ABSTRACT

Title of Dissertation: ESSAYS ON CURRENCIES, CORPORATE BORROWING, AND INTERNATIONAL MACROECONOMICS

Seungeun Lee
Doctor of Philosophy, 2024

Dissertation Directed by: Professor Şebnem Kalemli-Özcan
Department of Economics

This dissertation studies corporate real and financial decisions in responses to the global macroeconomic environment. In Chapter 1, I study the dynamic relation between dollar invoicing in exports, dollar borrowing, and the global financial cycle. I document a positive co-movement between dollar invoicing in exports and firms' dollar borrowing, and also a positive link between dollar borrowing and the VIX. I write down a model consistent with these correlations: during global financial downturns when the VIX is high and dollar liquidity is tight, firms increase dollar invoicing to secure dollar revenues, facilitating dollar borrowing with these revenues as collateral. The model shows that an endogenous increase in dollar invoicing amplifies the responsiveness of dollar borrowing to positive global risk shocks (or safety shocks), affecting responses in variables like UIP premium, exchange rates, and foreign asset holdings. Empirical evidence from a comparison between Turkey and Thailand supports these insights.

Chapter 2 presents both empirical and theoretical analyses about the effects of macroprudential policy measures (MPMs). I first examine the impacts of MPMs on the response of corporate loans to a U.S. monetary expansion, using panel data constructed from Dealscan database, IMF macroprudential policy index (MPI), and other macro variables. I find that MPMs attenuate the increase in corporate loans responding to a U.S. monetary expansion, but the effects are dampened as the country's share of foreign loans goes up. This is because firms borrow more across borders with a decrease in the U.S. rate but MPMs cannot regulate the international borrowing. The introduction of capital flow management measures (CFMs) helps MPMs in managing corporate loans since they regulate capital inflows directly. My findings from a two-period model are consistent with the empirical evidence. I find that a special case of MPM, concentration limits, reduces the level and the growth of corporate loans when there is a decrease in the global interest rate. However, the effects of the MPM are dampened when firms are allowed to increase foreign borrowing, which can be resolved with the introduction of CFMs. An additional constraint imposed by a CFM sets a lower bound for a measure of the effectiveness of MPMs by limiting firms from borrowing overly from abroad.

ESSAYS ON CURRENCIES, CORPORATE BORROWING, AND INTERNATIONAL MACROECONOMICS

by

Seungeun Lee

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, College Park in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2024

Advisory Committee:
Professor Şebnem Kalemli-Özcan, Chair
Professor Pierre De Leo
Professor John Shea
Dr. Ruchir Agarwal
Professor Liu Yang

Dedication

To my parents and SY

Acknowledgments

I am indebted to the individuals whose contributions made this dissertation possible. Foremost among them is my advisor, Şebnem Kalemli-Özcan, whose advice, guidance, and encouragement have been instrumental over the past few years. She not only taught me the ways of scholarly thinking but also helped shape my academic contributions from the seed of a naive idea. I am grateful for her unwavering support of my research interests and for enriching them with her expertise and feedback.

My deep gratitude extends to Pierre De Leo, who generously invested time in collaborating on model building and discussing not only theoretical concepts but also my personal interests and career aspirations. His encouragement has consistently propelled me forward during moments of doubt, and I have always felt supported in pursuing my academic interests. I express sincere appreciation to John Shea for his meticulous review of multiple drafts of my second chapter. His guidance encompassed various aspects of storytelling, analysis, and writing, significantly enhancing the quality of my work.

I am thankful for the meaningful comments and guidance provided by my mentor, Ruchir Agarwal. His adeptness in articulating key points and expediting the research process has empowered me to grow as a scholar. I value the insightful discussions we have had, ranging from initial ideas to fully developed papers, which have enriched my academic journey. Special thanks are due to Liu Yang for readily agreeing to serve as the Dean's Representative upon my request.

Above all, I am deeply grateful to my family for their constant support and love. My parents, Jaee Hye Cho and Beom Jaee Lee, have been by my side, offering endless support throughout my life. Their belief in my pursuits and prioritization of my happiness have been fundamental to my journey. Finally, I extend thanks to my dearest Seyoung Jeon, whose presence enabled me to successfully complete this dissertation.

Table of Contents

List of Tables

List of Figures

Chapter 1: Dollar Invoicing and the Global Financial Cycle

1.1 Introduction

Recent literature in international macroeconoimcs has studied the choice of invoicing currencies in global markets, as demonstrated by works such as Goldberg and Tille (2008), Gopinath (2016), and Gopinath et al. (2020). Building on Engel (2006)'s seminal work, macroeconomic research has provided both theoretical and empirical analyses of the endogenous choice of invoicing currency in international trade pricing, including studies by Gopinath et al. (2010), Amiti et al. (2020), and Mukhin (2020). In particular, Gopinath and Stein (2019) argue for a significant role of firms' borrowing decisions in invoicing currency choice. However, the existing literature remains silent on the dynamic variations in firms' invoicing currency preferences over time. In this paper, I empirically document time-varying trends in dollar invoicing shares influenced by global risk factors and provide a theoretical explanation for these dynamics.

The purpose of this paper is to gain insight into the dynamics related to currency choices for invoicing in exports and borrowing, and to explore their roles in the propagation of shocks and policy effects. I first provide empirical observations about fluctuations in dollar invoicing and borrowing shares. Then, I present a theoretical model to elucidate the underlying mechanisms behind these observations. I begin with a baseline model that illustrates how a global risk shock increases the inclination of emerging market (EM) exporters to borrow in dollars instead of their own currency. Here, the global risk shock is an external shock in global uncertainty.[1] This, in turn, leads to an increased share of dollar invoicing in exports, because exporters seek to secure more dollar revenues that can be used as collateral to increase their dollar borrowing. I further extend the model to explore the dynamic responses of macro variables such as exchange rates, foreign asset accumulation, the price level, and output, to a positive global risk shock. I examine policy implications by relaxing several assumptions made in the baseline model, which is supported by empirical evidence comparing Turkey and Thailand.

Based on newly provided data on invoicing currency from Boz et al. (2020), I present two key empirical findings. First, for non-U.S. countries, there is a positive co-movement between dollar invoicing shares in exports and dollar borrowing shares over time.[2] Second, dollar borrowing shares are positively correlated with the VIX (the Chicago Board Options Exchange'sVolatility Index), a proxy for the global financial cycle. This indicates that during a global financial downturn, firms tend to borrow more in dollars. These empirical facts can be linked to the findings by di Giovanni et al. (2021), Kalemli-Ozcan et al. (2020), and Kalemli-Ozcan and Varela (2022), which present co-movements among firms' foreign currency borrowing, the UIP (Uncovered Interest Parity) premium, and the VIX. Notably, di Giovanni et al. (2021) show a positive co-movement between the shares of foreign currency loans and the VIX using Turkish data. Using the country-level data on invoicing currency choices in exports, I add empirical facts that establish a connection between firms' dollar invoicing decisions, dollar borrowing choices, and the global financial cycle.

[1]The theoretical definition of the global risk shock follows Kekre and Lenel (2021), defining it as an exogenous shock in the convenience yield on safe dollar assets. The paper refers to the shock as a "safety shock."

[2]Based on Amiti et al. (2020)'s finding that invoicing currency choice is significantly affected by exporters' characteristics rather than importers', I focus solely on invoicing shares in exports.

I propose the following mechanism to link these observations: When the VIX increases, the expected return on the home currency in non-U.S. countries relative to the dollar (the UIP premium) rises, reducing the relative cost of dollar borrowing. This shift occurs because heightened global uncertainty leads to an increased global demand for saving in dollars, driven by a higher non-pecuniary value (convenience yield) associated with holding safe dollar assets. As a result, firms are incentivized to increase the dollar share in their total borrowing. However, firms are often constrained in their ability to borrow in dollars due to their exposure to exchange rate risk. Lenders frequently require dollar-denominated collateral for dollar borrowing, motivating exporters to increase the share of dollar invoicing in their exports, thus securing more dollar revenue (see Gopinath and Stein (2019)). Consequently, both the shares of invoicing and borrowing in dollars tend to increase during global financial downturns. I present a regression analysis that establishes a close link between dollar invoicing and dollar borrowing, even when controlling for the VIX and the UIP premium in each country.[3]

To formalize this mechanism, I introduce a baseline model that incorporates endogenous shares of dollar invoicing and dollar borrowing by firms. This model extends the framework developed by Gopinath and Stein (2019) into a dynamic setup, integrating elements from Kekre and Lenel (2021) related to the "non-pecuniary" value associated with saving in dollars. The model consists of two countries: the U.S. and an EM. In this model, risk-averse depositors in the EM make choices regarding the currency in which they save — choosing between the dollar and the EM currency. These depositors have a non-pecuniary preference for holding safe dollar assets. Initially, they save in dollars by lending to domestic firm-bank coalitions, which are also

[3]The purpose of the regression analysis is not to establish causality but rather to demonstrate close relationships among the variables.

exporters. However, if EM firms cannot produce enough safe dollar assets to meet the demand for dollar savings from EM depositors, these depositors will seek out the foreign market and opt to save in safe dollar assets in the U.S. U.S. depositors save exclusively in dollar assets and in the U.S.

Exporters use deposits to finance their production by investing in capital. In my model, U.S. exporters exclusively receive payments in dollars when they sell their final goods. On the other hand, EM exporters choose the currency in which they invoice their exports. They decide on the share of dollar invoicing, while the remaining portion is invoiced in their home currency. They are motivated to invoice in dollars because EM exporters are constrained when borrowing in dollars, primarily due to the risk associated with exchange rate fluctuations if all their revenues are denominated in the EM currency. In addition, EM lenders may prefer not to extend dollar lending during financial downturns. Unless they can secure dollar collateral. To overcome this constraint and access dollar borrowing, EM exporters secure dollar-denominated revenues, often by increasing the share of dollar invoicing in their exports, thereby providing the necessary dollar collateral.

Suppose there is an exogenous increase in the non-pecuniary value of safe dollar assets, referred to as a global risk shock. This leads to an increase in the demand for saving in dollars, resulting in decreased returns for dollar saving. This means that the EM currency offers a higher risk premium, increasing the UIP premium. When the UIP premium rises, EM exporters seek to increase the share of dollar borrowing due to the reduced cost of borrowing in dollars compared to borrowing in EM currency. Suppose initially that the dollar invoicing share remains fixed. While the lower cost of dollar borrowing allows EM exporters to increase their dollar share of borrowing by a certain amount, they are unable to secure additional dollar collateral. Thus, they cannot meet the heightened demand for safe dollar assets from EM depositors. In response, EM depositors turn to U.S. safe dollar assets. This leads to an increased accumulation of foreign assets by the EM, boosting the demand for the dollar. As a result, the dollar appreciates, and the EM's exports increase.

Now, suppose EM firms can endogenously choose the currency for invoicing. In response to the global risk shock, exporters opt to increase the share of dollar invoicing to secure more dollar revenues. This enables them to borrow more in dollars, which, in turn, allows EM depositors to hold more safe dollar assets in domestic markets. Therefore, depositors are less inclined to transfer their savings to the U.S., resulting in a reduced foreign asset accumulation for the EM.[4] As a result, the impact of the global risk shock on dollar appreciation is dampened. The model highlights the role of endogeneity in the invoicing currency choice for exports in amplifying the response of EM firms' dollar borrowing while mitigating the appreciation of the dollar when faced with a global risk shock. By increasing the share of dollar invoicing in exports, EM exporters can secure more dollars for collateral to supply more safe dollar assets. This, in turn, bolsters the domestic asset market for safe dollar assets, reducing the need for depositors to save outside the country. Therefore, the increase in EM's foreign asset accumulation and the appreciation of the dollar are both attenuated.

I verify the robustness of this mechanism with an extended model, relaxing several assumptions in the baseline by adding consumption dynamics, labor, and monetary policy. The model, calibrated to Turkey and the U.S., revalidates the mechanism described above. It shows that an endogenous increase in the share of dollar invoicing in exports further amplifies dollar

[4]In this model, it is not possible for EM exporters to exclusively invoice all their exports in dollars and fully satisfy the domestic depositors' demand for saving in dollars due to the associated costs of dollar invoicing. The cost of dollar invoicing is assumed to be substantial enough to ensure that the EM's foreign asset accumulation remains positive.

borrowing of exporters and dampens the responses of other macro variables, to a global risk shock. In addition, I find that these amplifying/dampening effects also occur in response to U.S. and domestic monetary shocks. An exogenous increase in the U.S. interest rate through U.S. monetary tightening raises the UIP premium due to the EM monetary authority's response to control inflation caused by higher import prices. This, in turn, makes dollar borrowing relatively cheaper. When EM exporters can endogenously adjust the share of dollar invoicing in their exports, they further increase their borrowing in dollars, dampening the responses of the UIP premium and the exchange rate, similar to the global risk shock case. The same logic applies to an EM monetary tightening, after which an additional increase in dollar borrowing shares, driven by the increased share of dollar invoicing, prompts depositors to reduce foreign asset holdings further, amplifying the responses of the exchange rate and output.

To assess whether this theoretical insight finds support in the data, I compare the empirical responses of Turkey and Thailand to external shocks. I study these two countries because Turkey experiences high volatility in dollar invoicing shares in exports, indicating frequent changes in firms' invoicing currency choices. In contrast, Thailand maintains a relatively stable share of dollar invoicing.[5]

Examining the impulse responses of macro variables to a positive global risk shock, I observe that Turkey's dollar borrowing share increases more than that of Thailand, by 0.56 percentage point, while the responses of other variables are less pronounced in Turkey. A positive

[5]The reason behind the discrepancy between volatilities of invoicing currency choices in Turkey and Thailand may lie in their locations and trading partners. Turkey, which is located close to Europe, trades with many European countries including Germany, United Kingdom, Italy, Spain, and France. A significant euro share of invoicing in Turkish exports can be attributed to this, explaining relatively large fluctuations of dollar invoicing shares with the other portions invoiced in euros. On the other hand, Thailand does not observe large changes in invoicing currency shares, as most of their exports are steadily invoiced in dollars. The main trading partners of Thailand include Japan, Singapore, and Malaysia, where we expect a large share invoiced only in dollars. Thailand observes a very low fluctuation of dollar invoicing shares, fluctuating around 87%.

global risk shock is proxied by an exogenous increase in the VIX, and the dynamic responses are obtained through a local projection method. The share of dollar borrowing increases more significantly in Turkey compared to Thailand, by about 0.7 percentage points, while the increases in exchange rates and net exports are approximately 0.12 and 0.21 percentage points smaller in Turkey.[6] Through this analysis, I confirm the role of invoicing currency choice in either dampening or amplifying the responses of EMs to external shocks, as elucidated in the theoretical framework. This empirical evidence aligns with the theoretical predictions and underscores the significance of invoicing currency decisions in shaping EMs' responses to external shocks.

In sum, this paper primarily focuses on how exporters determine their invoicing currency choices in response to the global financial cycle and how endogenous invoicing affects aggregate responses to shocks. By connecting Gopinath and Stein (2019) and Kekre and Lenel (2021), I unveil a crucial mechanism that connects the decision to borrow in dollars with the choice of invoicing currencies, particularly in relation to global risk. This linkage allows for an examination of how shocks spread and the impact of policies in EMs, which can be either amplified or mitigated due to the endogenous response of invoicing currency choice. Understanding the dynamics of invoicing currency choices is essential for policymakers and researchers, as it plays a significant role in shaping economic outcomes during periods of global financial uncertainty.

1.1.1 Related Literature

Recent papers have emphasized the important role of invoicing currency choices in open economies. Goldberg and Tille (2008), Gopinath (2016), Gopinath et al. (2020), and Boz

[6] To compare the impacts of global risk shocks in two different countries, I attempt to mitigate the effects of country-specific characteristics by controlling for each country's capital account balance and incorporating lags of all variables in the specifications. This approach enhances the robustness of the comparison, particularly during periods when Turkey experienced a current account deficit while Thailand had a current account surplus.

et al. (2020) highlight the significance of the U.S. dollar as a dominant unit of account. In particular, Gopinath et al. (2020) introduce a novel open-economy framework that incorporates the Dominant Currency Paradigm (DCP), shedding light on exchange rate pass-through as a consequence of price stickiness. Zhang (2020) studies the role of invoicing currencies in transmitting U.S. monetary policy, while Barbiero (2020) investigates firms' currency mismatches arising from disparities in the invoicing currencies of their exports and imports. However, these papers primarily examine the impact of various invoicing currencies based on observed currency shares within their respective contexts.

A few papers have explored the endogenous choice of invoicing currency in international trade. Building on the seminal work of Engel (2006), which suggests a connection between currency choice and a firm's pricing decisions, Gopinath et al. (2010) provide a model that accounts for the endogenous invoicing currency choice in a dynamic environment. Mukhin (2020) extends these currency choice models to real-world data, finding that firm-specific characteristics, such as import intensity and size, play important roles in determining the invoicing currency. Amiti et al. (2020) and Javadekar et al. (2021) also match firm-level invoicing currency data with firm-level characteristics to examine firms' endogenous currency invoicing choices. However, these studies have largely remained silent regarding the dynamics and variations in invoicing behaviors over time. My contribution to this literature lies in investigating the cyclical co-movements of dollar invoicing choices with dollar borrowing shares empirically, while also presenting a model that offers insights into how invoicing and borrowing decisions are dynamically linked and how endogenous invoicing affects aggregate responses to shocks.

The idea of connecting real and financial outcomes to assess the significance of the U.S. dollar as an invoicing currency was first suggested by Gopinath and Stein (2019). Their work introduces a feedback loop between dollar invoicing and the demand for safe dollar assets. As the share of dollar invoicing in international trade increases, domestic importers pay more of their expenses in dollars. This, in turn, leads to a heightened demand for safe dollar assets, resulting in an increase in the safety premium. This increased privilege encourages firms to borrow in dollars, and consequently, they choose to invoice more of their exports in dollars, as it ensures dollar revenues in the following period. However, the starting point of this feedback loop is not clearly defined in the work of Gopinath and Stein (2019). In my paper, I propose the global financial cycle as one of the potential factors that drives firms' decisions regarding invoicing currency and borrowing. Specifically, firms' dollar borrowing shares increase because dollar borrowing becomes more attractive when importers are obligated to pay more for their imports in dollars. I suggest that the UIP condition is violated due to an increase in the non-pecuniary value of safe dollar claims, particularly during global financial downturns. This links firms' choices for invoicing and borrowing currencies to the global risk cycle.

By presenting the effects of a shock to the demand for safe dollar claims while considering endogenous invoicing currency choices, I contribute to the broader literature that examines convenience yields (Engel (2016), Engel and Wu (2020), Jiang et al. (2020), Jiang et al. (2021), and Valchev (2020)). Notably, I connect the insights of Gopinath and Stein (2019) with the work of Kekre and Lenel (2021), which investigates the consequences of time-varying demand for safe dollar assets. In particular, Kekre and Lenel (2021) quantifies the impacts of safety shocks, considering heterogeneity in risk-bearing capacity, to study the global transmission of monetary and fiscal policies. It's important to note that in the framework of Kekre and Lenel (2021), all domestically produced goods are invoiced in the domestic currency. By instead endogenizing the choice of invoicing currency, I illustrate how the effects of a global risk shock can be mitigated or amplified.

In addition to studying the role of endogenous invoicing currency decisions in the propagation of shocks related to convenience yields, I contribute to the literature on the policy implications of invoicing currency. I provide insights into how policy impacts are amplified or dampened as the choice of invoicing currency endogenously responds to policy shocks. Recently, the international macro literature has emphasized the importance of invoicing currency for the dynamics of the economy, especially concerning exchange rates and terms of trade. Gopinath et al. (2020) and Boz et al. (2020) focus on the impacts of policy shocks when exports are invoiced in dollars rather than in the home currency in small open countries. Meanwhile, Corsetti and Pesenti (2007), Devereux and Engel (2003), and Egorov and Mukhin (2023) provide analyses of the importance of invoicing currency in studying international policy spillovers and optimal exchange rate policies. Adding to this literature, I focus on the role of *endogenous* changes in the share of dollar invoicing in studying the response to policy shocks, rather than solely focusing on the role of different currencies of pricing.

1.1.2 Layout

The rest of this paper proceeds as follows. Section 1.2 provides the empirical observations that serve as the foundation of this paper. Section 1.3 introduces a baseline model, while Section 1.4 provides analytical insights derived from this model. Section 1.5 extends the model and studies dynamic responses, and Section 1.6 concludes.

Table 1.1: An Example of Valuation Effects

	Dollar-invoiced	Yen-invoiced
Value in invoicing currency	\$1M	¥100M
¥100 = \$1		
Value in \$	\$1M	\$1M
Share of \$ invoicing	50%	50%
¥120 = \$1		
Value in \$	\$1M	\$0.83M
Share of \$ invoicing	54.5%	45.5%

1.2 Empirical Analysis

As indicated in recent papers (Gopinath (2016), Boz et al. (2020)), invoicing currency decisions are relatively stable over time. A specific invoicing currency tends to maintain its dominance and is not frequently displaced by others. However, I observe common patterns in the cyclical movements of invoicing currencies and corporate borrowing across various countries. I present two prominent empirical observations. First, dollar invoicing shares in exports co-move positively with dollar borrowing shares. Second, there exists a positive correlation between the shares of borrowing in dollars and the VIX. Based on these observations, I propose a hypothesis suggesting that exporters' decisions to borrow in dollars may function as a key mechanism linking the global financial cycle and the choice of invoicing currency. I find further empirical support for this proposed mechanism, using panel regression analyses.

1.2.1 Data

Based on an analysis of newly introduced data on invoicing currency presented in Boz et al. (2020), I examine the dynamics of invoicing choices over time. The dataset provides country-level information about the annual shares of exports invoiced in various currencies.[7] The dataset has some missing values. For example, the dollar invoicing data for Croatia spans from 2000 to 2018, but with gaps in 2015 and 2017. To focus on the time-varying and cyclical movements of invoicing shares, I limit my analysis to 21 countries that possess time series data longer than 12 years without any missing values.[8]

Due to the absence of an international standard for the exact definition of trade invoicing shares, there are certain challenges in interpreting the data. In some cases, Boz et al. (2020) proxy for invoicing currency using payment or settlement currency. For instance, the calculation of dollar invoicing shares in South Korea involves the use of settlement currency, whereas invoicing currency is directly applied in the case of Japan. However, survey evidence suggests that, in general, invoicing and settlement currencies tend to coincide in international trade (see Ito et al. (2011) and Friberg and Wilander (2011)). Therefore, in this paper, I use the terms "pricing currency" and "invoicing currency" interchangeably.

Moreover, it is important to acknowledge that the calculation of invoicing shares involves translating transaction values into a common currency, which can introduce significant valuation effects. For example, consider a Japanese firm that exports goods both to the United States (*in dollars*) and to Thailand (*in yen*). Suppose that in 2019, the firm's exports to the U.S. amounted to one million dollars, while its exports to Thailand were valued at a hundred million yen. As

[7] I focus exclusively on shares of invoicing currency in exports, assuming that these decisions are made by exporters. This assumption aligns with previous studies by Engel (2006), Gopinath et al. (2010), and Amiti et al. (2020), who explore the endogenous invoicing currency choices of exporters. Empirically, Amiti et al. (2020) provide evidence suggesting that invoicing currency choices primarily depend on exporters' characteristics rather than importers'.

[8] My sample countries include Australia, Belgium, Brazil, Chile, Colombia, Czech Republic, France, Germany, Greece, Indonesia, Italy, Japan, Luxembourg, New Zealand, Norway, Portugal, Russia, South Korea, Spain, Thailand, and Turkey. This list consists of countries with time series data spanning at least 10 periods of de-trended data after merging with borrowing data from the BIS Global Liquidity Indicators.

illustrated in Table 1.1, if the exchange rate changes from 100 yen per dollar to 120 yen per dollar, the share of dollar invoicing for the firm would change from 50 percent to 54.4 percent, even though there has been no change in the transaction values or invoicing currencies. The appreciation of a specific currency can result in an increase in the shares of invoicing in that currency. To mitigate this currency-related distortion, I adjust the dollar invoicing shares using constant exchange rates from the year 2000, as elaborated in Appendix A.1.1.

For calculating dollar borrowing shares, I use the BIS Global Liquidity Indicators (GLI) database, which draws data from the BIS Locational Banking Statistics and BIS International Debt Securities Statistics. This database allows for the calculation of aggregate shares of dollar borrowing by firms. Specifically, I derive these shares by dividing the total dollar credit to non-financial corporations by total credit to non-financial corporations. The total dollar credit is the sum of debt securities and loans denominated in dollars. The construction of these dollar borrowing shares follows Kalemli-Ozcan et al. (2020).

Table 1.2 provides summary statistics of dollar borrowing shares and dollar invoicing shares across the sample countries. The dataset comprises 21 countries that have annual data available for both invoicing and borrowing currency shares, covering a minimum of 12 consecutive years. On average, approximately 55.8% of exports are invoiced in dollars, while firms' dollar borrowing accounts for 6% of the total. Dollar borrowing shares tend to be lower since they encompass all firms in the respective countries, whereas dollar invoicing shares specifically include only exporters.[9] Dollar invoicing shares exhibit considerable variation, ranging from 7.3% to 99.7%, while dollar borrowing shares range from 0.2% to 40%. The table

[9] "Total credit to non-financial corporations" may include credit extended to firms that do not engage in dollar borrowing. Therefore, the number of firms included in "Total credit" can significantly exceed the number of firms included in "Total dollar credit."

Table 1.2: Summary Statistics

	Mean	Median	Min	Max	Std	Obs	# countries
Dollar Inv. Shares in Exports							
Raw data	55.8	56.7	7.3	99.7	4.6	340	21
Cyclical components	0.0	0.0	-10.9	10.8	2.3	305	21
Dollar Borr. Shares							
Raw data	6.0	3.0	0.2	40.0	7.3	340	21
Cyclical components	0.0	-0.04	-7.0	12.9	1.4	305	21
VIX							
Raw data	19.5	17.6	11.0	31.8	6.0	21	-
Cyclical components	0.0	-1.2	-5.4	10.9	4.1	19	-

Notes: The table presents summary statistics for all observations obtained after merging the datasets for invoicing and borrowing currencies. The variables in the table represent adjusted percentages, as detailed in Appendix A.1.1, for both dollar invoicing and dollar borrowing shares. The corresponding summary statistics for the raw data are presented in the Appendix. Cyclical components are estimated using the Hamilton (2018) filter. *Source: Boz et al. (2020) and BIS Global Liquidity Indicator*

also presents within-country standard deviations, reflecting variations over time. The annual standard deviations for dollar invoicing shares and dollar borrowing shares are 4.6% and 7.3%, respectively. The VIX varies from 11 to 31.8, with a mean value of 19.5. In addition, the table provides summary statistics for the cyclical components of these variables, obtained by detrending the data using the Hamilton (2018) filter. The cyclical components for dollar invoicing shares and dollar borrowing shares range from -10.9 to 10.8 and -7 to 12.9, respectively. The time-series standard deviations indicate that dollar invoicing shares exhibit more variation than dollar borrowing shares, with standard deviations of 2.3 and 1.4, respectively.

1.2.2 Stylized Facts

I present two stylized facts regarding the cyclical fluctuations in dollar invoicing and dollar borrowing shares, observed from the country-level data.

Fact 1: There is a positive co-movement between dollar shares of invoicing in exports and dollar shares of borrowing

Figure 1.1 depicts the cyclical fluctuations in dollar invoicing and borrowing shares. The figure draws the common factors of the de-trended variables, estimated using a dynamic factor model following Stock and Watson (1999). For consistency, I focus on countries with complete data available for the period spanning from 2000 to 2018.[10] The figure demonstrates a positive co-movement between dollar invoicing shares and dollar borrowing shares, indicating a significant correlation of 70%.[11] This finding builds on the work of Gopinath and Stein (2019), who identify a positive cross-section correlation between aggregate dollar borrowing and dollar invoicing shares in imports across different countries. I show that this positive correlation also holds over time.

Fact 2: Dollar borrowing shows a positive co-movement with the VIX

I also explore the relationship between dollar borrowing and the global financial cycle, represented by the VIX. Figure 1.2 illustrates the cyclical dynamics of dollar borrowing shares and the VIX, with the data de-trended using the Hamilton (2018) filter. The blue long-dashed line represents the common factor of dollar borrowing shares, estimated using the dynamic factor model based on Stock and Watson (1999). The red dotted-dashed line depicts the VIX. The

[10] The list of these countries comprises the Czech Republic, France, Greece, Japan, Norway, South Korea, Thailand, and Turkey. Detailed country-by-country correlations for all sample countries can be found in Appendix A.1.3.

[11] I also observe a positive co-movement between dollar invoicing shares and dollar borrowing shares when using non-adjusted data, as presented in Appendix A.1.1.

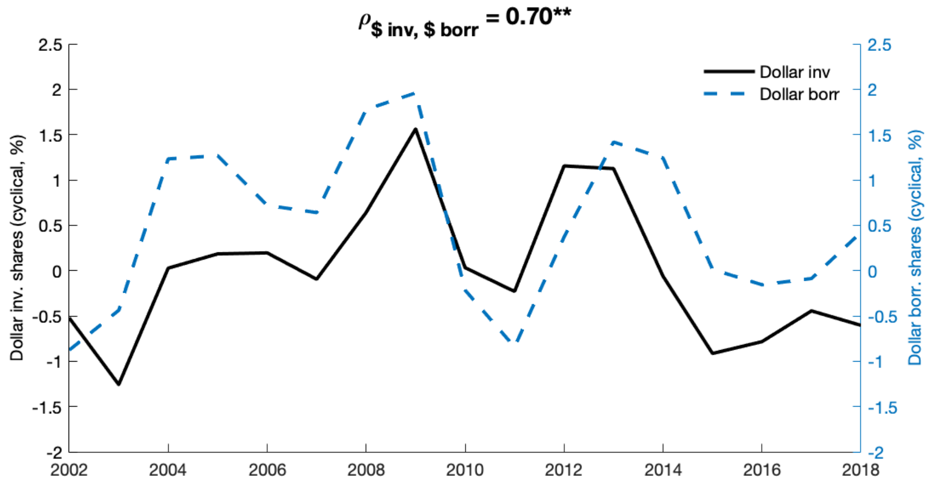

Figure 1.1: Co-movements between Dollar Invoicing and Dollar Borrowing Shares

Notes: The data is annual and covers the period from 2000 to 2018. The series starts from 2002, although the underlying data begin in 2000, as the cyclical components are calculated based on 2-year-ahead forecast errors using the Hamilton (2018) filter. The common factors of dollar invoicing shares and dollar borrowing shares in the sample are estimated using a dynamic factor model (Stock and Watson (1999)). The variables are adjusted to constant exchange rates, following the methods described in Appendix A.1.1. ** indicates significance at the 5% level.

figure shows a notable increase in dollar borrowing shares and the VIX during the 2007-08 global financial crisis, followed by a decrease after the crisis subsided. Moreover, we observe simultaneous increases in both the VIX and dollar borrowing shares after 2012, coinciding with events such as the U.S. taper tantrum and the European crisis.

Several studies have consistently emphasized the close relationship between the global financial cycle and credit markets. For instance, di Giovanni et al. (2021) shows a positive co-movement between firms' foreign currency borrowing and the UIP risk premium in Turkey, both of which exhibit correlations with the VIX. This finding aligns with the observations presented above, given that a substantial portion of Turkey's foreign currency borrowing is denominated in dollars. Similarly, Kalemli-Ozcan and Varela (2022) identify co-movements between UIP premia and the VIX in the context of emerging market countries, suggesting an

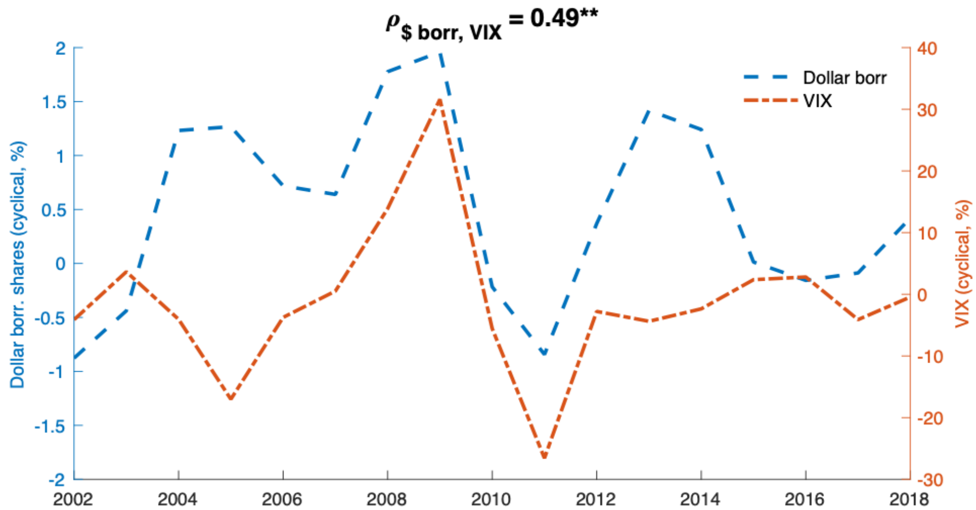

Figure 1.2: Dollar Borrowing Shares and the VIX

Notes: The data is annual and covers the period from 2000 to 2018. The series starts from 2002, because the cyclical components are calculated based on 2-year-ahead forecast errors using the Hamilton (2018) filter. The common factors of dollar borrowing shares are estimated using a dynamic factor model (Stock and Watson (1999)). The variables are adjusted to constant exchange rates, following the methods described in Appendix A.1.1. ** indicates significance at the 5% level.

increased tendency for dollar borrowing during periods of high global risk, when higher expected excess returns on domestic currency make dollar borrowing relatively more affordable. This observation is in line with theoretical arguments by Salomao and Varela (2018a) and Gopinath and Stein (2019), emphasizing that decreases in excess returns for the dollar provide an incentive for dollar borrowing. Adding to these existing findings, I provide an additional observation of a positive co-movement between dollar borrowing and the global financial cycle within my sample countries, complementing the observed positive correlation between dollar borrowing and dollar invoicing shares.

