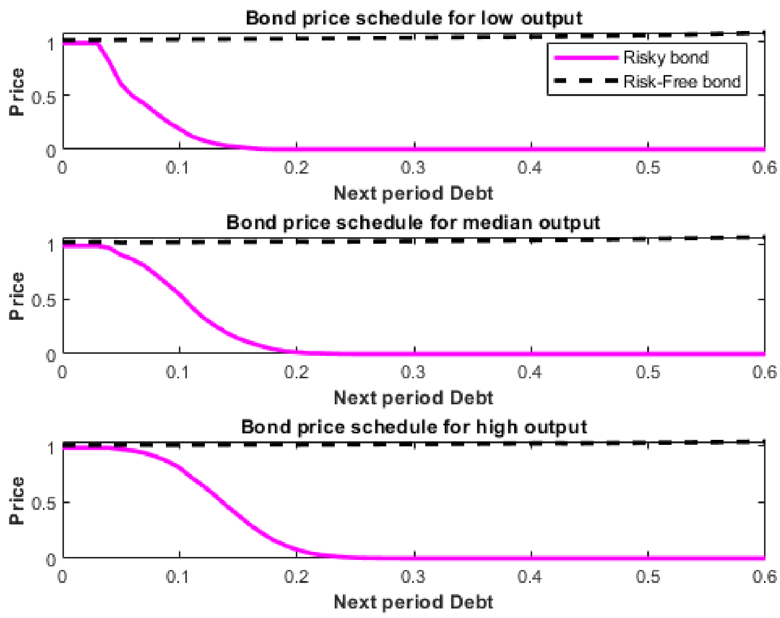
4.6.2 Bond Price Schedule

With respect to the bond price schedule, Figures 4.4 and 4.5 plot the bond price for each realization of output endowment in our baseline calibration for each of *FC* and *LC* economies. In all panels, the horizontal axis represents the next period debt issuance, while the vertical axis the bond price itself. Solid lines represent the risky government bond,

9 As we have assumed previously, the optimal response to inflation in case of a sovereign default is zero. However, in order to understand the dynamics of prices, we plot the amount of inflation choice in the case the government assume its obligations.

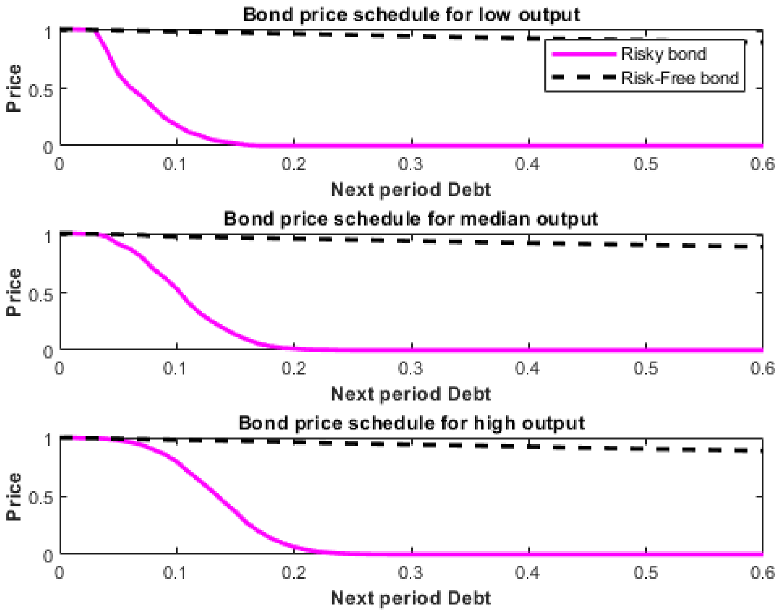
which depends on both default risk and nominal exchange devaluation, and dashed lines the ones representing the risk-free bond. The risky bond price declines when bond issuance in the next period increases once the probability of default also rise and the nominal exchange rate devaluation increases. Moreover, one can notice that in times of turmoil, the decreasing path of risky bond price is convex, while for high output realizations, it shows a concave shape as the default risk increases. One interpretation for this goes in line with the counter-cyclical default risk. With low realizations of output, not only is default more likely, but the market access reflected in bond prices also collapses faster when compared to the high output scenario.

Figure 4.4 – Bond Price Schedule for *FC Economy*



Therefore, it seems that the mechanism we are looking for holds as the following: Our model has shown counter-cyclical default, real exchange rate and inflation, and pro-cyclical debt issuance. This result goes in line with the stylized fact presented in Section 4.3.2, that states a positive correlation between the mean inflation in our covered period and the average nominal share of external debt holdings. We also find that our model dynamics show that debt accumulation is more easily achieved for the case of the *FC Economy*, while for the *LC Economy*, inflation appears to be a good option in the lack of debt issuance capacity. Moreover, it seems that if the government can only borrow from

Figure 4.5 – Bond Price Schedule for *LC Economy*



external investors, inflation could be indeed a mechanism to get over default: By inflating the economy, the sovereign can free up resources for consumption instead of deciding to default in its obligations. And finally, the risky bond price schedule, which depends on both the default risk and nominal exchange rate depreciation, shows distinct behaviors depending on the output realization.

4.6.3 Simulation

It is interesting to look closer the relation between inflation and default: What is the role of inflation cost in this dynamics? What is the optimal level of debt that makes the sovereign to choose higher level of inflation instead of a default? In this subsection, we simulate our economy for 100,000 periods and compare our baseline calibration with different values for the inflation cost and the observed in our panel data. Table 4.2 reports the average simulated variables for our benchmark models of *FC* and *LC* economies, together with the correlation with output and volatilities.

The first thing to notice is that our baseline model matches the majority of moments observed in our data for Brazil.[10] With respect to the average levels in our economy,

[10] Again, our benchmark data comes from our panel defined in Section 4.3.1.

the first thing to notice is that our model predicts a positive default frequency for both bond denominations, while Brazil has not shown any debt crisis from 2004 to 2019. However, our simulation predicts closely the average default risk premium, which is given in our data by the average *J.P. Morgan's Emerging Market Bond Global Index (EMBIG)* during the covered period. The *EMBIG*, being a real-time gauge for a country sovereign spread, can be a proxy that represents the probability of default: With widening levels directly correlated with higher default risk and narrowing indexes associated with a lower probability of default. This variable is different from what we call nominal spreads, defined in this paper as the difference between the average Brazilian and the average United States (US) nominal interest rates, which we underestimate in our model when compared to the observed in data, when bonds are assumed to be nominal, but matches properly with data when considering the *FC Economy*.

Table 4.2 – Model Simulation

Moment	Data	Model FC	Model LC	Inflation Costs for LC economy						
Average Levels				$\gamma = 0$	$\gamma = 0{,}5$	$\gamma = 2.0$	$\gamma = 2{,}5$	$\gamma = 5$	$\gamma = 10$	$\gamma = \infty$
Debt/GDP		7.75	7.63	7.03	7.12	7.78	7.83	7.92	7.99	8.08
Inflation	5.63	0.00	2.90	58.88	6.82	1.92	1.55	0.81	0.48	0.00
Default frequency	0.00	2.63	1.60	1.17	1.33	1.70	1.73	1.80	1.85	1.85
Default risk premium	2.81	2.80	1.69	1.09	1.44	1.74	1.76	1.81	1.88	1.87
Nominal spread	9.77	0.00	4.73	63.97	8.52	3.79	3.43	2.72	2.44	1.94
Standard deviation										
Inflation	1.73	0.00	0.65	8.14	1.38	0.45	0.38	0.26	0.10	0.00
Default Risk Premium	0.98	1.31	1.11	1.82	1.05	1.11	1.11	1.09	1.09	1.11
Nominal spread	3.77	0.00	0.81	1.04	1.27	0.73	0.71	0.66	0.62	0.62
RER	0.72	2.27	2.08	2.16	2.02	2.10	2.12	2.15	2.16	2.15
Correlation with GDP										
Inflation	-0.04	NaN	0.50	0.63	0.50	0.48	0.43	0.44	0.25	0.00
Default Risk Premium	-0.72	-0.83	-0.87	-0.86	-0.88	-0.87	-0.86	-0.86	-0.86	-0.86
Nominal spread	-0.35	NaN	0.57	0.94	0.85	0.38	0.33	0.29	0.03	-0.05
RER	-0.23	-0.81	-0.85	-0.83	-0.88	-0.84	-0.84	-0.83	-0.83	-0.83

When looking at volatilities, our model predicts well the standard deviation for inflation and default risk premium, but underestimates the volatility of nominal spread and overestimates the variability of the real exchange rate. But, in general, the gap between the volatilities from the model and the observed in our covered period are not that large. And finally, the model predicts an average pro-cyclicality of inflation in the *LC Economy*, while data shows that this variable tends to be acyclical. Our simulated economy also fails to predict the cyclicality of the nominal spread, but it does correctly for the counter-cyclicality of default risk premium and the real exchange rate.

We also do an exercise comparing different linear inflation costs parameters (γ) in the *LC Economy* model. The first and expected result is that as the parameter increases, the optimal choice for inflation is reduced. From one side, when there is no cost ($\gamma = 0$), the average inflation choice is 58.88%. However, from the other side, when costs tend to infinity, the sovereign never chooses inflation.

But a more interesting result is the role of inflation cost at the default frequency. When the cost parameter is positive, higher values of γ gives us a higher default frequency and a higher default risk premium. This could be an indication that our mechanism works: When there are no incentives to inflate the economy, the sovereign chooses to default. This is the base case for the *FC Economy*. But when bonds are assumed to be nominal as in the *LC Economy*, inflation appears to be a reasonable choice in order to avoid sovereign default. This is reflected both by the default risk itself and by the premium parameter. Finally, when inflation costs are positive, the amount of debt to GDP ratio also increases, which can be also interpreted as a channel for the trade-off between sovereign default and inflation.

For the rest of moments, only inflation shows significant changes in volatility and correlation with GDP for different values of γ. Firstly, it seems that as costs increase, the volatility of inflation reduce. And secondly, no matter the degree of inflation cost, our model always shows a positive correlation between inflation and output. And, moreover, this pro-cyclicality is higher when inflation is costless for the economy.

Our results suggest that there is a distinction on default incentives depending on the debt denomination of the economy. While the *FC Economy* simulation shows that when debt is denominated in real terms, inflation is not an option, for the *LC Economy*, the choice of inflation surges as an alternative of sovereign default.

4.7 Conclusion

The main goal of this paper was to deepen our understanding of the dynamics of sovereign default and price levels, particularly by exploring the trade-off between inflation and default. We approached this by examining scenarios in which sovereign governments issue mixed debt portfolios, consisting of real (foreign currency or inflation-linked) and nominal (local currency) bonds. Our key finding is that, under high levels of indebtedness, a government issuing nominal debt may find it optimal to respond with inflation rather than defaulting, thereby avoiding the costs associated with sovereign default.

To investigate this trade-off, we developed two versions of a quantitative sovereign default model: One for an economy that issues only foreign-currency-denominated debt (*FC Economy*) and another for an economy that issues only local-currency-denominated debt (*LC Economy*), which includes the additional option to inflate the economy. After calibrating the model to Brazil, we found that the trade-off between inflation and default is supported by the results. Simulations of the model over an extended period showed that most of the statistical moments of the simulated economy are closely aligned with the observed data.

Our analysis also confirmed several empirical trends observed in our database. For instance, we found a positive correlation between inflation and nominal debt denomination, as well as evidence that debt accumulation is more constrained in the *LC Economy* compared to the *FC Economy* The model alsosuccessfully simulated an increased probability of default in the *LC Economy* under higher inflation costs. Furthermore, the model accurately replicated many statistical moments, including the average default risk premium, the counter-cyclicality of sovereign default, the behavior of the real exchange rate and inflation, and the pro-cyclicality of debt issuance.

Nevertheless, this paper leaves room for further exploration. One area for improvement is the consideration of debt ownership. Emerging economies often hold a significant portion of their debt domestically, which implies that risk-averse local households play a critical role in debt pricing. Extending the model to incorporate this dynamic could yield richer insights into the interplay between sovereign default, inflation, and debt structure. We leave this for future research.

In conclusion, this paper highlights the importance of the debt structure in the relationship between sovereign default and inflation, demonstrating the critical role inflation plays in economies subject to default risk, such as Brazil and other emerging markets.

5 General Conclusion

The three research articles in this dissertation contribute to the literature on international macroeconomics and finance by exploring important issues related to sovereign debt, market access in frontier economies, and the implications of foreign exchange interventions by central banks. Each chapter addresses a distinct but interconnected aspect of international economics and finance, providing both theoretical insights and empirical evidence that improve our understanding of how global economic policies and market dynamics influence sovereign decision-making and economic outcomes.

The first article, presented in Chapter 2, examines the impact of central bank foreign exchange interventions on currency markets, using the case of Norges Bank's FX transactions. The results show that central bank announcements have significant effects on short-term volatility and currency returns, underscoring the critical role of transparency and communication in monetary policy. These findings are particularly relevant for policy makers considering the design of FX interventions and their potential market effects.

Chapter 3 extends the analysis of sovereign debt by focusing on frontier economies. Empirical investigation of market access reveals that both domestic macroeconomic conditions and global factors are key determinants of whether low-income countries can issue sovereign debt in international markets. Furthermore, the forecast analysis provides a forward-looking perspective on how these economies could continue to integrate into global financial markets, providing valuable guidance to both policymakers and investors.

The third paper, in Chapter 4, explores the management of sovereign debt in emerging economies. By examining the role of nominal debt and portfolio structure, the research highlights how inflationary pressures and the risk of default are related in sovereign decision making. The model developed and calibrated in this chapter offers interesting insights into how governments may opt for costly inflation to avoid default, a finding with useful implications for policymakers in managing sovereign debt crises.

Together, these essays make several important contributions to the field of international macroeconomics and finance. Methodologically, the thesis employs a combination of quantitative modeling, panel data analysis, and empirical forecasting. In addition, the research sheds light on key policy-relevant issues, including sovereign debt management, market access for frontier economies, and the role of central banks in stabilizing currency markets.

In conclusion, this thesis improves our understanding of the challenges and opportunities faced by sovereign economies in the global financial system. The findings provide important knowledge for future research and have significant implications for policymakers when targeting macroeconomic stability. By integrating insights from sovereign debt, market access, and foreign exchange interventions, this work contributes to a more comprehensive view of the interactions between government policies and global markets.

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APPENDIX A – Chapter 2

A.1 Robustness in the volatility equation

A.1.1 Adding lags in the volatility equation

Table A.1 – Volatility equation with the addition of lags

5 min: Annoucement								
	constant	V_{NBI}	lag1	lag2	lag3	lag4	lag5	lag6
Estimate	-1.261	0.574	0.418	0.078	0.098	0.075	0.071	0.096
t value	-146.219	9.006	345.162	59.436	75.112	56.994	53.872	79.384
5 min: Surprises								
	constant	V_{NBI}	lag1	lag2	lag3	lag4	lag5	lag6
Estimate	-1.260	1.203	0.418	0.078	0.098	0.075	0.071	0.096
t value	-146.155	6.322	345.192	59.426	75.100	56.995	53.882	79.404
5 min: Big Surprises								
	constant	V_{NBI}	lag1	lag2	lag3	lag4	lag5	lag6
Estimate	-1.260	1.371	0.418	0.078	0.098	0.075	0.071	0.096
t value	-146.149	5.881	345.190	59.425	75.098	56.995	53.890	79.402

A.1.2 Seasonal effects on volatility

Table A.2 – Volatility equation with seasonality

5 min: Annoucement			
	Seasonal Component	V_{NBI}	Lagged volatility
Estimate	0.482	0.382	0.518
t value	466.150	5.891	504.169
5 min: Surprises			
	Seasonal Component	V_{NBI}	lag1
Estimate	0.482	1.103	0.518
t value	466.153	5.692	504.158
5 min: Big Surprises			
	Seasonal Component	V_{NBI}	lag1
Estimate	0.482	1.268	0.518
t value	466.153	5.342	504.155

A.2 Results for EURNOK FX rate

Table A.3 – Annoucements only (EURNOK)

5 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	-3.39E-07	6.49E-05	-4.05E-02	-2.71	0.82	0.67
t value	-7.29E-01	1.76E+00	-3.28E+01	-358.39	9.33	722.90
10 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	-1.71E-06	1.62E-05	-4.27E-02	-2.23	0.71	0.69
t value	-1.83E+00	3.07E-01	-2.46E+01	-241.25	9.16	554.17
30 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	-3.89E-06	-1.11E-04	-4.24E-02	-1.87	0.41	0.69
t value	-1.41E+00	-1.23E+00	-1.41E+01	-139.91	6.05	320.36

Table A.4 – Surprises (EURNOK)

5 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.00	0.00	-0.04	-2.71	1.32	0.67
t value	-0.71	0.98	-32.77	-358.32	5.09	722.96
10 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	-1.72E-06	2.85E-04	-4.27E-02	-2.23	1.22	0.69
t value	-1.84E+00	1.84E+00	-2.45E+01	-241.16	5.37	554.21
30 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	-4.03E-06	3.41E-04	-4.24E-02	-1.87	1.01	0.69
t value	-1.47E+00	1.29E+00	-1.41E+01	-139.83	5.08	320.52

Table A.5 – Big Surprises (EURNOK)

5 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.00	0.00	-0.04	-2.71	1.33	0.67
t value	-0.72	4.30	-32.77	-358.31	4.21	722.96
10 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.00	0.00	-0.04	-2.23	1.22	0.69
t value	-1.84	1.84	-24.54	-241.16	5.37	554.21
30 min						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.00	0.00	-0.04	-2.23	1.29	0.69
t value	-1.48	3.24	-14.10	-241.15	4.64	554.21

A.3 Anticipation Effects

Table A.6 – Anticipation placebo test for 5 minutes return

Announcements Only						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.0000	0.0000	-0.0281	-2.78399	0.118273	0.635651
t value	-0.658	-0.874	-27.452	-385.573	1.750303	677.3863
Surprises						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.0000	-0.0001	-0.0281	-2.78389	-0.04057	0.635661
t value	-0.665	-0.499	-27.453	-385.566	-0.20106	677.4033
Big Surprises						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.0000	0.0001	-0.0281	-2.78389	-0.07993	0.635662
t value	-0.668	0.459	-27.455	-385.566	-0.32345	677.4042

A.4 Negative and Positive Surprises

Table A.7 – Effect for positive surprises

	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Positive Surprises						
5-min return						
Estimate	0.000	0.000	-0.028	-2.784	1.313	0.636
t value	-0.673	1.603	-27.449	-385.609	6.507	677.394
10-min return						
Estimate	0.000	0.000	-0.025	-2.296	1.149	0.665
t value	-1.206	1.483	-17.163	-259.101	6.305	519.255
30-min return						
Estimate	0.000	0.001	-0.025	-1.930	0.840	0.663
t value	-1.211	3.144	-17.161	-150.368	4.842	298.081
Positive Big Surprises						
5-min return						
Estimate	0.000	0.001	-0.028	-2.784	1.463	0.636
t value	-0.680	4.341	-27.450	-385.603	5.920	677.395
10-min return						
Estimate	0.000	0.001	-0.028	-2.784	1.463	0.636
t value	-1.692	2.295	-11.288	-385.603	5.920	677.395
30-min return						
Estimate	0.000	0.001	-0.028	-1.930	1.181	0.663
t value	-1.696	3.489	-11.284	-150.373	5.560	298.098

Table A.8 – Effect for negative surprises

Negative Surprises						
5-min return						
	α	β_{NBI}	β_r	α_v	V_{NBI}	ϕ
Estimate	0.000	0.000	-0.028	-2.78	0.40	0.64
t value	-0.674	1.082	-27.4558	-385.58	2.95	677.40
10-min return						
Estimate	-9.67E-07	0.000	-0.025	-2.296	0.391	0.665478
t	-1.211	1.435	-17.172	-259.067	3.21668	519.2633
30-min return						
Estimate	0.000	0.000	-0.028	-1.930	0.306	0.663
t	-1.680	0.539	-11.288	-150.327	2.647	298.105
Big Negative Surprises						
5-min return						
Estimate	0.000	0.000	-0.028	-2.784	0.358	0.635653
t value	-0.673	0.894	-27.455	-385.580	2.757748	677.3992
10-min return						
Estimate	0.000	0.000	-0.025	-2.296	0.394	0.665
t	-1.210	1.382	-17.171	-259.067	3.361	519.265
30-min return						
Estimate	0.000	0.000	-0.028	-1.930	0.290	0.663
t	-1.680	0.545	-11.288	-150.326	2.601	298.106

APPENDIX B – Chapter 3

B.1 Boxes

B.1.1 Box 1: The IMF Low-Income Country Facilities Framework.

The IMF's Low-Income Country (LIC) Facilities framework was established in 2009 with the objective of providing concessional financing to poorer and more vulnerable member countries. The framework includes three lending facilities and one non-financial instrument. Loans to LICs via these facilities are currently provided at zero interest rates until at least end-June 2021 through the IMF-administered Poverty Reduction and Growth Trust (PRGT), which operates on a self-sustaining basis, with income from investments of the trust covering the subsidy costs of concessional lending. To maintain the viability of the trust fund, there are limits on the size of PRGT loans. The LIC facilities framework determines which IMF members can access PRGT resources based on an assessment of their level of income per capita, access to international financial markets, and the existence and severity of short-term vulnerabilities.[1] Every two years, a review of members' eligibility to access the PRGT is conducted based on a transparent and rule-based framework, with the aim of recommending which members should enter into or graduate from the PRGT-eligible list.