To summarize, I present two stylized facts about the dynamic co-movements of invoicing and borrowing currency decisions. First, dollar invoicing shares in exports positively co-move with dollar borrowing shares of firms.[12] Second, dollar borrowing shares exhibit positive co-movements with the VIX. Drawing from these facts, I propose that dollar borrowing serves as a key channel linking dollar invoicing in exports and the global financial cycle. As the cost of dollar borrowing decreases during periods of global financial instability, firms choose to invoice a larger share of their exports in dollars, thereby securing dollar revenues that can be used as collateral to expand their dollar borrowing. In the next section, I provide a theoretical model that outlines this mechanism in detail.

1.3 The Baseline Model

Possible Mechanism

Consider an exporter who purchases capital K_t for the production of goods. To finance this capital investment, the exporter requires borrowing, which can be in either the home currency, $B_{h,t}$, or in dollars, $B_{\$,t}$:

$$K_t = B_{h,t} + \varepsilon_t B_{\$,t}$$

where ε_t is the exchange rate between the home currency and the dollar, which rises when the dollar appreciates. The exporter decides the currency in which to invoice its exports, choosing between the home currency and the dollar.

I assume that the exporter's dollar borrowing is limited, ensuring that the repayment of

[12] In Appendix A.1.2, I show that these cyclical movements are not solely driven by the performance fluctuations of large exporters.

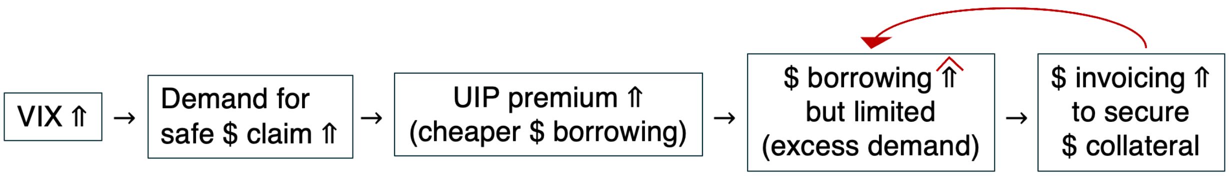

Figure 1.3: Mechanism

dollar debt does not exceed the expected dollar revenue:[13]

$$R_{\$,t}B_{\$,t} \leq \mathbb{E}_t RV_{\$,t+1} \tag{1.1}$$

where $R_{\$,t}$ denotes the dollar borrowing rate, and $\mathbb{E}_t RV_{\$,t+1}$ is the expected revenues denominated in dollars. This constraint effectively requires that firms must use dollar-denominated collateral when engaging in dollar borrowing. This constraint becomes binding when the UIP condition is violated, resulting in an excess return on the home currency. Studies such as Gilmore and Hayashi (2011) and Hassan (2013) document that safe dollar assets typically yield lower expected returns compared to the risk-free assets of most other currencies. Therefore, suppose that the constraint on dollar borrowing is always binding: $R_{\$,t}B_{\$,t} = \mathbb{E}_t RV_{\$,t+1}$. In addition, assume that the borrowing constraint is tight enough that the firm must also secure a positive amount of borrowing in the home currency to finance its production ($B_{h,t} > 0$).

The mechanism underlying the observations in Stylized Facts 1 and 2 is illustrated in Figure 1.3. When the VIX increases, the UIP premium also goes up, as documented in di Giovanni et al. (2021) and Kalemli-Ozcan and Varela (2022), meaning a reduction in the cost of dollar borrowing. This occurs because global investors intensify their demand for holding safe assets

[13] The constraint can be expressed as a multiple of the expected dollar revenue (i.e., $\lambda \mathbb{E}_t RV_{\$,t+1}$ for a constant λ). For simplicity, I focus on the case where $\lambda = 1$.

denominated in dollars, considering the dollar as a safe-haven currency. The heightened demand for dollar-denominated risk-free assets leads to an increase in the price of saving in dollars ($R_{\$,t} \Downarrow$). Then, the constraint on dollar borrowing faced by firms is loosened for a given level of expected dollar revenues. With dollar borrowing now more cost-effective, firms choose to borrow more in dollars ($B_{\$,t} \Uparrow$). This explains the positive co-movement observed between the VIX and dollar borrowing shares in both the existing literature and in Stylized Fact 2.

As dollar borrowing becomes cheaper than borrowing in the home currency, firms seek to increase the share of dollar borrowing. However, the constraint (1.1) limits the extent to which firms can borrow in dollars. In response, firms raise the share of dollar invoicing in their exports, thereby increasing the expected revenues denominated in dollars, $RV_{\$,t+1}$, which can serve as collateral for dollar borrowing. This, in turn, relaxes the constraint on dollar borrowing, allowing the share of dollar borrowing to increase even further. Thus, a high VIX results in an increase in dollar invoicing, reinforcing the rise in dollar borrowing, as described in Figure 1.3.

I begin with a baseline model that establishes a link between global uncertainty and the choices made by EM exporters concerning dollar borrowing and dollar invoicing. This model is simple on both the demand and production sides, aiming to illustrate how EM exporters' decisions regarding borrowing and invoicing respond to an external shock that affects the global demand for safe dollar assets.

The model adapts Gopinath and Stein (2019) to investigate the impact of high global uncertainty on the shares of dollar borrowing and dollar invoicing in exports. Gopinath and Stein (2019) demonstrate that an increased demand for safe dollar assets induces exporters to both invoice and borrow more in dollars, thereby amplifying the violation of the UIP. Depositors

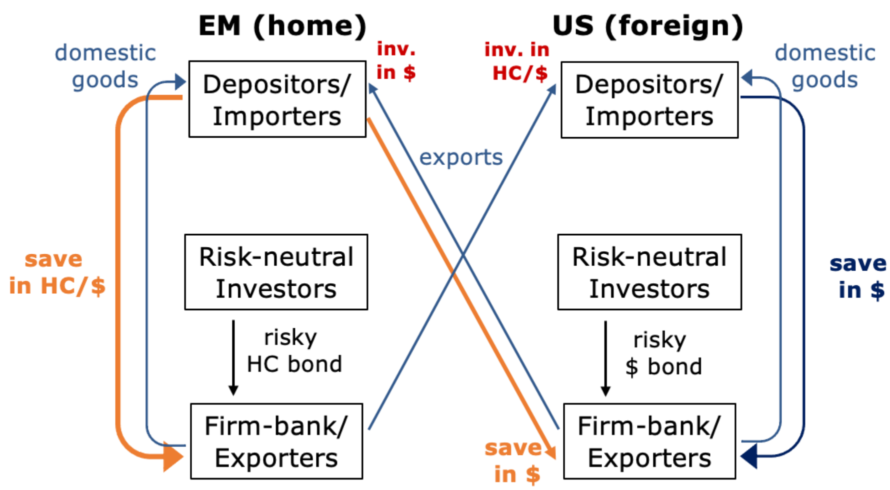

Figure 1.4: Model Structure

demand more safe dollar assets when dollar shares of imports increase, which feeds back to an increase in dollar shares of exports. I depart from Gopinath and Stein (2019) in three key aspects. First, I focus on scenarios where high global risk prompts depositors to exhibit a stronger preference for saving in dollars due to the dollar's status as a safe-haven currency. The external shock that intensifies depositors' interest in safe dollar assets is referred to as a *"global risk shock."*[14] Second, by introducing a dynamic model that incorporates the endogenous determination of exchange rates, I examine the evolving impact of increased global uncertainty on the external balance, exchange rates, and the dollar borrowing and invoicing decisions of EMs. Lastly, I investigate how time-varying endogenous invoicing currency choices influence the responses of other key EM variables to the global risk shock.

Figure 1.4 explains the structure of the model. The world is comprised of two countries: the U.S. and an EM. The EM can be seen as a collective representation of multiple EM countries. Each country hosts three distinct types of agents: risk-averse depositors, risk-neutral investors, and exporters. Depositors, representing households with consumption and savings decisions,

[14] Kekre and Lenel (2021) refers to this shock as a safety shock.

are present in both countries. EM depositors have the option to save in both dollars and their home currency, while U.S. depositors exclusively engage in dollar-based savings. When EM depositors choose to save in dollars, they initially acquire safe dollar claims from domestic firms. In case the supply of these claims is insufficient, they turn to foreign sources. U.S. depositors, on the other hand, focus solely on domestic saving activities. Each country's depositors own risk-neutral investors. These investors receive endowments from their respective owners, invest in risky assets, and subsequently deliver returns to the owners in the next period. The markets for risky bonds in dollars and home currency are segmented.

Exporters, represented as bank-firm coalitions, seek financing for their production investments. EM exporters engage in borrowing in both dollars and EM currency, while U.S. exporters exclusively borrow in dollars. EM exporters make choices regarding the currency in which they will receive revenues, a decision referred to as the invoicing currency choice. EM exporters determine the share of dollar invoicing, with the remaining being invoiced in the home currency. These EM exporters also participate in domestic trade, where payments are exclusively made in EM currency. U.S. exporters, in contrast, exclusively invoice in dollars for both domestic transactions and exports. Details are provided below.

1.3.1 Depositors/Importers

U.S. depositors

The representative U.S. depositor engages in consumption of the domestically-produced non-tradable good, C_t^*, and the imported foreign good, M_t^*. The depositor saves in dollars, $D_{\$,t}^*$, with returns at rate $R_{\$,t}$. The U.S. depositor's objective is to solve

$$\max_{C_t^*, M_t^*, D_{\$,t}^*} \mathbb{E}_0 \sum_{t=0}^{\infty} (\beta^*)^t [C_t^* + \chi_m^* ln(M_t^*) + \omega_t^* ln(D_{\$,t}^*)]$$

subject to the budget constraint:

$$\begin{aligned} & C_t^* + \{\varepsilon_t^{-1}(1-\eta_{t-1}) + \eta_{t-1}\} M_t^* + D_{\$,t}^* + W_t^* \\ & \leq \Pi_t^* + R_{\$,t-1} D_{\$,t-1}^* + \xi_t^* R_{R,t-1}^* W_{t-1}^* \end{aligned} \tag{1.2}$$

where Π_t^* represents profits transferred from exporters, W_t^* is an endowment transferred to a risk-neutral investor owned by the U.S. depositor, and ε_t denotes the exchange rate between the EM currency and the dollar at time t, where an increase in ε_t implies dollar appreciation. The parameter χ_m^* reflects the depositor's preference for imported goods, and the price of one unit of EM goods expressed in dollars is given by $\{\varepsilon_t^{-1}(1-\eta_{t-1}) + \eta_{t-1}\}$. EM exporters choose the currency in which they invoice their exports to the U.S. depositor. A share $\eta_{t-1} \in [0,1]$ of the U.S. depositor's imports from the EM at time t is denominated in dollars.[15] The price of the domestic good in each country is normalized to unity, thus eliminating the distinction between the terms of trade and the real exchange rate between EM currency and the dollar, $\{\varepsilon_t^{-1}(1-\eta_{t-1}) + \eta_{t-1}\}^{-1}$.[16] $\xi_{t+1}^* R_{R,t-1}^*$ represents the returns that U.S. risk-neutral investors receive from investing in risky assets. $R_{R,t-1}^*$ denotes the interest rate, and ξ_{t+1}^* is stochastic. I assume a linear utility function in domestic consumption to simplify the model and to focus on the dynamics related to borrowing and invoicing choices. This assumption can be relaxed in later extensions of the model to explore

[15]The share of dollar invoicing in EM exports at time t is determined at time $t-1$ by EM exporters, which will be described in detail, in the next subsection.

[16]This normalization follows that of Akinci and Queralto (2021). In the extended model, prices of domestically-produced goods will fluctuate, making the distinction between the terms of trade and the real exchange rate relevant.

policy implications.

The term $\omega_t^* ln(D_{\$,t}^*)$ captures a preference for holding safe dollar claims. This formulation aligns with Kekre and Lenel (2021), which incorporates a preference for risk-free dollar bonds in household utility functions. It also follows the approach of Gopinath and Stein (2019) and recent studies including Krishnamurthy and Vissing-Jorgensen (2012), Stein (2012), Greenwood et al. (2015), Sunderam (2015), and Nagel (2016) employing a utility function that explicitly includes a preference for money-like assets. In particular, ω_t^* represents a time-varying demand for safety. When global uncertainty increases, there is an exogenous rise in the U.S. depositor's preference for safe dollar assets, denoted by ω_t^*. This can be interpreted as a flight to safety during periods of high global risk.[17] The first-order conditions for the U.S. depositor are as follows:

$$M_t^* = \frac{\varepsilon_t \chi_m^*}{\varepsilon_t \eta_{t-1} + 1 - \eta_{t-1}} \tag{1.3}$$

$$1 = \frac{\omega_t^*}{D_{\$,t}^*} + \beta^* R_{\$,t} \tag{1.4}$$

EM depositors

EM depositors face a problem analogous to that of U.S. depositors, with their discount factor denoted as β, a preference parameter over imports denoted as χ_m, domestic consumption denoted as C_t, and imports denoted as M_t. EM depositors also own risk-neutral investors to whom they provide endowments upon request. The risk-neutral investors generate returns from investment in risky home currency assets, earning the interest on such assets. EM depositors engage in saving in both dollars and the home currency, and they express preferences over safe

[17]We can also think of ω_t^* as a variable measuring depositor risk aversion. U.S. depositors become more risk-averse during highly uncertain periods that trigger a flight to safety, as in Vayanos (2004), a characteristic that also applies to EM depositors.

dollar claims, denoted as ω_t.

In sum, the problem faced by EM depositors can be formulated as follows:

$$\max_{C_t, M_t, D_{h,t}, D_{\$,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t [C_t + \chi_m ln(M_t) + \omega_t ln(D_{\$,t})]$$

subject to

$$\begin{aligned} & C_t + \varepsilon_t M_t + D_{h,t} + \varepsilon_t D_{\$,t} + W_t \\ & \leq \Pi_t + R_{h,t-1} D_{h,t-1} + \varepsilon_t R_{\$,t-1} D_{\$,t-1} + \xi_t R_{R,t-1} W_{t-1} \end{aligned} \tag{1.5}$$

where $D_{h,t}$ and $D_{\$,t}$ denote savings in the home currency and in dollars, respectively. W_t represents an endowment transferred to a risk-neutral investor owned by the EM depositor. $\xi_{t+1} R_{R,t-1}$ is the returns that EM risk-neutral investors receive from investing in risky assets, where $R_{R,t-1}$ denotes the interest rate, and ξ_{t+1} is stochastic. Then the first-order conditions for the EM depositor are as follows:

$$\varepsilon_t M_t = \chi_m \tag{1.6}$$

$$\beta R_{h,t} = 1 \tag{1.7}$$

$$D_{\$,t} = \frac{\omega_t}{\beta(\varepsilon_t R_{h,t} - \mathbb{E}_t \varepsilon_{t+1} R_{\$,t})} \tag{1.8}$$

Suppose EM depositors never borrow but only engage in saving ($D_{h,t}, D_{\$,t} > 0$). Then the EM depositor saves a positive amount in dollars only when they have a positive preference for safe dollar claims (i.e., $\omega_t > 0$). When $\omega_t > 0$, the UIP condition is violated, implying a positive UIP premium on the EM currency. This deviation from UIP, u_t, indicates that the EM currency is expected to yield higher returns relative to the dollar in equilibrium when EM depositors favor saving in dollars. This arises because the heightened demand for dollar risk-free bonds leads to an increase in the relative price of saving in dollars:

$$u_t \equiv \frac{R_{h,t}}{R_{\$,t}} \frac{\varepsilon_t}{\mathbb{E}_t \varepsilon_{t+1}} = \frac{R_{h,t}}{\mathbb{E}_t \varepsilon_{t+1} R_{\$,t}} \frac{\omega_t}{D_{\$,t}} + 1 > 1 \tag{1.9}$$

The UIP condition holds when $\omega_t = 0$.

1.3.2 Risk-Neutral Investors

In each country, there are risk-neutral investors who invest in risky assets. These markets for risky assets are segmented for each country. The inclusion of risk-neutral investors in the model is important due to the stochastic nature of firms' returns from capital. Unlike risk-averse investors, who are unwilling to permit borrowers to utilize their safe assets to support uncertain capital investments, risk-neutral investors step in. Therefore, exporters not only utilize safe assets for financing their capital acquisitions but also rely on risky assets provided by risk-neutral investors to supplement this aspect.

U.S. risk-neutral investors

Every period, the U.S. risk-neutral investor receives an endowment of W_t^*, consumes domestic goods, $C_{N,t}^*$, and invests $A_{R,t}^*$ in dollar risky assets with expected returns of $\mathbb{E}_t \xi_{t+1}^* R_{R,t}^*$. After receiving returns from the risky assets, the investor returns the endowment with interest, $\xi_{t+1}^* R_{R,t}^* W_t^*$, to the depositor. A risk-neutral investor chooses how much to receive from its owner, W_t^*, and purchases dollar risky assets supplied by exporters. The risk-neutral investor seeks to maximize

$$\mathbb{E}_0 \sum_{t=0}^{\infty} (\delta^*)^t C^*_{N,t}$$

subject to the resource constraint:

$$C^*_{N,t} + A^*_{R,t} + \xi^*_t R^*_{R,t-1} W^*_{t-1} \leq \xi^*_t R^*_{R,t-1} A^*_{R,t-1} + W^*_t$$

where δ^* denotes the investor's discount factor.

EM risk-neutral investors

Similarly, the EM risk-neutral investor is endowed with W_t, consumes EM goods, $C_{N,t}$, and invests $A_{R,t}$ in home-currency risky assets, with expected returns $\mathbb{E}_t \xi_{t+1} R_{R,t}$. Assuming $\mathbb{E}_t \xi_{t+1} = \mathbb{E}_t \xi^*_{t+1} = 1$, the first-order conditions of EM and U.S. risk-neutral investors are given by:

$$\delta R_{R,t} = 1, \quad \delta^* {R_{R,t}}^* = 1$$

Since both investors are risk-neutral, they can invest in risky assets with high expected returns, which indicates that they are less patient than depositors. I assume the risk-neutral investors' discount factor is smaller than that of depositors: $0 < \delta < \beta < \beta^*$. I also assume that the U.S. risk-neutral investors are equally patient as the EM investors, so $\delta^* = \delta$.[18]

[18] I can assume that EM risk-neutral investors are less patient than the U.S. risk-neutral investors ($\delta^* > \delta > 0$) without significantly impacting the analysis results.

1.3.3 Exporters/Firm-Bank Coalitions

A continuum of exporters, each belonging to a depositor in their respective countries, has a two-period lifespan. In their first period t, exporters enter the market, invest in capital yielding a risky return, engage in production, sell their products, and receive revenues. Due to uncertainty associated with returns on capital investment, these firms secure necessary funds for investment through a combination of borrowing from domestic depositors and borrowing from risk-neutral investors.

U.S. exporters

U.S. exporters borrow in dollars, $B^*_{\$,t}$, from U.S. depositors to fund their investment in capital, K^*_t. They invoice all of their revenues in dollars. Let Z^*_{t+1} represent the dividend generated by their capital investment. The objective of U.S. exporters is to maximize their expected profits:

$$\mathbb{E}_t\Pi^*_{t+1} = \mathbb{E}_t[(Z^*_{t+1} + Q^*_{t+1})K^*_t - R_{\$,t}B^*_{\$,t} - \xi^*_{t+1}R^*_{R,t}B^*_{R,t} + \frac{\psi}{2}(1-\alpha)^2\eta_t^2 K_t\varepsilon_t^{-1}]$$

with discount factor β^* subject to the constraints $R_{\$,t}B^*_{\$,t} \leq (Z^*_L + Q^*_L)K^*_t$ and $B^*_{\$,t} + B^*_{R,t} \geq Q^*_t K^*_t$. Here, $B^*_{R,t}$ represents funds borrowed from U.S. risk-neutral investors using risky bonds, and Q^*_t is the market price of a unit of capital in the U.S. Z^*_L and Q^*_L denote the worst realizations of Z^*_{t+1} and Q^*_{t+1}, respectively.[19] The last term in the objective function is the cost of dollar invoicing, which EM exporters pay to U.S. exporters. This cost reflects the

[19]Suppose $Z^*_L + Q^*_L \leq R_{\$,t}$, then $B^*_{\$,t} = (Z^*_L + Q^*_L)K^*_t / R_{\$,t}$. It means that we need risky bonds $B^*_{R,t}$ to finance the capital investment, as Z^*_{t+1} is stochastic.

advantage enjoyed by U.S. exporters operating in the U.S., as they can sell their goods in dollars without incurring the additional risk associated with exchange rate fluctuations. The details of this cost are elaborated in the EM exporter's problem below.

EM exporters

EM exporters finance their investments in capital, K_t, through a combination of funds borrowed from EM depositors using risk-free bonds $B_{h,t}$ and $B_{\$,t}$, as well as funds borrowed from EM risk-neutral investors using risky bonds $B_{R,t}$:

$$Q_t K_t \leq B_{h,t} + \varepsilon_t B_{\$,t} + B_{R,t}$$

where Q_t is the price of capital. The exporters determine the invoicing currency in which they will receive dividends from their capital investments. The revenue of EM exporters can be expressed the sum of dividends from capital investments and the change in the value of the capital they hold:

$$\{\alpha + (1-\alpha)(1-\eta_t + \varepsilon_{t+1}\eta_t)\} Z_{t+1} K_t + Q_{t+1} K_t$$

where $\eta_t \in [0,1]$ denotes the share of dollar invoicing, which is an endogenous variable chosen by the exporter. $\alpha \in [0,1]$ is the share of the returns from capital used for domestic sales to EM depositors, with the remaining share being exported to the U.S.

The borrowing of EM exporters from depositors is constrained by the requirement that their debt repayment in expectation should not exceed their revenue under the worst possible realization of returns from capital. This constraint can be expressed as:

$$R_{h,t}B_{h,t} + \mathbb{E}_t\varepsilon_{t+1}R_{\$,t}B_{\$,t} \leq \{\alpha + (1-\alpha)(1-\eta_t + \mathbb{E}_t\varepsilon_{t+1}\eta_t)\}Z_L K_t + Q_L K_t \tag{1.10}$$

where Z_L and Q_L are the worst realizations of Z_{t+1} and Q_{t+1}.

When EM depositors have a preference for saving in dollars ($\omega_t > 0$), EM exporters are incentivized to borrow in dollars as much as possible due to the relatively cheaper cost of dollar borrowing compared to borrowing in the EM currency. However, from the lender's perspective, lending in dollars to EM exporters can be risky unless the exporters have a sufficient amount of expected dollar revenues to repay the dollar debt. Suppose the dollar appreciates to its highest possible value at time $t+1$, denoted as $\bar{\varepsilon}$, while the EM exporter has borrowed up to the limit using only dollars at time t (i.e., $B_{h,t} = 0$ and $\mathbb{E}_t\varepsilon_{t+1}R_{\$,t}B_{\$,t} = \{\alpha+(1-\alpha)(1-\eta_t+\mathbb{E}_t\varepsilon_{t+1}\eta_t)\}Z_L K_t + Q_L K_t$). Then, the exporter would need to repay $\bar{\varepsilon}R_{\$,t}B_{\$,t}$ in debt, which, in the worst scenario for Z_{t+1} and Q_{t+1}, would exceed its realized revenue ($\frac{\bar{\varepsilon}}{\mathbb{E}_t\varepsilon_{t+1}}\{\alpha+(1-\alpha)(1-\eta_t+\mathbb{E}_t\varepsilon_{t+1}\eta_t)\}Z_L K_t + \frac{\bar{\varepsilon}}{\mathbb{E}_t\varepsilon_{t+1}}Q_L K_t > \{\alpha + (1-\alpha)(1-\eta_t + \bar{\varepsilon}\eta_t)\}Z_L K_t + Q_L K_t$). This could lead to default because the exporter is required to pay more than they receive. Therefore, an additional constraint is imposed on the EM exporter's dollar borrowing to ensure that the maximum repayment of dollar-denominated debt does not exceed the worst realization of dollar-invoiced revenues.

The EM exporter's profit-maximization problem can be stated as:

$$\begin{aligned} \max_{B_{h,t},B_{\$,t},B_{R,t},\eta_t,K_t} & \beta\mathbb{E}_t\Pi_{t+1} \\ &= \beta\mathbb{E}_t[\{\alpha + (1-\alpha)(1-\eta_t + \varepsilon_{t+1}\eta_t)\}Z_{t+1}K_t + Q_{t+1}K_t \\ &- R_{h,t}B_{h,t} - \varepsilon_{t+1}R_{\$,t}B_{\$,t} - \xi_{t+1}R_{R,t}B_{R,t} - \frac{\psi}{2}(1-\alpha)^2\eta_t^2 K_t] \end{aligned} \tag{1.11}$$

subject to

$$B_{h,t} + \varepsilon_t B_{\$,t} + B_{R,t} \geq Q_t K_t \tag{1.12}$$

$$R_{h,t} B_{h,t} + \mathbb{E}_t \varepsilon_{t+1} R_{\$,t} B_{\$,t} \leq \{\alpha + (1-\alpha)(1 - \eta_t + \mathbb{E}_t \varepsilon_{t+1} \eta_t)\} Z_L K_t + Q_L K_t \tag{1.13}$$

$$R_{\$,t} B_{\$,t} \leq (1-\alpha)\eta_t Z_L K_t \tag{1.14}$$

where I assume that there is a quadratic cost associated with dollar invoicing, $\frac{\psi}{2}(1-\alpha)^2\eta_t^2 K_t$ with $\psi > 0$, as in Gopinath and Stein (2019).[20]

Define λ_t, μ_t, and γ_t to be the Lagrange multipliers on the constraints (1.12), (1.13), and (1.14), respectively. Then the first-order conditions for the EM exporter's problem are given below:

$$[B_{R,t}] \quad \lambda_t = \beta R_{R,t} \tag{1.15}$$

$$[B_{h,t}] \quad \lambda_t = (\beta + \mu_t) R_{h,t} \tag{1.16}$$

$$[B_{\$,t}] \quad \varepsilon_t \lambda_t = R_{\$,t}[(\beta + \mu_t)\mathbb{E}_t \varepsilon_{t+1} + \gamma_r] \tag{1.17}$$

$$[\eta_t] \quad \beta(1-\alpha)^2 \psi \eta_t = (\mathbb{E}_t \varepsilon_{t+1} - 1)(\beta Z + \mu_t Z_L) + \gamma_t Z_L \tag{1.18}$$

$$\begin{aligned}[K_t] \quad \lambda_t Q_t + \frac{\beta\psi}{2}(1-\alpha)^2\eta_t^2 &= \{\alpha + (1-\alpha)(1 - \eta_t + \mathbb{E}_t \varepsilon_{t+1} \eta_t)\}(\beta Z + \mu_t Z_L) \\ &\quad + (1-\alpha)\eta_t Z_L \gamma_t + \beta \mathbb{E}_t Q_{t+1} + \mu_t Q_L \end{aligned} \tag{1.19}$$

[20]Gopinath and Stein (2019) interpret the cost as a proxy for the risk aversion of the ultimate owners of EM exporters. When the owners of these exporters are EM residents who primarily consume goods denominated in their home currency, they tend to prefer a profit stream that is also denominated in their home currency. In this paper, the exporters are owned by depositors who consume both domestic and foreign goods. The cost related to dollar invoicing occurs because EM depositors will collect profits converted to the home currency and then make consumption decisions. Even if EM depositors have high consumption of imported goods, they still incur costs related to converting profits from dollars to the home currency and then back to dollars.

where $Z \equiv \mathbb{E}_t Z_{t+1}$ denotes the expected dividends from capital. Z_{t+1} and the exchange rate ε_{t+1} are assumed to be independent from each other.

When the U.S. depositor has a particular preference for holding risk-free dollar bonds ($\omega_t^* > 0$), it leads to a violation of the UIP condition, resulting in an excess return on EM currency compared to the dollar. Then the EM exporter's constraint on dollar borrowing (1.14) becomes binding. Holding the share of dollar invoicing fixed, the EM exporter's dollar borrowing can be written as:

$$B_{\$,t} = \frac{1}{R_{\$,t}}(1-\alpha)\bar{\eta} Z_L K_t \tag{1.20}$$

where $\bar{\eta} \in [0,1]$ is a constant. If the EM exporter endogenously chooses the optimal share of dollar invoicing in its exports, from the first-order conditions (1.15) - (1.18), the share of dollar invoicing, η_t, can be expressed as follows:

$$\begin{aligned}\eta_t &= \frac{1}{\beta\psi(1-\alpha)^2}[(\mathbb{E}_t\varepsilon_{t+1}-1)(\beta Z + \mu_t Z_L) + \gamma_t Z_L] \\ &= \frac{1}{\psi(1-\alpha)^2}[(\mathbb{E}_t\varepsilon_{t+1}-1)(Z - Z_L) + Z_L R_{R,t}(\beta^*\varepsilon_t u_t - \beta)] \end{aligned}\tag{1.21}$$

where $\mu_t = \beta(\frac{R_{R,t}}{R_{h,t}} - 1) > 0$ and $\gamma_t = \beta R_{R,t}(\frac{\varepsilon_t}{R_{\$,t}} - \frac{\mathbb{E}_t\varepsilon_{t+1}}{R_{h,t}}) > 0$. Note that η_t is increasing in the expected exchange rate and the UIP premium. If the dollar is expected to appreciate ($\mathbb{E}_t\varepsilon_{t+1} \Uparrow$), the EM exporter's dollar-denominated revenues are expected to increase when converted to the EM currency, incentivizing the firm to invoice a larger portion of its exports in dollars. On the other hand, an increase in the UIP premium, u_t, means that the relative cost of dollar borrowing declines compared to borrowing in home currency. Therefore, the EM exporter's desire to borrow in dollars rises, prompting the firm to invoice a larger amount in dollars to secure additional dollar collateral. This aligns with empirical findings and substantiates the mechanism discussed in Section 1.2.

1.3.4 Closing the Economy

I assume a fixed supply of capital in both the EM and the U.S., given by $\bar{K} > 0$.Then the capital market clearing condition is given by $K_t = K_t^* = \bar{K}$ for all periods t. Goods market clearing requires $C_t + C_{N,t} + (\varepsilon_t \eta_{t-1} + 1 - \eta_{t-1})M_t^* = \{\alpha + (1-\alpha)(1 - \eta_{t-1} + \varepsilon_t \eta_{t-1})\} Z_t \bar{K}$ and $C_t^* + C_{N,t}^* + M_t = Z_t^* \bar{K}$. The home- currency safe claims held by EM depositors should be equal to the home-currency borrowing of EM exporters: $D_{h,t} = B_{h,t}$. Similarly, the safe dollar claims held by the U.S. and EM depositors should equal the sum of dollar borrowing by EM and U.S. exporters: $D_{\$,t} + D_{\$,t}^* = B_{\$,t} + B_{\$,t}^*$. Lastly, the risky asset markets must clear: $A_{R,t} = B_{R,t}$ and $A_{R,t}^* = B_{R,t}^*$

1.3.5 Global Risk Shock and Equilibrium

1.3.5.1 Global Risk Shock

The time-varying preference of EM depositors for safe dollar assets, denoted as ω_t, follows a log AR(1) process:

$$log\omega_t - log\bar{\omega} = \rho_\omega (log\omega_{t-1} - log\bar{\omega}) + e_{\omega,t} \tag{1.22}$$

where $\bar{\omega}$ refers to the steady-state value of ω_t and $0 \leq \rho_\omega < 1$. The innovation $e_{\omega,t}$ is drawn from a normal distribution with mean zero and variance one. A positive exogenous shock to $e_{\omega,t}$ corresponds to a positive global risk shock, as worldwide depositors tend to demand more dollar savings when the global economy becomes riskier.