The criteria for member countries' entry into and graduation from the PRGT-eligible list are differentiated, with the latter being more stringent in order to minimize the risk of reverse-graduation. Countries enter the list if their income per capita is below a certain threshold and they do not have access to international financial markets on a durable and substantial basis. Countries are expected to graduate from the list when they have achieved income per capita levels above a certain threshold for a specified period, or have established access to international financial markets on a durable and substantial basis (and have income above a certain threshold), and do not face serious short-term vulnerabilities. Furthermore, to ensure the targeting of scarce PRGT resources to the most vulnerable, prior to reaching the graduation stage, LICs with income per capita above a certain threshold, substantial access to international financial markets, and lowtomoderate debt risks are only able to tap concessional resources in a blend with non-concessional resources. [2] Higher-income LICs with substantial past market access that are

[1] A few small and micro-states are also included on account of their size and vulnerabilities.

[2] PRGT-eligible members meeting the income or market access criteria for blending should tap Fund

at high risk of debt distress are also presumed to blend, but only if they are deemed to have prospective market access in light of debt risks.

Assessing whether an IMF member country has past and prospective market access is therefore critical for the PRGT lending framework. While there are clearly laid out rules to determine past marketaccess,the assessment of prospective market access for countries at high risk of debt distress relies mainly on the assessment of forward-looking debt vulnerabilities and judgement. The analysis on determinants of frontier economies' market access in this paper provides useful information to help inform this judgment.[3]

B.1.2 Box 2: Effects of Pull and Push Factors on Market Access in Emerging Economies

The analysis in this paper examines factors affecting market access in a specific group of low-income countries (LICs) that we refer to as frontier economies. While comparable analysis on these economies is sparse given their relatively recent entry into international financial markets, the literature is rich with similar analyses for emerging economies. As highlighted in Section 3.2, Comelli (2012) analyze the effects of both pull and push factors on sovereign bond spreads of 28 emerging economies between 1998 and 2011, while Presbitero et al. (2015) study the ability of 48 Emerging Market and Developing Economies (EMDEs) to issue bonds in international markets.

The proxies for market access and explanatory variables used in our paper are similar to the specifications in the two mentioned papers. Our results are in line with their results for emerging markets, which also find that macroeconomic fundamentals as well as external conditions matter for market access. Specifically, sound macroeconomic fundamentals and more favorable external conditions—as reflected through a lower VIX index—are associated with a higher probability of issuance. In addition, Presbitero et al. (2015) also find a negative relationship between the level of reserves and the probability of issuing, reflecting countries' financing needs rather than their fundamentals. Finally, we also find a negative relationship between the US interest rate and market access in emerging markets in our robustness analysis using 10-year treasury rates.

However, in a few aspects, our results differ from these previous studies. First, as opposed to Presbitero et al. (2015), inflation has both statistical and economic significance in our regression on sovereign spreads, with higher inflation linked to higher spreads.

resources in a blend of ocncessional PRGT resources with non-concessional GRA resources in a ratio of 1:2.

[3] Depending on the rating of debt distress, the assessment of past market access on a durable and sustainable basis is determined by whether a member has borrowed from international financial markets in two/three of the last five years in a cumulative amount of at least 25/50 percent of quota, by the time of this writing.

Second, Presbitero et al. (2015) find robust evidence for catalytic effects from IMF support on emerging markets' odds of issuing a bond, while we find the opposite in our robustness analysis, and statistically insignificant results in our main odds of issuance analysis. Table B.1 summarizes the impact of key variables on market access in these papers and ours.

Table B.1 – Factors Affecting Market Access in Emerging Economies vs Frontier Economies

	Pull Factors				Push Factors	
	Reserve Assets	IMF Support	Inflation	Others Fundamentals	US interest rates/growth	VIX
Presbitero et (2015)	↓	↑	-	↑	↓	↓
Comelli (2012)	-	-	-	↑	↓	↓
This paper	↓	↓	↓	↑	↓	↓

B.2 Summary Statistics

Table B.2 – Summary Statistics

Statistic	N	Mean	St. Dev.	Min	Max
PPG Bond Disbursements (USD Billions)	198	0.3	0.7	0,0	5,0
PPG Bond Stock (USD Billions)	198	1,0	1.7	0,0	11,0
GDP Growth	198	5.6	3.2	-6,0	17.3
GDP per capital (USD Thousands)	198	4.2	2.4	0.9	14.2
Government Debt to GDP	198	41.4	18.7	8.6	119.9
Current Account to GDP	198	-7.2	10.4	-41.8	27.2
Reserve in Months of Imports (%GDP)	198	12.2	6.7	3.6	34.4
Rule of Law percentile rank	198	28.9	15.6	2.8	60.6
Private Credit to GDP	169	23.5	13.1	2.7	63.9
EMBIG Index	105	558.3	276.4	0,0	1702.7
Inflation rate	198	6.8	5.1	-2.2	33.2
US growth	198	1.9	1.5	-2.5	2.9
VIX Index	198	18.2	5.5	11.1	31.6
US 10 Years Bond Yield	198	2.5	0.6	1.8	3.9
US policy interest rate	198	0.6	0.8	0.1	2.4

B.3 Main Regression Tables

Regressions tables in the next pages.

Table B.3 – PPG bonds to GDP regressions

	Dependent variable:							
	PPG Bond Stock							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	1.076**	0.541	1.096**	0.295	0.395	1.595	0.318	−0.373
	(0.516)	(1.544)	(0.503)	(1.981)	(0.363)	(1.094)	(0.364)	(1.817)
GDP growth (t-1)	0.016	0.004	0.009	−0.004	0.048	0.062*	0.047	0.057*
	(0.043)	(0.030)	(0.042)	(0.036)	(0.053)	(0.036)	(0.052)	(0.032)
Current Account to GDP (t-1)	−0.004	−0.027	−0.015	−0.026	0.015	−0.004	0.011	−0.003
	(0.019)	(0.019)	(0.020)	(0.022)	(0.013)	(0.007)	(0.014)	(0.007)
Reserves Assets/Months of Imports (t-1)	−0.037	−0.110**	−0.032	−0.060	−0.139	−0.041	−0.126	−0.027
	(0.150)	(0.051)	(0.110)	(0.097)	(0.090)	(0.052)	(0.080)	(0.054)
Government Debt to GDP (t-1)	0.027	0.054***	0.013	0.051***	0.032***	0.041***	0.028**	0.039**
	(0.017)	(0.017)	(0.016)	(0.015)	(0.011)	(0.016)	(0.012)	(0.017)
Inflation (t-1)	−0.095***	−0.006	−0.101**	−0.021	−0.044*	−0.0004	−0.047*	−0.018
	(0.032)	(0.041)	(0.041)	(0.038)	(0.024)	(0.016)	(0.028)	(0.023)
Private Credit to GDP (t-1)	0.051***	0.028	0.051***	0.030	0.043***	0.065***	0.044***	0.071***
	(0.020)	(0.042)	(0.019)	(0.041)	(0.013)	(0.017)	(0.013)	(0.017)
IMF Support	−0.428	−0.129	−0.394	−0.053	−0.284	−0.172	−0.330	−0.208
	(0.361)	(0.286)	(0.388)	(0.260)	(0.327)	(0.160)	(0.336)	(0.159)
Rule of Law (t-1)	0.032**	0.122***	0.036**	0.136***	0.027***	0.047**	0.027***	0.050**
	(0.015)	(0.035)	(0.015)	(0.031)	(0.009)	(0.018)	(0.008)	(0.020)
VIX Index	−0.041*	0.014			−0.031**	−0.011		
	(0.022)	(0.022)			(0.015)	(0.017)		
US growth (t-1)	0.021	−0.023			0.027	−0.040		
	(0.067)	(0.132)			(0.026)	(0.027)		
EMBI	−0.0003	−0.001**	0.0003	−0.001*				
	(0.001)	(0.001)	(0.001)	(0.001)				
Constant	−1.152				−0.889			
	(1.106)				(0.981)			
Pooling	*Yes*	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*Yes*	*Yes*
Observations	103	103	103	103	183	183	183	183
R^2	0.617	0.564	0.589	0.282	0.531	0.554	0.433	0.256
Adjusted R^2	0.565	0.422	0.488	-0.061	0.501	0.473	0.367	0.072

*Robust and clustered standard errors by country.

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

Table B.4 – Probability of Issuance regressions: Non-Linear Marginal Effects

	Dependent variable: Probability of PPG Bond Issuance					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDPpc) (t-1)	0.241*	0.242*	-0.000289	0.240**	0.234**	0.525
	(0.102)	(0.102)	(0.00151)	(0.0825)	(0.0821)	(0.702)
GDP growth (t-1)	-0.0156	-0.0174	-0.0000225	-0.00250	-0.00277	-0.00406
	(0.0154)	(0.0135)	(0.000142)	(0.00788)	(0.00775)	(0.00764)
Current Account to GDP (t-1)	0.00391	0.00261	0.0000488	0.00428	0.00390	0.00839
	(0.0101)	(0.00769)	(0.000311)	(0.00309)	(0.00304)	(0.00751)
Reserves Assets/Months of Imports (t-1)	-0.0609	-0.0631	-0.000114	-0.0644	-0.0660	-0.0342
	(0.0426)	(0.0415)	(0.000705)	(0.0360)	(0.0341)	(0.0329)
Government Debt to GDP (t-1)	-0.00599*	-0.00623*	-0.00000657	-0.00240	-0.00257	-0.00579
	(0.00288)	(0.00270)	(0.0000452)	(0.00261)	(0.00251)	(0.00687)
Inflation (t-1)	-0.0126	-0.0132	0.000000320	-0.0141	-0.0141	-0.00470
	(0.0104)	(0.0105)	(0.0000232)	(0.00901)	(0.00898)	(0.00550)
Private Credit to GDP (t-1)	-0.00463	-0.00497	-0.0000502	-0.00363	-0.00362	-0.0109
	(0.00315)	(0.00305)	(0.000315)	(0.00203)	(0.00201)	(0.00976)
IMF Support	-0.0418	-0.0444	-0.000169	-0.0857	-0.0858	-0.0312
	(0.0617)	(0.0643)	(0.00110)	(0.0643)	(0.0627)	(0.0425)
Rule of Law (t-1)	0.00582**	0.00588**	0.0000317	0.00415*	0.00435*	0.00134
	(0.00201)	(0.00188)	(0.000205)	(0.00171)	(0.00171)	(0.00359)
VIX Index	-0.0268*	-0.0267**	-0.0000273	-0.0181	-0.0172*	-0.0116
	(0.0106)	(0.00990)	(0.000169)	(0.0103)	(0.00876)	(0.00741)
US growth (t-1)	0.0423	0.0441	0.0000509	0.0159	0.0159	0.0111
	(0.0475)	(0.0465)	(0.000329)	(0.0168)	(0.0158)	(0.0118)
EMBI	-0.000403*	-0.000425*	-0.000000537			
	(0.000205)	(0.000201)	(0.00000347)			
RE Logit	Yes	No	No	Yes	No	No
RE Probit	No	Yes	No	No	Yes	No
Conditional Logit (Country FE)	No	No	Yes	No	No	Yes
Observations	103	103	102	183	183	165

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.5 – Probability of Issuance regressions: LPM

	Dependent variable:							
	Probability of PPG Bond Issuance							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	0.192	0.00434	0.248**	1.201	0.194*	0.445	0.192*	0.473
	(0.107)	(0.703)	(0.0934)	(1.171)	(0.0764)	(0.396)	(0.0756)	(0.730)
GDP growth (t-1)	-0.0116	-0.00998	-0.0110	-0.00857	0.00130	-0.00623	0.00109	-0.00678
	(0.0134)	(0.0132)	(0.0119)	(0.0118)	(0.00943)	(0.00901)	(0.00904)	(0.00898)
Current Account to GDP (t-1)	0.00153	0.0371***	0.000836	0.0380**	0.00414	0.00657	0.00413	0.00633
	(0.00643)	(0.00783)	(0.00645)	(0.0104)	(0.00292)	(0.00359)	(0.00297)	(0.00356)
Reserves Assets/Months of Imports (t-1)	-0.0448	-0.121*	-0.0286	-0.0646	-0.0641*	-0.0902*	-0.0545	-0.0792*
	(0.0396)	(0.0558)	(0.0442)	(0.0667)	(0.0295)	(0.0321)	(0.0307)	(0.0342)
Government Debt to GDP (t-1)	-0.00382	-0.00692	-0.00296	-0.00602	-0.000532	-0.00543	-0.000104	-0.00459
	(0.00234)	(0.00573)	(0.00289)	(0.00751)	(0.00204)	(0.00457)	(0.00220)	(0.00452)
Inflation (t-1)	-0.00980	-0.000582	-0.0134	-0.00823	-0.00786	0.000877	-0.00923	-0.0000212
	(0.0114)	(0.0168)	(0.0105)	(0.0176)	(0.00675)	(0.00686)	(0.00770)	(0.00943)
Private Credit to GDP (t-1)	-0.00425	-0.0337*	-0.00559	-0.0503*	-0.00279	-0.00822	-0.00316	-0.00891
	(0.00341)	(0.0153)	(0.00323)	(0.0195)	(0.00209)	(0.00632)	(0.00216)	(0.00730)
IMF Support	-0.0343	-0.0636	-0.0187	-0.00766	-0.0909	-0.0756	-0.0760	-0.0519
	(0.0778)	(0.128)	(0.0788)	(0.131)	(0.0705)	(0.0710)	(0.0683)	(0.0678)
Rule of Law (t-1)	0.00401*	0.0304*	0.00397*	0.0401*	0.00393*	0.00779	0.00408*	0.0100
	(0.00158)	(0.0108)	(0.00168)	(0.0151)	(0.00199)	(0.00816)	(0.00197)	(0.00857)
VIX Index	-0.0259***	-0.0261*			-0.0124*	-0.0176*		
	(0.00769)	(0.0118)			(0.00539)	(0.00635)		
US growth (t-1)	0.0116	-0.0141			0.00240	0.00202		
	(0.0413)	(0.0476)			(0.0117)	(0.0120)		
EMBI	-0.000126	-0.0000645	-0.0000553	0.000192				
	(0.000190)	(0.000194)	(0.000169)	(0.000192)				
Constant	1.090***				0.593***			
	(0.274)				(0.176)			
Pooling	Yes	No	No	No	Yes	No	No	No
Country FE	No	Yes	No	Yes	No	Yes	No	Yes
Time FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	103	103	103	103	183	183	183	183

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.6 – EMBIG regressions

	Dependent variable:			
	EMBIG Index			
	(1)	(2)	(3)	(4)
Log(GDPpc) (t-1)	−60.743	−1,079.748***	−47.778	−997.252***
	(74.991)	(200.910)	(73.582)	(347.839)
GDP growth (t-1)	−24.912***	−10.951	−22.430**	−9.278
	(9.653)	(7.521)	(9.632)	(7.533)
Current Account to GDP (t-1)	−8.472**	−5.342	−7.691**	−6.380**
	(4.072)	(3.824)	(3.634)	(3.148)
Reserves Assets/Months of Imports (t-1)	−41.622*	−64.116***	−43.008**	−82.952***
	(23.312)	(20.049)	(21.744)	(24.900)
Government Debt to GDP (t-1)	4.249**	8.978***	5.543***	8.615***
	(1.825)	(2.867)	(1.964)	(2.476)
Inflation (t-1)	11.263	18.657***	10.742*	19.667***
	(7.117)	(7.100)	(6.373)	(5.289)
Private Credit to GDP (t-1)	−2.440	16.340*	−2.490	18.501*
	(2.095)	(8.449)	(2.098)	(9.485)
IMF Support	−28.936	−91.284*	−31.105	−101.355**
	(52.283)	(48.889)	(46.296)	(40.278)
Rule of Law (t-1)	−1.474	1.348	−2.043	−1.529
	(1.079)	(4.280)	(1.294)	(3.079)
VIX Index	15.149**	3.226		
	(7.206)	(7.103)		
US growth (t-1)	56.109***	95.738***		
	(12.633)	(15.339)		
Constant	355.796**			
	(165.779)			
Pooling	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*
Observations	99	99	99	99
R^2	0.522	0.494	0.550	0.495
Adjusted R^2	0.462	0.348	0.441	0.273

*Robust and clustered standard errors by country. — *p<0.1; **p<0.05; ***p<0.01

B.4 Robustness Exercises

Regressions tables in the next pages.

Table B.7 – PPG bonds to GDP regressions - US Bond 10 Years Yields

	Dependent variable:							
	PPG Bond Stock							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	1.096**	0.613	1.096**	0.295	0.380	1.260	0.318	−0.373
	(0.533)	(1.637)	(0.503)	(1.981)	(0.363)	(1.015)	(0.364)	(1.817)
GDP growth (t-1)	0.016	0.002	0.009	−0.004	0.050	0.056	0.047	0.057*
	(0.043)	(0.032)	(0.042)	(0.036)	(0.052)	(0.035)	(0.052)	(0.032)
Current Account to GDP (t-1)	−0.004	−0.028	−0.015	−0.026	0.015	−0.003	0.011	−0.003
	(0.019)	(0.019)	(0.020)	(0.022)	(0.014)	(0.007)	(0.014)	(0.007)
Reserves Assets/Months of Imports (t-1)	−0.016	−0.083	−0.032	−0.060	−0.113	−0.003	−0.126	−0.027
	(0.136)	(0.062)	(0.110)	(0.097)	(0.090)	(0.048)	(0.080)	(0.054)
Government Debt to GDP (t-1)	0.028*	0.054***	0.013	0.051***	0.034***	0.041***	0.028**	0.039**
	(0.017)	(0.017)	(0.016)	(0.015)	(0.012)	(0.015)	(0.012)	(0.017)
Inflation (t-1)	−0.099***	−0.008	−0.101**	−0.021	−0.050*	−0.010	−0.047*	−0.018
	(0.036)	(0.035)	(0.041)	(0.038)	(0.025)	(0.019)	(0.028)	(0.023)
Private Credit to GDP (t-1)	0.050**	0.029	0.051***	0.030	0.043***	0.067***	0.044***	0.071***
	(0.020)	(0.034)	(0.019)	(0.041)	(0.013)	(0.017)	(0.013)	(0.017)
IMF Support	−0.428	−0.114	−0.394	−0.053	−0.282	−0.149	−0.330	−0.208
	(0.360)	(0.290)	(0.388)	(0.260)	(0.327)	(0.168)	(0.336)	(0.159)
Rule of Law (t-1)	0.033**	0.120***	0.036**	0.136***	0.027***	0.046***	0.027***	0.050**
	(0.015)	(0.033)	(0.015)	(0.031)	(0.009)	(0.018)	(0.008)	(0.020)
VIX Index	−0.027	0.030			−0.017	0.001		
	(0.026)	(0.018)			(0.017)	(0.017)		
US Bond 10yr yield (t-1)	−0.267	−0.233			−0.316**	−0.240*		
	(0.246)	(0.197)			(0.138)	(0.140)		
EMBI	−0.0003	−0.001***	0.0003	−0.001*				
	(0.001)	(0.0004)	(0.001)	(0.001)				
Constant	−0.815				−0.368			
	(1.314)				(1.018)			
Pooling	*Yes*	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*Yes*	*Yes*
Observations	103	103	103	103	183	183	183	183
R^2	0.620	0.571	0.589	0.282	0.539	0.561	0.433	0.256
Adjusted R^2	0.569	0.432	0.488	-0.061	0.509	0.482	0.367	0.072

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.8 – PPG bonds to GDP regressions - IMF ECF/SCF Support Arrangement

	Dependent variable:							
	PPG Bond Stock							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	0.662	0.157	0.698	0.328	0.244	1.460	0.178	−0.274
	(0.579)	(1.550)	(0.575)	(1.881)	(0.370)	(1.130)	(0.368)	(1.823)
GDP growth (t-1)	0.025	0.007	0.018	−0.001	0.050	0.064*	0.050	0.060*
	(0.039)	(0.028)	(0.037)	(0.035)	(0.051)	(0.034)	(0.051)	(0.031)
Current Account to GDP (t-1)	0.0001	−0.035*	−0.011	−0.039*	0.016	−0.007	0.012	−0.006
	(0.020)	(0.019)	(0.021)	(0.022)	(0.014)	(0.007)	(0.015)	(0.008)
Reserves Assets/Months of Imports (t-1)	0.028	−0.096**	0.035	−0.039	−0.103	−0.031	−0.087	−0.017
	(0.156)	(0.047)	(0.108)	(0.090)	(0.094)	(0.052)	(0.087)	(0.050)
Government Debt to GDP (t-1)	0.024	0.056***	0.010	0.055***	0.032***	0.044***	0.027**	0.041**
	(0.015)	(0.016)	(0.015)	(0.013)	(0.011)	(0.015)	(0.012)	(0.016)
Inflation (t-1)	−0.075**	−0.005	−0.083**	−0.021	−0.044**	−0.001	−0.047*	−0.017
	(0.031)	(0.040)	(0.038)	(0.038)	(0.022)	(0.016)	(0.025)	(0.022)
Private Credit to GDP (t-1)	0.066***	0.045	0.066***	0.045	0.051***	0.069***	0.051***	0.072***
	(0.023)	(0.042)	(0.022)	(0.040)	(0.016)	(0.016)	(0.016)	(0.016)
IMF PRGT-ECF Support	0.225	0.035	0.159	0.033	0.083	−0.189	0.050	−0.227
	(0.595)	(0.277)	(0.638)	(0.353)	(0.459)	(0.186)	(0.465)	(0.219)
IMF PRGT-SCF Support	−0.963***	−0.928***	−1.023***	−0.850***	−0.625*	−0.793***	−0.607*	−0.642***
	(0.274)	(0.288)	(0.378)	(0.290)	(0.341)	(0.184)	(0.314)	(0.152)
Rule of Law (t-1)	0.032**	0.128***	0.036**	0.137***	0.027***	0.052***	0.027***	0.051***
	(0.016)	(0.033)	(0.016)	(0.031)	(0.009)	(0.017)	(0.009)	(0.020)
VIX Index	−0.055**	0.012			−0.038**	−0.014		
	(0.027)	(0.022)			(0.017)	(0.018)		
US growth (t-1)	0.101	−0.001			0.049*	−0.034		
	(0.073)	(0.125)			(0.027)	(0.028)		
EMBI	−0.0002	−0.001**	0.0004	−0.001**				
	(0.001)	(0.001)	(0.001)	(0.0005)				
Constant	−1.361				−1.017			
	(1.068)				(0.886)			
Pooling	*Yes*	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*Yes*	*Yes*
Observations	103	103	103	103	183	183	183	183
R^2	0.622	0.591	0.597	0.321	0.533	0.571	0.432	0.272