The U.S. depositors' preference for saving in dollars, denoted as ω_t^*, follows

$$log\omega_t^* - log\bar{\omega}^* = \rho_\omega(log\omega_{t-1}^* - log\bar{\omega}^*) + e_{\omega,t}^* \tag{1.23}$$

where $log\bar{\omega}^* = \Gamma^* log\bar{\omega}$, $\Gamma^* > 0$, and $e_{\omega,t}^* = \Gamma^* e_{\omega,t}$ are the steady-state level of the U.S. depositor's preference for safe dollar assets and the innovation. Thus, global and U.S. demands for safe dollar assets are perfectly correlated. I will focus on the case where ω_t and ω_t^* are positive.

1.3.5.2 Equilibrium

The equilibrium of the two-country model is defined as follows.

Definition 1. (Equilibrium) *An equilibrium is a sequence of prices and quantities such that:*

1. *EM and U.S. depositors choose* $\{C_t, M_t, D_{h,t}, D_{\$,t}\}$ *and* $\{C_t^*, M_t^*, D_{\$,t}^*\}$*, respectively, to maximize utilities subject to resource constraints.*
2. *EM and U.S. risk-neutral investors choose* $\{C_{N,t}, A_{R,t}, W_t\}$ *and* $\{C_{N,t}^*, {A_{R,t}}^*, W_t^*\}$*, respectively, to maximize utilities subject to the resource constraints.*
3. *EM and U.S. exporters choose* $\{B_{h,t}, B_{\$,t}, B_{R,t}, \eta_t, K_t\}$ *and* $\{{B_{\$,t}}^*, B_{R,t}^*, K_t^*\}$*, respectively, to maximize the expected profits subject to resource constraints and borrowing constraints.*
4. *Prices and interest rates are determined so that goods, capital, home-currency credit, and dollar credit markets clear.*

To focus on tracing the impact of a global risk shock on specific EM variables, I simplify the equilibrium conditions as follows. The full equilibrium conditions for the baseline model are presented in Appendix A.2.1. To begin with, combining EM depositors' resource constraint and market clearing conditions results in the following balance-of-payments condition:

$$\varepsilon_t \chi_m^* - \chi_m - \frac{\psi}{2}(1-\alpha)^2 \eta_{t-1}^2 \bar{K} = \varepsilon_t \{D_{\$,t} - B_{\$,t} - R_{\$,t-1}(D_{\$,t-1} - B_{\$,t-1})\} \tag{1.24}$$

where the left-hand-side is comprised of the EM's home-currency value of net exports, $NX_t = \varepsilon_t \chi_m^* - \chi_m$, net of the cost of dollar invoicing, $\frac{\psi}{2}(1-\alpha)^2 \eta_{t-1}^2 \bar{K}$. The right-hand-side, $FA_t = \varepsilon_t \{D_{\$,t} - B_{\$,t} - R_{\$,t-1}(D_{\$,t-1} - B_{\$,t-1})\}$, is the net EM accumulation of foreign assets in home currency terms. I will redefine $NX_{\$,t} = NX_t/\varepsilon_t$ and $FA_{\$,t} = FA_t/\varepsilon_t$ as net exports and the foreign asset accumulation translated into dollars.

Then, given the realizations of exogenous ω_t and ω_t^*, the following equations determine the

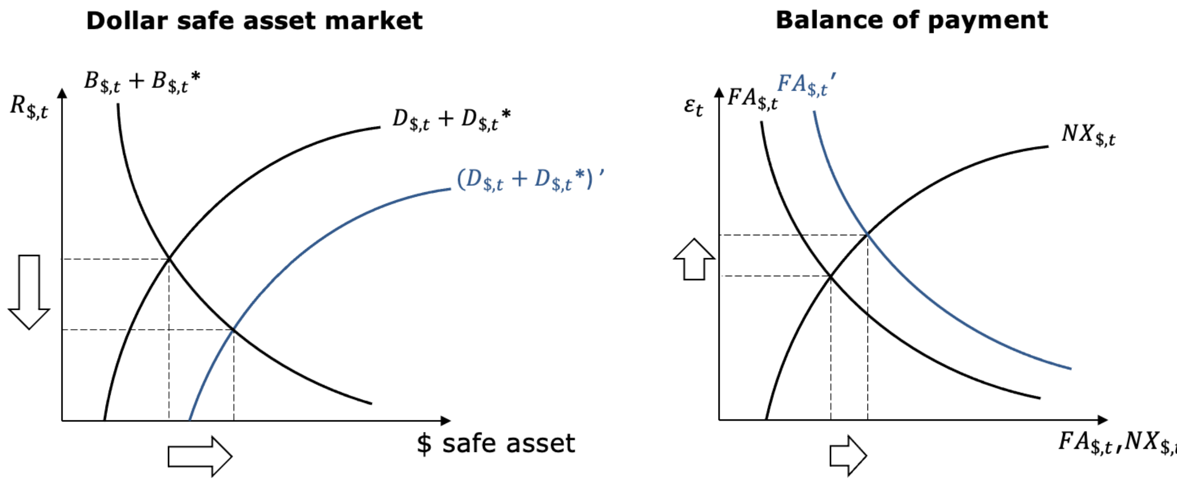

Figure 1.5: Equilibrium and a Global Risk Shock: Fixed share of dollar invoicing

evolution of variables $D_{\$,t}, D^*_{\$,t}, B_{\$,t}, B^*_{\$,t}, \eta_t, R_{\$,t}, \varepsilon_t$, and u_t:

$$D_{\$,t} = \frac{\omega_t}{\varepsilon_t - \beta \mathbb{E}_t \varepsilon_{t+1} R_{\$,t}} \quad \text{[EM demand for dollar assets]}$$

$$D^*_{\$,t} = \frac{\omega^*_t}{1 - \beta^* R_{\$,t}} \quad \text{[U.S. demand for dollar assets]}$$

$$R_{\$,t} B_{\$,t} = (1-\alpha)\eta_t Z_L \bar{K} \quad \text{[EM dollar borrowing]}$$

$$R_{\$,t} B^*_{\$,t} = (Z^*_L + Q^*_L)\bar{K} \quad \text{[U.S. dollar borrowing]}$$

$$(1-\alpha)^2 \psi \eta_t = (\mathbb{E}_t \varepsilon_{t+1} - 1)(Z - Z_L) + Z_L \delta^{-1}\left(\frac{\varepsilon_t}{R_{\$,t}} - \beta\right) \quad \text{[EM dollar invoicing]}$$

$$\varepsilon_t \chi^*_m - \chi_m - \frac{\psi}{2}(1-\alpha)^2 \eta^2_{t-1}\bar{K} = \varepsilon_t \{D_{\$,t} - B_{\$,t} - R_{\$,t-1}(D_{\$,t-1} - B_{\$,t-1})\} \quad \text{[B.o.P]}$$

$$B_{\$,t} + B^*_{\$,t} = D_{\$,t} + D^*_{\$,t} \quad \text{[Dollar asset market]}$$

$$u_t = \frac{\varepsilon_t}{\mathbb{E}_t \varepsilon_{t+1}} \frac{R_{h,t}}{R_{\$,t}} \quad \text{[UIP premium]} \qquad (1.25)$$

The steady state of the system can be solved as shown in Appendix A.2.2.

1.4 Analytical Insights

In the remainder of the analysis, I will characterize the dynamic effects of an unexpected increase in ω_t, resulting from a one-time positive shock $e_{\omega,t}$ that persists with a first-order autoregressive parameter ρ_ω. To describe the effects of this global risk shock, I will use first-order log approximations, where $\hat{X}$ denotes the log deviation of variable X from its steady state value. I will trace the impact of the shock on dollar borrowing, dollar invoicing, and the external balance of the EM, as well as its impact on the exchange rate and the UIP premium.

1.4.1 Fixed Share of Dollar Invoicing and a Global Risk Shock

Proposition 1. **(Case I: $\hat{\eta}_t = 0$)** *Consider the case where the share of dollar invoicing by EM exporters is fixed. On the impact of a positive shock to EM and U.S. depositors' demand for safe dollar assets ($\hat{\omega}_t > 0$):*

- *EM and U.S. depositors' dollar saving increases ($\hat{D}_{\$,t}, \hat{D}^*_{\$,t} \propto \hat{\omega}_t$);*
- *the dollar interest rate decreases and EM exporters' dollar borrowing increases ($\hat{R}_{\$,t} \propto -\hat{\omega}_t$ and $\hat{B}_{\$,t} \propto \hat{\omega}_t$);*
- *the UIP premium increases ($\hat{u}_t \propto \hat{\omega}_t$);*
- *the EM's net exports and net foreign assets increase ($\widehat{NX}_{\$,t}, \widehat{FA}_{\$,t} \propto \hat{\omega}_t$);*
- *the dollar appreciates and is expected to depreciate ($\hat{\varepsilon}_t \propto \hat{\omega}_t$ and $\mathbb{E}_t\hat{\varepsilon}_{t+1} \propto -\hat{\omega}_t$).*

The proof of this proposition, like all others, is provided in Appendix A.2.2..

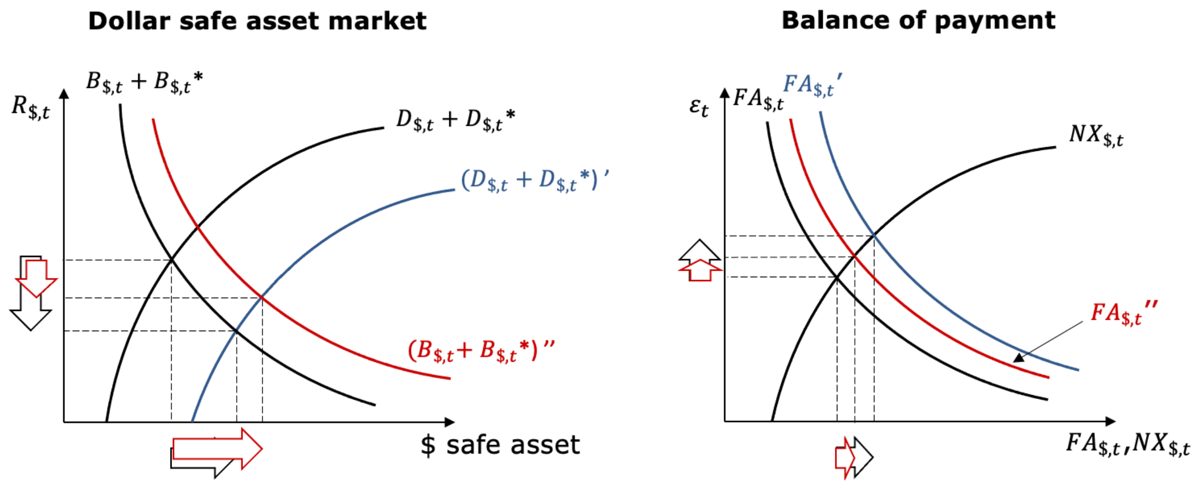

Figure 1.6: Equilibrium and a Global Risk Shock: Endogenous share of dollar invoicing

Figure 1.5 provides an intuitive illustration of the dynamics described in the above proposition. In response to a positive global risk shock ($\hat{\omega}_t > 0$), both EM and U.S. depositors increase their demand for saving in dollars, shifting the demand curve for safe dollar assets, $D_{\$,t} + D^*_{\$,t}$, to the right. Due to the higher demand for safe dollar assets, the price of saving in dollars increases, leading to lower dollar interest rates, $R_{\$,t} \downarrow$. With lower dollar borrowing rates, EM exporters can increase their dollar borrowing slightly. EM depositors, seeking to save more in dollars than what EM exporters can supply, increase their investment in U.S. assets, raising EM's net foreign asset accumulation. The increased demand for dollars leads to dollar appreciation. This makes EM imports from the U.S. more expensive and EM exports more competitive, resulting in increased net exports.[21] Depositors anticipate lower demand for dollars in the next period, contributing to an expected depreciation of the dollar. The increase in the expected depreciation of the dollar relative to the EM currency, along with the decrease in the current dollar borrowing rate, leads to a higher UIP premium.

[21]The model assumes that the price elasticity of demand is 1 for imported goods, so imports increase at the same rate as import prices.

1.4.2 Endogeneity in Dollar Invoicing and a Global Risk Shock

Proposition 2. **(Case II: $\hat{\eta}_t \neq 0$)** *Consider the case where EM exporters choose the share of dollar invoicing endogenously. On the impact of a positive shock to EM and U.S. depositors' demand for safe dollar assets ($\hat{\omega}_t > 0$):*

- *the EM exporter's share of dollar invoicing increases ($\hat{\eta}_t \propto \hat{\omega}_t$);*
- *EM and U.S. depositors' dollar savings increase more than in Case I ($\hat{D}^{II}_{\$,t} > \hat{D}^{I}_{\$,t} \propto \hat{\omega}_t$ and $\hat{D}^{II*}_{\$,t} > \hat{D}^{I*}_{\$,t} \propto \hat{\omega}_t$);*
- *the dollar interest rate decreases, but less than in Case I ($\hat{R}^{II}_{\$,t} > \hat{R}^{I}_{\$,t} \propto -\hat{\omega}_t$), while EM exporters' dollar borrowing increases more than in Case I ($\hat{B}^{II}_{\$,t} > \hat{B}^{I}_{\$,t} \propto \hat{\omega}_t$);*
- *the UIP premium increases, but less than in Case I ($\hat{u}^{I}_t > \hat{u}^{II}_t \propto \hat{\omega}_t$);*
- *EM's net exports and net foreign assets increase, but less than in Case I ($\widehat{NX}^{I}_{\$,t} > \widehat{NX}^{II}_{\$,t} \propto \hat{\omega}_t$ and $\widehat{FA}^{I}_{\$,t} > \widehat{FA}^{II}_{\$,t} \propto \hat{\omega}_t$);*
- *the dollar appreciates, but less than in Case I ($\hat{\varepsilon}^{I}_t > \hat{\varepsilon}^{II}_t \propto \hat{\omega}_t$).*

where $\hat{X}^{I}_t$ and $\hat{X}^{II}_t$ denote the log approximated values of a variable X_t in Cases I and II, respectively.

Figure 1.6 depicts the responses of variables to a sudden global risk shock when the EM's invoicing currency decision is endogenous. Similar to Case I, a positive global risk shock increases the demand for safe dollar claims by both EM and U.S. depositors, initially leading to a decrease in the equilibrium dollar interest rate. As the dollar borrowing cost becomes cheaper due to lower interest rates, EM exporters increase the share of their borrowing in dollars. Unlike in CaseI, where the share of dollar invoicing was fixed, EM exporters can now boost their access to safe dollar borrowing by raising the share of dollar invoicing in their exports. This shift in the supply of safe dollar lending results in a smaller decrease in the dollar interest rate and a larger increase in the equilibrium level of total safe dollar assets in the market.

With the dollar interest rate decreasing less than in Case I, the UIP premium increases but to a lesser extent. This indicates that safe dollar claims become less expensive than in Case I, due to the increased supply by EM exporters. EM depositors are less inclined to invest in U.S. assets as EM exporters can now supply more safe dollar assets. This decreased flight to U.S. assets results in a smaller increase in EM's net foreign asset accumulation. While the dollar appreciates in response to increased demand, the effect is less pronounced than in Case I due to the moderation in the increase in the UIP premium.

1.4.3 Main Mechanism and Literature

The analytical insights presented in this section shed light on the connection between the choice of invoicing currency by EM exporters and the global demand for safe dollar assets. Extending the work of Kekre and Lenel (2021), who explore the impact of an increase in the non-pecuniary value of holding dollars, driving a flight to safety, I elucidate the relationship between this phenomenon and EM exporters' borrowing decisions. In the framework of Kekre and Lenel (2021), a global risk shock amplifies the global demand for safe dollar claims, raising the risk premium (or UIP premium) on currencies of non-U.S. countries relative to the dollar. The increase in the UIP premium, in turn, encourages a higher share of dollar borrowing by bond issuers due to the more favorable borrowing conditions in dollars. Moreover, the surge in

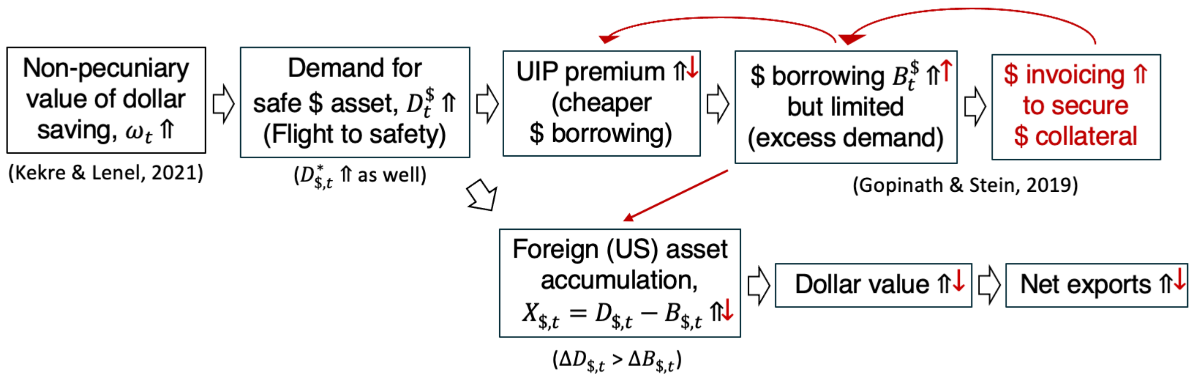

Figure 1.7: Main Mechanism

demand for safe dollar claims stimulates increased investments in U.S. risk-free dollar assets, strengthening the value of the dollar. However, Kekre and Lenel (2021) does not account for the endogenous decisions made by EM exporters regarding their invoicing currency choices.

On the other hand, Gopinath and Stein (2019) emphasize the link between the choice of borrowing currencies and invoicing currencies. They study how the dollar becomes dominant both as a unit of account and as a safe store of value. As a larger share of EM's imports is denominated in dollars, EM depositors increase their demand for saving in dollars to secure more dollars for payment. However, EM exporters face a comparative disadvantage in creating safe claims in dollars, incurring a higher cost associated with securing dollar-denominated collateral. This discrepancy results in a violation of the UIP condition. Since EM exporters' dollar borrowing requires dollar collateral, they invoice more exports in dollars, creating a feedback loop that further increases the dollar's share of import invoicing in other EM countries.

In this paper, I extend the analytical framework of Gopinath and Stein (2019), which explores the relationship between borrowing and invoicing currency decisions. I apply the framework to the global economy, providing a dynamic analysis of how macro variables respond to different shocks, with a particular focus on global risk shocks, U.S. monetary shocks, and domestic monetary shocks, as previously studied by Kekre and Lenel (2021). Figure 1.7 describes the complete mechanism introduced in the baseline model, which effectively bridges the gap between two distinct literatures. Drawing from Kekre and Lenel (2021), an increase in the non-pecuniary value of saving in dollars results in a higher global demand for safe dollar assets, which can be interpreted as a flight to safety. This increases the risk premium associated with EM currencies relative to the dollar, making dollar borrowing relatively more cost-effective than borrowing in EM currencies. Therefore, EM exporters seek more dollar borrowing. Simultaneously, the rise in demand for safe dollar claims by EM depositors can lead to an increase in foreign asset accumulation, provided there is no corresponding increase in the supply of domestic safe dollar claims. This implies that capital flows out of the EM into the U.S., resulting in an appreciation of the dollar. I assume an elasticity of demand equal to one, indicating that the dollar's appreciation leads to increased exports to the U.S. by EMs, thereby increasing EM's net exports.

By combining the two mechanisms provided in the existing literature, I identify a new feedback effect that links EM exporters' choice of invoicing currency and the responses of macro variables to a global risk shock. When EM exporters can endogenously choose the currency of invoicing, they increase the share of dollar invoicing to secure more dollar collateral and enhance their capacity for dollar borrowing. As the dollar's share in EM borrowing goes up, the EM supply of safe dollar assets increases, reducing the risk premium associated with the EM currency. Moreover, the increase in EM exporters' dollar borrowing means that EM depositors save more in dollars within the domestic dollar asset market, attenuating the need to seek external options. Therefore, the increase in EM's foreign asset holdings is mitigated, attenuating the appreciation of the dollar and the expansion of EM's net exports. In short, the endogenous increase in the share of dollar invoicing amplifies the response of EM firms' dollar borrowing and mitigates the responses of the UIP premium, EM's foreign asset accumulation, net exports, and the exchange rate.

1.5 Dynamic Responses to External Shocks: Full Model

In this section, I extend the model to incorporate New Keynesian properties, enabling a more robust analysis of the economic impacts associated with dollar invoicing decisions. The major extensions to the model concern: consumption dynamics, labor, and monetary policy. By introducing these extensions, I aim to explore the impacts of a positive global risk shock, a U.S. monetary tightening, and a domestic monetary shock. When there is a global risk shock, the endogenous change in invoicing currency acts as a mechanism dampening the impact on several macro variables, including the UIP premium, foreign asset holdings, exchange rates, and net exports of the EM, which is consistent with the analytical insights introduced in the previous section.

In response to a U.S. monetary tightening, the share of dollar invoicing increases. This is because borrowing in dollars becomes more attractive, due to the increase in the EM interest rate made by the monetary authority in response to inflation caused by higher import prices resulting from dollar appreciation. This endogenous change amplifies the response of EM exporters' reliance on dollar borrowing while mitigating the responses of key macro variables, including the exchange rate, output, and consumption. Similarly, when the domestic monetary authority increases the EM interest rate, the UIP premium rises, motivating EM firms to borrow more in dollars. When the share of dollar invoicing in exports changes endogenously, the firms' capacity for dollar borrowing expands further, amplifying the responses of the exchange rate, foreign asset accumulations, output, and inflation.

1.5.1 Model Extension

1.5.1.1 Investors

Both U.S. and EM depositors now have per-period utility functions that are non-linear functions of consumption, labor, and their holdings of safe dollar claims. Specifically, U.S. and EM depositors aim to maximize their utilities:

$$U(C_t^i, N_t^i, D_{\$,t}^i) = \frac{1}{1-\sigma_c} C_t^{i\,1-\sigma_c} - \frac{\kappa}{1+\varphi} N_t^{i\,1+\varphi} + \omega_t^i ln(\frac{D_{\$,t}^i}{P_t^i}) \tag{1.26}$$

where $i \in \{EM, U.S.\}$, $\sigma_c > 0$ is the depositors' coefficient of relative risk aversion, and $\varphi > 0$ is the inverse of the Frisch elasticity of labor supply. κ scales the disutility of labor.

Depositors' consumption bundles comprise domestically produced goods, $C_{h,t}^i$, and imports from the other country, M_t^i, for $i \in \{EM, U.S.\}$. Defining ξ^i as the weights of domestic goods in consumption, the consumption bundles are then expressed as:

$$C_t^i = [\xi^{i\,\frac{1}{\sigma}} (C_{h,t}^i)^{\frac{\sigma-1}{\sigma}} + (1-\xi^i)^{\frac{1}{\sigma}} (M_t^i)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma}{\sigma-1}}$$

where $\sigma > 1$ is the elasticity of demand, assumed to be identical for both EM and the U.S. The demand for goods produced in EM and the U.S. by depositors can be written as follows:

$$C_{h,t}^* = \xi^* (\frac{P_{h,t}^*}{P_t^*})^{-\sigma} C_t^*, \quad M_t^* = (1-\xi^*)[\frac{\{\eta_{t-1} + (1-\eta_{t-1})\varepsilon_t^{-1}\} P_{h,t}}{P_t^*}]^{-\sigma} C_t^*$$
$$C_{h,t} = \xi (\frac{P_{h,t}}{P_t})^{-\sigma} C_t, \quad M_t = (1-\xi)(\frac{\varepsilon_t P_{h,t^*}}{P_t})^{-\sigma} C_t$$

where $P_t^* = [\xi^* (P_{h,t}^*)^{1-\sigma} + (1-\xi^*)\{\eta_{t-1} + (1-\eta_{t-1})\varepsilon_t^{-1}\}^{1-\sigma} P_{h,t}^{1-\sigma}]^{\frac{1}{1-\sigma}}$ and $P_t = [\xi P_{h,t}^{1-\sigma} + (1-\xi)(\varepsilon_t P_{h,t}^*)^{1-\sigma}]^{\frac{1}{1-\sigma}}$ are the consumer price indices in the U.S. and EM.

The budget constraints for each depositor h in the U.S. and EM are

$$P_t^* C_t^* + D_{\$,t}^* + W_{r,t}^* \leq W_t^*(h) N_t^*(h) + \Pi_{f,t}^* + \Pi_{k,t}^* + (1+i_{\$,t-1}) D_{\$,t-1}^* + (1+i_{R,t-1}^*) W_{t-1}^*$$

$$P_t C_t + D_{h,t} + \varepsilon_t D_{\$,t} + W_{r,t}$$
$$\leq W_t(h) N_t(h) + \Pi_{f,t} + \Pi_{k,t} + (1+i_{h,t}) D_{h,t-1} + \varepsilon_t (1+i_{\$,t-1}) D_{\$,t-1} + (1+i_{R,t-1}) W_{t-1}$$

where $\Pi_{f,t}^*$ and $\Pi_{f,t}$ are profits of final producers (exporters), and $\Pi_{k,t}^*$ and $\Pi_{k,t}^*$ are profits of capital producers, both owned by the depositors. Note that EM depositors save both in dollars and the EM currency, while U.S. depositors save only in dollars. From the optimality conditions of the depositors, Euler equations for safe claims can be derived:

$$\beta^*(1+i_{\$,t}) = \mathbb{E}_t \frac{P_{t+1}^*}{P_t^*} (\frac{C_t^*}{C_{t+1}^*})^{-\sigma_c} - \frac{\omega_t^*}{D_{\$,t}^*} \mathbb{E}_t \frac{P_{t+1}^*}{{C_{t+1}^*}^{-\sigma_c}}$$
$$\beta(1+i_{h,t}) = \mathbb{E}_t \frac{P_{t+1}}{P_t} (\frac{C_t}{C_{t+1}})^{-\sigma_c}, \quad \beta(1+i_{\$,t}) \mathbb{E}_t \varepsilon_{t+1} = \varepsilon_t \mathbb{E}_t \frac{P_{t+1}}{P_t} (\frac{C_t}{C_{t+1}})^{-\sigma_c} - \frac{\omega_t}{D_{\$,t}} \mathbb{E}_t \frac{P_{t+1}}{C_{t+1}^{-\sigma_c}}$$

Depositors adjust their wage rates with probability $1-\delta_w$, subject to a Calvo friction when setting wages. They face a downward-sloping labor demand given by $N_t(h)^i = (\frac{W_t(h)^i}{W_t^i})^{-\nu} N_t^i$, where $\nu > 1$ is the constant elasticity of labor demand, W_t^i is the aggregate nominal wage rate, and N_t^i is the aggregate labor input for country i. The standard optimality condition for wage setting in EM is given by

$$\mathbb{E}_t \sum_{m=0}^{\infty} (\delta_w \beta^i)^m (\frac{C_{t+m}^i}{C_t^i})^{-\sigma_c} \frac{P_t^i}{P_{t+m}^i} N_{t+m}^i (W_{t+m}^i)^{\nu(1+\varphi)} [\frac{\nu}{\nu-1} \kappa P_{t+m}^i (C_{t+m}^i)^{\sigma_c} (N_{t+m}^i)^{\varphi} - \frac{(\bar{W}_t(h)^i)^{1+\nu\varphi}}{(W_{t+m}^i)^{\nu} \varphi}] = 0 \tag{1.27}$$

where $\bar{W}_t(h)^i$ is the optimal reset wage in period t. The optimal wage is set as a constant markup over the expected weighted average of future marginal rates of substitution between consumption and labor and aggregate wage rates, during the duration of the wage. Sticky wages are adopted as in the standard literatures (see Gali (2008)). The risk-neutral investors solve the same problem as in the baseline model.

1.5.1.2 Producers

Capital producers use domestic labor and final goods to produce capital, which is then sold to exporters. Exporters utilize this capital for the production of final goods in the next period. The capital producers maximize profits, denoted as $\Pi_{k,t}^i = Q_t^i K_t^i - P_{h,t}^i X_t^i - W_t^i L_t^i$, subject to the Cobb-Douglas production function, $K_t^i = (X_t^i)^{\gamma} (L_t^i)^{1-\gamma}$ where $\gamma \in (0,1)$. The optimality condition, for capital producers is expressed as:

$$\gamma W_t^i L_t^i = (1-\gamma) P_{h,t}^i X_t^i \tag{1.28}$$

As in the baseline model, exporters function as final goods producers who acquire capital, produce final goods, and sell these goods both in domestic and foreign markets. Both U.S. and EM exporters solve the same problem as in the baseline, with the only extension being that

Table 1.3: Parameters

Parameter	Description	Value	Notes
Household			
β	Discount factor (EM)	0.9812	3-month deposit rate of Turkey
β^*	Discount factor (U.S. risk-averse)	0.9986	3-month U.S. treasury yield
δ, δ^*	Discount factor (U.S. & EM risk-neutral)	0.96	$\delta = \delta^* < \beta < \beta^*$
σ_c	Risk aversion	2	Gopinath et al. (2020)
φ^{-1}	Frisch elasticity of labor	0.5	Gopinath et al. (2020)
κ	Disutility of labor	0.5	Gopinath et al. (2020)
ν	Labor demand elasticity	4	Gopinath et al. (2020)
ξ, ξ^*	Home bias	0.7	Gopinath et al. (2020)
σ	Elasticity of demand	5	Gopinath et al. (2020)
σ_w	Wage rigidity	0.85	Christiano et al. (2011)
Production			
Z, Z^*	Average returns for capital (U.S. & EM)	1.5	
Z_L, Z_L^*	Worst returns for capital (U.S. & EM)	1	
ψ	Cost related to EM's dollar invoicing	0.1	Average $ inv. share in Turkey
γ	MPL	0.7	Gopinath et al. (2020)
Global risk shock			
ρ_ω	Persistence	0.4	Kekre & Lenel (2021)
$\bar{\omega}$	Safety skewness	0.002	Kekre & Lenel (2021)
Monetary policy			
ρ_m	Inertia parameter	0.5	Gopinath et al. (2020)
ϕ	Inflation sensitivity	1.5	Gopinath et al. (2020)
$\bar{i}_h$	steady state interest rate	$1/\beta - 1$	Gopinath et al. (2020)

they now receive revenues with prices determined in the market. In the baseline, the prices of final goods were normalized, and only the exchange rate determined the relative price between domestic and imported goods.

1.5.1.3 Monetary Policy

The domestic risk-free interest rate in EM is determined by the monetary authority and follows an inflation-targeting Taylor rule with inertia:

$$i_{h,t} - \bar{i}_h = \rho_m(i_{h,t-1} - \bar{i}_h) + (1 - \rho_m)\phi_m \pi_t + e^h_{i,t} \tag{1.29}$$

where ϕ_m captures the sensitivity of policy rates to domestic price inflation, and ρ_m captures the inertia in setting rates. i_h is the target nominal interest rate. The shock to the interest rate, $e^h_{i,t}$, follows an AR(1) process: $e^h_{i,t} = \rho_e e_{i,t-1} + \epsilon_{m,t}$, where $\epsilon_{m,t} \sim N(0,1)$. The U.S. interest rate is set by the U.S. monetary authority as:

$$i_{\$,t} = \bar{i}_\$ + e^\$_{i,t} \tag{1.30}$$

where $e^\$_{i,t}$ follows an AR(1) process and captures a shock in U.S. monetary policy.

1.5.2 Calibration

Table 1.3 provides a list of parameter values employed in the simulation, with quarters as the time period, spanning the sample from 2000 to 2018, consistent with the empirical analysis. The household parameters are set to values standard in the literature and follow Gopinath et al. (2020). The discount factor in EM, β, is set lower than the discount factor in the U.S., β^*. This difference reflects the higher steady-state interest rate in EM, indicative of a higher premium on the EM currency compared to the dollar. This captures the positive UIP premium observed in EM. Specifically, the calibration matches the discount factor to the 3-month deposit rate for Turkey and the 3-month U.S. treasury yield for the U.S. The cost parameter, ψ, is calibrated to match the average share of dollar invoicing in exports of Turkey, 56%.