Table B.9 – PPG bonds to GDP regressions - VIX x Rule of Law interactions

	Dependent variable:							
	PPG Bond Stock							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	1.041**	0.530	1.046**	0.418	0.360	1.669	0.283	−0.645
	(0.501)	(1.539)	(0.469)	(2.193)	(0.350)	(1.110)	(0.353)	(1.725)
GDP growth (t-1)	0.022	0.003	0.014	−0.004	0.050	0.061*	0.048	0.055*
	(0.044)	(0.029)	(0.040)	(0.035)	(0.052)	(0.035)	(0.051)	(0.031)
Current Account to GDP (t-1)	−0.005	−0.027	−0.018	−0.027	0.014	−0.003	0.010	−0.003
	(0.017)	(0.021)	(0.018)	(0.022)	(0.013)	(0.007)	(0.014)	(0.007)
Reserves Assets/Months of Imports (t-1)	−0.035	−0.111**	−0.050	−0.057	−0.123	−0.031	−0.115	−0.024
	(0.144)	(0.052)	(0.108)	(0.094)	(0.088)	(0.045)	(0.081)	(0.054)
Government Debt to GDP (t-1)	0.023	0.055***	0.004	0.052***	0.031***	0.038**	0.026**	0.034**
	(0.017)	(0.018)	(0.015)	(0.018)	(0.011)	(0.016)	(0.012)	(0.017)
Inflation (t-1)	−0.092***	−0.005	−0.096**	−0.021	−0.043*	−0.0003	−0.046*	−0.018
	(0.030)	(0.042)	(0.037)	(0.038)	(0.024)	(0.016)	(0.027)	(0.022)
Private Credit to GDP (t-1)	0.052***	0.030	0.053***	0.030	0.044***	0.063***	0.045***	0.069***
	(0.018)	(0.045)	(0.017)	(0.042)	(0.012)	(0.017)	(0.012)	(0.016)
IMF Support	−0.344	−0.146	−0.276	−0.064	−0.241	−0.129	−0.287	−0.166
	(0.361)	(0.313)	(0.380)	(0.283)	(0.329)	(0.176)	(0.335)	(0.157)
Rule of Law (t-1)	0.081*	0.116**	0.102***	0.133***	0.070***	0.064**	0.070***	0.069**
	(0.042)	(0.053)	(0.035)	(0.044)	(0.024)	(0.028)	(0.024)	(0.028)
VIX Index	0.030	0.005			0.028	0.015		
	(0.026)	(0.036)			(0.027)	(0.035)		
US growth (t-1)	0.034	−0.022			0.036	−0.030		
	(0.061)	(0.134)			(0.025)	(0.028)		
EMBI	−0.0001	−0.001*	0.001	−0.001				
	(0.001)	(0.001)	(0.001)	(0.001)				
VIX Index x Rule of Law (t-1)	−0.003	0.0004	−0.004***	0.0002	−0.002**	−0.001	−0.002**	−0.001
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	−2.444**				−1.996*			
	(1.013)				(1.186)			
Pooling	*Yes*	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*Yes*	*Yes*
Observations	103	103	103	103	183	183	183	183
R^2	0.628	0.564	0.610	0.282	0.543	0.559	0.448	0.268

Table B.10 – PPG bonds to GDP regressions - Bloomberg Commodities Index (BCOM)

	Dependent variable:							
	PPG Bond Stock							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	1.074**	0.480	1.096**	0.295	0.351	0.751	0.318	−0.373
	(0.517)	(1.835)	(0.503)	(1.981)	(0.368)	(1.346)	(0.364)	(1.817)
GDP growth (t-1)	0.012	0.004	0.009	−0.004	0.049	0.063*	0.047	0.057*
	(0.040)	(0.030)	(0.042)	(0.036)	(0.053)	(0.035)	(0.052)	(0.032)
Current Account to GDP (t-1)	−0.011	−0.027	−0.015	−0.026	0.011	−0.004	0.011	−0.003
	(0.019)	(0.019)	(0.020)	(0.022)	(0.015)	(0.007)	(0.014)	(0.007)
Reserves Assets/Months of Imports (t-1)	−0.057	−0.111**	−0.032	−0.060	−0.131	−0.039	−0.126	−0.027
	(0.135)	(0.051)	(0.110)	(0.097)	(0.086)	(0.048)	(0.080)	(0.054)
Government Debt to GDP (t-1)	0.019	0.054***	0.013	0.051***	0.028**	0.038**	0.028**	0.039**
	(0.016)	(0.018)	(0.016)	(0.015)	(0.011)	(0.017)	(0.012)	(0.017)
Inflation (t-1)	−0.095***	−0.006	−0.101**	−0.021	−0.042*	−0.005	−0.047*	−0.018
	(0.035)	(0.041)	(0.041)	(0.038)	(0.024)	(0.016)	(0.028)	(0.023)
Private Credit to GDP (t-1)	0.051***	0.028	0.051***	0.030	0.044***	0.065***	0.044***	0.071***
	(0.019)	(0.042)	(0.019)	(0.041)	(0.013)	(0.016)	(0.013)	(0.017)
IMF Support	−0.464	−0.131	−0.394	−0.053	−0.339	−0.221	−0.330	−0.208
	(0.375)	(0.282)	(0.388)	(0.260)	(0.337)	(0.161)	(0.336)	(0.159)
Rule of Law (t-1)	0.033**	0.121***	0.036**	0.136***	0.026***	0.043**	0.027***	0.050**
	(0.015)	(0.033)	(0.015)	(0.031)	(0.008)	(0.019)	(0.008)	(0.020)
VIX Index	−0.027	0.014			−0.019	−0.015		
	(0.021)	(0.026)			(0.014)	(0.019)		
US growth (t-1)	−0.080	−0.022			−0.008	−0.028		
	(0.071)	(0.135)			(0.027)	(0.033)		
BCOM Index	−0.098***	−0.004			−0.075***	−0.046		
	(0.031)	(0.035)			(0.020)	(0.034)		
EMBI	−0.0002	−0.001**	0.0003	−0.001*				
	(0.001)	(0.001)	(0.001)	(0.001)				
Constant	10.096**				7.604***			
	(4.166)				(2.613)			
Pooling	*Yes*	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*Yes*	*Yes*
Observations	103	103	103	103	183	183	183	183
R^2	0.637	0.564	0.589	0.282	0.548	0.560	0.433	0.256

Table B.11 – Probability of Issuance regressions: Non-Linear Marginal effects - US Bond 10 Years Yields

	Dependent variable:					
	Probability of PPG Bond Issuance					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDPpc) (t-1)	0.267**	0.269**	-0.000700	0.261**	0.254**	0.372
	(0.103)	(0.101)	(0.00374)	(0.0889)	(0.0883)	(0.414)
GDP growth (t-1)	-0.0190	-0.0196	-0.000159	-0.0000984	0.000421	-0.00120
	(0.0138)	(0.0123)	(0.00104)	(0.00826)	(0.00811)	(0.00584)
Current Account to GDP (t-1)	0.00280	0.00215	0.000337	0.00464	0.00450	0.00860
	(0.00914)	(0.00745)	(0.00219)	(0.00318)	(0.00303)	(0.00625)
Reserves Assets/Months of Imports (t-1)	-0.0708	-0.0719	-0.000836	-0.0549	-0.0542	-0.0251
	(0.0481)	(0.0477)	(0.00532)	(0.0381)	(0.0373)	(0.0166)
Government Debt to GDP (t-1)	-0.00517	-0.00514	-0.0000448	-0.00119	-0.00113	-0.00355
	(0.00305)	(0.00300)	(0.000316)	(0.00283)	(0.00273)	(0.00362)
Inflation (t-1)	-0.0141	-0.0146	-0.00000441	-0.0167	-0.0166	-0.00546
	(0.00957)	(0.00965)	(0.000142)	(0.00978)	(0.00971)	(0.00494)
Private Credit to GDP (t-1)	-0.00545	-0.00571	-0.000362	-0.00409	-0.00402	-0.00883
	(0.00309)	(0.00297)	(0.00232)	(0.00248)	(0.00244)	(0.00587)
IMF Support	-0.0394	-0.0441	-0.00115	-0.115	-0.119	-0.0524
	(0.0603)	(0.0617)	(0.00777)	(0.0696)	(0.0691)	(0.0511)
Rule of Law (t-1)	0.00522*	0.00527*	0.000240	0.00394	0.00398	0.00240
	(0.00221)	(0.00208)	(0.00160)	(0.00209)	(0.00211)	(0.00356)
VIX Index	0.00961	0.00930	-0.0000795	-0.00973	-0.00829	-0.00752
	(0.0203)	(0.0199)	(0.000443)	(0.0146)	(0.0140)	(0.00482)
US 10yr Bond Yield (t-1)	-0.243	-0.241	-0.000673	-0.130	-0.139	-0.0440
	(0.139)	(0.140)	(0.00494)	(0.0939)	(0.0914)	(0.0564)
EMBI	-0.000494*	-0.000509*	-0.00000349			
	(0.000240)	(0.000233)	(0.0000236)			
RE Logit	Yes	No	No	Yes	No	No
RE Probit	No	Yes	No	No	Yes	No
Conditional Logit (Country FE)	No	No	Yes	No	No	Yes
Observations	99	99	98	169	169	152

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.12 – Probability of Issuance regressions: LPM - US Bond 10 Years Yields