Following Christiano et al. (2011), the parameter for wage stickiness is set to 0.85, corresponding to a year and a half average duration of wages. The parameters related to the global risk shock are calibrated following Kekre and Lenel (2021), as I adopt their concept of the safety shock. The safety persistence parameter, ρ_ω, is set to 0.4, and the skewness parameter,

$\bar{\omega}$, is set to 0.002. Regarding the monetary policy rule, the inertia parameter, ρ_m, is set to 0.5, and the inflation sensitivity parameter, ϕ_m, is set to 1.5, in line with standard values found in the literature (see Gopinath et al. (2020)).

1.5.3 Dynamic Responses

1.5.3.1 A Positive Global Risk Shock

Figure 1.8 plots the impulse responses to a one percentage point increase in the non-pecuniary value of safe dollar assets, which is what I refer to as a global risk shock. This exogenous increase in the value of holding dollar safe assets results in a surge in depositors' demand for dollar savings, leading to a reduction in the premium given to the dollar. Therefore, the UIP premium for the EM increases (Fig.1.8(b)). The rise in the premium for the EM currency implies that, from a borrower's perspective, it becomes relatively cheaper to borrow in dollars than in the EM currency, motivating EM exporters to increase their dollar borrowing (Fig. 1.8(c)). If these exporters were unable to increase the share of exports invoiced in dollars, their ability to increase the share of dollar borrowing would be limited due to the collateral required for dollar borrowing. This case is depicted by the blue dashed line in the figure. If exporters can endogenously increase the share of dollar invoicing in their exports, they will do so to secure more dollar collateral for dollar borrowing (Fig. 1.8(d)). Therefore, the share of dollar borrowing increases further, as shown by the red line in the figure. In this case, since the supply of dollar safe claims increases further, the increase in the UIP premium is dampened.

As EM depositors increase their demand for dollar savings, they accumulate a larger volume of safe dollar assets by lending to EM exporters. However, since EM exporters' dollar

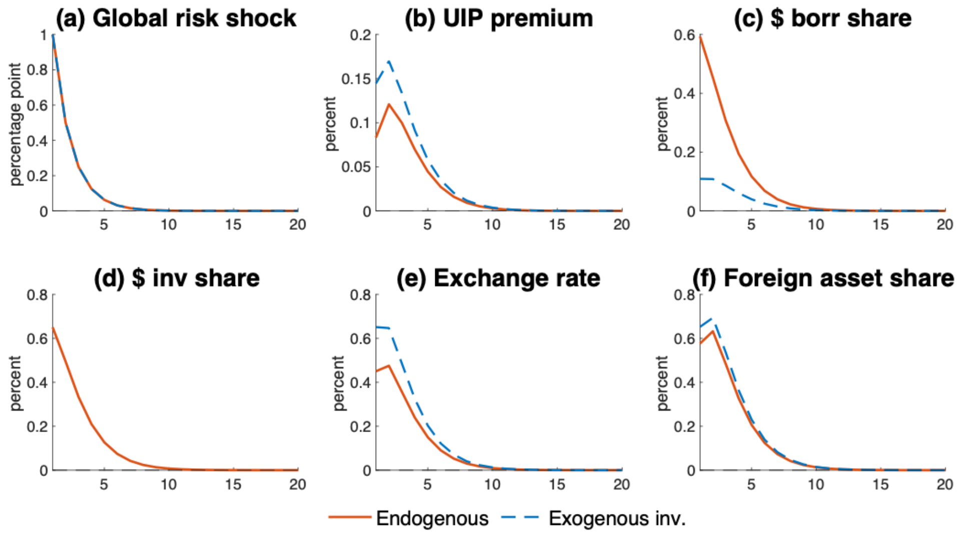

Figure 1.8: Impulse Responses of the EM to a Global Risk Shock

collateral is limited, EM depositors invest some of their savings abroad, by purchasing U.S. securities. This increases the EM's share of foreign assets relative to total assets (Fig.1.8(f)). This increase in the foreign asset share results in higher dollar appreciation. When EM exporters have the capacity to enhance the supply of safe dollar assets by securing additional dollar collateral, primarily through increasing their share of dollar invoicing in exports, the responses of the foreign asset share and the exchange rate are attenuated.

1.5.3.2 A U.S. Monetary Tightening

Figure 1.9 illustrates the responses of the EM economy to a one percentage point increase in the U.S. interest rate. In response to the U.S. interest rate hike, the EM monetary authority raises its own interest rate to counter potential inflationary pressures stemming from higher import prices due to the stronger dollar. The immediate increase in the EM interest rate is even higher than the U.S. shock, by 1.5%p, raising the UIP premium on the EM currency. Since borrowing in dollars becomes cheaper, EM exporters respond by increasing the share of dollar borrowing,

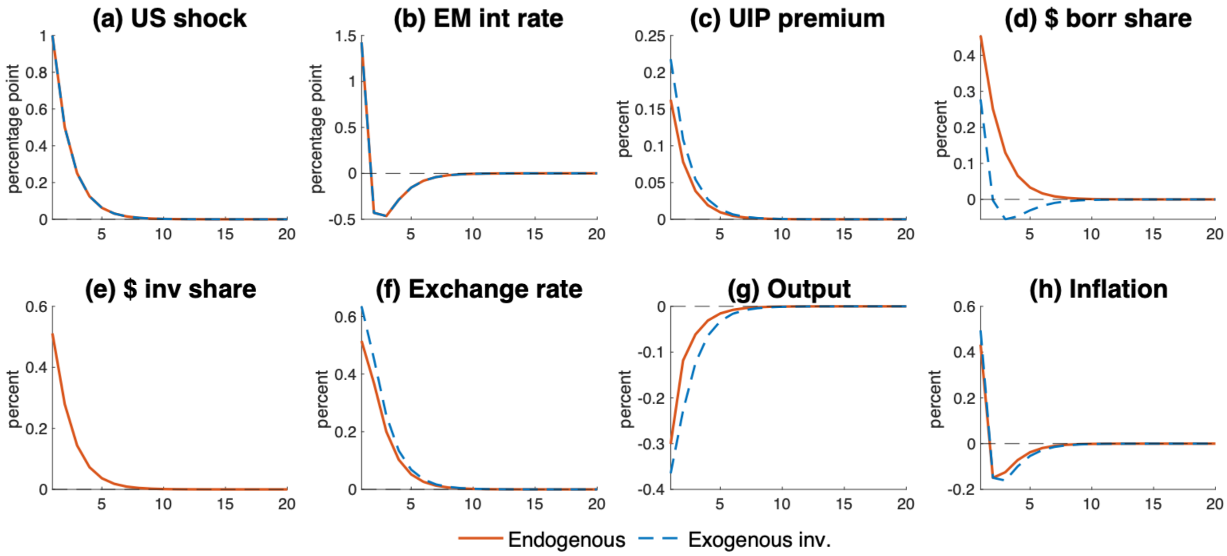

Figure 1.9: Impulse Responses of the EM to a U.S. Monetary Tightening

as shown in Fig.1.9(d). When the share of dollar invoicing is fixed (dashed line), the response turns negative in the third period, likely because the EM interest rate experiences subsequent decrease two periods after rising in response to the shock. This may be because the EM inflation is immediately tamed by the EM monetary authority, prompting a downward adjustment in the interest rate to prevent excessive economic downturns. When the U.S. interest rate rises, the demand for saving in dollars by EM depositors increases. However, this increased demand cannot be entirely met in the domestic market due to the limitations on borrowing capacity faced by EM exporters. Therefore, depositors save in dollars abroad, leading to an appreciation of the dollar. Since higher interest rates encourage more savings from EM depositors, resulting in reduced savings and reduced consumption, this ultimately leads to a decrease in domestic output.

Similarly to the global risk shock, when EM exporters are unable to adjust the invoicing currency for their exports, their ability to increase dollar borrowing is restricted. However, if they have the flexibility to increase the share of dollar invoicing, they respond to the U.S. monetary shock by raising the invoicing share by 0.5% as shown in Fig.1.9(e). This allows exporters to

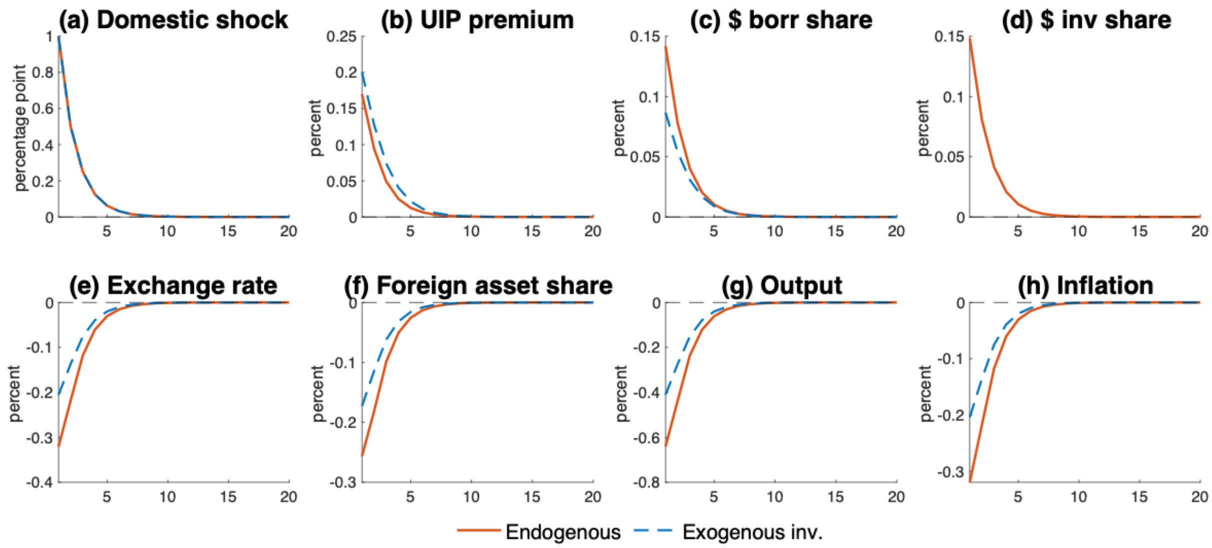

Figure 1.10: Impulse Responses of the EM to a Domestic Monetary Tightening

borrow more in dollars, increasing the supply of safe dollar claims in the domestic dollar asset market. This reduces the demand for saving in the U.S., mitigating the appreciation of the dollar by about 0.1$p. Furthermore, since the increase in the supply of safe dollar assets reduces the return on dollar savings by moderating the rise in the UIP premium, there is a smaller increase in total EM saving, which mitigates the decline in EM consumption and output. Note that the responses of output and consumption can vary, either being amplified or mitigated, depending on the sensitivity of demand for savings. If the price elasticity of demand for safe assets is low, resulting in EM depositors increasing their overall savings with higher supply, EM consumption and output will decrease even more.

1.5.3.3 A Domestic Monetary Tightening

Figure 1.10 shows the responses to a domestic monetary tightening within the EM. The figure depicts the responses of EM variables to a one percentage point increase in the EM interest rate. As the EM interest rate rises, the UIP premium goes up. This results in EM firms borrowing

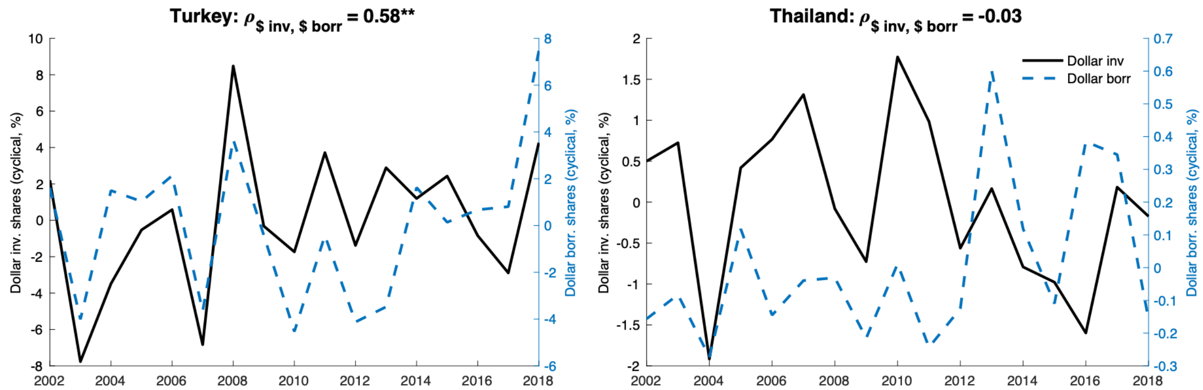

Figure 1.11: Turkey vs. Thailand: Dollar Invoicing/Borrowing Shares

more in dollars, as the borrowing cost in EM currency has become relatively higher. To secure more dollar collateral, EM firms increase their dollar invoicing shares. Simultaneously, the higher EM interest rate implies that depositors will receive a higher return from safe claims in EM currency. Therefore, depositors seek to hold more domestic assets, reducing the proportion of foreign assets in their portfolios. This, in turn, leads to a depreciation of the dollar. When the dollar invoicing share can respond to domestic monetary policy, EM exporters increase the share of dollar invoicing in their exports, amplifying the response of firms' dollar borrowing shares. This increase supplies more safe dollar claims, which dampens the increase in the UIP premium. However, unlike the global risk shock, the increase in dollar invoicing shares further amplifies the decline in the foreign asset share. This happens because the UIP premium does not increase as significantly. EM output decreases further due to an overall increase in EM depositors' savings. Note that EM inflation decreases due to the drop in the domestic interest rate, and the response is further amplified when EM exporters raise the share of dollar invoicing in their exports.

1.5.4 Empirical Evidence: Turkey vs. Thailand

In this section, I verify the theoretical observations using empirical data. The model analyses have demonstrated that endogenous changes in dollar invoicing shares can either mitigate or amplify the responses of EM macro variables to external shocks. To test this observation against real-world data, we compare two countries: Turkey, which experiences significant fluctuations in dollar invoicing shares, and Thailand, where these shares are less volatile.

Figure 1.11 presents the cyclical movements of dollar invoicing and borrowing shares in Turkey and Thailand. Notably, the share of dollar invoicing exhibits higher volatility in Turkey, ranging from -8 to 8 percentage deviations from the trend. In contrast, Thailand's share fluctuates within a narrower range, typically between -2 and 2 percentage points. Moreover, the co-movement between dollar invoicing and borrowing shares is evident in Turkey, as indicated by a significantly positive correlation of 58%. In Thailand, I do not observe a clear correlation between these two shares. Therefore, based on the theory, I anticipate Turkey to exhibit a larger impact of endogenous invoicing currency choice, whereas Thailand is expected to experience a lesser impact.

To conduct the comparison, I first examine the response of dollar invoicing shares in Turkey and Thailand to a positive global risk shock, as measured by an increase in the VIX. To investigate these responses, I employ the following local projection model:

$$\$INV_{t+h} = \beta_h VIX_t + \beta_h^w W + \epsilon_{t+h}, \quad h = 0, 1, 2, ... \tag{1.31}$$

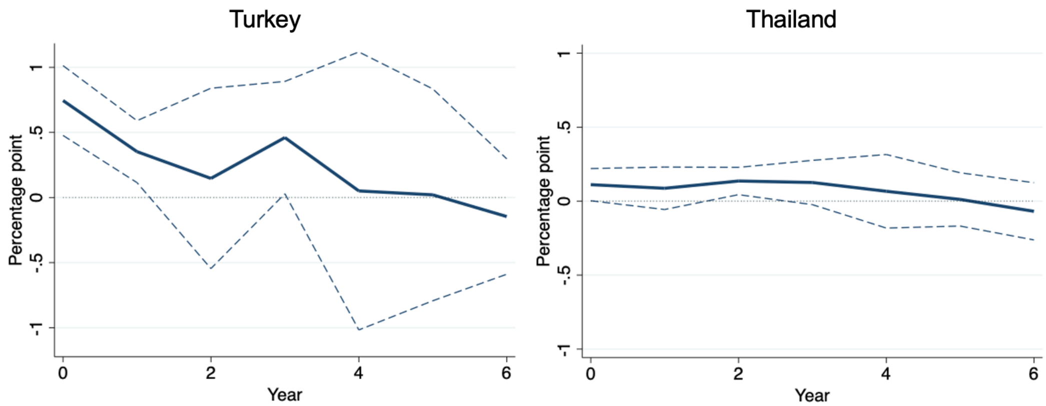

Figure 1.12: Turkey vs. Thailand: Responses of Dollar Invoicing Shares to a Global Risk Shock

where β_h is the impulse response coefficient of the VIX on the share of dollar invoicing in exports. W is the set of control variables, including the current account balance and two lags of the dependent variable and the VIX.

Given that invoicing currency choice is available on an annual basis, I estimate the responses at the yearly level. In both Turkey and Thailand, the share of dollar invoicing responds significantly to the shock, with an immediate increase of 0.76 %p in Turkey and a smaller immediate increase of less than 0.2 %p in Thailand. This significant increase persists for six years in Turkey, but only two years for Thailand.

To validate the shock propagation dynamics outlined in the theoretical analyses, I examine the responses of key EM macro variables, including dollar borrowing shares, the UIP premium, exchange rates, and net exports, to a global risk shock. I employ local projections as described earlier, but use quarterly data to capture clearer patterns with higher frequency. Figure 1.13 illustrates the dynamic responses of the UIP premium, dollar borrowing shares, exchange rates, and net exports in Turkey and Thailand following a positive increase in the VIX. When global uncertainty increases exogenously, I observe that macro variables presented in the figure increase in both countries.

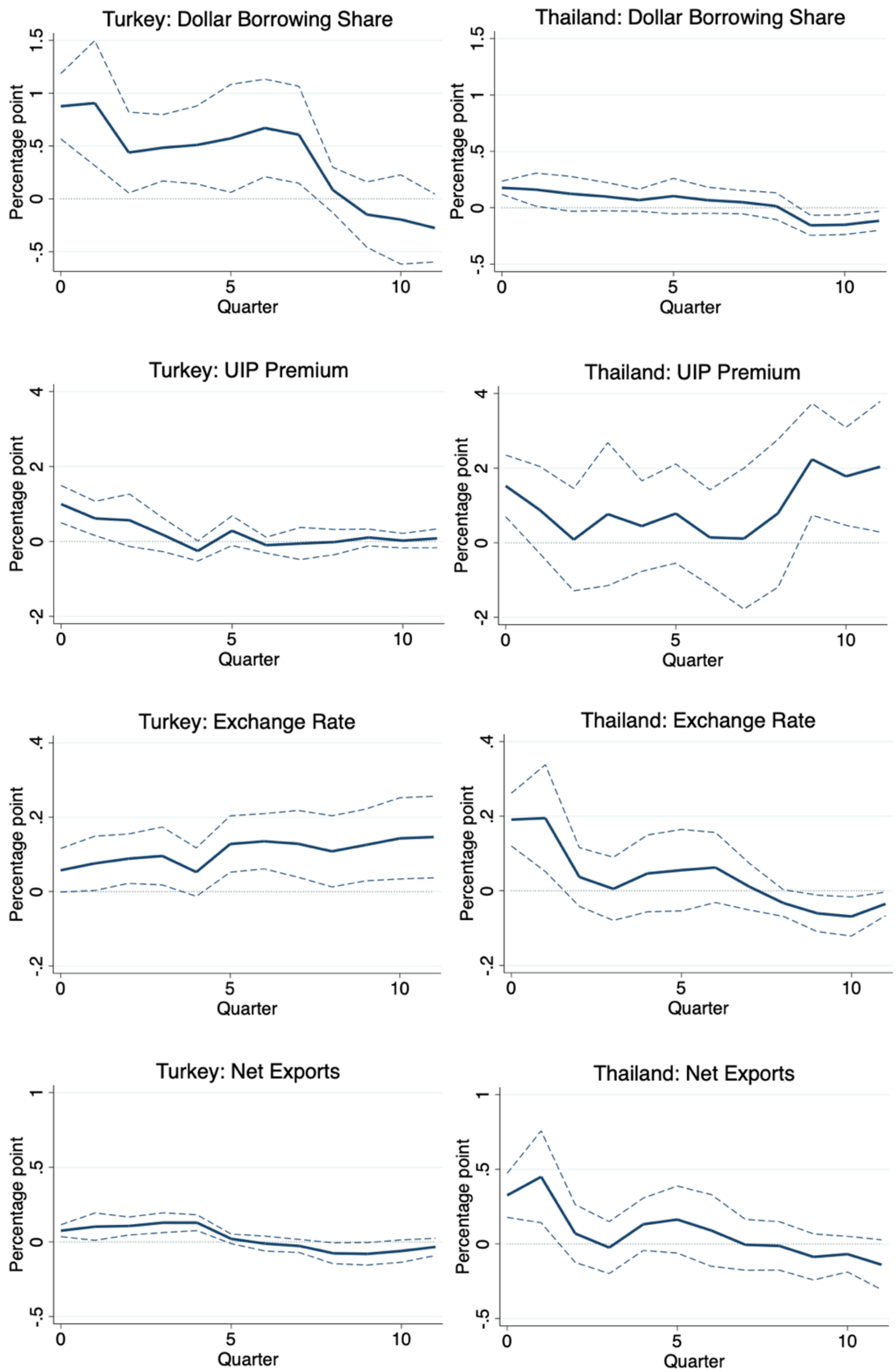

Figure 1.13: Turkey vs. Thailand: Responses of Macro Variables to a Global Risk Shock

The figures show that the increase in the share of dollar borrowing is more pronounced in Turkey, while other macro variables respond more significantly in Thailand. When there is a one unit increase in the VIX, the share of dollar borrowing in Turkey goes up by 0.9%p, significantly higher than the 0.2%p increase observed in Thailand. On the other hand, the rise in the UIP premium, the exchange rate, and net exports is less marked in Turkey than in Thailand. Specifically, Turkey experiences increases of 1%p, 0.08%p, and 0.09%p, respectively, whereas Thailand shows larger increases of 1.8%p, 0.2%p, and 0.3%p. This observation aligns with the theoretical results outlined in the previous section. As the share of dollar invoicing increases to a greater extent in Turkey compared to Thailand, firms in Turkey can more effectively secure dollar collateral, which can then be used to further increase their dollar borrowing shares. This dampens the increase in the UIP premium in response to the global risk shock, as the domestic supply of safe dollar claims increases. Depositors in Turkey are less inclined to shift their savings to U.S. securities compared to those in Thailand, resulting in a mitigation of currency depreciation in Turkey. Furthermore, I observe that exports increase to a lesser extent in Turkey compared to Thailand.

1.6 Conclusion

In this paper, I established a dynamic link between exporters' choices of invoicing currency and borrowing decisions, shedding light on their cyclical co-movements. Through country-level data analysis, I observe positive correlations between dollar invoicing shares and dollar borrowing shares over time, along with a positive association between dollar borrowing shares and the global financial cycle, as represented by the VIX. I suggest that dollar borrowing decisions play a key role in shaping exporters' choices of invoicing currency, influenced by global financial conditions.

To show this mechanism, I present a general equilibrium model where exporters not only choose the currency for borrowing but also determine the share of exports invoiced in dollars. When there is a heightened demand for safe dollar claims, the cost of borrowing in dollars falls relative to borrowing in other currencies. Therefore, EM firms try to increase their dollar borrowing, constrained by the dollar- denominated revenues they expect to receive. Since the domestic firms lack the capacity to provide sufficient safe dollar claims, EM depositors fulfill their increased demand for saving in dollars by investing in U.S. safe assets, such as U.S. treasuries. This leads to a capital outflow from EM to the U.S., resulting in an appreciation of the dollar. However, if EM exporters can endogenously increase the share of dollar invoicing, they can augment their capacity for dollar borrowing in response to global risk shocks. This implies that part of the greater demand for saving in dollars by EM depositors can be satisfied domestically, mitigating the increase in foreign savings and dampening the appreciation of the dollar. Furthermore, I show that the effects of U.S. and domestic monetary policy shocks can also be either dampened or amplified based on the endogenous response of invoicing currency choices.

I explore the dynamic connection between changes in global financial conditions, firms' decisions on invoicing currency, and their choices of borrowing currencies. I present an open macro framework to elucidate the significance of endogenous changes in invoicing currency in propagating external shocks, including global risk and monetary policy shocks. I find a crucial role for exporters' invoicing currency decisions, suggesting that these decisions should be considered by policy makers and forecasters.

Chapter 2: Corporate Cross-Border Borrowing and Macroprudential Policy

2.1 Introduction

Many countries, especially emerging markets, have adopted macroprudential measures (MPMs) and capital flow management measures (CFMs) that go beyond conventional monetary policy and financial regulations since the Global Financial Crisis. MPMs build buffers that can keep agents from increasing leverage excessively during booms and from being vulnerable to adverse exogenous shocks. The buffers can be relaxed during a financial crisis, helping the transmission of monetary policy in the event of such stress. CFMs are measures that restrict capital flows. If MPMs regulate the foreign exchange market, they may also serve to limit capital flows. Thus, these measures are often referred to as CFM/MPMs.[1]

In this paper, I will present both theoretical and empirical analyses on the impacts of macroprudential policy when firms have the option to borrow directly from abroad and the economy experiences a decline in the global interest rate. When the U.S. engages in monetary expansion, overseas firms may ramp up their borrowing due to decreased borrowing costs. However, it is possible that an excessive surge in corporate borrowing heighten the economy's susceptibility to subsequent currency shocks or financial crises, as agents are exposed to more default risk. Therefore, non-U.S. central banks may opt for macroprudential policies to curb

[1]These classifications can be found in Das et al. (2023).

excessive borrowing by agents. In this paper, I demonstrate that macroprudential policies curb the expansion of corporate loans in response to U.S. monetary expansion, albeit the effects diminishes when a larger portion of borrowing originates from foreign sources. Since traditional MPMs lack the capability to regulate capital inflows from abroad and primarily focus on domestic markets, firms may resort to increasing cross-border loans, which remain unaffected by macroprudential policies, in response to a global decrease in borrowing rates. The incorporation of CFMs alongside MPMs can help address these leakages, as CFMs directly restrict capital inflows through corporate cross-border loans.[2]

In the empirical part, I study the impacts of MPMs and how they are influenced by a higher share of foreign loans. Furthermore, I investigate how the impacts of MPMs vary when they are coordinated with CFMs. By constructing panel data using loan-level information provided in *Thomson Reuters Dealscan* and other macro variables, I show that macroprudential policies significantly attenuate both the level and the response of non-U.S. corporate loans to a U.S. monetary expansion. However, the effects of MPMs are significantly dampened as the country's share of foreign loans goes up, unless CFMs are conducted simultaneously. These results hold for macroprudential policies targeting either borrowers or lenders. When MPMs are implemented with CFMs in place, these policy measures significantly reduce corporate loans and the response of the loans to a U.S. monetary expansion, while a higher share of foreign loans does not dampen this effect. Thus, when firms are able to borrow more from abroad, it is more efficient for the central bank to adopt CFMs in addition to MPMs if they want to tame the increase in total corporate borrowing. However, when the sample countries are divided into two groups, advanced

[2]CFMs often target capital outflows from the country, but for the purposes of this analysis, I exclusively consider CFMs pertaining to inflows.

and emerging markets, I find that this is the case only for emerging market countries. In advanced countries, MPMs are sufficient to manage corporate loans, which indicates that CFMs are not needed to regulate firms' leakages toward the international market. In fact, advanced countries have not conducted CFMs as much as emerging markets have done.

Next, I provide a two-period model extended from Cespedes et al. (2017) to study the impact of macroprudential policy on corporate loans when the global interest rate is decreased by U.S. monetary expansion. In the model, firms finance loans from both domestic banks and the foreign market. Considering that most domestic markets are financially less stable than the international market, savers may require a higher risk premium domestically (see Bocola and Lorenzoni (2017)). Therefore, I assume that firms face lower borrowing rates when they borrow from abroad. This corporate cross-border borrowing is constrained to be less than some multiple of their expected revenue, which can be regarded as collateral. Banks finance their lending to firms by borrowing from the international market at rate R^{**}. They also lend to foreign borrowers at interest rate R^{*}, which is less than or equal to the domestic rate R. Banks have financial constraints that limit the total borrowing from abroad to a fraction of their expected revenue. Banks can borrow across borders at a lower rate than firms (i.e., $R^{**} < R^{*} \leq R$) since they are commonly regarded more stable than firms.

I present analytical solutions for scenarios where there is a decline in international rates and the central bank implements macroprudential policies. A decrease in global interest rates may prompt firms to expand their total loans due to lower borrowing costs and increased net worth. I demonstrate that the introduction of a macroprudential policy can mitigate this increase in corporate loans, with a focus on a specific type of MPM known as *"Concentration Limits"*. This policy restricts banks from exposing themselves excessively to a limited number of borrowers by limiting the amount of domestic lending to a fraction of their own net worth, thus capping the proportion of assets held by domestic borrowers. While this policy effectively curtails the rise in corporate loans in response to a decrease in global interest rates, its effectiveness may diminish when firms have greater access to foreign borrowing. However, this diminishing effect can be offset by implementing CFMs in conjunction with MPMs. CFMs that restrict corporate cross-border borrowing can enhance the effectiveness of macroprudential policies by preventing an excessive surge in firms' cross-border borrowing. This theoretical insight aligns with empirical evidence drawn from loan-level data on non-U.S. firms.

In sum, I first provide empirical evidence demonstrating that macroprudential policies can temper the increase in corporate loans in response to U.S. monetary expansion. I show that this effect weakens as the proportion of foreign borrowing rises, and that MPMs can maintain their effectiveness even in the presence of corporate cross-border borrowing if implemented alongside CFMs. Additionally, I offer a theoretical model illustrating the mechanisms underlying these effects. In the model, I illustrate how macroprudential policies limiting bank assets allocated as loans to domestic firms can mitigate the response of corporate loans to a decline in global interest rates. Furthermore, I demonstrate that the overall efficacy of macroprudential policies may be compromised in the presence of increased cross-border borrowing by firms, a challenge that can be addressed through the introduction of CFMs.

2.1.1 Related Literature

There is a growing literature studying the effects of macroprudential policy. Lim et al. (2011) is one of the first studies to analyze the links between macroprudential policy and credit booms. They suggest that MPMs such as limits on Loan-to-Value ratio (LTV) and Debt-to-Income ratio (DTI) can be effective in mitigating cyclical responses of credit and leverage. Their work was followed by empirical literature such as Bruno et al. (2017), Cerutti et al. (2017), Claessens et al. (2013), Dell'Ariccia et al. (2012), and Zhang and Zolit (2014). Based on micro-level data analysis, Aiyar et al. (2014) and Jimenez et al. (2012) also find a role for macroprudential policy in taming credit supply cycles. This paper contributes to this strand of literature by examining how the effects of macroprudential policy depend on the share of foreign borrowing in total corporate borrowing. Using loan-level information provided in the Dealscan database, I show how the effects of macroprudential policy can be dampened when the country's share of foreign borrowing is higher.

This paper also adds to the strand of literature analyzing the effects of macroprudential policy in an open economy setup (Aoki et al. (2016), Cespedes et al. (2017), Dedola et al. (2013), Nuguer (2016), Ueda (2012)), by suggesting that macroprudential policy effects are dampened when a significant share of loans occur across borders. Based on the open economy models with financial intermediation by Gertler and Karadi (2011) and Gertler and Kiyotaki (2010a), these papers study the implications of MPMs theoretically. I adopt and modify the two-period model suggested by Cespedes et al. (2017), who discuss the effects of unconventional policies when lenders have occasionally binding collateral constraints. I modify their setup by allowing firms to borrow across borders while banks also lend to the international markets. This model allows me to study how corporate cross- border loans affect macroprudential policies in an open economy.

Previous work that studies corporate borrowing in foreign currency (Bianchi (2011), Mendoza (2010), Korinek (2011)). Salomao and Varela (2018b) and Hardy (2018) analyze firms' decisions on the mixture of borrowing in local currency and in foreign currency. However, few papers study firms' decisions over-borrowing from different countries. Instead of focusing on firms' borrowing in different currencies, I study the importance of firms' decisions on whether to borrow domestically or across borders. Corporate cross- border loans can significantly affect macroprudential policies because those loans cannot be directly regulated with MPMs.

The last strand of literature that is related to this paper studies the effects of CFMs in regulating agents' borrowing decisions. There have been some papers that discuss the costs of capital controls (Chari and Henry (2004), Gourinchas et al. (2010), Maggiori (2017)). Keller (2019) argues that capital controls can induce banks to lend more to firms in foreign currency. Nevertheless, many authors have demonstrated benefits of capital controls in managing financial stability and over-borrowing (Bianchi (2011), Brunnermeier and Sannikov (2015), Korinek and Sandrii (2016), Mendoza (2010), Ostry et al. (2012), Schmitt-Grohe and Uribe (2012)). This paper adds to this literature, emphasizing the benefits of CFMs in preventing the effects of MPMs from being dampened by corporate cross-border loans. Bengui and Bianchi (2014) argue that agents borrowing from sectors other than recognized domestic markets are regarded as capital leakages, which limit the effectiveness of CFMs. In this paper, agents can borrow from abroad, but these are not unregulated leakages in terms of capital flow management because agents are subject to constraints on cross-border borrowing.

2.1.2 Layout

The rest of this paper proceeds as follows. Section 2.2 provides empirical evidence on the effectiveness of MPMs and how they differ depending on the presence of CFMs. Section 2.3 presents a model to explain the mechanism behind the findings in Section 2.2. Section

2.4 provides analytical solutions, 2.5 studies the impact of MPMs and CFMs, and Section 2.6 concludes.

2.2 Empirical Analysis

This section provides empirical evidence on the impact on non-U.S. firms of macroprudential policy during U.S. monetary expansions. I show how macroprudential policy measures (MPMs) can help in mitigating the increase in total corporate loans in response to U.S. monetary expansions. In addition, I examine a measure of the share of foreign loans in total corporate loans and show that the effectiveness of macroprudential policy is dampened as the foreign loan share goes up. This is because MPMs can only regulate domestic loans, not foreign capital inflows. This dampening is observed for both lender- and borrower-targeted policy measures. However, when MPMs are conducted simultaneously with capital flow management measures (CFMs), the effects of the MPMs in attenuating corporate loans become more significant. Furthermore, there is no dampening impact on the effectiveness of macroprudential policy as the share of foreign loans goes up. Finally, I study the effectiveness of MPMs separately in advanced and emerging countries. The dampening impact of higher foreign loans and the need for CFMs exist only in emerging countries, while MPMs can sufficiently manage corporate loans in advanced countries.

2.2.1 Data Construction

My data includes information about corporate loans from Dealscan, the Macroprudential Policy Index (MPI) from Cerutti et al. (2017), and other macro variables taken from FRED. Total corporate loans and the share of foreign loans by country and year are calculated by aggregating loan-level data on the deal amount, lender type, lender shares, currency, and the exchange rate provided in Dealscan. Dealscan contains rich balance-sheet information and covers large listed firms in a number of countries. I only use the international part of the database, excluding borrowing firms from the United States.[3] The database provides information about loan packages in which multiple lenders participate in lending to a single firm. I calculate the total corporate loans for each country each year in dollars by first multiplying the loan amount by the exchange rate and then adding across loans. Using lender shares and information about lenders' locations, I can separately calculate the amount of corporate loans from domestic and foreign lenders, respectively. Using these numbers, I obtain the annual level and the growth of corporate loans in a country over the period 2000 - 2014. In addition, I calculate the share of foreign loans in total corporate loans in each country, averaged over the period 1990 to 1999.

MPI measures the number of macroprudential policy buffers that a country imposes in a certain period. The index is constructed by Cerutti et al. (2017) using a comprehensive IMF survey, called Global Macroprudential Policy Instruments (GMPI). The MPI measures cover 12 different instruments, which can be divided into two groups: borrower-targeted and lender-targeted.[4] The MPI index does not measure the intensity of the policies but simply counts the

[3]The data covers 40 countries including Argentina, Australia, Belgium, Brazil, Canada, Chile, China, Croatia, Denmark, Egypt, Finland, France, Georgia, Germany, Greece, India, Indonesia, Ireland, Italy, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Peru, Philippines, Poland, Portugal, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Thailand, Turkey, the United Arab Emirates, and the United Kingdom.

[4]Debt-to-Income Ratio (DTI); Time-Varying/Dynamic Loan-Loss Provisioning (DP); General Countercyclical Capital Buffer/Requirement (CTC); Leverage Ratio (LEV); Capital Surcharges on SIFIs (SIFI); Limits on Interbank Exposures (INTER); Concentration Limits (CONC); Limits on Foreign Currency Loans (FC); Limits on Domestic Currency Loans (CG); Levy/Tax on Financial Institutions (TAX); Loan-to-Value Ratio Caps (LTV_CAP); FX and/or Countercyclical Reserve Requirements (RR_REV). Debt-to-Income Ratio (DTI) and Loan-to-Value Ratio Caps (LTV_CAP) are classified as borrower-targeted policies, and the others are regarded as being aimed at financial institutions in Cerutti et al. (2017).

number of instruments that were in place in a particular country in a given period since it is difficult to capture the degree of intensity without subjectivity. In addition, I construct an indicator of CFMs based on the "IMF 2019 taxonomy of CFMs," which provides data starting in 1991. The taxonomy records whether certain types of CFMs for capital inflows or outflows were conducted during a certain period. Since my paper studies the effects of policies that aim to mitigate the increase in corporate loans in response to U.S. monetary expansion, I focus only on CFMs that regulate capital inflows, can be classified into 6 different types.[5] The CFM indicator is a binary measure that takes a value of 1 when there is at least one CFM in place.

U.S. monetary expansions are measured as a decrease in the Wu-Xia shadow rate estimated by Wu and Xia (2016) since the Federal Funds rates reached their zero lower bound (ZLB) after the 2007 financial crisis.[6] The shadow rate incorporates the Fed's easing through unconventional policies as well as monetary policies to help understand the effects of quantitative easing on the economy. Therefore, I assume that there is a U.S. monetary expansion when the shadow rate is lower than in the previous period. To control for country-specific economic fluctuations, I also use macroeconomic variables such as policy rates and the growth in real GDP for each country. The data I use covers the period 2000 - 2014 at a yearly frequency, for which I have information about corporate loans, MPMs, CFMs, U.S. monetary policy, and other macroeconomic variables.

2.2.2 Descriptive Statistics

Table 2.1 presents descriptive statistics for the main regression variables. I find large variation in the dependent variables, the growth and the level of corporate loans, which range

[5]Reserve requirement; Limit; Stamp duty; Tax; Approval requirement; Other. Details are described in "IMF 2019 taxonomy of CFMs."

[6]The Wu-Xia shadow funds rate was developed by Wu and Xia (2016) to understand the exact stance of monetary policy and other policy tools after the federal funds rate reached near zero.

Table 2.1: Summary Statistics of Main Regression Variables

	Mean	Median	Min	Max	Std. Dev.	Obs
Dependent Variables						
Total corporate loan growth (%)	18.99	17.96	-710.44	977.18	141.98	559
Total corporate loan level (logged)	1.27	1.38	-7.13	5.47	2.08	576
Independent Variables						
(Country-year level variables)						
MPI_all	2.58	2	0	12	2.16	600
MPI_lender	2.14	2	0	10	1.68	600
MPI_borrower	0.44	0	0	2	0.69	600
CFM	0.11	0	0	1	0.31	600
Policy rate (%)	4.37	2.98	-0.09	183.2	8.81	588
GDP growth (%)	2.76	2.91	-16.43	14.19	3.47	600
(Country level variables)						
Foreign share	0.78	0.87	0.28	1	0.22	40
(Year level U.S. variables)						
U.S. expansion	0.67	1	0	1	0.47	15
U.S. shadow funds rate (%)	1.46	1.35	-2.74	6.24	2.65	15

Notes: The table presents summary statistics for all observations from 2000 - 2014. The level of total corporate loans is denominated in billions of U.S. dollars. Sources are Dealscan, the IMF database, and FRED. “MPI_all” is an index of all macroprudential policies, “MPI_lender” indexes lender-targeted policies, and “MPI_borrower” indexes borrower-targeted policies. “CFM” is an index of capital flow management policies, constructed based on the “IMF 2019 taxonomy of capital flow management measures.” “Foreign share” denotes the share of foreign loans in total corporate loans.

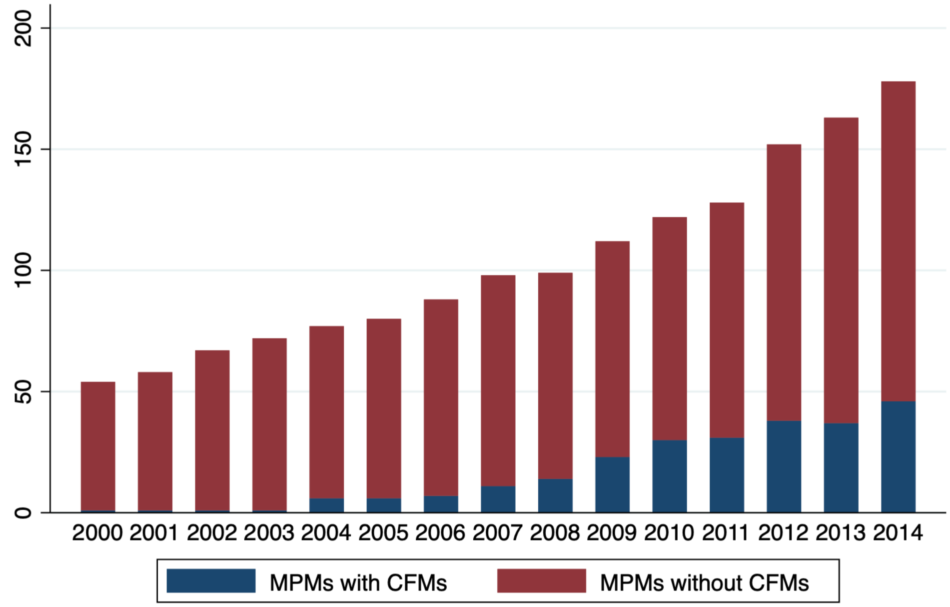

Figure 2.1: Macroprudential policies with and without CFMs

Source: Cerutti et al. (2017) and IMF 2019 Taxonomy of CFMs

from -710.44 to 977.18 percentage points and from -7.13 to 5.47 in logged values, with a standard deviation of 141.98 and 2.08, respectively. The table also describes variation in the macroprudential policy index, which ranges from 0 to 12 with a standard deviation of 2.16 and a mean of 2.58. Among these policies, lender-targeted policies show more variation, ranging from 0 to 10 with a standard deviation of 1.68 and a mean of 2.14, while the borrower-targeted policy index has a mean of 0.44 and a standard deviation of 0.69. In addition, the indicator of CFMs has a mean of 0.11 and a standard deviation of 0.31. Policy rates and GDP growth vary from -0.09 to 183.2 and from -16.43 to 14.19, respectively, with means of 4.37 and 2.76. The average share of foreign loans in total corporate loans is 0.78 across countries, with a standard deviation of 0.22. The dummy for U.S. expansion and the U.S. shadow funds rate also show ample variation, with standard deviations of 0.47 and 2.65.

Figure 2.1 shows changes over time in the number of MPMs adopted by sample countries with and without CFMs. "MPMs with CFMs" indicates the number of MPMs that are conducted when at least one CFM is in place. "MPMs without CFMs" counts the number of MPMs that are conducted without any CFMs in place. As depicted in the figure, the total number of macroprudential measures in place in the sample countries increased over time, starting with just above 50 in 2000 and ending at over 175 in 2014. The number of macroprudential measures conducted with CFMs also increased over the sample period after countries first introduced CFMs in 2004. However, more than 75 percent of MPMs are still adopted without any capital control management measures in place.

2.2.3 Empirical Analysis

2.2.3.1 Empirical Strategy

I analyze how the usage of various macroprudential policies affects corporate loans when there is a U.S. monetary expansion. In addition, I estimate how a country's predetermined share of foreign loans in total corporate loans affects the impact of macroprudential policy instruments. I estimate the following baseline regression model:

$$
\begin{aligned}
Y_{i,t} = {} & \beta \cdot Macropru_{i,t} \times USexp_{t-1} \times Share_i \\
& + \alpha_1 \cdot Macropru_{i,t} \times USexp_{t-1} + \alpha_2 \cdot Macropru_{i,t} \times Share_i + \alpha_3 \cdot Share_i \times USexp_{t-1} \\
& + \gamma_1 \cdot Macropru_{i,t} + \gamma_2 \cdot USexp_{t-1} + \lambda_1 \cdot PR_{i,t-1} + \lambda_2 \cdot GDP_{i,t-1} + \lambda_3 \cdot Y_{i,t-1} + \theta_i + \epsilon_{i,t}
\end{aligned}
\tag{2.1}
$$

where $Y_{i,t}$ is the level or the growth rate of total corporate loans in the country i at time t. $Macropru_{i,t}$ is a measure of the aggregate MPI. $Share_i \equiv (\frac{FB_i}{D_iB+FB_i})$ is the aggregate share of corporate loans from foreign markets in total corporate loans for country i, averaged from 1990 to 1999. FB is the amount borrowed from foreign banks while DB is the amount borrowed from domestic banks. I measure the foreign borrowing share using data from 1990 to 1999 to avoid the endogeneity of this share concerning credit shocks occurring after 2000. $USexp_{t-1}$ is a dummy indicating U.S. monetary expansion as measured by the Wu-Xia shadow rate. $PR_{i,t-1}$ refers to the central bank policy rate and $GDP_{i,t-1}$ is the GDP growth rate in country i at time $t-1$. θ_i refers to country fixed effects included to capture country-specific conditions, and $\epsilon_{i,t}$ denotes the error terms. Standard errors are clustered at the country level.

The main coefficients of interest are α_1 and β, which measure the effects of macroprudential policies on the response of total corporate loans to U.S. monetary expansions and the impact of a higher foreign loan share on these responses. After a U.S. monetary expansion at time $t-1$, corporate loans may increase due to a decrease in the borrowing rate, and the central bank may conduct macroprudential policies to mitigate this response at time t. This is because an excessive increase in firms' leverage may expose the economy to more risks and make it vulnerable to unexpected crises.[7] However, since MPMs can regulate only domestic loans, the effects of MPMs can be dampened when firms are allowed to borrow across borders. In extreme cases, when firms borrow only from foreign lenders, macroprudential policies will not have any impact on corporate loans.

[7]The policies also extend to households; however, this paper specifically focuses on firms' borrowing.

Table 2.2: The Effects of Macroprudential Policy

	(1) Growth	(2) Growth	(3) Level	(4) Level
$Macropru_{i,t} \times USexp_{t-1} \times Share_i(\beta)$		0.320***		0.334***
		(0.127)		(0.084)
$Macropru_{i,t} \times USexp_{t-1}(\alpha_1)$	-0.083	-0.460***	-0.090	-0.436***
	(0.077)	(0.124)	(0.057)	(0.127)
$USexp_{t-1}(\gamma_2)$	0.302	0.601*	0.783**	1.312***
	(0.310)	(0.347)	(0.321)	(0.374)
$Macropru_{i,t} \times Share_i(\alpha_2)$		-0.312		-0.492**
		(0.271)		(0.230)
$Share_i \times USexp_{t-1}(\alpha_3)$		-0.445		-0.722***
		(0.290)		(0.199)
$Macropru_{i,t}(\gamma_1)$	0.033	0.257	0.324***	0.645***
	(0.085)	(0.189)	(0.064)	(0.178)
$PR_{i,t-1}(\lambda_1)$	-0.001	-0.004	-0.007**	-0.006*
	(0.002)	(0.003)	(0.003)	(0.003)
$GDP_{i,t-1}(\lambda_2)$	0.068***	0.059***	0.040*	0.022
	(0.019)	(0.020)	(0.020)	(0.020)
$Y_{i,t-1}(\lambda_3)$	-0.424***	-0.436***	0.336***	0.325***
	(0.036)	(0.035)	(0.059)	(0.055)
Countries	40	40	40	40
Country FE	Yes	Yes	Yes	Yes
Observations	547	547	547	547
R^2	0.238	0.255	0.337	0.355
F statistic	34.1	30.4	25.8	19.6

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

2.2.3.2 Macroprudential Policy Measures

Table 2.2 shows the baseline regression results. Columns (1) and (3) show that macroprudential policy is not significantly effective in reducing the growth or level of corporate loans when there is expansionary monetary policy in the U.S. However, when I include additional interaction terms in Eq. (2.1), I find that macroprudential policies have significant mitigating effects on the response of corporate loans to U.S. monetary expansion although these effects are dampened by a high foreign loan share. In column (2), macroprudential policy instruments negatively and significantly mitigate the increase in corporate loans in response to U.S. monetary expansion. A one-unit increase in the MPI index reduces the responsive growth rate of corporate loans to U.S. monetary expansion by 0.46 percentage points. However, this effect is dampened as the share of foreign loans in total corporate loans increases. For example, when firms in a country have a foreign loan share of 0.5, a one-unit increase in the MPI mitigates the increase in corporate loans only by 0.3percentage points. This is because MPMs cannot regulate cross-border borrowing by firms.Therefore, a higher share of foreign loans in corporate loans implies higher leakages from the macroprudential policies. The results are similar when I study the effects on the level of corporate loans, as reported in column (4) of the table.

Table 2.3 reports qualitatively similar results when I focus separately on lender- and borrower-targeted policies. In Columns (1) and (2) of the table, a one-unit increase in the MPI index attenuates the response of corporate loans to a U.S. monetary expansion by 0.52 and 1.77 percentage points when the macroprudential policy measures are lender- and borrower-targeted, respectively. A foreign loan share of 0.5 dampens the mitigating effects of these two types of policies by 0.23 and 0.81 percentage points, respectively.

Table 2.3: The Effects of Macroprudential Policy: Borrower- vs. Lender- targeted

	(1) Growth_Lender	(2) Growth_Borrower	(3) Level_Lender	(4) Level_Borrower
$Macropru_{i,t} \times USexp_{t-1} \times Share_i(\beta)$	0.449***	1.610**	0.384***	1.907***
	(0.113)	(0.614)	(0.090)	(0.674)
$Macropru_{i,t} \times USexp_{t-1}(\alpha_1)$	-0.524***	-1.773**	-0.459***	-1.938***
	(0.133)	(0.758)	(0.137)	(0.705)
$USexp_{t-1}(\gamma_2)$	0.671*	0.314	1.233***	1.576***
	(0.334)	(0.237)	(0.325)	(0.395)
$Macropru_{i,t} \times Share_i(\alpha_2)$	-0.391	-0.800	-0.591**	-1.854
	(0.312)	(1.082)	(0.252)	(1.118)
$Share_i \times USexp_{t-1}(\alpha_3)$	-0.548*	-0.292	-0.741***	-0.714***
	(0.288)	(0.229)	(0.205)	(0.177)
$Macropru_{i,t}(\gamma_1)$	0.240	1.015	0.802***	2.051**
	(0.222)	(0.854)	(0.187)	(0.939)
$PR_{i,t-1}(\lambda_1)$	-0.004	-0.003	-0.006*	-0.009***
	(0.003)	(0.002)	(0.003)	(0.003)
$GDP_{i,t-1}(\lambda_2)$	0.057***	0.066***	0.024	0.030
	(0.020)	(0.020)	(0.019)	(0.020)
$Y_{i,t-1}(\lambda_3)$	-0.435***	-0.433***	0.317***	0.371***
	(0.035)	(0.035)	(0.057)	(0.060)
Countries	40	40	40	40
Country FE	Yes	Yes	Yes	Yes
Observations	547	547	547	547
R^2	0.265	0.285	0.395	0.343
F statistics	29.3	28.4	35.6	39.5

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

Table 2.4: The Effects of Macroprudential Policy: Together with CFMs

	(1) Growth	(2) Growth	(3) Level	(4) Level
$Macropru_{i,t} \times USexp_{t-1} \times CFM_{i,t}(\beta)$		-0.284**		-0.294***
		(0.116)		(0.101)
$Macropru_{i,t} \times USexp_{t-1}(\alpha_1)$	-0.083	-0.064	-0.090	-0.085
	(0.077)	(0.075)	(0.057)	(0.059)
$USexp_{t-1}(\gamma_3)$	0.302	0.303	0.781**	0.743**
	(0.312)	(0.311)	(0.328)	(0.341)
$Macropru_{i,t} \times CFM_{i,t}(\alpha_2)$		0.235		0.372***
		(0.139)		(0.102)
$CFM_{i,t} \times USexp_{t-1}(\alpha_3)$		0.450**		0.684**
		(0.251)		(0.323)
$Macropru_{i,t}(\gamma_1)$	0.033	0.020	0.324***	0.309***
	(0.085)	(0.086)	(0.064)	(0.065)
$CFM_{i,t}(\gamma_2)$		-0.349		-0.731**
		(0.357)		(0.279)
$PR_{i,t-1}(\lambda_1)$	-0.001	-0.001	-0.007**	-0.007**
	(0.002)	(0.003)	(0.003)	(0.003)
$GDP_{i,t-1}(\lambda_2)$	0.068***	0.066***	0.040**	0.034**
	(0.019)	(0.019)	(0.020)	(0.020)
$Y_{i,t-1}(\lambda_3)$	-0.424***	-0.425***	0.336***	0.329***
	(0.036)	(0.036)	(0.059)	(0.056)
Countries	40	40	40	40
Country FE	Yes	Yes	Yes	Yes
Observations	547	547	547	547
R^2	0.234	0.253	0.363	0.341
F statistics	41.6	29.3	52.9	42.6

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

2.2.3.3 Capital Flow Management Measures

Since MPMs can regulate only domestic loans, central banks often adopt CFMs that limit capital inflows from foreign lenders. Under my hypothesis, the introduction of CFMs may help MPMs in mitigating the response of corporate loans to U.S. monetary expansions by directly regulating corporate borrowing from the international markets. I use the following specification to study the effects of macroprudential policy with and without CFMs in place:

$$\begin{aligned}
Y_{i,t} &= \beta \cdot Macropru_{i,t} \times USexp_{t-1} \times CFM_{i,t} \\
&+ \alpha_1 \cdot Macropru_{i,t} \times USexp_{t-1} + \alpha_2 \cdot Macropru_{i,t} \times CFM_{i,t} + \alpha_3 \cdot CFM_{i,t} \times USexp_{t-1} \\
&+ \gamma_1 \cdot Macropru_{i,t} + \gamma_2 \cdot CFM_{i,t} + \gamma_3 \cdot USexp_{t-1} \\
&+ \lambda_1 \cdot PR_{i,t-1} + \lambda_2 \cdot GDP_{i,t-1} + \lambda_3 \cdot Y_{i,t-1} + \theta_i + \epsilon_{i,t}
\end{aligned} \tag{2.2}$$

where $CFM_{i,t}$ is a binary measure of whether at least one CFM is in place in country i for period t. The interpretation of the main coefficients in Eq. (2.2) is as follows: β captures the effect of macroprudential policy when there is at least one CFM in place. α_1 shows the effect of MPMs in regulating the response (or level) of corporate loans when the central bank does not adopt CFMs. Standard errors are clustered at the country level.

Columns (1) and (3) of Table 2.4 revisit the results from Columns (1) and (3) in Table 2.2. As discussed previously, the coefficient estimates of $Macropru_{i,t} \times USexp_{t-1}$ are not statistically significant, meaning that macroprudential policy is not effective on average in mitigating the response of corporate loans when there is expansionary monetary policy in the U.S. However, when I take into account the implementation of CFMs, I observe an impact of MPMs on corporate loans. The first and second rows of Columns (2) and (4) in Table 2.4 show that macroprudential policies are effective in attenuating corporate loans when they are conducted together with CFMs, although MPMs alone cannot significantly tame firms' borrowing.

To further investigate this empirical result, I extend the specification in Eq. (2.1) to a four-way interaction regression as:

$$\begin{aligned}
Y_{i,t} = {} & \beta \cdot Macropru_{i,t} \times USexp_{t-1} \times Share_i \times CFM_{i,t} \\
& + \alpha_1 \cdot Macropru_{i,t} \times USexp_{t-1} \times Share_i + \alpha_2 \cdot Macropru_{i,t} \times Share_i \times CFM_{i,t} \\
& + \alpha_3 \cdot Macropru_{i,t} \times USexp_{t-1} \times CFM_{i,t} + \alpha_4 \cdot USexp_{t-1} \times Share_i \times CFM_{i,t} \\
& + \delta_1 \cdot Macropru_{i,t} \times USexp_{t-1} + \delta_2 \cdot Macropru_{i,t} \times Share_i + \delta_3 \cdot Macropru_{i,t} \times CFM_{i,t} \\
& + \delta_4 \cdot USexp_{t-1} \times Share_i + \delta_5 \cdot USexp_{t-1} \times CFM_{i,t} + \delta_6 \cdot Share_i \times CFM_{i,t} \\
& + \gamma_1 \cdot Macropru_{i,t} + \gamma_2 \cdot CFM_{i,t} + \gamma_3 \cdot USexp_{t-1} \\
& + \lambda_1 \cdot PR_{i,t-1} + \lambda_2 \cdot GDP_{i,t-1} + \lambda_3 \cdot Y_{i,t-1} + \theta_i + \epsilon_{i,t}
\end{aligned} \tag{2.3}$$

where variables are defined as before. Standard errors are clustered at the country level.

Table 2.5 reports estimates for the main coefficients derived from Eq. (2.3). The first three rows in the table show that the effects of MPMs are significantly dampened by a higher share of foreign loans when no CFM is in place. In Column (1), a one-unit increase in the macroprudential policy index significantly reduces the response of total corporate loans by 0.30 percentage points when a country does not engage in cross-border borrowing. However, this effect is dampened as the share of foreign loans in total loans rises in the absence of CFM. Conversely, when at least one CFM is adopted, the effects of macroprudential policies are reinforced as the foreign loan share increases. The second row of the table demonstrates that a one-percentage-point increase in the share of foreign loans reduces the impact of macroprudential policy on corporate loan growth by 0.003 percentage points. Nonetheless, with the presence of at least one CFM, this effect is attenuated by 0.002 percentage points, signifying that the implementation of CFMs assists macroprudential policies in further curbing corporate loan growth. This synergy arises from CFMs' capacity to regulate capital inflows from the international market, thereby preventing firms from increasing borrowing when U.S. interest rates decline. Consequently, CFMs can complement MPMs in mitigating firms' propensity to increase borrowing in response to a decrease in the U.S. policy rate.

2.2.3.4 Advanced vs. Emerging Market Countries

In this section, I further analyze the effects of macroprudential policy, examining how these effects are tempered by an increased share of foreign loans, and the significance of implementing CFMs alongside MPMs, particularly in the context of comparing advanced countries with emerging markets. Tables 2.6 and 2.7 show that the results for emerging markets mirror those for all countries. Notably, the third row of Columns (1) and (4) in Table 2.6 reveals that, on average, macroprudential policies fail to significantly diminish corporate borrowing in response to a decrease in the U.S. rate. This is primarily attributed to the dampening effects of a higher share of foreign loans, as elucidated in the first and third rows of Columns (2) and (5). However, the second row of Columns (3) and (6) illustrates that MPMs can effectively restrain firms from engaging in excessive borrowing when implemented with CFMs in place. Moreover, the first row

Table 2.5: The Effects of Macroprudential Policy: with or without CFMs

	(1) Growth	(2) Level
$Macropru_{i,t} \times USexp_{t-1} \times Share_i \times CFM_{i,t}(\beta)$	-0.217***	-0.136***
	(0.083)	(0.089)
$Macropru_{i,t} \times USexp_{t-1} \times Share_i(\alpha_1)$	0.297***	0.269**
	(0.091)	(0.097)
$Macropru_{i,t} \times Share_i \times CFM_{i,t}(\alpha_2)$	0.727***	1.372***
	(0.181)	(0.189)
$Macropru_{i,t} \times USexp_{t-1} \times CFM_{i,t}(\alpha_3)$	0.708***	1.325***
	(0.178)	(0.185)
$USexp_{t-1} \times Share_i \times CFM_{i,t}(\alpha_4)$	3.615***	6.764***
	(0.908)	(0.946)
$Macropru_{i,t} \times USexp_{t-1}(\delta_1)$	-0.418***	-0.383**
	(0.142)	(0.170)
$Macropru_{i,t} \times Share_i(\delta_2)$	-0.214	-0.473*
	(0.304)	(0.208)
$Macropru_{i,t} \times CFM_{i,t}(\delta_3)$	-0.709***	-1.331***
	(0.176)	(0.184)
$USexp_{t-1} \times Share_i(\delta_4)$	-0.473	-0.765***
	(0.304)	(0.208)
$USexp_{t-1} \times CFM_{i,t}(\delta_5)$	-3.534***	-6.606***
	(0.885)	(0.924)
$Share_i \times CFM_{i,t}(\delta_6)$	-3.621***	-6.802***
	(0.893)	(0.933)
$Macropru_{i,t}(\gamma_1)$	0.179	0.606***
	(0.224)	(0.212)
$CFM_{i,t}(\gamma_2)$	3.543***	6.640***
	(0.874)	(0.914))
$USSR_{t-1}(\gamma_3)$	0.602*	-1.301***
	(0.355)	(0.399)
$PR_{i,t-1}(\lambda_1)$	-0.005	-0.006*
	(0.003)	(0.003)
$GDP_{i,t-1}(\lambda_2)$	0.059***	0.017
	(0.021)	(0.020)
$Y_{i,t-1}(\lambda_3)$	-0.436***	0.318***
	(0.035)	(0.056)
Countries	40	40
Country FE	Yes	Yes
Observations	547	547
R^2	0.295	0.365
F statistics	19.4	17.3

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

of Table 2.7 underscores that with at least one CFM in place, the efficacy of MPMs in reducing corporate loans in responses to U.S. monetary expansion remains unaffected by a higher share of foreign loans.

Table 2.6: The Effects of Macroprudential Policy in Emerging Countries

	(1) Growth	(2) Growth	(3) Growth	(4) Level	(5) Level	(6) Level
$Macropru_{i,t} \times USexp_{t-1} \times Share_i(\beta)$		0.595***			0.427***	
		(0.103)			(0.085)	
$Macropru_{i,t} \times USexp_{t-1} \times CFM_{i,t}(\beta')$			-0.392***			-0.281**
			(0.127)			(0.125)
$Macropru_{i,t} \times USexp_{t-1}(\alpha_1)$	-0.019	-0.719***	-0.004	-0.042	-0.587***	-0.025
	(0.098)	(0.074)	(0.089)	(0.074)	(0.141)	(0.072)
$USexp_{t-1}(\gamma_2)$	0.351	0.385	0.425	0.092	0.772	0.162
	(0.542)	(0.615)	(0.575)	(0.403)	(0.462)	(0.405)
$Macropru_{i,t} \times CFM_{i,t}(\alpha_2)$			0.228			0.433***
			(0.158)			(0.131)
$Macropru_{i,t} \times Share_i(\alpha_2')$		-0.842***			-0.632***	
		(0.211)			(0.181)	
$Share_i \times USexp_{t-1}(\alpha_3)$		-0.855***			-0.826***	
		(0.335)			(0.257)	
$CFM_{i,t} \times USexp_{t-1}(\alpha_3')$			0.938***			0.594
			(0.225)			(0.364)
$Macropru_{i,t}(\gamma_1)$	0.022	0.679***	0.154	0.354***	0.833***	0.353***
	(0.098)	(0.098)	(0.095)	(0.084)	(0.130)	(0.074)
$CFM_{i,t}(\gamma_2)$			-0.180			-0.579*
			(0.379)			(0.306)
$PR_{i,t-1}(\lambda_1)$	-0.001	0.001	-0.0001	-0.005**	-0.005	-0.005**
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.002)
$GDP_{i,t-1}(\lambda_2)$	0.055***	0.025*	0.048***	0.015	-0.009	-0.010
	(0.016)	(0.013)	(0.015)	(0.023)	(0.022)	(0.022)
$Y_{i,t-1}(\lambda_3)$	-0.346***	-0.376***	-0.354***	0.419***	0.403***	0.382***
	(0.069)	(0.056)	(0.069)	(0.072)	(0.062)	(0.069)
Countries	17	17	17	17	17	17
Country FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	224	224	224	224	224	224
R^2	0.185	0.257	0.199	0.493	0.533	0.513
F statistics	50.3	43.6	29.8	25.6	16.5	13.2

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

However, when I focus on advanced countries only, the results are drastically different. The second row of Columns (1) and (3) in Table 2.8 indicates significant and negative effects of macroprudential policies in mitigating corporate loans in response to expansionary policy in

Table 2.7: The Effects of Macroprudential Policy in Emerging Markets: with or without CFMs

	(1) Growth	(2) Level
$Macropru_{i,t} \times USexp_{t-1} \times Share_i \times CFM_{i,t}(\beta)$	-0.362***	-0.266***
	(0.059)	(0.062)
$Macropru_{i,t} \times USexp_{t-1} \times Share_i(\alpha_1)$	0.569***	0.462**
	(0.078)	(0.188)
$Macropru_{i,t} \times Share_i \times CFM_{i,t}(\alpha_2)$	0.757***	0.987***
	(0.234)	(0.216)
$Macropru_{i,t} \times USexp_{t-1} \times CFM_{i,t}(\alpha_3)$	0.736***	0.951***
	(0.229)	(0.215)
$USexp_{t-1} \times Share_i \times CFM_{i,t}(\alpha_4)$	3.751***	4.850***
	(1.166)	(1.096)
$Macropru_{i,t} \times USexp_{t-1}(\delta_1)$	-0.779***	-0.517*
	(0.095)	(0.292)
$Macropru_{i,t} \times Share_i(\delta_2)$	-0.878***	-0.647**
	(0.197)	(0.274)
$Macropru_{i,t} \times CFM_{i,t}(\delta_3)$	-0.737***	-0.958***
	(0.227)	(0.211)
$USexp_{t-1} \times Share_i(\delta_4)$	-0.966**	-0.930***
	(0.404)	(0.290)
$USexp_{t-1} \times CFM_{i,t}(\delta_5)$	-365.8***	-473.7***
	(115.6)	(106.7)
$Share_i \times CFM_{i,t}(\delta_6)$	-375.0***	-489.4***
	(115.6)	(106.7)
$Macropru_{i,t}(\gamma_1)$	0.742***	0.815***
	(0.102)	(0.256)
$CFM_{i,t}(\gamma_2)$	179.4***	132.0***
	(24.06)	(29.20)
$USSR_{t-1}(\gamma_3)$	0.350	0.591
	(0.665)	(0.516)
$PR_{i,t-1}(\lambda_1)$	-0.0001	-0.004*
	(0.002)	(0.003)
$GDP_{i,t-1}(\lambda_2)$	0.024	-0.018
	(0.015)	(0.023)
$Y_{i,t-1}(\lambda_3)$	-0.372***	0.376***
	(0.057)	(0.066)
Countries	17	17
Country FE	Yes	Yes
Observations	224	224
R^2	0.275	0.548
F statistics	18.6	14.6

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

the U.S. When I extend the specification to include the foreign loan share, neither the effects of MPMs nor the impact of the foreign loan share appear to be significant. This means that the effects of MPMs in reducing firms' borrowing are not significantly dampened by a higher share of foreign loans. Since interest rates are not particularly high in advanced countries, borrowing from foreign lenders may not be a better alternative to domestic borrowing in those countries. Therefore, macroprudential policies are effective in regulating firms' total loans even if there are no CFMs in place. In fact, summary statistics listed in the Appendix B.1 show that CFMs are adopted far less in advanced countries in comparison to emerging markets.