	Dependent variable:							
	Probability of PPG Bond Issuance							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	0.202	-0.180	0.245*	0.857	0.205*	0.293	0.216*	0.481
	(0.104)	(0.732)	(0.0976)	(1.070)	(0.0895)	(0.393)	(0.0864)	(0.735)
GDP growth (t-1)	-0.0139	-0.00951	-0.0114	-0.00521	0.000202	-0.00602	-0.000286	-0.00584
	(0.0134)	(0.0151)	(0.0124)	(0.0127)	(0.00881)	(0.0102)	(0.00876)	(0.0102)
Current Account to GDP (t-1)	0.000749	0.0402**	0.000702	0.0429**	0.00484	0.00763	0.00474	0.00731
	(0.00619)	(0.00965)	(0.00667)	(0.0120)	(0.00259)	(0.00397)	(0.00280)	(0.00384)
Reserves Assets/Months of Imports (t-1)	-0.0460	-0.106	-0.0289	-0.0564	-0.0599	-0.0730	-0.0600	-0.0703
	(0.0516)	(0.0703)	(0.0544)	(0.0765)	(0.0345)	(0.0380)	(0.0346)	(0.0386)
Government Debt to GDP (t-1)	-0.00286	-0.00581	-0.00300	-0.00631	-0.000563	-0.00370	-0.000388	-0.00273
	(0.00286)	(0.00619)	(0.00336)	(0.00673)	(0.00234)	(0.00472)	(0.00258)	(0.00461)
Inflation (t-1)	-0.0103	-0.000165	-0.0131	-0.00753	-0.0117	-0.00921	-0.0112	-0.00753
	(0.0103)	(0.0130)	(0.0105)	(0.0161)	(0.00712)	(0.00825)	(0.00922)	(0.0109)
Private Credit to GDP (t-1)	-0.00504	-0.0388*	-0.00566	-0.0529*	-0.00352	-0.0104	-0.00396	-0.0116
	(0.00336)	(0.0149)	(0.00335)	(0.0214)	(0.00275)	(0.00765)	(0.00284)	(0.00935)
IMF Support	-0.0304	-0.0598	-0.0178	-0.000422	-0.122	-0.131	-0.105	-0.0996
	(0.0711)	(0.125)	(0.0745)	(0.127)	(0.0659)	(0.0752)	(0.0665)	(0.0744)
Rule of Law (t-1)	0.00364*	0.0335*	0.00407*	0.0442*	0.00369	0.00864	0.00421	0.0114
	(0.00184)	(0.0113)	(0.00183)	(0.0152)	(0.00248)	(0.00753)	(0.00233)	(0.00825)
VIX Index	0.00365	-0.0270			-0.0123	-0.0195		
	(0.0211)	(0.0255)			(0.0127)	(0.0161)		
US 10yr Bond Yield (t-1)	-0.233	-0.0552			-0.0784	-0.0598		
	(0.138)	(0.143)			(0.0890)	(0.0940)		
EMBI	-0.000213	-0.000129	-0.0000705	0.000204				
	(0.000205)	(0.000315)	(0.000243)	(0.000325)				
Constant	1.245***				0.832***			
	(0.297)				(0.196)			
Pooling	Yes	No	No	No	Yes	No	No	No
Country FE	No	Yes	No	Yes	No	Yes	No	Yes
Time FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	99	99	99	99	169	169	169	169

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.13 – Probability of Issuance regressions: Non-Linear Marginal Effects - IMF ECF/SCF

	Dependent variable:					
	Probability of PPG Bond Issuance					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDPpc) (t-1)	0.165	0.172	-0.00445	0.214*	0.209*	0.548
	(0.132)	(0.130)	(0.0209)	(0.0845)	(0.0811)	(0.449)
GDP growth (t-1)	-0.0165	-0.0178	-0.000233	-0.00365	-0.00363	-0.00494
	(0.0144)	(0.0130)	(0.00134)	(0.00816)	(0.00776)	(0.00750)
Current Account to GDP (t-1)	0.00450	0.00360	0.000495	0.00424	0.00404	0.00781
	(0.00869)	(0.00712)	(0.00283)	(0.00284)	(0.00272)	(0.00482)
Reserves Assets/Months of Imports (t-1)	-0.0515	-0.0533	-0.00107	-0.0626	-0.0638	-0.0361
	(0.0471)	(0.0453)	(0.00604)	(0.0361)	(0.0334)	(0.0204)
Government Debt to GDP (t-1)	-0.00640*	-0.00649*	-0.0000531	-0.00353	-0.00351	-0.00625
	(0.00298)	(0.00278)	(0.000334)	(0.00259)	(0.00248)	(0.00430)
Inflation (t-1)	-0.00986	-0.0104	0.0000543	-0.0131	-0.0129	-0.00496
	(0.0112)	(0.0114)	(0.000416)	(0.00969)	(0.00950)	(0.00657)
Private Credit to GDP (t-1)	-0.00163	-0.00215	-0.000529	-0.00277	-0.00282	-0.0123*
	(0.00375)	(0.00369)	(0.00303)	(0.00283)	(0.00264)	(0.00535)
IMF PRGT-ECF Support	-0.0528	-0.0569	-0.0274	-0.152*	-0.158*	-0.186*
	(0.100)	(0.102)	(0.158)	(0.0681)	(0.0667)	(0.0857)
IMF PRGT-SCF Support	-0.315	-0.284	-0.0552	-0.300*	-0.282*	-0.278*
	(0.193)	(0.163)	(0.319)	(0.149)	(0.127)	(0.142)
Rule of Law (t-1)	0.00573*	0.00590*	0.000427	0.00465*	0.00477*	0.00510
	(0.00268)	(0.00245)	(0.00247)	(0.00210)	(0.00205)	(0.00553)
VIX Index	-0.0264**	-0.0264**	-0.000258	-0.0195	-0.0187*	-0.0136*
	(0.00996)	(0.00930)	(0.00138)	(0.00998)	(0.00837)	(0.00559)
US growth (t-1)	0.0515	0.0522	0.000410	0.0216	0.0214	0.0143
	(0.0468)	(0.0464)	(0.00240)	(0.0171)	(0.0158)	(0.0112)
EMBI	-0.000400	-0.000423*	-0.00000594			
	(0.000212)	(0.000212)	(0.0000334)			
RE Logit	Yes	No	No	Yes	No	No
RE Probit	No	Yes	No	No	Yes	No
Conditional Logit (Country FE)	No	No	Yes	No	No	Yes
Observations	103	103	102	183	183	165

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.14 – Probability of Issuance regressions: LPM - IMF ECF/SCF

	Dependent variable:							
	Probability of PPG Bond Issuance							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	0.134	-0.124	0.204	1.004	0.170*	0.411	0.175*	0.458
	(0.128)	(0.730)	(0.116)	(1.135)	(0.0790)	(0.418)	(0.0822)	(0.746)
GDP growth (t-1)	-0.0119	-0.0102	-0.0115	-0.00938	-0.000827	-0.00583	-0.00384	-0.00633
	(0.0134)	(0.0129)	(0.0119)	(0.00991)	(0.00888)	(0.00893)	(0.00799)	(0.00913)
Current Account to GDP (t-1)	0.00180	0.0331**	0.000593	0.0328**	0.00390	0.00508	0.00339	0.00427
	(0.00631)	(0.00804)	(0.00619)	(0.0104)	(0.00280)	(0.00334)	(0.00273)	(0.00336)
Reserves Assets/Months of Imports (t-1)	-0.0377	-0.117*	-0.0239	-0.0678	-0.0692*	-0.0874*	-0.0707*	-0.0785*
	(0.0424)	(0.0530)	(0.0458)	(0.0604)	(0.0295)	(0.0323)	(0.0292)	(0.0345)
Government Debt to GDP (t-1)	-0.00430	-0.00601	-0.00352	-0.00552	-0.00143	-0.00427	-0.00282	-0.00376
	(0.00231)	(0.00599)	(0.00260)	(0.00703)	(0.00211)	(0.00484)	(0.00273)	(0.00476)
Inflation (t-1)	-0.00847	0.000606	-0.0128	-0.00623	-0.00693	0.000922	-0.00497	0.000704
	(0.0126)	(0.0170)	(0.0116)	(0.0179)	(0.00646)	(0.00648)	(0.00752)	(0.00885)
Private Credit to GDP (t-1)	-0.00182	-0.0272	-0.00369	-0.0431*	-0.00179	-0.00675	-0.00288	-0.00809
	(0.00397)	(0.0151)	(0.00403)	(0.0184)	(0.00301)	(0.00619)	(0.00368)	(0.00697)
IMF PRGT-ECF Support	-0.0501	-0.220	-0.0682	-0.209	-0.135*	-0.159	-0.157*	-0.146
	(0.113)	(0.185)	(0.0985)	(0.153)	(0.0681)	(0.0847)	(0.0644)	(0.0801)
IMF PRGT-SCF Support	-0.220	-0.367	-0.202	-0.315	-0.247*	-0.341**	-0.283**	-0.334*
	(0.154)	(0.264)	(0.155)	(0.285)	(0.101)	(0.114)	(0.0882)	(0.117)
Rule of Law (t-1)	0.00401	0.0297**	0.00392	0.0364*	0.00378	0.00867	0.00482	0.0102
	(0.00224)	(0.00968)	(0.00241)	(0.0152)	(0.00229)	(0.00889)	(0.00273)	(0.00943)
VIX Index	-0.0267***	-0.0265*			-0.0152**	-0.0185*		
	(0.00780)	(0.0116)			(0.00533)	(0.00658)		
US growth (t-1)	0.0171	-0.00512			0.00929	0.00473		
	(0.0413)	(0.0447)			(0.0104)	(0.0122)		
EMBI	-0.0000970	-0.0000529	-0.0000319	0.000152				
	(0.000218)	(0.000176)	(0.000192)	(0.000162)				
Constant	1.105***							
	(0.284)							
Pooling	Yes	No	No	No	Yes	No	No	No
Country FE	No	Yes	No	Yes	No	Yes	No	Yes
Time FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	103	103	103	103	183	183	183	183

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.15 – Probability of Issuance regressions: LPM - VIX x Rule of Law interactions