2.2.3.5 Discussion

In this section, I have presented empirical evidence regarding the effects of macroprudential policies across different countries. The findings indicate that MPMs, when implemented alone, do not exert a significant influence on firms' borrowing responses to U.S. monetary expansion. This lack of substantial impact stems from the dampening effect observed as the share of foreign loans increases, which holds true when analyzing the effects of lender- and borrower-targeted MPMs separately. Given that macroprudential policies are not inherently designed to regulate capital inflows from abroad, firms' utilization of foreign loans acts as a leakage from these policy measures. Consequently, the significant effectiveness of MPMs is only realized when they are implemented alongside CFMs. CFMs serve as complementary measures to MPMs by regulating the international borrowing activities of domestic firms.

When examining different subsamples of countries, disparities in results emerge. In emerging markets, the efficacy of MPMs is diminished when firms have greater access to

Table 2.8: The Effects of Macroprudential Policy in Advanced Countries

	(1) Growth	(2) Growth	(3) Level	(4) Level
$Macropru_{i,t} \times USexp_{t-1} \times Share_i(\beta)$		-0.0574		0.186
		(0.338)		(0.251)
$Macropru_{i,t} \times USexp_{t-1}(\alpha_1)$	-0.152**	-0.102	-0.163***	-0.216
	(0.073)	(0.180)	(0.051)	(0.162)
$USexp_{t-1}(\gamma_2)$	-0.052	-0.055	-0.143**	-0.189**
	(0.042)	(0.044)	(0.063)	(0.075)
$Macropru_{i,t} \times Share_i(\alpha_2)$		0.428		-0.213
		(0.450)		(0.438)
$Share_i \times USexp_{t-1}(\alpha_3)$		–0.007		-0.602*
		(0.488)		(0.335)
$Macropru_{i,t}(\gamma_1)$	0.042	-0.282	0.318***	0.398
	(0.115)	(0.253)	(0.083)	(0.281)
$PR_{i,t-1}(\lambda_1)$	-0.075	-0.062	0.051	0.027
	(0.062)	(0.059)	(0.070)	(0.079)
$GDP_{i,t-1}(\lambda_2)$	0.092**	0.097*	0.077**	0.060*
	(0.044)	(0.048)	(0.035)	(0.035)
$Y_{i,t-1}(\lambda_3)$	-0.458***	-0.465***	0.275***	0.262***
	(0.039)	(0.039)	(0.081)	(0.079)
Countries	23	23	23	23
Country FE	Yes	Yes	Yes	Yes
Observations	323	323	323	323
R^2	0.279	0.284	0.248	0.255
F statistics	26.2	21.9	25.0	22.9

Notes: Standard errors are in parenthesis. Standard errors are corrected for clustering of observations at the country level. Sample spans 2000 - 2014. $*p < 0.10, **p < 0.05, ***p < 0.01$

international borrowing. However, the presence of CFMs can augment MPMs' capacity to regulate corporate loans in response to expansionary U.S. monetary policy. On the other hand, advanced countries less frequently rely on CFMs, as MPMs alone prove adequate in mitigating the response of total corporate loans to U.S. monetary expansion. These findings suggest that future research should delve into the impacts of CFMs using richer datasets, particularly considering that some countries have only recently adopted CFMs as policy instruments. In the subsequent section, I present a simple theoretical model featuring firms and banks to elucidate the mechanisms underlying my empirical findings.

2.3 The Model

I now provide a simple small open economy model with two periods and two goods, tradables and non-tradables. The basic structure of the model is adopted from Cespedes et al. (2017). The difference is that firms can borrow directly from abroad as well as from domestic banks. Banks lend not only to domestic firms but also to foreign borrowers. I define the real exchange rate as the relative price of tradables in terms of non-tradables. The economy consists of capital producers, tradable goods producers, and banks. Figure 2.2 illustrates the structure of the model. Firms can borrow both from domestic banks and foreign markets, with interest rates R and R^*, respectively, where $R \geq R^*$. Domestic banks finance lending to firms by borrowing from international markets at rate $R^{**} < R^*$. The banks lend to domestic firms at rate R and to foreign borrowers at rate R^*. They are willing to do this because borrowing rates are low in the international markets. I assume that there are a large number of foreign borrowers and foreign lenders in the international market, so corporate cross-border borrowing and banks' cross-border

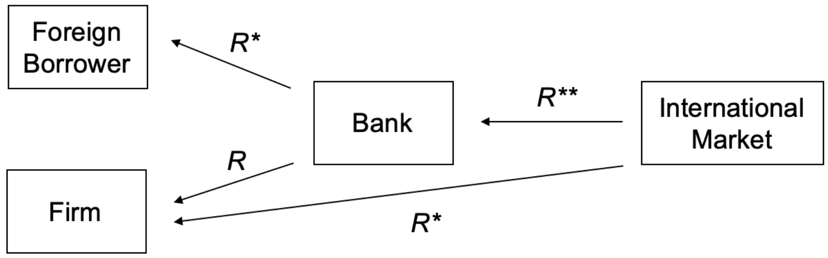

Figure 2.2: Structure of the Model

lending are determined only by the demand of firms and the supply of banks, without affecting the international rates. Therefore, interest rates R^* and R^{**} are exogenously given in this economy while R is determined by demand and supply for domestic loans.

The timeline of events is displayed in Figure 2.3. In the first period, tradable goods producers (firms, hereafter) are endowed with tradables T_f and non-tradables N_f, and banks are given tradables T_b and non-tradables N_b. Capital producers produce capital by combining tradables I_T and non-tradables I_N, and firms buy capital to use for production in the second period. Firms borrow L and D_f from domestic banks and the international market, respectively. In the second period, firms produce using capital purchased in the first period. Banks finance their loans by borrowing from international markets. The banks lend both to domestic firms (L) and foreign borrowers (F). Time is discrete.

2.3.1 Baseline Setup

2.3.1.1 Households

The household consumes tradables in the second period only. Non-tradables are used only for capital formation. Household consumption in the second period is funded by the profits of

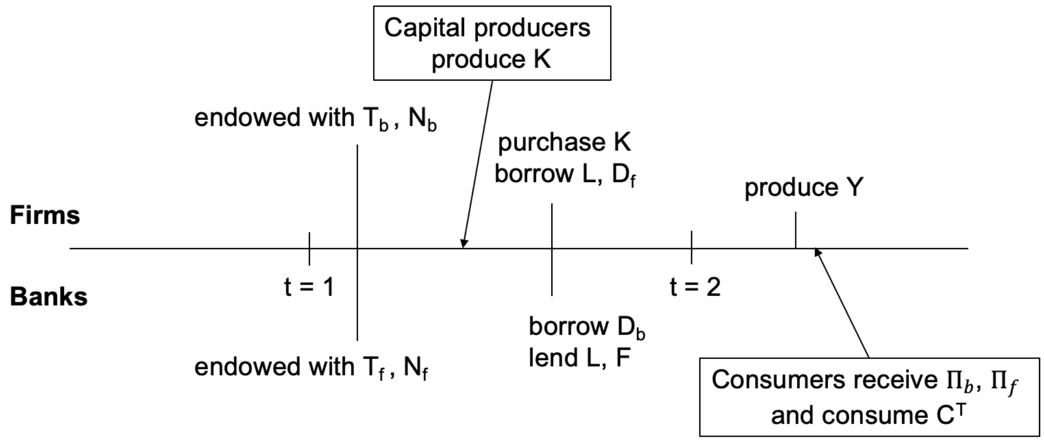

Figure 2.3: Timeline

the representative bank and the representative firm:

$$C^T = \Pi_b + \Pi_f$$

2.3.1.2 Capital Producers

In the first period, capital producers combine tradables and non-tradables to produce capital, using a Cobb-Douglas aggregator:

$$K = \kappa I_N^{\gamma} I_T^{1-\gamma} \tag{2.4}$$

where I_N and I_T are inputs from non-tradables and tradables, and $\kappa = \frac{1}{\gamma^{\gamma}(1-\gamma)^{1-\gamma}}$ where $\gamma \in (0, 1)$.

A representative capital producer's optimization problem is

$$\max_{I_N, I_T} \quad Q\kappa I_N^{\gamma} I_T^{1-\gamma} - I_N - SI_T$$

where Q is the price of capital and S is the price of tradables, both expressed in terms of non-tradables. The first-order conditions are

$$\gamma\kappa Q I_N^{\gamma-1} I_T^{1-\gamma} = 1$$

$$(1-\gamma)\kappa Q I_N^{\gamma} I_T^{-\gamma} = S$$

Using these conditions, the prices of capital and tradables are related as follows:

$$Q = S^{1-\gamma} \tag{2.5}$$

where $S = P_T/P_N$ is defined as the real exchange rate.

If K is the aggregate demand for capital, from Eqs. (2.4), (2.5), and the first-order conditions, the optimal demand for non-tradables will be

$$I_N = \gamma Q K = \gamma S^{1-\gamma} K \tag{2.6}$$

2.3.1.3 Firms

In the first period, a firm purchases capital K to produce in the second period and is endowed with tradables T_f and non-tradables N_f. The firm can borrow tradables from domestic banks at interest rate R, or from foreign banks at interest rate R^*. Since domestic markets are financially less stable, we assume that $R \geq R^* \geq 1$. The firm's resource constraint expressed in tradables is

$$\frac{QK}{S} = L + D_f + T_f + \frac{N_f}{S} \tag{2.7}$$

where D_f denotes the amount borrowed from international markets and L is the amount borrowed from domestic banks by firms. The firm's cross-border borrowing is limited to a fraction of its expected revenue:

$$R^* D_f \leq \xi Y \tag{2.8}$$

where $\xi \in (0, 1)$ is a constant and the price of tradable output Y is normalized to 1.

Then given the prices Q, R, and R^*, the representative firm's period 1 problem is

$$\max_{K,L,D_f} \quad \Pi^f = Y - RL - R^* D_f$$

$$\text{s.t.} \quad \frac{QK}{S} = L + D_f + T_f + \frac{N_f}{S}$$

$$R^* D_f \leq \xi Y$$

where $Y = AK^\alpha$ is tradable output with $A > 0$ and $0 < \alpha \leq 1$.

Suppose the firm's initial net worth is sufficiently small (i.e., $0 < T_f + \frac{N_f}{S} < \frac{QK}{S} - \frac{\xi}{R^*} AK^\alpha$) where K is the optimal demand for capital. For $R > R^*$, the firm prefers foreign loans because of the lower borrowing rate, so the constraint (2.8) binds. For $R = R^*$, a firm is indifferent between getting domestic loans and foreign loans. The firm's demand for domestic loans is

$$L = \begin{cases} \frac{QK}{S} - (T_f + \frac{N_f}{S}) - \frac{\xi}{R^*}AK^\alpha & \text{if} \quad R > R^* \\ \in [\frac{QK}{S} - (T_f + \frac{N_f}{S}) - \frac{\xi}{R^*}AK^\alpha, \frac{QK}{S} - (T_f + \frac{N_f}{S})] & \text{if} \quad R = R^* \end{cases} \tag{2.9}$$

Similarly, the demand for foreign loans is

$$D_f = \begin{cases} \frac{\xi}{R^*}AK^\alpha & \text{if} \quad R > R^* \\ \in [0, \frac{\xi}{R^*}AK^\alpha] & \text{if} \quad R = R^* \end{cases} \tag{2.10}$$

Now, suppose instead that the firm is given sufficient net worth at the beginning of period 1 (i.e., $T_f + \frac{N_f}{S} \geq \frac{QK}{S} - \frac{\xi}{R^*}AK^\alpha$). Then, even for $R > R^*$, Eq. (2.8) is not binding unless $L = 0$. But since borrowing from domestic market is more expensive than international borrowing, firms increase foreign borrowing up to the limit and do not borrow from domestic banks ($L = 0$). Then the firm's loan demands can be written as

$$L = \begin{cases} 0 & \text{if} \quad R > R^* \\ \in [0, \frac{QK}{S} - (T_f + \frac{N_f}{S})] & \text{if} \quad R = R^* \end{cases} \tag{2.11}$$

$$D_f = \begin{cases} \frac{QK}{S} - (T_f + \frac{N_f}{S}) & \text{if} \quad R > R^* \\ \in [0, \frac{QK}{S} - (T_f + \frac{N_f}{S})] & \text{if} \quad R = R^* \end{cases} \tag{2.12}$$

For any $R \geq R^*$ and any level of initial net worth $T_f + \frac{N_f}{S} > 0$, the firm's demand for capital satisfies

$$(1-\xi+\frac{R}{R^*}\xi)\alpha A K^{\alpha-1} = \frac{RQ}{S} \\ = RS^{-\gamma} \tag{2.13}$$

2.3.1.4 Banks

The bank lends L at interest rate R to domestic firms and lends F at R^* to foreign borrowers. It finances this lending by borrowing D_b from the international market at interest rate $R^{**}(< R^* \leq R)$ in the first period. The bank's resource constraint in terms of tradables is

$$L + F = D_b + T_b + \frac{N_b}{S} \tag{2.14}$$

The bank faces a collateral constraint on foreign loans. The constraint can be rationalized following Gertler and Kiyotaki (2010b). Suppose banks can default and retain a fraction $1-\theta$ of the payments made by their own borrowers. The international lenders want to prevent the banks' absconding by limiting the expected profit from default. The resulting constraint is

$$R^{**}D_b \leq \theta(RL + R^*F) \tag{2.15}$$

Since the bank can borrow from abroad at an interest rate lower than R and R^*, the constraint (2.15) is always binding.

The bank's optimization problem in the first period is

$$
\begin{aligned}
\max_{L,F,D_b} \quad & \Pi^b = RL + R^*F - R^{**}D_b \\
& \text{s.t.} \quad L + F = D_b + T_b + \frac{N_b}{S} \\
& \qquad\quad R^{**}D_b \leq \theta(RL + R^*F)
\end{aligned}
\tag{2.16}
$$

where $0 < \theta < 1$.

When $R > R^*$, the bank can earn more interest on domestic lending than on cross-border lending. Therefore, it will lend only domestically as long as there is a sufficient number of domestic borrowers. On the other hand, if $R = R^*$, then the bank is indifferent between lending to domestic firms and to foreign borrowers. Thus, the bank's supply of domestic and international loans will be

$$
L = \begin{cases} \frac{R^{**}}{R^{**}-\theta R}(T_b + \frac{N_b}{S}) & \text{if} \quad R > R^* \\ \\ \in [0, \frac{R^{**}}{R^{**}-\theta R^*}(T_b + \frac{N_b}{S})] & \text{if} \quad R = R^* \end{cases} \tag{2.17}
$$

$$
F = \begin{cases} 0 & \text{if} \quad R > R^* \\ \\ \in [0, \frac{R^{**}}{R^{**}-\theta R^*}(T_b + \frac{N_b}{S})] & \text{if} \quad R = R^* \end{cases} \tag{2.18}
$$

For any $R \geq R^*$, the bank's demand for cross-border borrowing will be

$$
D_b = \frac{\theta R}{R^{**} - \theta R}(T_b + \frac{N_b}{S}) \tag{2.19}
$$

2.3.2 Equilibrium

2.3.2.1 Non-tradables Market and Interest Spread

Since non-tradables are used only for producing capital, demand for non-tradables is given by Eq. (2.6). The supply is given by the aggregate endowment of non-tradables. Therefore, $N^d = \gamma S^{1-\gamma} K$ and $N^s = N_f + N_b$. Then, the market clearing condition for non-tradables, $N^d = N^s \equiv N$ implies

$$S^{1-\gamma} = \frac{N}{\gamma K} \tag{2.20}$$

Hence, the real exchange rate can be linked to the demand for capital. With Eqs. (2.13) and (2.20), I can obtain the following equilibrium relationship between the interest rate and the real exchange rate:

$$R = \frac{(1-\xi)\alpha A(\frac{\gamma}{N})^{1-\alpha} S^{(1-\gamma)(1-\alpha)+\gamma}}{1 - \frac{\xi}{R^*}\alpha A(\frac{\gamma}{N})^{1-\alpha} S^{(1-\gamma)(1-\alpha)+\gamma}}$$

Defining S_0 as the real exchange rate in the case of $R = R^*$, then

$$R^* = \alpha A(\frac{\gamma}{N})^{1-\alpha} S_0^{(1-\gamma)(1-\alpha)+\gamma}$$

I can define the interest spread as a function of the real exchange rate:

$$\phi = \frac{R}{R^*} = \frac{(1-\xi)(\frac{S}{S_0})^{(1-\gamma)(1-\alpha)+\gamma}}{1 - \xi(\frac{S}{S_0})^{(1-\gamma)(1-\alpha)+\gamma}} \equiv \phi(S) \tag{2.21}$$

where $\phi'(S) > 0$. The intuition behind this equilibrium relationship is that higher R reduces demand for capital, which reduces demand for non-tradable goods. Then the price of non-tradables, P_N, decreases and thus S goes up. Therefore, a higher interest spread is associated with real exchange rate depreciation.

2.3.2.2 Loan Market

Case 0: Closed Economy

Consider the case where the economy is closed. Both firms and banks cannot borrow across borders (i.e., $\xi = \theta = 0$). In this case, from the borrowing constraint (2.8) and Eq. (2.20), the firm's loan demand will be

$$L^d = \frac{N}{\gamma S} - (T_f + \frac{N_f}{S}) \tag{2.22}$$

Since the bank cannot finance its domestic lending from abroad, it will lend to firms using their initial net worth. Therefore, the supply of domestic loans by banks will be

$$L^s = T_b + \frac{N_b}{S} \tag{2.23}$$

Figure 2.4 depicts the supply and demand of domestic loans for the closed economy case. The real exchange rate, S, is measured along the vertical axis while the quantity of domestic loans, L, is measured along the horizontal axis. Since $\frac{\partial L^s}{\partial S} = -\frac{N_b}{S^2} < 0$, and $N_b < \frac{N_f + N_b}{\gamma} - N_f$ for $\gamma \in (0, 1)$, the loan demand function has a slope that is steeper than that of loan supply function. The real exchange rate and domestic loans in equilibrium are given by S^* and L^* in the figure.

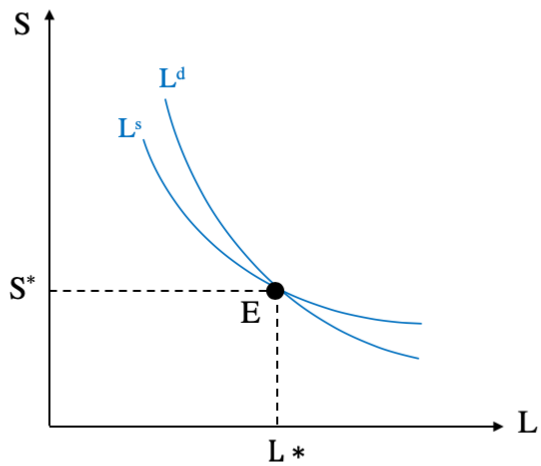

Figure 2.4: Equilibrium in the Loan Market in a Closed Economy

Case 1: Open economy with no corporate cross-border borrowing

Next, consider the case without corporate cross-border borrowing ($\xi = 0$) in an open economy, in which banks can borrow from abroad ($\theta > 0$) but cannot lend to foreign firms. Then, loan demand by domestic firms will be Eq. (2.22). Since there is no corporate cross-border borrowing, domestic banks also do not lend to foreign corporate borrowers ($F = 0$). Thus, the supply of domestic loans by banks is given by

$$L^s = \frac{R^{**}}{R^{**} - \theta R^* \phi(S)} (T_b + \frac{N_b}{S}) \tag{2.24}$$

Since banks are not lending abroad, S is not necessarily bounded below by S_0. The elasticity of L^s with respect to S can be expressed as below:

$$\frac{\partial L^s}{\partial S} \frac{S}{L^s} = -\frac{N_b/S}{T_b + N_b/S} + \frac{\theta \phi(S)}{R^{**}/R^* - \theta \phi(S)} \frac{(1-\gamma)(1-\alpha)+\gamma}{1 - \xi(S/S_0)^{(1-\gamma)(1-\alpha)+\gamma}} \tag{2.25}$$

The first term in the right-hand-side corresponds to the net worth effect, in which changes in the

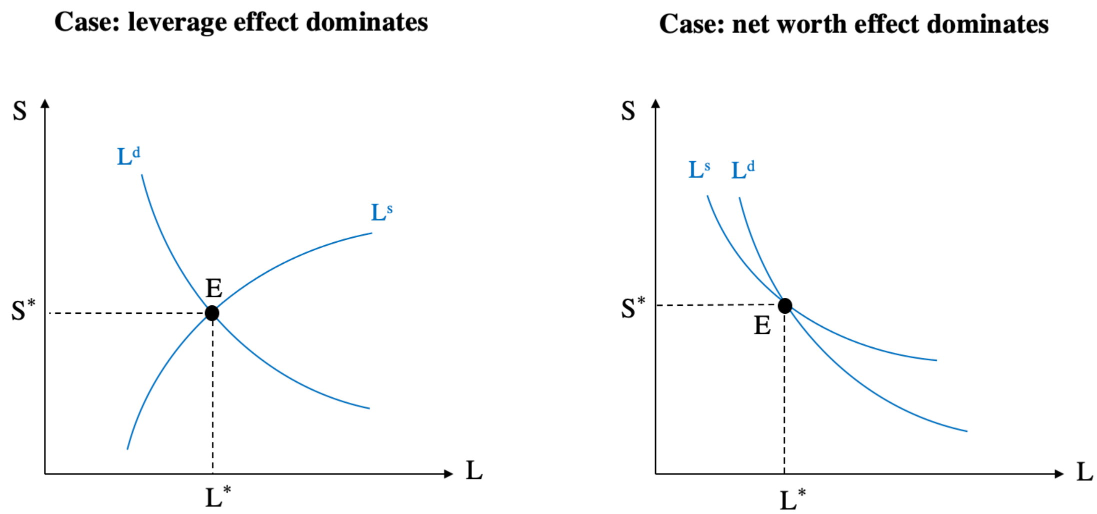

Figure 2.5: Equilibrium in the Loan Market w/o Corporate Cross-Border Borrowing

real exchange rate affect the supply of loans via banks' net worth. This effect also appears in the closed economy case. When the exchange rate goes up, the value of banks' net worth decreases, which reduces the supply of loans. The second term can be interpreted as the leverage effect, which is affected by the interest spread ϕ, exogenous rates R^*, R^{**}, and the financial frictions parameter θ. An increase in the exchange rate implies an increase in the domestic interest rate, which induces banks to lend more in the domestic market. This effect means that banks increase leverage in response to an increase in the exchange rate.

Figure 2.5 draws the loan supply and demand functions in this case. The left panel of the figure depicts the equilibrium in which the leverage effect dominates the net worth effect in the elasticity of loan supply. The loan supply function is increasing in S. L^d and L^s are the equilibrium levels of domestic loans and the exchange rate. The right panel of the figure shows the domestic loan market in which the net worth effect dominates the leverage effect of loan supply. The loan supply function is decreasing in S for $S \geq S_0$, and the supply and demand for domestic loans meet at the equilibrium point E.

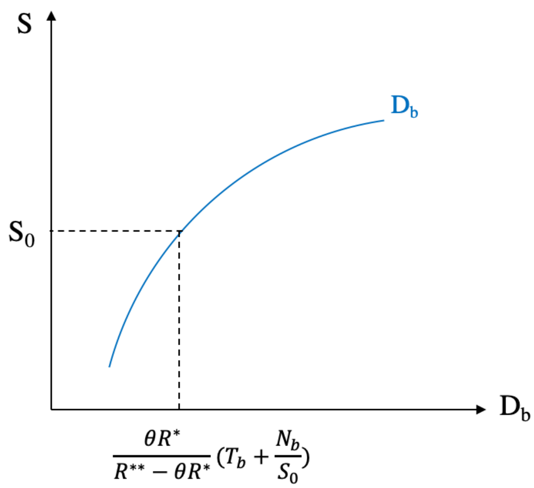

Figure 2.6: Demand Function for Foreign Loans by Banks

Finally, the equilibrium levels of banks' cross-border borrowing is decided solely by their own demand. Therefore, the equilibrium level of banks' cross-border borrowing can be written as

$$D_b^* = \frac{\theta R^* \phi(S)}{R^{**} - \theta R^* \phi(S)}(T_b + \frac{N_b}{S}) \tag{2.26}$$

Figure 2.6 depicts the banks' demand function for cross-border loans. As the exchange rate goes up, the bank wants to lend more to domestic firms because the marginal revenue is larger. Therefore, the bank tries to borrow more across borders as S increases, which results in a demand function for foreign loans that is increasing in S.

Case 2: Open economy with corporate cross-border borrowing

Now consider the case in which cross-border borrowing and lending are allowed (i.e., $\xi > 0$ and $\theta > 0$). Then domestic firms borrow both from domestic banks and the international market, and banks can lend to both domestic and foreign firms. For $0 < T_f + \frac{N_f}{S} < \frac{N}{\gamma S} - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^{\alpha}$, the domestic demand for loans by firms can be written as

$$L^d = \begin{cases} \frac{N}{\gamma S} - (T_f + \frac{N_f}{S}) - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha & \text{if} \quad S > S_0 \\ \in [\frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0}) - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha, \frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0})] & \text{if} \quad S = S_0 \end{cases}$$

where Eq. (2.21) means that $R > R^* \Leftrightarrow S > S_0$ and $R = R^* \Leftrightarrow S = S_0$.

For $T_f + \frac{N_f}{S} \geq \frac{N}{\gamma S} - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha$, loan demand can be written as

$$L^d = \begin{cases} 0 & \text{if} \quad S > S_0 \\ \in [0, \frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0})] & \text{if} \quad S = S_0 \end{cases}$$

Figure 2.7 shows the graphs for domestic loan demand. For $0 < T_f + \frac{N_f}{S} < \frac{N}{\gamma S} - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha$, if $S > S_0$,

$$\frac{\partial L^d}{\partial S} = -\frac{1}{S}(\frac{N}{\gamma S} - \frac{N_f}{S} + \alpha(1-\gamma)\frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha) < 0 \tag{2.27}$$

since $\frac{N}{\gamma S} - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha < \frac{N}{\gamma S} - \alpha(1-\gamma)\frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha$ for any $\alpha, \gamma \in (0,1)$. Thus, demand for domestic loans increases as S goes down until $S = S_0$. For $S = S_0$, firm demand for domestic loans is between $\frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0}) - \frac{\xi}{R^*}A(\frac{N}{\gamma S_0^{1-\gamma}})^\alpha$ and $\frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0})$. For $T_f + \frac{N_f}{S} \geq \frac{N}{\gamma S} - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha$, a firm does not demand domestic loans when S is higher than S_0. This is because the firm can finance its capital investment using only foreign loans at lower borrowing rates. When $S = S_0$, the firm is indifferent between borrowing domestically and from abroad. Thus, the loan demand by firms ranges from zero to $\frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0})$.

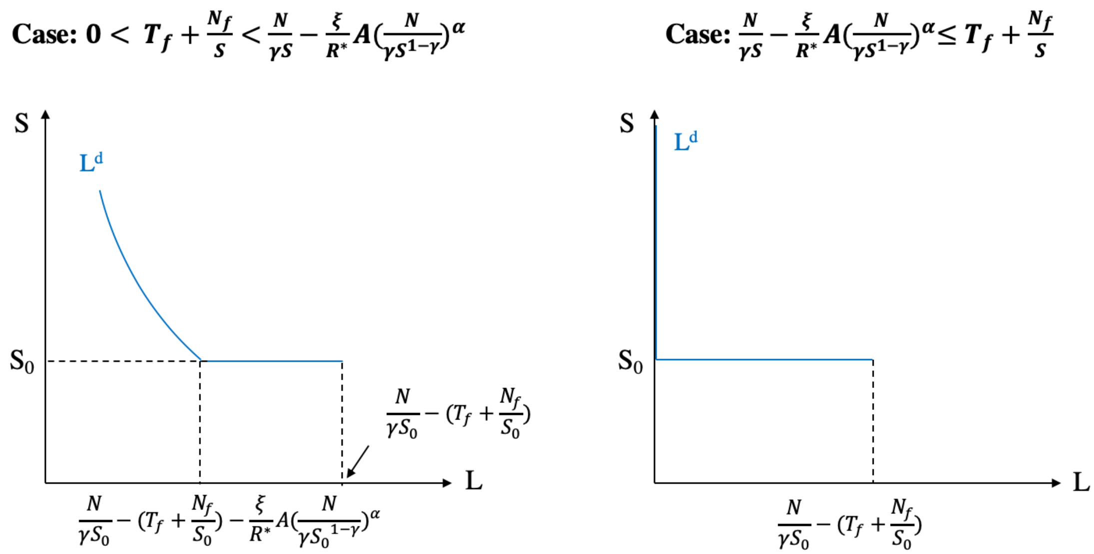

Figure 2.7: Demand Functions for Domestic Loans by Firms

The domestic supply for loans by banks will be

$$L^s = \begin{cases} \frac{R^{**}}{R^{**} - \theta R^* \phi(S)} (T_b + \frac{N_b}{S}) & \text{if} \quad S > S_0 \\ \\ \in [0, \frac{R^{**}}{R^{**} - \theta R^*} (T_b + \frac{N_b}{S_0})] & \text{if} \quad S = S_0 \end{cases}$$

which is the same as Eq. (2.24) in Case 1 for $S > S_0$, while the bank is content with any amount of lending up to a multiple $\frac{R^{**}}{R^{**} - \theta R}$ of its own net worth for $S = S_0$. Assuming $S > S_0$, the elasticity of L^s with respect to S can be expressed as Eq. (2.25). Figure 2.8 depicts the supply function for domestic loans. When the leverage effect dominates the net worth effect, as shown in the left panel, the loan supply function is increasing in S for $S > S_0$ because an increase in the exchange rate raises the marginal revenue of domestic lending. When $S = S_0$, the bank is indifferent between lending to domestic firms and to foreign borrowers, so it lends any amount up to $\frac{R^{**}}{R^{**} - \theta R^*} (T_b + \frac{N_b}{S_0})$ domestically. When the net worth effect dominates, as shown in the right panel, banks' initial net worth is devalued as S increases, and this affects the banks' ability to

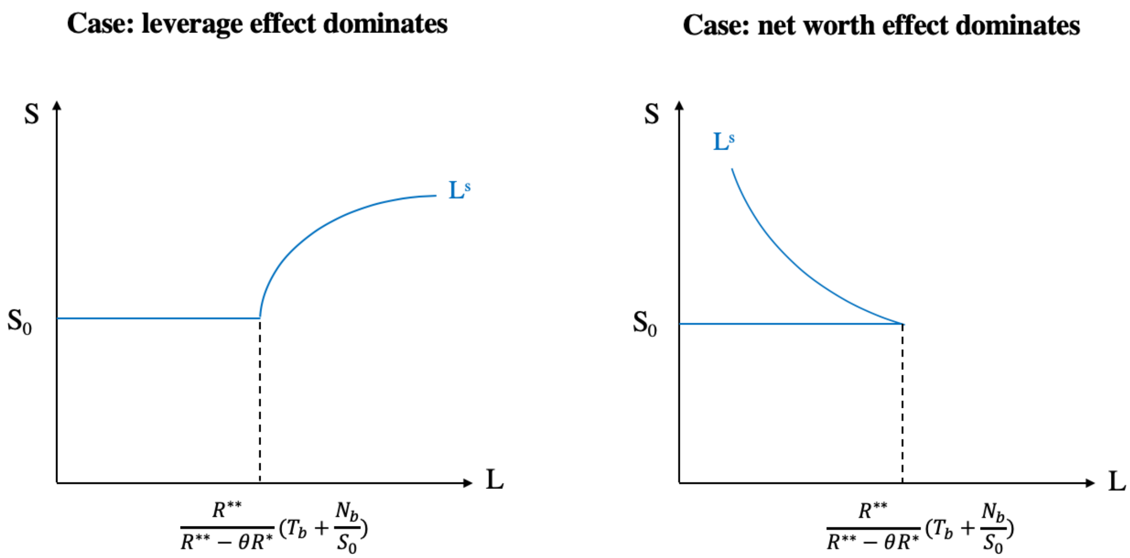

Figure 2.8: Supply Functions for Domestic Loans by Banks

borrow across borders. Therefore, loan supply decreases as S goes up for $S > S_0$. When $S = S_0$, the bank lends up to a multiple $\frac{R^{**}}{R^{**}-\theta R^*}$ of its own net worth.

The equilibrium level of corporate cross-border loans will be decided solely by the firm's demand, because there are a large number of competitive lenders in the foreign market and R^* is exogenous with respect to domestic firms. Hence, the equilibrium will be

$$D_f = \begin{cases} \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha & \text{if} \quad S > S_0 \\ \in [0, \frac{\xi}{R^*}A(\frac{N}{\gamma S_0^{1-\gamma}})^\alpha] & \text{if} \quad S = S_0 \end{cases}$$

for $0 < T_f + \frac{N_f}{S} < \frac{N}{\gamma S} - \frac{\xi}{R^*}A(\frac{N}{\gamma S^{1-\gamma}})^\alpha$. Otherwise, when firms' net worth is sufficiently large, the equilibrium level of corporate cross-border loans can be written as

$$D_f = \begin{cases} \frac{N}{\gamma S} - (T_f + \frac{N_f}{S}) & \text{if} \quad S > S_0 \\ \in [0, \frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0})] & \text{if} \quad S = S_0 \end{cases}$$

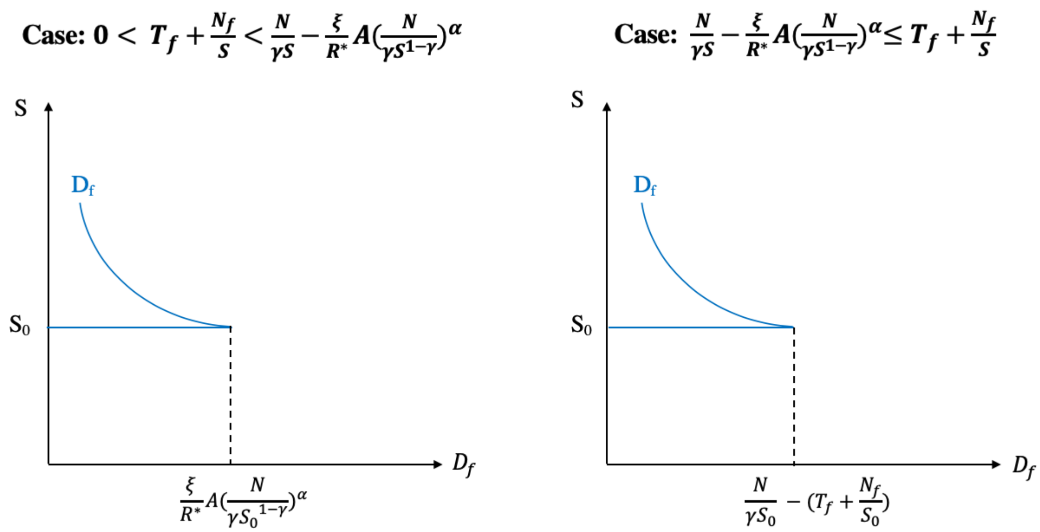

Figure 2.9: Demand Functions for Foreign Loans by Firms

Figure 2.9 shows the demand function for foreign loans by firms. The left panel shows the case in which firms' net worth is sufficiently small. When $S = S_0$, the firm borrows any amount of foreign loans up to the limit, $\frac{\xi}{R^*}A(\frac{N}{\gamma S_0^{1-\gamma}})^\alpha$. When $S > S_0$, the demand for foreign loans increases as S goes down. This is because a decrease in the exchange rate increases the value of the firm's net worth, which loosens its constraint on foreign borrowing. When the firm's net worth is sufficiently large, the firm's borrowing constraint for foreign loans is not binding. Therefore, the firm borrows up to $\frac{N}{\gamma S_0} - (T_f + \frac{N_f}{S_0})$ for $S = S_0$, and the demand is decreasing in S when $S > S_0$.

The equilibrium level of banks' cross-border borrowing is the same as Eq. (2.26), while its cross-border lending can be written as

$$F = \begin{cases} 0 & \text{if} \quad S > S_0 \\ \in [0, \frac{\theta R^*}{R^{**} - \theta R^*}(T_b + \frac{N_b}{S_0})] & \text{if} \quad S = S_0 \end{cases}$$

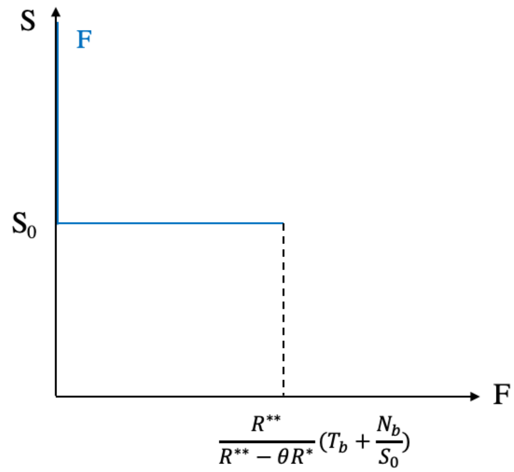

Figure 2.10: Supply Function for Foreign Loans by Banks

Figure 2.10 shows the supply function for cross-border loans by banks. When $S > S_0$, the bank earns more when it lends to domestic firms because R is bigger than R^*. Therefore, it does not lend to international borrowers. On the other hand, when $S = S_0$, the bank is indifferent between lending to domestic borrowers and to international borrowers, so it is content with lending any amount up to a multiple $\frac{\theta R^*}{R^{**}-\theta R^*}$ of its own net worth.

2.4 Analytic Solutions

In this section, I will provide analytic solutions for a specific case of the model. For simplicity, I assume that capital is produced only with non-tradables, and that firms and banks are endowed only with non-tradable goods ($T_b = T_f = 0$). In addition, I will focus on the case where firms' net worth is sufficiently small.

2.4.1 Special Case: No Domestic Tradable Endowments

Assuming that capital producers use only non-tradables in producing capital, the aggregator for capital production will be

$$K = I_N$$

By solving the representative capital producer's problem, the price of capital in terms of non-tradables is $Q = 1$, and $I_N = K$ is the aggregate demand for capital.

Suppose firms and banks are endowed only with non-tradable goods (i.e., $T_f = 0, T_b = 0$). The representative firm's period 1 problem becomes

$$\max_{K,L,D_f} \quad \Pi^f = AK^\alpha - RL - R^* D_f$$

$$\text{s.t.} \quad \frac{K}{S} = L + D_f + \frac{N_f}{S}$$

$$R^* D_f \leq \xi AK^\alpha$$

where $A > 0, 0 < \alpha \leq 1$ and $\xi \in (0, 1)$.

Suppose firms' net worth is sufficiently small (i.e., $0 < \frac{N_f}{S} < \frac{K}{S} - \frac{\xi}{R^*} AK^\alpha$). Firm's demand for domestic and cross-border loans are then

$$L^d = \begin{cases} \frac{K}{S} - \frac{N_f}{S} - \frac{\xi}{R^*} AK^\alpha & \text{if} \quad R > R^* \\ \in [\frac{K}{S} - \frac{N_f}{S} - \frac{\xi}{R^*} AK^\alpha, \frac{K}{S} - \frac{N_f}{S}] & \text{if} \quad R = R^* \end{cases} \tag{2.28}$$

$$D_f = \begin{cases} \frac{\xi}{R^*} AK^{\alpha} & \text{if} \quad R > R^* \\ \\ \in [0, \frac{\xi}{R^*} AK^{\alpha}] & \text{if} \quad R = R^* \end{cases} \tag{2.29}$$

The firm's demand for capital is determined by

$$\alpha AK^{\alpha-1} = \frac{1}{1 - \xi + \frac{R}{R^*}\xi} \frac{R}{S} \tag{2.30}$$

Suppose $R^{**} = 1 + \sigma(R^* - 1) < R^*$ where $0 < \sigma < 1$. The bank's borrowing rate is smaller than the firm's borrowing rate across borders, but both rates are affected by U.S. monetary expansion. Then, the bank's optimization problem in the first period is

$$\max_{L,F,D_b} \quad \Pi^b = RL + R^*F - (1 + \sigma(R^* - 1))D_b$$

$$\text{s.t.} \qquad L + F = D_b + \frac{N_b}{S}$$

$$(1 + \sigma(R^* - 1))D_b \leq \theta(RL + R^*F)$$

where $0 < \theta < 1$ and $0 < \sigma < 1$.

The bank's supply of domestic loans and demand and supply for cross-border loans is

$$L^s = \begin{cases} \frac{1+\sigma(R^*-1)}{1+\sigma(R^*-1)-\theta R} \frac{N_b}{S} & \text{if} \quad R > R^* \\ \\ \in [0, \frac{1+\sigma(R^*-1)}{1+(\sigma-\theta)R^*-\sigma} \frac{N_b}{S}] & \text{if} \quad R = R^* \end{cases} \tag{2.31}$$

$$F = \begin{cases} 0 & \text{if} \quad R > R^* \\ \\ \in [0, \frac{1+\sigma(R^*-1)}{1+(\sigma-\theta)R^*-\sigma} \frac{N_b}{S}] & \text{if} \quad R = R^* \end{cases} \tag{2.32}$$

$$D_b = \frac{\theta R}{1 + \sigma(R^* - 1) - \theta R} \frac{N_b}{S} \tag{2.33}$$

where $0 < \theta < 1$ and $0 < \sigma < 1$.

2.4.2 Equilibrium Solutions

The demand for non-tradables, $N^d = I_N = K$, must equal the aggregate endowment of non-tradables. The market clearing condition means

$$N \equiv N_f + N_b = K$$

Using Eqs. (2.30)-(2.33), the interest rate can be written as a function of the real exchange rate:

$$R = \frac{(1 - \xi)\alpha A N^{\alpha - 1} S}{1 - \frac{\xi}{R^*}\alpha A N^{\alpha - 1} S}$$

Defining S_0 as the real exchange rate in the case of $R = R^*$, then

$$R^* = \alpha A N^{\alpha - 1} S_0$$

Then the interest spread can be defined as a function of the real exchange rate:

$$\phi(S) = \frac{R}{R^*} = \frac{(1 - \xi)S}{S_0 - \xi S} \tag{2.34}$$

where $\phi'(S) = \frac{(1-\xi)S_0}{(S_0 - \xi S)^2} > 0$.

In the domestic loan market, demand and supply for loans must be equal in equilibrium.

Plugging in $K = N$, the firm's demand and the bank's supply for domestic loans are

$$L^d = \begin{cases} \frac{N_b}{S} - \frac{\xi}{R^*} A N^\alpha & \text{if} \quad S > S_0 \\ \in [\frac{N_b}{S_0} - \frac{\xi}{R^*} A N^\alpha, \frac{N_b}{S_0}] & \text{if} \quad S = S_0 \end{cases}$$

$$L^s = \begin{cases} \frac{1+\sigma(R^*-1)}{1+\sigma(R^*-1)-\theta R^* \phi(S)} \frac{N_b}{S} & \text{if} \quad S > S_0 \\ \in [0, \frac{1+\sigma(R^*-1)}{1+(\sigma-\theta)R^*-\sigma} \frac{N_b}{S_0}] & \text{if} \quad S = S_0 \end{cases}$$

Consider the case in which $S > S_0$. The loan supply $L^s = \frac{1+\sigma(R^*-1)}{1+\sigma(R^*-1)-\theta R^* \phi(S)} \frac{N_b}{S}$ is always larger than the loan demand $L^d = \frac{N_b}{S} - \frac{\xi}{R^*} A N^\alpha$ since $\frac{\xi}{R^*} A N^\alpha > 0$ and $\theta R^* \phi(S) > 0$. Therefore, the equilibrium level of the exchange rate is determined at $S = S_0$. Suppose a firm prefers to borrow from foreign lenders than from domestic banks when $R = R^*$ because foreign lenders are financially more stable. Then the equilibrium level of domestic loan will be $\frac{N_b}{S_0} - \frac{\xi}{R^*} A N^\alpha$.

Figure 2.11 depicts how the equilibrium in the domestic loan market is determined by demand and supply of loans. The left-hand-side of the figure shows the case where the leverage effect dominates the net worth effect so that the loan supply function is increasing in S for $S > S_0$. The right-hand-side of the figure shows the case in which the slope of the loan supply function is negative. In both cases, the equilibrium level of the exchange rate is S_0, and the equilibrium level of domestic loans is $\frac{N_b}{S_0} - \frac{\xi}{R^*} A N^\alpha$, which is point E in the figure.

The levels of domestic and foreign loans in equilibrium are written as

$$L^* = \frac{N_b}{S_0} - \frac{\xi}{R^*} A N^\alpha = \frac{\alpha A N^{\alpha-1}}{R^*} N_b - \frac{\xi}{R^*} A N^\alpha$$
$$D_f^* = \frac{\xi}{R^*} A N^\alpha$$

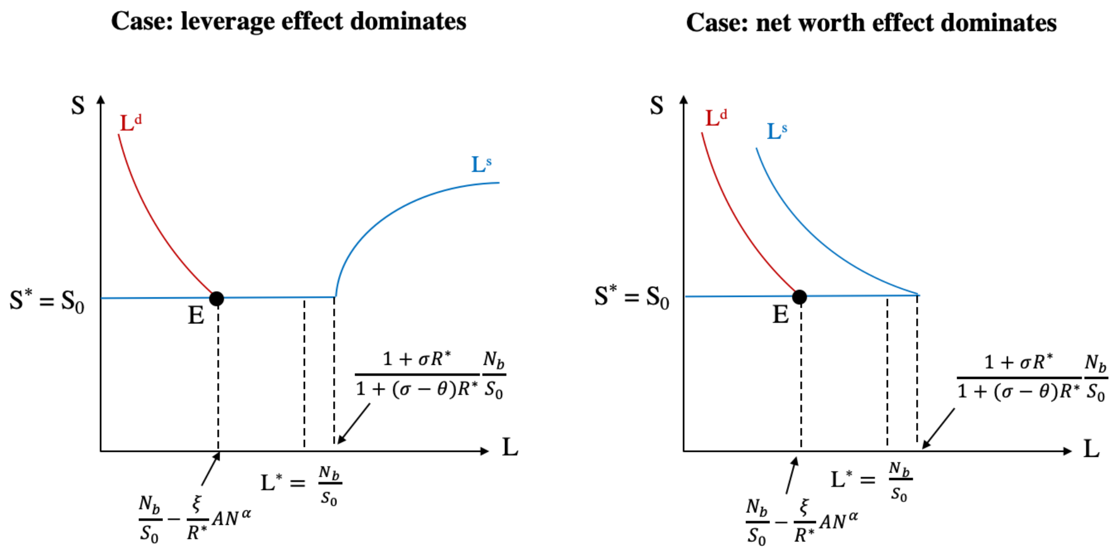

Figure 2.11: The Equilibrium in the Loan Market: Special Case

where $S_0 = \frac{R^*}{\alpha A N^{\alpha-1}}$. The equilibrium levels of banks' cross-border borrowing and lending are

$$D_b^* = F^* = \frac{\alpha A N^{\alpha-1}\theta N_b}{1+\sigma R^* - \theta R^*}$$

2.5 Policies

With the analytic solutions, I will study the effects of macroprudential policy measures (MPMs) and capital flow management measures (CFMs) when there is a U.S. monetary expansion. The macroprudential policy is effective in reducing total corporate loans when the global interest rate goes down, but the effect is dampened when firms' share of foreign borrowing in total loans is higher. This theoretical analysis can be linked to the empirical evidence in Section 2.2 that the mitigating effects of macroprudential policy on corporate loans in response to the U.S. monetary expansions are dampened with a high share of foreign loans in total corporate borrowing. In addition, I show that applying CFMs together with macroprudential policy can help in preventing the dampening effect, which coincides with the empirical finding that the attenuating effects of MPMs that are conducted together with CFMs are not significantly dampened by a higher foreign loan share.

2.5.1 U.S. Monetary Expansion

Suppose there is a decrease in the global interest rate R^{**} due to a U.S. monetary expansion. Since $R^* = 1 + \frac{1}{\sigma}(R^{**} - 1)$ is a function of R^{**}, it is also reduced. Define T^* as total corporate loans (i.e., $T^* = L^* + D_f^* = \frac{\alpha A N^{\alpha-1}}{R^*} N_b$). Then, T^* is decreasing in R^*:

$$\frac{\partial T^*}{\partial R^*} = \frac{\partial L^*}{\partial R^*} = -\frac{\alpha A N^{\alpha-1}}{{R^*}^2} N_b < 0 \tag{2.35}$$

When R^* decreases, domestic firms increase foreign borrowing because the borrowing rate is lower than before. They also increase domestic borrowing because a decrease in the global interest rate induces R to fall, as supply becomes bigger than demand for domestic loans when $R > R^*$. Therefore, total corporate loans after the U.S. monetary expansion will be

$$T^* - \frac{\partial T^*}{\partial R^*} = \frac{\alpha A N^{\alpha-1}}{R^*} N_b (1 + \frac{1}{R^*}) \quad > \quad T^* = \frac{\alpha A N^{\alpha-1}}{R^*} N_b \tag{2.36}$$

Since corporate loans increase in response to the decrease in R^*, the equilibrium level of loans after the U.S. monetary expansion will be larger than before the change.

2.5.2 Introduction of Macroprudential Policy

As discussed in the previous section, a U.S. monetary expansion can induce total corporate loans to increase. However, an excessive increase in corporate loans may cause problems because agents could be exposed to more default and currency risk, making the economy more vulnerable to subsequent currency shocks or financial crises. Hence, many central banks conduct macroprudential policies to limit the increase in corporate borrowing. Since it is difficult to regulate domestic firms, central banks often use lender-targeted policy measures that intervene in the decisions of financial institutions. In this section, I study the effects of macroprudential policy that limits banks' concentration of credit to domestic borrowers. In addition, I demonstrate that the effects of macroprudential policy can be dampened when firms' cross-border loans are less restricted. In turn, this dampening can be mitigated with the introduction of capital flow management policy measures.

Concentration Limits

In this section, I study a special case of macroprudential policies, called "*Concentration Limits*." The policy limits the fraction of bank assets held as loans to specific borrowers. In my model, if R is larger than R^*, a bank supplies loans only to domestic borrowers because it can earn more revenue by lending domestically. However, domestic borrowers may be more risky than international borrowers because the domestic market is less stable than foreign markets. Therefore, the central bank may limit the fraction of the bank's assets held as loans to domestic borrowers. To study the effects of this policy, I impose an additional restriction on domestic lending on the representative bank's problem. Other assumptions will be the same as in the previous section.

Modified Bank's Problem

Consider an additional constraint on bank lending that limits the amount of lending to domestic borrowers to a fraction of the bank's own initial net worth. This constraint operates to keep banks from lending too much to domestic firms, and induces them to lend to international borrowers as well. The constraint on the bank's lending is

$$L \leq \lambda \frac{N_b}{S} \tag{2.37}$$

where $0 < \lambda < 1$.

Then, the bank's problem can be rewritten as

$$\max_{L_m, F_m, D_{b,m}} \quad \Pi^b = RL_m + R^* F_m - (1 + \sigma(R^* - 1)) D_{b,m}$$

$$\text{s.t.} \qquad L_m + F_m = D_{b,m} + \frac{N_b}{S}$$

$$(1 + \sigma(R^* - 1)) D_{b,m} \leq \theta(RL_m + R^* F_m)$$

$$L_m \leq \lambda \frac{N_b}{S}$$

where $L_m, F_m,$ and $D_{b,m}$ denote bank lending to domestic borrowers, lending to international borrowers, and the amount borrowed from international markets. Also, $0 < \theta < 1$, and $0 < \lambda < 1$.

The optimal supply of domestic loans, and banks' demand and supply for cross-border loans will be

$$L_m^s = \begin{cases} \frac{\lambda N_b}{S} & \text{if} \quad S > S_0 \\ \\ \in [0, \frac{\lambda N_b}{S_0}] & \text{if} \quad S = S_0 \end{cases}$$

$$F_m = \begin{cases} \frac{(1-\lambda)(1+\sigma(R^*-1))+\theta R^* \phi(S)\lambda}{1+\sigma(R^*-1)-\theta R^*} \frac{N_b}{S} & \text{if} \quad S > S_0 \\ \\ \in [\frac{(1-\lambda)(1+\sigma(R^*-1))+\theta R^* \lambda}{1+\sigma(R^*-1)-\theta R^*} \frac{N_b}{S_0}, \frac{1+\sigma(R^*-1)}{1+\sigma(R^*-1)-\theta R^*} \frac{N_b}{S_0}] & \text{if} \quad S = S_0 \end{cases}$$

$$D_{b,m} = \frac{\theta R^*(1-\lambda) + \theta R \lambda}{1+\sigma(R^*-1)-\theta R^*} \frac{N_b}{S_0} \quad \text{for} \quad S \geq S_0$$

The firm's problem is the same as in the case without macroprudential policy. I denote $D_{f,m}$ as the amount borrowed from the international market by firms.

Equilibrium

Note that $\frac{\partial L_m^s}{\partial S} = -\frac{\lambda N_b}{S^2} < 0$, which means that the net worth effect dominates the leverage effect in the elasticity of loan supply. Since $0 < \lambda < 1$, $|\frac{\partial L_m^s}{\partial S}| = \frac{\lambda N_b}{S^2} < |\frac{\partial L_m^d}{\partial S}| = \frac{N_b}{S^2}$, which means that the slope of the loan demand function is steeper than that of the loan supply function. Therefore, in the presence of macroprudential policy that imposes a limit on bank lending to domestic firms, multiple equilibria arise as in Figure 2.12 (points E and E'). I will focus on the equilibrium at point E because it is plausible that the domestic rate is higher than the world interest rate.

In the domestic loan market, demand and supply for loans are equalized as at point E in Figure 2.12, implying that

$$\frac{N_b}{S} - \frac{\xi}{R^*} A N^\alpha = \frac{\lambda N_b}{S} \tag{2.38}$$

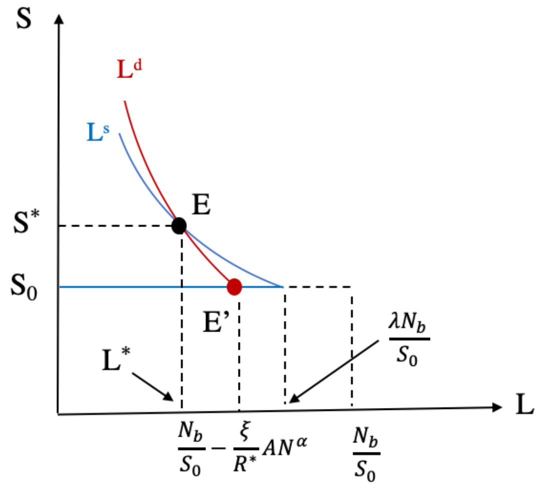

Figure 2.12: The Equilibrium in the Loan Market: Macroprudential Policy

Solving the above equation, the equilibrium levels of the interest rate and the exchange rate are

$$R_m = \frac{(1-\xi)(1-\lambda)\alpha N_b}{\xi(N-(1-\lambda)\alpha N_b)} R^*, \quad S_m^* = \frac{(1-\lambda)N_b}{\xi A N^\alpha} R^*$$

The equilibrium levels of corporate loans be expressed as follows:

$$L_m^* = \frac{\lambda}{1-\lambda}\frac{\xi A N^\alpha}{R^*}, \quad D_{f,m}^* = \frac{\xi A N^\alpha}{R^*}$$

Defining total corporate loans in the presence of concentration limits as $T_m^* = L_m^* + D_{f,m}^*$, the equilibrium level of total corporate loans is

$$T_m^* = \frac{1}{1-\lambda}\frac{\xi A N^\alpha}{R^*} < T^* = \frac{\alpha A N^{\alpha-1}}{R^*} N_b$$

since $R > R^* \Leftrightarrow (1-\lambda)\alpha N_b > \xi N$. Thus, the equilibrium level of total corporate loans is reduced when macroprudential policy limits the amount of domestic loans.

U.S. Monetary Expansion

The responses of loans to changes in the world interest rate can be now written as

$$\frac{\partial L_m^*}{\partial R^*} = -\frac{\lambda}{1-\lambda}\frac{\xi A N^\alpha}{R^{*2}}, \quad \frac{\partial D_{f,m}^*}{\partial R^*} = -\frac{\xi A N^\alpha}{R^{*2}}$$

$$\frac{\partial T_m^*}{\partial R^*} = -\frac{1}{1-\lambda}\frac{\xi A N^\alpha}{R^{*2}} < 0 \tag{2.39}$$

Then the equilibrium level of total corporate loans after the U.S. monetary expansion will be

$$T_m^* - \frac{\partial T_m^*}{\partial R^*} = \frac{1}{1-\lambda}\frac{\xi A N^\alpha}{R^*}(1+\frac{1}{R^*}) < T^* - \frac{\partial T^*}{\partial R^*} = \frac{\alpha A N^{\alpha-1}}{R^*}N_b(1+\frac{1}{R^*}) \tag{2.40}$$

since $R > R^* \Leftrightarrow (1-\lambda)\alpha N_b > \xi N$. Thus, the equilibrium level of corporate loans after U.S. monetary expansion is lower when the central bank introduces macroprudential policy that limits the concentration of credit.

The Effectiveness of the Policy

I can measure the effectiveness of macroprudential policy in affecting the level of corporate loans as

$$\frac{T^* - \frac{\partial T^*}{\partial R^*}}{T_m^* - \frac{\partial T_m^*}{\partial R^*}} = (1-\lambda)\frac{\alpha N_b}{\xi N} \equiv M_1 \tag{2.41}$$

which is larger than 1.

Alternatively, I can measure the effectiveness of MPM in attenuating the response of corporate loans to monetary expansion as with

$$\frac{\partial T^*}{\partial R^*} - \frac{\partial T_m^*}{\partial R^*} = -\frac{1}{1-\lambda}\frac{\xi A N^\alpha}{R^{*2}} + \frac{\alpha A N^{\alpha-1}}{R^{*2}} \equiv M_2 \tag{2.42}$$

which is larger than 0. Since the purpose of the macroprudential policy is to reduce the equilibrium level of total corporate loans and its responses to the U.S. monetary expansion, the policy is more effective as M_1 and M_2 are larger.

Note that both measures of effectiveness of the macroprudential policy, M_1 and M_2, are decreasing in ξ:

$$\frac{\partial M_1}{\partial \xi} = -(1-\lambda)\frac{\alpha N_b}{\xi^2 N} < 0, \quad \frac{\partial M_2}{\partial \xi} = -\frac{1}{1-\lambda}\frac{A N^\alpha}{R^{*2}} < 0$$

Since a firm can borrow from abroad up to a fraction ξ of its expected revenue, an increase in ξ means that the firm is allowed to borrow more from international lenders. Therefore, the above equation means that the effects of the macroprudential policy are dampened when firms can borrow more from international markets. This is because the macroprudential policy on credit concentration cannot control capital flows incurred by corporate cross-border borrowing. This is shown in the equilibrium levels of corporate loans across borders:

$$\frac{\partial D_f^*}{\partial R^*} = \frac{\partial D_{f,m}^*}{\partial R^*} = -\frac{\xi A N^\alpha}{R^*}$$
$$D_f^* - \frac{\partial D_f^*}{\partial R^*} = D_{f,m}^* - \frac{\partial D_{f,m}^*}{\partial R^*} = \frac{\xi A N^\alpha}{R^*}(1 + \frac{1}{R^*})$$

Firms borrow more from the international market in response to a decrease in the U.S. rate but macroprudential policy cannot regulate this response. This means that the effectiveness of MPMs will be dampened as the firm's constraint on foreign loans is loosened (i.e., $\xi \Uparrow$). Thus, there are leakages from macroprudential policy in reducing corporate loans and mitigating their responses to U.S. monetary expansion.

2.5.3 Capital Flow Management Policy

I have shown that macroprudential policy that limits credit concentration reduces the equilibrium level of total loans and mitigates the response of those loans to a decrease in the world interest rate. However, the effects are dampened when firms are able to finance loans from abroad, because they can shift toward the international market when domestic loans are limited. However, an additional introduction of capital flow management policy measures can minimize these leakages from the effects of macroprudential policy. The CFM policy can be conducted together with the macroprudential policy, imposing an additional constraint on corporate foreign loans that is occasionally binding.

Since an increase in ξ induces firms to shift more toward foreign loans when domestic loans are restricted, it can dampen the effects of macroprudential policy in attenuating the increase in total corporate loans in response to U.S. monetary expansion. Therefore, suppose the central bank decides to directly limit firms' foreign borrowing to some multiple of its expected revenue. The constraint will be

$$D_f \leq \rho A K^{\alpha} \tag{2.43}$$

where $0 < \rho < 1$. When ξ is small enough (i.e., $\xi \leq \rho R^*$), the constraint is not binding. However, when ξ becomes larger than ρR^*, it will bind.

The firm's problem with the additional constraint imposed by the CFM will be

$$\max_{L_c, D_{f,c}, K} \quad \Pi^f = AK^\alpha - RL_c - R^* D_{f,c}$$
$$\text{s.t.} \quad \frac{K}{S} = L_c + D_{f,c} + \frac{N_f}{S}$$
$$R^* D_{f,c} \leq \xi A K^\alpha$$
$$D_{f,c} \leq \rho A K^\alpha$$

where $A > 0$, $0 < \alpha \leq 1$, $0 < \xi < 1$, and $0 < \rho < 1$.

When $\xi \leq \rho R^*$, there is no effect of the CFM because the constraint (2.43) is not binding. For $\xi > \rho R^*$, the optimal demand for domestic and foreign loans by the firm will be

$$L_c^d = \frac{N_b}{S} - \rho A N^\alpha, \quad D_{f,c} = \rho A N^\alpha \tag{2.44}$$

The bank's problem does not change with the introduction of the CFM constraint, so the bank's decisions are the same as in the previous section.