	Dependent variable:							
	Probability of PPG Bond Issuance							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	0.195	0.00361	0.252**	1.326	0.200**	0.432	0.199**	0.528
	(0.110)	(0.708)	(0.0975)	(1.190)	(0.0758)	(0.388)	(0.0746)	(0.755)
GDP growth (t-1)	-0.0121	-0.0100	-0.0115	-0.00919	0.000490	-0.00597	0.000173	-0.00632
	(0.0135)	(0.0129)	(0.0121)	(0.0122)	(0.00908)	(0.00935)	(0.00883)	(0.00943)
Current Account to GDP (t-1)	0.00161	0.0371***	0.00114	0.0374**	0.00435	0.00646	0.00436	0.00628
	(0.00653)	(0.00759)	(0.00658)	(0.0106)	(0.00285)	(0.00359)	(0.00292)	(0.00357)
Reserves Assets/Months of Imports (t-1)	-0.0450	-0.122	-0.0271	-0.0616	-0.0703*	-0.0920*	-0.0605*	-0.0800*
	(0.0405)	(0.0564)	(0.0449)	(0.0643)	(0.0298)	(0.0331)	(0.0307)	(0.0344)
Government Debt to GDP (t-1)	-0.00347	-0.00687	-0.00228	-0.00494	-0.000586	-0.00488	-0.0000956	-0.00347
	(0.00242)	(0.00575)	(0.00276)	(0.00732)	(0.00205)	(0.00454)	(0.00213)	(0.00429)
Inflation (t-1)	-0.0100	-0.000528	-0.0138	-0.00830	-0.00734	0.000869	-0.00887	-0.000158
	(0.0117)	(0.0171)	(0.0110)	(0.0179)	(0.00670)	(0.00689)	(0.00789)	(0.00957)
Private Credit to GDP (t-1)	-0.00432	-0.0336*	-0.00572	-0.0498*	-0.00284	-0.00788	-0.00326	-0.00836
	(0.00354)	(0.0154)	(0.00334)	(0.0200)	(0.00212)	(0.00643)	(0.00220)	(0.00766)
IMF Support	-0.0412	-0.0648	-0.0284	-0.0181	-0.0995	-0.0834	-0.0852	-0.0604
	(0.0738)	(0.126)	(0.0744)	(0.135)	(0.0698)	(0.0700)	(0.0674)	(0.0696)
Rule of Law (t-1)	-0.00000894	0.0299	0	0.0364	0	0	0	0
	(0.00958)	(0.0164)	(.)	(0.0177)	(.)	(.)	(.)	(.)
VIX Index	-0.0317*	-0.0267			-0.0227*	-0.0223*		
	(0.0141)	(0.0196)			(0.00940)	(0.00949)		
US growth (t-1)	0.0105	-0.0141			0.00118	0.000207		
	(0.0437)	(0.0474)			(0.0125)	(0.0131)		
EMBI	-0.000148	-0.0000679	-0.0000875	0.000158				
	(0.000204)	(0.000220)	(0.000183)	(0.000223)				
VIX Index x Rule of Law (t-1)	0.000235	0.0000260	0.000312	0.000253	0.000393	0.000203	0.000448	0.000296
	(0.000519)	(0.000539)	(0.000522)	(0.000439)	(0.000424)	(0.000392)	(0.000460)	(0.000429)
Constant	1.195**	1.867	6.546**	-1.320	0.801**	0.751	4.295	0.0757
	(0.411)	(0.946)	(2.417)	(2.110)	(0.274)	(0.532)	(2.423)	(1.189)
Pooling	Yes	No	No	No	Yes	No	No	No
Country FE	No	Yes	No	Yes	No	Yes	No	Yes
Time FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	103	103	103	103	183	183	183	183

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.16 – Probability of Issuance regressions: Non-Linear Marginal Effects - Bloomberg Commodities Index (BCOM)

	Dependent variable:					
	Probability of PPG Bond Issuance					
	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDPpc) (t-1)	0.244*	0.249*	0.000585	0.246**	0.241**	0.0581
	(0.101)	(0.101)	(0.000446)	(0.0793)	(0.0798)	(0.366)
GDP growth (t-1)	-0.0165	-0.0190	-0.0000200	-0.00310	-0.00356	-0.000376
	(0.0155)	(0.0135)	(0.0000274)	(0.00771)	(0.00770)	(0.00247)
Current Account to GDP (t-1)	0.00638	0.00443	0.0000374	0.00479	0.00421	0.000660
	(0.0107)	(0.00785)	(0.0000489)	(0.00313)	(0.00308)	(0.00431)
Reserves Assets/Months of Imports (t-1)	-0.0477	-0.0497	-0.0000560	-0.0632	-0.0658	-0.00261
	(0.0589)	(0.0581)	(0.0000861)	(0.0382)	(0.0355)	(0.0176)
Government Debt to GDP (t-1)	-0.00327	-0.00356	-0.000000387	-0.00148	-0.00194	-0.000401
	(0.00367)	(0.00347)	(0.00000630)	(0.00260)	(0.00249)	(0.00265)
Inflation (t-1)	-0.0132	-0.0139	-0.00000411	-0.0151	-0.0147	-0.000382
	(0.00993)	(0.0100)	(0.0000188)	(0.00906)	(0.00895)	(0.00277)
Private Credit to GDP (t-1)	-0.00471	-0.00523	-0.0000401	-0.00385*	-0.00382*	-0.000927
	(0.00283)	(0.00272)	(0.0000517)	(0.00195)	(0.00192)	(0.00608)
IMF Support	-0.0457	-0.0462	-0.000130	-0.0812	-0.0814	-0.00252
	(0.0517)	(0.0546)	(0.000123)	(0.0636)	(0.0625)	(0.0162)
Rule of Law (t-1)	0.00554*	0.00553*	0.0000393	0.00424*	0.00448**	0.000264
	(0.00232)	(0.00219)	(0.0000445)	(0.00165)	(0.00165)	(0.00140)
VIX Index	-0.0367**	-0.0363**	-0.0000291	-0.0208	-0.0188*	-0.000996
	(0.0135)	(0.0129)	(0.0000426)	(0.0118)	(0.00955)	(0.00656)
US growth	0.0963	0.0923*	0.0000315	0.0257	0.0219	0.000883
	(0.0534)	(0.0464)	(0.0000773)	(0.0182)	(0.0156)	(0.00610)
BCOM Index	0.0303*	0.0296*	0.0000511	0.00999	0.00752	0.000890
	(0.0145)	(0.0148)	(0.0000475)	(0.00687)	(0.00626)	(0.00515)
EMBI	-0.000442*	-0.000464*	-0.000000325			
	(0.000214)	(0.000208)	(0.000000480)			
RE Logit	Yes	No	No	Yes	No	No
RE Probit	No	Yes	No	No	Yes	No
Conditional Logit (Country FE)	No	No	Yes	No	No	Yes
Observations	103	103	102	183	183	165

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.17 – Probability of Issuance regressions: LPM - Bloomberg Commodities Index (BCOM)

	Dependent variable:							
	Probability of PPG Bond Issuance							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log(GDPpc) (t-1)	0.192	0.652	0.248**	1.201	0.196*	0.657	0.192*	0.473
	(0.103)	(0.797)	(0.0934)	(1.171)	(0.0782)	(0.604)	(0.0756)	(0.730)
GDP growth (t-1)	-0.0109	-0.0108	-0.0110	-0.00857	0.000797	-0.00640	0.00109	-0.00678
	(0.0138)	(0.0120)	(0.0119)	(0.0118)	(0.00922)	(0.00914)	(0.00904)	(0.00898)
Current Account to GDP (t-1)	0.00305	0.0369***	0.000836	0.0380**	0.00439	0.00677	0.00413	0.00633
	(0.00683)	(0.00676)	(0.00645)	(0.0104)	(0.00284)	(0.00352)	(0.00297)	(0.00356)
Reserves Assets/Months of Imports (t-1)	-0.0403	-0.114	-0.0286	-0.0646	-0.0681*	-0.0907*	-0.0545	-0.0792*
	(0.0482)	(0.0642)	(0.0442)	(0.0667)	(0.0294)	(0.0331)	(0.0307)	(0.0342)
Government Debt to GDP (t-1)	-0.00203	-0.00295	-0.00296	-0.00602	-0.000685	-0.00482	-0.000104	-0.00459
	(0.00279)	(0.00653)	(0.00289)	(0.00751)	(0.00194)	(0.00417)	(0.00220)	(0.00452)
Inflation (t-1)	-0.00970	-0.00176	-0.0134	-0.00823	-0.00738	0.00205	-0.00923	-0.0000212
	(0.0112)	(0.0170)	(0.0105)	(0.0176)	(0.00664)	(0.00785)	(0.00770)	(0.00943)
Private Credit to GDP (t-1)	-0.00422	-0.0350	-0.00559	-0.0503*	-0.00280	-0.00813	-0.00316	-0.00891
	(0.00309)	(0.0169)	(0.00323)	(0.0195)	(0.00214)	(0.00657)	(0.00216)	(0.00730)
IMF Support	-0.0263	-0.0490	-0.0187	-0.00766	-0.0890	-0.0634	-0.0760	-0.0519
	(0.0736)	(0.126)	(0.0788)	(0.131)	(0.0697)	(0.0717)	(0.0683)	(0.0678)
Rule of Law (t-1)	0.00376*	0.0398*	0.00397*	0.0401*	0.00409*	0.00888	0.00408*	0.0100
	(0.00165)	(0.0151)	(0.00168)	(0.0151)	(0.00200)	(0.00890)	(0.00197)	(0.00857)
VIX Index	-0.0292***	-0.0209			-0.0136**	-0.0166*		
	(0.00696)	(0.0133)			(0.00521)	(0.00751)		
US growth (t-1)	0.0343	-0.0234			0.00416	-0.000925		
	(0.0379)	(0.0458)			(0.0121)	(0.0133)		
BCOM Index	0.0220	0.0412			0.00294	0.0115		
	(0.0184)	(0.0286)			(0.00680)	(0.0150)		
EMBI	-0.000160	-0.0000583	-0.0000553	0.000192				
	(0.000189)	(0.000225)	(0.000169)	(0.000192)				
Constant	-1.446							
	(2.294)							
Pooling	Yes	No	No	No	Yes	No	No	No
Country FE	No	Yes	No	Yes	No	Yes	No	Yes
Time FE	No	No	Yes	Yes	No	No	Yes	Yes
Observations	103	103	103	103	183	183	183	183

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.18 – EMBIG regressions - IMF ECF/SCF Support Arrangement

	Dependent variable:			
	EMBIG Index			
	(1)	(2)	(3)	(4)
Log(GDPpc) (t-1)	−55.843	−1,052.293***	−53.175	−1,083.911***
	(74.493)	(166.963)	(71.648)	(346.990)
GDP growth (t-1)	−24.123***	−9.856	−21.683**	−8.186
	(8.780)	(6.732)	(8.713)	(6.907)
Current Account to GDP (t-1)	−8.496**	−4.563	−7.448**	−6.101
	(3.897)	(4.882)	(3.431)	(4.412)
Reserves Assets/Months of Imports (t-1)	−39.997*	−61.748***	−39.491*	−83.339***
	(22.425)	(20.982)	(21.313)	(27.232)
Government Debt to GDP (t-1)	4.122**	8.335***	5.542***	7.811***
	(1.912)	(2.882)	(1.947)	(2.510)
Inflation (t-1)	11.719*	19.039***	11.668**	20.613***
	(6.559)	(7.325)	(5.802)	(5.767)
Private Credit to GDP (t-1)	−2.880	12.976*	−2.482	16.776*
	(2.276)	(7.511)	(2.169)	(8.907)
IMF PRGT-ECF Support	32.234	−108.741	43.466	−122.070***
	(43.416)	(75.232)	(39.636)	(44.319)
IMF PRGT-SCF Support	54.126	27.344	31.853	−27.784
	(106.018)	(104.262)	(85.619)	(86.826)
Rule of Law (t-1)	−1.314	0.352	−1.893	−2.627
	(1.033)	(4.749)	(1.209)	(3.640)
VIX Index	14.603**	3.231		
	(6.961)	(6.969)		
US growth (t-1)	58.674***	96.088***		
	(12.757)	(13.274)		
Constant	324.448**			
	(163.742)			
Pooling	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*
Observations	99	99	99	99
R^2	0.524	0.487	0.551	0.482
Adjusted R^2	0.458	0.330	0.436	0.242

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.19 – EMBIG regressions - VIX x Rule of Law interactions

	Dependent variable:			
	EMBIG Index			
	(1)	(2)	(3)	(4)
Log(GDPpc) (t-1)	−50.608	−1,018.684***	−35.938	−527.909
	(76.929)	(179.063)	(77.145)	(365.441)
GDP growth (t-1)	−24.201***	−11.502**	−21.452**	−10.278**
	(9.204)	(5.535)	(8.795)	(5.039)
Current Account to GDP (t-1)	−7.513*	−5.891**	−6.447*	−7.529***
	(3.944)	(2.637)	(3.424)	(2.589)
Reserves Assets/Months of Imports (t-1)	−40.423*	−62.849***	−37.928*	−67.040***
	(20.711)	(16.178)	(21.355)	(22.196)
Government Debt to GDP (t-1)	5.002***	9.595***	6.597***	11.011***
	(1.824)	(2.373)	(2.143)	(1.729)
Inflation (t-1)	10.071	18.470***	9.121	17.445***
	(7.399)	(6.863)	(6.513)	(4.447)
Private Credit to GDP (t-1)	−2.476	18.427**	−2.616	18.314**
	(2.371)	(8.544)	(2.362)	(8.752)
IMF Support	−49.215	−116.247***	−52.535	−123.872***
	(48.739)	(40.867)	(42.931)	(33.141)
Rule of Law (t-1)	−12.806**	−11.876**	−13.691**	−12.717***
	(5.979)	(5.233)	(5.452)	(2.848)
VIX Index	−2.321	−16.114		
	(13.395)	(10.985)		
US growth (t-1)	49.251***	88.478***		
	(11.060)	(13.020)		
VIX Index x Rule of Law (t-1)	0.659**	0.742**	0.683**	0.781***
	(0.330)	(0.332)	(0.282)	(0.188)
Constant	643.880***			
	(221.852)			
Pooling	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*
Observations	99	99	99	99
R^2	0.550	0.546	0.580	0.551
Adjusted R^2	0.487	0.407	0.472	0.343

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

Table B.20 – EMBIG regressions - Bloomberg Commodities Index (BCOM)

	Dependent variable:			
	EMBIG Index			
	(1)	(2)	(3)	(4)
Log(GDPpc) (t-1)	−58.827	−1,108.834***	−47.778	−997.252***
	(74.200)	(284.135)	(73.582)	(347.839)
GDP growth (t-1)	−24.606**	−10.912	−22.430**	−9.278
	(9.639)	(7.507)	(9.632)	(7.533)
Current Account to GDP (t-1)	−7.939**	−5.329	−7.691**	−6.380**
	(3.947)	(3.718)	(3.634)	(3.148)
Reserves Assets/Months of Imports (t-1)	−39.282*	−64.476***	−43.008**	−82.952***
	(23.725)	(21.937)	(21.744)	(24.900)
Government Debt to GDP (t-1)	4.839**	8.802***	5.543***	8.615***
	(1.879)	(2.762)	(1.964)	(2.476)
Inflation (t-1)	11.139	18.706**	10.742*	19.667***
	(7.032)	(7.277)	(6.373)	(5.289)
Private Credit to GDP (t-1)	−2.414	16.413*	−2.490	18.501*
	(2.092)	(8.375)	(2.098)	(9.485)
IMF Support	−24.213	−91.933*	−31.105	−101.355**
	(53.112)	(50.171)	(46.296)	(40.278)
Rule of Law (t-1)	−1.477	0.934	−2.043	−1.529
	(1.123)	(6.138)	(1.294)	(3.079)
VIX Index	13.804*	2.982		
	(8.135)	(6.169)		
US growth (t-1)	63.958***	96.118***		
	(14.001)	(15.278)		
BCOM Index	8.379	−1.827		
	(7.963)	(12.067)		
Constant	−616.345			
	(937.324)			
Pooling	*Yes*	*No*	*No*	*No*
Country FE	*No*	*Yes*	*No*	*Yes*
Time FE	*No*	*No*	*Yes*	*Yes*
Observations	99	99	99	99
R^2	0.529	0.495	0.550	0.495
Adjusted R^2	0.464	0.339	0.441	0.273

*Robust and clustered standard errors by country. *p<0.1; **p<0.05; ***p<0.01

APPENDIX C – Chapter 4

C.1 Data

C.1.1 List of countries

Table C.1 – List of compounding countries divided by development stage

Advanced Markets (AM)	Emerging Markets (EM)
Australia	Argentina
Austria	Brazil
Belgium	Bulgaria
Canada	Chile
Czech Republic	China
Denmark	Colombia
Finland	Egypt
France	Hungary
Germany	India
Greece	Indonesia
Ireland	Malaysia
Italy	Mexico
Japan	Peru
South Korea	Philippines
Netherlands	Poland
New Zealand	Romania
Portugal	Russia
Slovenia	South Africa
Spain	Thailand
Sweden	Turkey
Switzerland	Ukraine
United Kingdom	Uruguay
United States	

C.1.2 Debt Ownership and Denomination

The debt structure used in this paper is based on Sunder-Plassmann (2020) approach using Arslanalp and Tsuda (2014a) database. In their database, foreign holdings of general government debt exclude foreign official loans, while data on foreign ownership of local-currency central government debt are only available for emerging markets. That is why we obtain shares for the denomination of debt only for emerging economies. As Sunder-Plassmann (2020), we use this measure as a proxy for foreign ownership of local-currency general government debt securities.

We infer debt portfolio shares as the following: First, as described in Section 4.3.1, there is a share δ of debt held by domestic investors. In its turn, x is the total share of nominal debt, defined as the ratio between local currency government debt securities and the general government debt securities. We define the variable y as the external share of nominal debt as the ratio of external local currency central government debt securities and the local currency central government debt securities, all obtained from Arslanalp and Tsuda (2014a) database.

Given these definitions, we can infer values for α, the real share of domestic debt and κ, the real share of external debt as

$$\alpha = 1 - \frac{x(1-y)}{\delta}$$

$$\kappa = 1 - \frac{xy}{1-\delta}$$

Finally, the debt structure in our empirical motivation can be summarized as Table C.2:

Table C.2 – Debt Structure

	Nominal	Real	Nom+Real
Domestic	$\delta(1-\alpha)$	$\delta\alpha$	δ
External	$(1-\delta)(1-\kappa)$	$(1-\delta)\kappa$	$1-\delta$
Int+Ext	x	$1-x$	1

C.2 Model

C.2.1 Resource Constraint

In the market clearing conditions presented in Section 4.4.3, Equation (4.15) described our resource constraint in *LC Economy*. However, it would be useful to reduce the dimension of our problem in order to turn the computational procedure feasible. One option for that is to write the problem in a recursive manner, following Ottonello and Perez (2019).

For this, we take the solution for aggregate price in (4.12) and define the real exchange rate (RER) ε_t as

$$\varepsilon_t = \frac{e_t}{P_t} = w\left(\frac{c_{T,t}}{c_{N,t}}\right)^{\omega-1} \tag{C.1}$$

Moreover, from the inflation definition in (4.13) and the RER defined as (C.1), we can re-write our resource constraint (4.15) as

$$c_{T,t} = y_{T,t} + \frac{1}{\pi_t P_{t-1}\varepsilon_t}(q_t b_{t+1} - b_t) \tag{C.2}$$

Then, denoting an arbitrary detrended variable as $\hat{x}_t = \frac{x_t}{P_{t-1}}$ and defining $\tilde{q}_t = \frac{q_t}{\varepsilon_t}$ as the detrended price of the bond, we obtain a dimension-reduced detrended resource constraint:

$$c_{T,t} = y_{T,t} + \tilde{q}_t\hat{b}_{t+1} - \frac{1}{\varepsilon_t\pi_t}\hat{b}_t \tag{C.3}$$

C.2.2 Solution Algorithm

The equilibrium dynamics are approximated by value-function iteration over a discretized state space. We run two versions of the model: A *FC Economy* assuming only real inflation-linked debt and a *LC Economy* model when government bond is assumed to be nominal. First, we discretize the exogenous process for tradable output using 200 equally space points for $\ln y_{T,t}$. To construct the transition probability matrix of the process, we apply the procedure proposed by Schmitt-Grohé and Uribe (2016), simulating a time series of length 10 million drawn from process described in (4.8). Also, as described in Appendix C.2.1, for the *LC Economy* set-up, we incur to a detrended version of our economy in order to reduce the dimension of our problem and turn the computation more feasible. Thus, the algorithm is based in the resource constraint described by Equation (C.3). The rest of algorithm can be written as the following:

1. Discretize the exogenous AR(1) process for y_T.
2. For each economy, create an equally spaced grid for $\hat{B}$.[1]
3. Create an equally spaced grid for π.[2]
4. Guess price schedules for the economy $\tilde{Q}^0$.
    a) Calculate tradable consumption in autarky $c_T = y_T^{def}$ and the value of permanent autarky.
    b) Calculate $\hat{B}'$ in repayment given prices and the continuation value V^0.
    c) Calculate value of repayment V^R given optimal policies and continuation value.
    d) Calculate the value of default V^D given V^0.
    e) Derive default policies comparing the value functions at each grid point.
    f) Update the new value function V^1 as the maximum of the value of default and repayment.
    g) Substitute $V^1 = V^0$.
    h) Repeat (ii)-(vii) until convergence in value function.
5. Given optimal default policies, calculate $\tilde{Q}$ using pricing rule derived from the detrended economy in C.2.1.
6. Update prices and repeat until convergence in $\tilde{Q}$.

After prices converge, we derive the policy functions for bond $b = P_{t-1}\hat{b}$ and inflation π, together with the bond price schedule for $q = \varepsilon\tilde{q}$ and then simulate the model economy 100,000 time periods from the theoretical model. We discard the first 10,000 periods to avoid any dependence on the starting conditions. Then, we identify the dynamics for default, debt issuance, the real exchange rate and inflation as a function of the outstanding debt, along with the bond price schedule.

As last remark, for our model economy, the optimal inflation in response to default is zero. Thus, we plot the dynamics for this variable in the case the government chooses to honor its obligations, even when default is the optimal choice.

[1] It was used 61 grid points.
[2] For inflation, it was used 121 grid points.