In the domestic loan market, $L_c^d = L_c^s$ gives the equilibrium level of the exchange rate as

$$S_c = \frac{(1-\lambda)N_b}{\rho A N^\alpha}$$

Then the equilibrium levels of domestic, international, and total corporate loans will be

$$L_c^* = \frac{\lambda}{1-\lambda}\rho A N^\alpha, \quad D_{f,c}^* = \rho A N^\alpha, \quad T_c^* = \frac{1}{1-\lambda}\rho A N^\alpha$$

Since T_c^* is not a function of R^*, total corporate loans do not respond to a decrease in the global interest rate R^*. Hence, total corporate loans after the U.S. monetary expansion will be

$$T_c^* - \frac{\partial T_c^*}{\partial R^*} = \frac{1}{1-\lambda}\rho A N^{\alpha}$$

Similarly to the case with only macroprudential policy, I can measure the effectiveness of CFM in conjunction with MPM in restricting the level of corporate loans as

$$\frac{T_m^* - \frac{\partial T_m^*}{\partial R^*}}{T_c^* - \frac{\partial T_c^*}{\partial R^*}} = (1 + \frac{1}{R^*})\frac{\xi}{\rho R^*} \equiv C_1 \tag{2.45}$$

which is larger than 1 for $\xi > \rho R^*$. The effectiveness of CFM together with MPM in regulating the response of corporate loans can be measured as

$$-\frac{\partial T_m^*}{\partial R^*} = \frac{1}{1-\lambda}\frac{\xi A N^{\alpha}}{{R^*}^2} \equiv C_2 > 0 \tag{2.46}$$

since $\frac{\partial T_c^*}{\partial R^*} = 0$. These measures show that imposing a CFM constraint on firms makes macroprudential policy more effective than in the case where macroprudential policy is conducted alone.

Moreover, the effects of the additional CFM constraint are larger when ξ is higher. Defining CM_1 and CM_2 as measures of the effectiveness of the CFM in regulating the level and the response of corporate loans, respectively, these measures can be expressed as

$$\frac{T^* - \frac{\partial T^*}{\partial R^*}}{T_c^* - \frac{\partial T_c^*}{\partial R^*}} = \frac{(1-\lambda)\alpha N_b}{\rho R^* N}(1 + \frac{1}{R^*}) \equiv CM_1 \tag{2.47}$$

$$-\frac{\partial T^*}{\partial R^*} = \frac{\alpha A N^{\alpha-1}}{{R^*}^2} \equiv CM_2 \tag{2.48}$$

CM_1 is larger than 1, and is not affected by ξ. CM_2 is larger than 0, and also is not a function of ξ. Therefore, firms' leakages toward foreign loans are limited by the CFM constraint, which prevents the effects of macroprudential policy from being dampened. In sum, the effects of macroprudential policy with a CFM constraint can be written as

$$\text{Policy Effects}_{level} = \begin{cases} (1-\lambda)\frac{\alpha N_b}{\xi N} & \text{if} \quad \xi \leq \rho R^* \\ \\ (1-\lambda)\frac{\alpha N_b}{\rho R^* N}(1+\frac{1}{R^*}) & \text{if} \quad \xi > \rho R^* \end{cases} \tag{2.49}$$

$$\text{Policy Effects}_{response} = \begin{cases} -\frac{1}{1-\lambda}\frac{\xi A N^{\alpha}}{{R^*}^2} + \frac{\alpha A N^{\alpha-1}}{{R^*}^2} & \text{if} \quad \xi \leq \rho R^* \\ \\ \frac{\alpha A N^{\alpha-1}}{{R^*}^2} & \text{if} \quad \xi > \rho R^* \end{cases} \tag{2.50}$$

Figure 2.13 depicts the policy effects as ξ changes. The left panel of the figure shows the effects of policies on the level of corporate loans while the right panel depicts the policy effects on the response of firm borrowing. For $\xi > \rho R^*$, the dotted line in the figure describes the effects of macroprudential policy without any capital flow management. The policy effects are shown to be severely dampened when the firm's borrowing constraint on foreign loans is loosened with an increase in ξ. The solid line depicts the effects of having a CFM constraint in addition to the macroprudential policy. The CFM is in effect when ξ crosses the threshold ρR^*. When the CFM constraint is binding, the macroprudential policy can have more effects than in the case without the CFM, and the effects are not dampened with a change in ξ.

In my model, since firms can borrow from the international markets as well as domestic

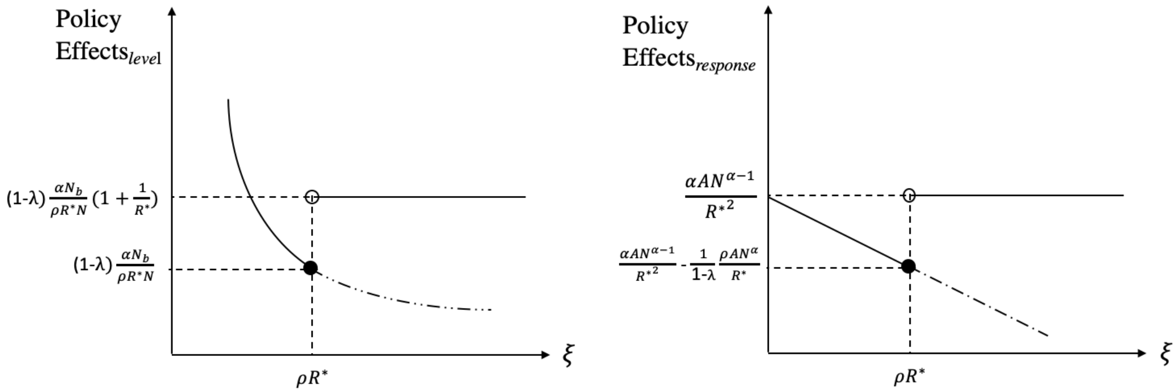

Figure 2.13: The Effectiveness of the Policy Measures

banks, macroprudential policy that limits domestic loans cannot fully manage the firms' total borrowing. As firms can finance their capital investment across borders instead of borrowing only from the domestic markets, there are leakages in the effects of macroprudential policy that limits domestic banks' credit concentration. This dampening impact can be mitigated by introducing an additional policy measure that limits capital flows. In this section, I have shown that CFMs that limit the amount borrowed from abroad can keep the effectiveness of macroprudential policy from being severely dampened by a loosening of firm's constraint on foreign loans, which is consistent with my empirical findings.

2.6 Conclusion

The purpose of my paper is to understand the effects of macroprudential policies on corporate loans in response to a U.S. monetary expansion. The empirical evidence in the paper suggests that macroprudential policies alone cannot regulate the response of corporate loans effectively when there is expansionary monetary policy in the U.S. This is because the policy effects are dampened when firms can borrow more from abroad, as MPMs only focus on domestic agents' decisions. However, MPMs can effectively regulate corporate loans when CFMs are in place, because CFMs can deal with foreign capital inflows incurred by firms' foreign borrowing. This finding is relevant for emerging countries, which have adopted several CFMs in recent years. In advanced countries, MPMs alone are effective in keeping firms from increasing their loans because domestic firms do not substantially leak toward the international markets. This can explain the fact that the advanced countries have not adopted CFMs frequently in recent decades.

The second part of this paper presents a theoretical model that can help to interpret these empirical results. The model allows firms to borrow from the international market while banks can also lend to foreign borrowers. When a central bank introduces macroprudential policies, it can effectively reduce corporate loans and mitigate their response to a decrease in the world interest rate. However, the effects are dampened when firms' constraints for foreign borrowing are loosened. This dampening effect can be addressed with the introduction of CFMs together with MPMs, which can keep firms from increasing foreign loans excessively. The analytical solutions of a special case, in which firms and banks are endowed only with non-tradable goods, show that the existence of CFMs can set a lower bound on firms' borrowing to boost the effectiveness of MPMs.

Appendix A: Chapter 1 Appendix

A.1 Data Appendix

A.1.1 Adjustment of Invoicing Currency Shares

The dataset classifies currencies of invoicing into four categories: dollars ($), euros (€), home currency (hc), and others. Among the sample countries, European countries including the Czech Republic, France, and Portugal record trade values in euros. South Korea, Thailand, and Turkey translate the values into dollars when reporting, while Japan and Norway use their own currencies. Suppose exports are invoiced in currency k and values are translated into currency l where $k \in \{\$, €, hc, other\}$ and $l \in \{\$, €, hc\}$. Define X_t^k as the share of invoicing in currency k at t. Define the relative share of invoicing in euros to dollars as $A_t \equiv \frac{X_t^{€}}{X_t^{\$}}$ and in the home currency to dollars as $B_t \equiv \frac{X_t^{\text{hc}}}{X_t^{\$}}$. Then the relative share of other currencies to dollars is $(\frac{1}{X_t} - 1 - A_t - B_t)$.

Suppose x_t is the currency l value of exports that are invoiced in dollars. Then the share of dollar invoicing at t, $X_t^{\$}$, is calculated based on currency l values of transactions invoiced in currency $k \in \{\$, €, hc, other\}$, as presented in the first row of Table A.1. Define $\varepsilon_{k/l,t}$ as the bilateral exchange rate between currencies k and l for $k, l \in \{\$, €, hc\}$. $\varepsilon_{other/l,t}$ is calculated as $\varepsilon_{other/l,t} = \varepsilon_{other/\$,t} \times \varepsilon_{\$/l,t}$ where $\varepsilon_{other/\$,t}$ denotes the dollar index that proxies the value of

Table A.1: Construction of Adjusted Dollar Invoicing Shares

Currency of Inv. (k)	Dollar	Euro	HC	Other
Values in l	x_t	$A_t x_t$	$B_t x_t$	$(\frac{1}{X_t^{\$}} - 1 - A_t - B_t)x_t$
Values in k (XR_t)	$x_t \varepsilon_{\$/l,t}$	$A_t x_t \varepsilon_{€/l,t}$	$B_t x_t \varepsilon_{hc/l,t}$	$(\frac{1}{X_t^{\$}} - 1 - A_t - B_t)x_t \varepsilon_{other/l,t}$
Adjusted values in l (XR_0)	$x_t \frac{\varepsilon_{\$/l,t}}{\varepsilon_{\$/l,0}}$	$A_t x_t \frac{\varepsilon_{€/l,t}}{\varepsilon_{€/l,0}}$	$B_t x_t \frac{\varepsilon_{hc/l,t}}{\varepsilon_{hc/l,0}}$	$(\frac{1}{X_t^{\$}} - 1 - A_t - B_t)x_t \frac{\varepsilon_{other/l,t}}{\varepsilon_{other/l,0}}$

Notes: Currency l is the currency of record. For an example of Japan, l is ¥. k is the currency of invoicing/pricing.

dollars relative to currencies other than the euro and the home currency.[1] Since transaction values are given in current terms, the values in the currency of invoicing (k) are given as in the second row of Table A.1. To get the adjusted shares of dollar invoicing, I apply the exchange rates from 2000 when converting the trade values into currency l. Then the adjusted dollar invoicing share at t can be calculated as

$$\begin{aligned} \Rightarrow \hat{X}_t^{\$} &= \frac{x_t \frac{\varepsilon_{\$/l,t}}{\varepsilon_{\$/l,0}}}{x_t \frac{\varepsilon_{\$/l,t}}{\varepsilon_{\$/l,0}} + A_t x_t \frac{\varepsilon_{€/l,t}}{\varepsilon_{€/l,0}} + B_t x_t \frac{\varepsilon_{hc/l,t}}{\varepsilon_{hc/l,0}} + (\frac{1}{X_t^{\$}} - 1 - A_t - B_t)x_t \frac{\varepsilon_{other/l,t}}{\varepsilon_{other/l,0}}} \\ &= \frac{1}{1 + A_t \frac{\varepsilon_{€/\$,t}}{\varepsilon_{€/\$,0}} + B_t \frac{\varepsilon_{hc/\$,t}}{\varepsilon_{hc/\$,0}} + (\frac{1}{X_t^{\$}} - 1 - A_t - B_t) \frac{\varepsilon_{other/\$,t}}{\varepsilon_{other/\$,0}}} \end{aligned} \tag{A.1}$$

which does not depend on the reporting currency l.

Similarly, dollar borrowing shares are adjusted with the constant exchange rate following the same method as in dollar invoicing shares. Table A.2 compares summary statistics for non-adjusted data with adjusted data. The statistics do not differ significantly from their unadjusted counterparts. Adjusted dollar invoicing shares vary from 7.3% to 99.7%, while non-adjusted

[1] This may generate some errors in the adjustment because the dollar index is calculated based on main currencies, including the euro and some home currencies. However, the dataset does not specify which currencies are included in the "Other" category, so I use the general index. Since the purpose of adjusting the variables is to see if the properties of dollar invoicing shares are explained by dollar valuation effects, this procedure is reasonable if the adjustments reflect the appreciation and depreciation of the dollar.

shares vary from 5.5% to 99.5%. The Mean is higher after adjustments. Adjusted dollar borrowing shares vary from 0.2% to 40%, while non-adjusted dollar borrowing shares vary from 0.2% to 31.7%.

Table A.2: Summary Statistics

	Mean	Median	Min	Max	Std	Obs	# countries
Dollar Inv. Shares in Exports							
Raw data							
Adjusted	55.8	56.7	7.3	99.7	4.6	340	21
Non-adjusted	52.3	50.4	5.5	99.5	3.3	340	21
Cyclical components							
Adjusted	0.0	0.0	-10.9	10.8	2.3	305	21
Non-adjusted	0.0	0.05	-6.1	7.7	1.7	305	21
Dollar Borr. Shares							
Raw data							
Adjusted	6.0	3.0	0.2	40.0	7.3	340	21
Non-adjusted	5.0	2.8	0.2	31.7	2.3	340	21
Cyclical components							
Adjusted	0.0	-0.04	-7.0	12.9	1.4	305	21
Non-adjusted	0.0	-0.03	-7.5	4.9	1.0	305	21

Notes: The table presents summary statistics for all observations after merging the datasets for invoicing and borrowing currencies. The variables represent percentages. Cyclical components are estimated using the Hamilton (2018) filter. *Source: Boz et al. (2020) and BIS Global Liquidity Indicator*

Figures A.1 - A.2 repeat the exercise for the stylized facts with the non-adjusted data. The co-movements of dollar borrowing and dollar invoicing with the VIX become weaker, but the positive correlation between dollar borrowing and dollar invoicing shares becomes much stronger, with an 88% correlation.

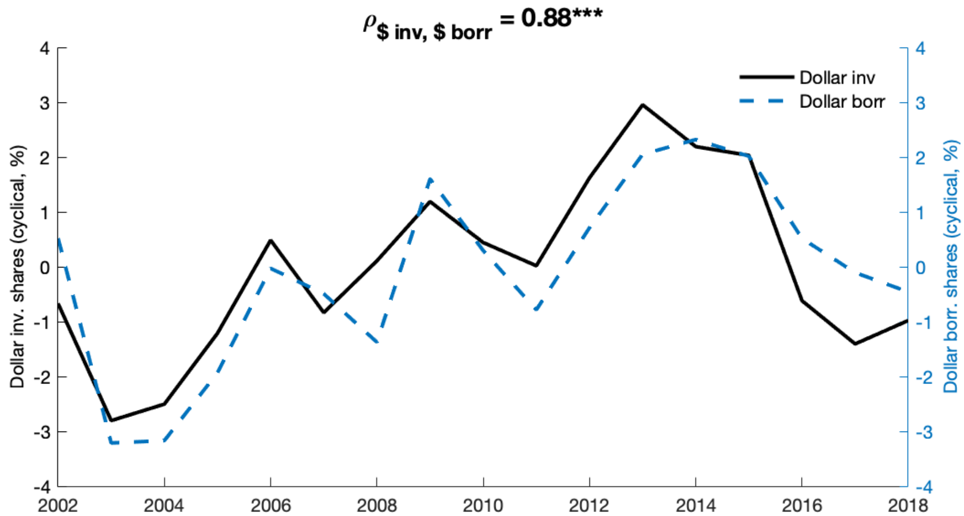

Figure A.1: Co-movements between Dollar Invoicing and Dollar Borrowing Shares, Non-adjusted

Notes: The data is annual and covers the period from 2000 to 2018. The series starts from 2002, although the underlying data begin in 2000, as the cyclical components are calculated based on 2-year-ahead forecast errors using the Hamilton (2018) filter. The common factors of dollar invoicing shares and dollar borrowing shares in the sample are estimated using a dynamic factor model (Stock and Watson (1999)). ** indicates significance at the 5% level.

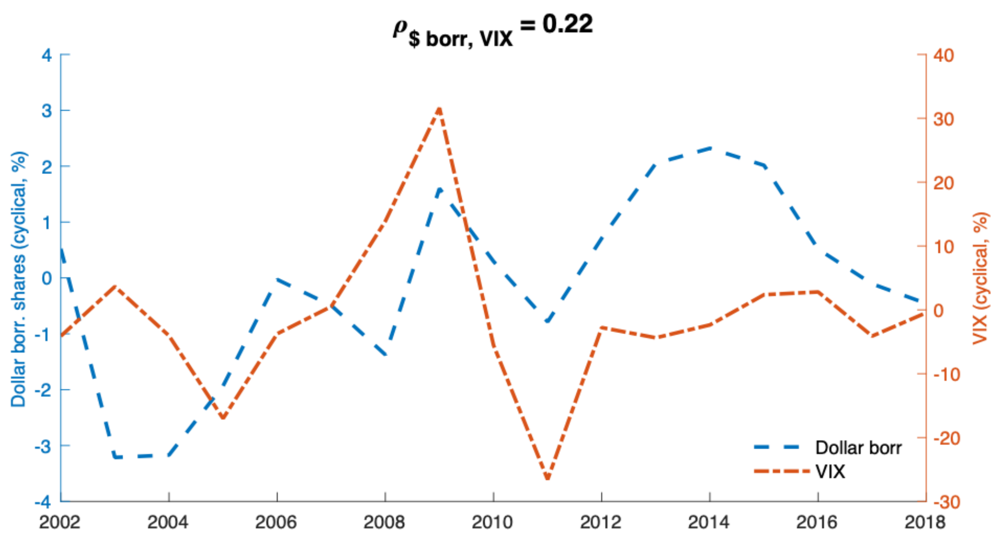

Figure A.2: Dollar Borrowing Shares, Dollar Invoicing Shares, and the VIX, Non-adjusted

Notes: The data is annual and covers the period from 2000 to 2018. The series starts from 2002, although the underlying data begin in 2000, as the cyclical components are calculated based on 2-year-ahead forecast errors using the Hamilton (2018) filter. The common factors of dollar invoicing and dollar borrowing shares are estimated by the dynamic factor model (Stock and Watson (1999)).

A.1.2 Composition Effects of Cyclical Movements in Invoicing Currency Choices

It is possible that cyclical movements observed in Section II are caused by movements in large exporters' export shares. If large exporters that use dollar invoicing export more during the global financial downturn and less during the boom, it can explain the dynamic movements of dollar invoicing shares. However, Figures below show that this is not the case for the example of Korea. The four largest exporters in Korea do not explain the movements in dollar invoicing shares, both in raw data and in cyclical components. Therefore, it is hard to argue that the observed co-movements between dollar invoicing shares and the global financial cycle and dollar borrowing shares are driven by the composition effect.

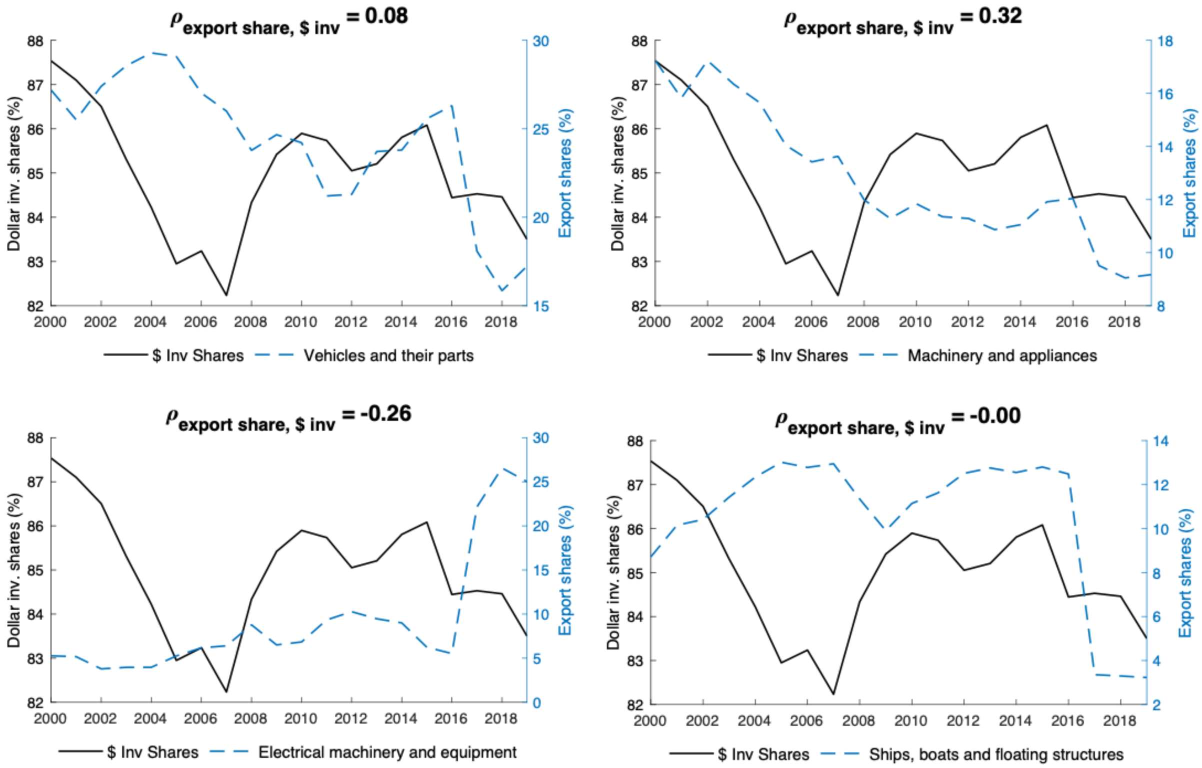

Figure A.3: Export Shares of the Largest Exporters in Korea

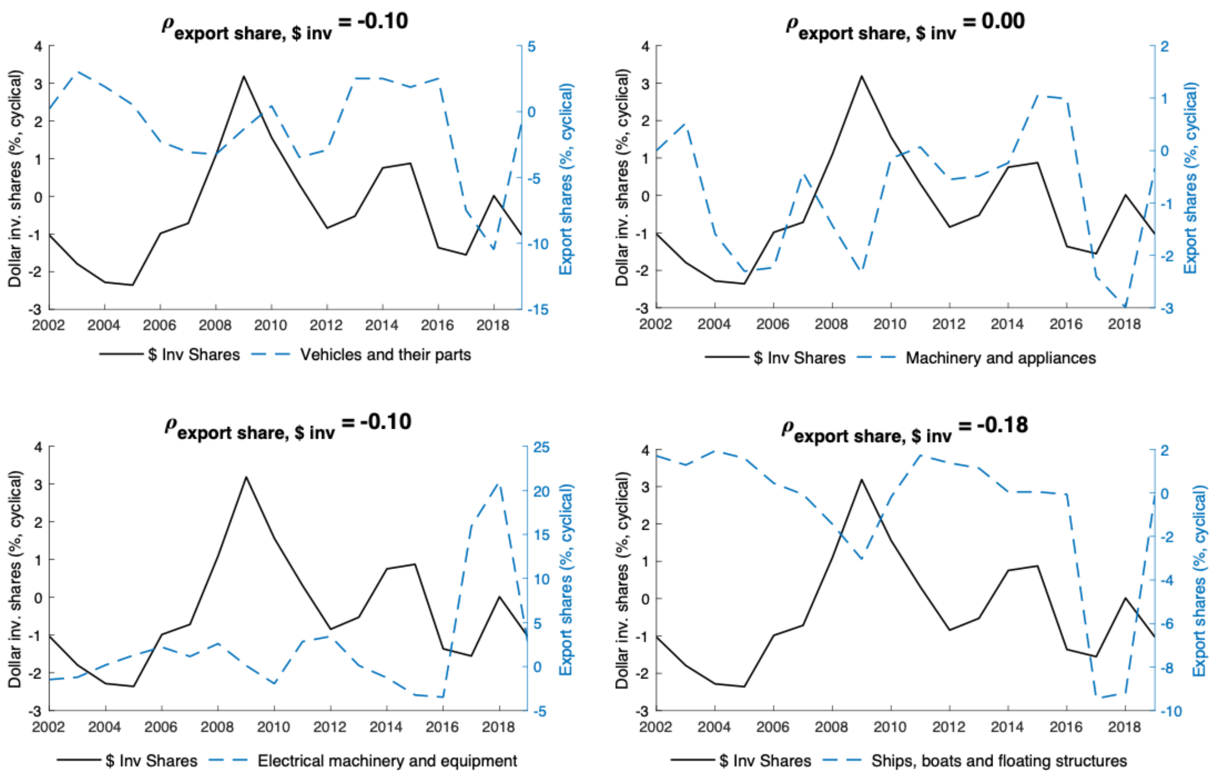

Figure A.4: Export Shares of the Largest Exporters in Korea: Cyclical

A.1.3 Correlations of Dollar Invoicing, the VIX, and Dollar Borrowing

Table A.3: Correlations of Dollar Invoicing Shares, the VIX, and Dollar Borrowing Shares

	Corr($ Inv, $ Borr)		Corr($ Borr, VIX)	
	non-adjusted	adjusted	non-adjusted	adjusted
Australia	-0.07	0.07	0.37	0.50
Belgium	0.77	0.86	0.56	0.79
Brazil	0.39	0.44	-0.03	0.21
Chile	0.04	0.32	0.01	0.02
Colombia	0.37	0.21	-0.08	-0.26
Czech Republic	0.00	0.08	-0.42	-0.35
France	0.46	0.29	0.09	0.37
Germany	-0.05	-0.38	0.38	0.65
Greece	0.05	-0.10	-0.20	0.01
Indonesia	0.25	-0.15	-0.25	-0.37
Italy	0.42	0.46	-0.11	-0.02
Japan	0.53	0.65	0.00	0.28
Luxembourg	0.35	0.39	0.16	0.38
New Zealand	0.34	0.52	0.15	0.25
Norway	-0.13	-0.25	-0.07	0.06
Portugal	-0.19	-0.02	0.05	0.20
Russia	-0.23	0.49	0.39	-0.48
South Korea	0.22	0.36	0.17	0.01
Spain	-0.21	0.14	0.61	0.83
Thailand	0.21	-0.03	-0.09	0.16
Turkey	0.07	0.58	0.47	0.52

Notes: The table presents country-level correlations for dollar invoicing shares, the VIX, and dollar borrowing shares. *Source: Boz et al. (2020), BIS Global Liquidity Indicator, and FRED*

A.2 Theoretical Proofs

A.2.1 Full Set of Equilibrium Conditions in the Baseline Model

Variables $\{C_t^*, M_t^*, D_{\$,t}^*, C_t, M_t, D_{h,t}, D_{\$,t}, u_t, C_{N,t}^*, W_t^*, C_{N,t}, W_t, B_{\$,t}^*, B_{R,t}^*, K_t^*, \Pi_t^*, Q_t^*, B_{h,t}, B_{\$,t}, B_{R,t}, \eta_t, K_t, \Pi_t, Q_t, \varepsilon_t, R_{\$,t}, R_{h,t}, A_{R,t}^*, A_{R,t}, R_{R,t}^*, R_{R,t}, \omega_t^*, \omega_t\}$ can be characterized by the set of equilibrium conditions:

$$C_t^* + (\varepsilon_t^{-1}(1-\eta_{t-1}) + \eta_{t-1})M_t^* + D_{\$,t}^* + W_t^* = \Pi_t^* + R_{\$,t-1}D_{\$,t-1}^* + \xi_t^* R_{R,t-1}^* W_{t-1}^* \tag{A.2}$$

$$M_t^* = \frac{\varepsilon_t \chi_m^*}{\varepsilon_t \eta_{t-1} + 1 - \eta_{t-1}} \tag{A.3}$$

$$\frac{\omega_t^*}{D_{\$,t}^*} + \beta^* R_{\$,t} = 1 \tag{A.4}$$

$$C_t + \varepsilon_t M_t + D_{h,t} + \varepsilon_t D_{\$,t} + W_t = \Pi_t + R_{h,t-1}D_{h,t-1} + \varepsilon_t R_{\$,t-1}D_{\$,t-1} + \xi_t R_{R,t-1}W_{t-1} \tag{A.5}$$

$$\varepsilon_t M_t = \chi_m \tag{A.6}$$

$$B_{h,t} = D_{h,t} \tag{A.7}$$

$$D_{\$,t} = \frac{\omega_t}{\beta(\varepsilon_t R_{h,t} - \mathbb{E}_t \varepsilon_{t+1} R_{\$,t})} \tag{A.8}$$

$$C_{N,t}^* + A_{R,t}^* + \xi_t^* R_{R,t-1}^* W_{t-1}^* = \xi_t^* R_{R,t-1}^* A_{R,t-1}^* + W_t^* \tag{A.9}$$

$$A_{R,t}^* = W_t^* \tag{A.10}$$

$$C_{N,t} + A_{R,t} + \xi_t R_{R,t-1} W_{t-1} = \xi_t R_{R,t-1} A_{R,t-1} + W_t \tag{A.11}$$

$$A_{R,t} = W_t \tag{A.12}$$

$$B^*_{\$,t} + B^*_{R,t} = Q^*_t K^*_t \tag{A.13}$$

$$R_{\$,t} B^*_{\$,t} = (Z^*_L + Q^*_L) K^*_t \tag{A.14}$$

$$K^*_t = \bar{K} \tag{A.15}$$

$$(Z^* + \mathbb{E}_t Q_{t+1}) + (\frac{R^*_{R,t}}{R_{\$,t}} - 1)(Z^*_L + Q^*_L) = Q^*_t R^*_{R,t} \tag{A.16}$$

$$Q_t K_t = B_{h,t} + \varepsilon_t B_{\$,t} + B_{R,t} \tag{A.17}$$

$$R_{h,t} B_{h,t} + \mathbb{E}_t \varepsilon_{t+1} R_{\$,t} B_{\$,t} = \{\alpha + (1-\alpha)(1 - \eta_t + \mathbb{E}_t \varepsilon_{t+1} \eta_t)\} Z_L K_t + Q_L K_t \tag{A.18}$$

$$R_{\$,t} B_{\$,t} = (1-\alpha)\eta_t Z_L K_t \tag{A.19}$$

$$K_t = \bar{K} \tag{A.20}$$

$$\psi(1-\alpha)^2 \eta_t = (Z - Z_L)(\mathbb{E}_t \varepsilon_{t+1} - 1) + R_{R,t} Z_L (\frac{\varepsilon_t}{R_{\$,t}} - \frac{1}{R_{h,t}}) \tag{A.21}$$

$$\begin{aligned} \frac{\psi}{2}(1-\alpha)^2 \eta_t^2 + R_{R,t} Q_t &= \{\alpha + (1-\alpha)(1 - \eta_t + \mathbb{E}_t \varepsilon_{t+1} \eta_t)\}[(Z - Z_L) + Z_L \frac{R_{R,t}}{R_{h,t}} \\ &\quad + (1-\alpha)\eta_t Z_L R_{R,t} (\frac{\varepsilon_t}{R_{\$,t}} - \frac{\mathbb{E}_t \varepsilon_{t+1}}{R_{h,t}} + (\mathbb{E}_t Q_{t+1} - Q_L) + Q_L \frac{R_{R,t}}{R_{h,t}} \end{aligned} \tag{A.22}$$

$$A^*_{R,t} = B^*_{R,t} \tag{A.23}$$

$$A_{R,t} = B_{R,t} \tag{A.24}$$

$$\Pi^*_t = (Z^*_t + Q^*_t) K^*_{t-1} - R_{\$,t-1} B^*_{\$,t-1} - \xi^*_t R^*_{R,t-1} B^*_{R,t-1} + \frac{\psi}{2}(1-\alpha)^2 \eta_{t-1}^2 K_{t-1} \varepsilon_{t-1}^{-1} \tag{A.25}$$

$$\begin{aligned} \Pi_t &= \{\alpha + (1-\alpha)(1 - \eta_{t-1} + \varepsilon_t \eta_{t-1})\} Z_t K_{t-1} + Q_t K_{t-1} \\ &\quad - R_{h,t-1} B_{h,t-1} - \varepsilon_t R_{\$,t-1} B_{\$,t-1} - \xi_t R_{R,t-1} B_{R,t-1} - \frac{\psi}{2}(1-\alpha)^2 \eta_{t-1}^2 K_{t-1} \end{aligned} \tag{A.26}$$

$$C_t + C_{N,t} + M^*_t(\varepsilon_t \eta_{t-1} + 1 - \eta_{t-1}) = \{\alpha + (1-\alpha)(1 - \eta_{t-1} + \varepsilon_t \eta_{t-1})\} Z_t K_{t-1} \tag{A.27}$$

$$\beta R_{h,t} = 1 \tag{A.28}$$

$$B_{\$,t} + B^*_{\$,t} = D_{\$,t} + D^*_{\$,t} \tag{A.29}$$

$$\delta R_{R,t} = 1 \tag{A.30}$$

$$\delta^* R^*_{R,t} = 1 \tag{A.31}$$

$$u_t = \frac{\beta}{\beta^*}\frac{R_{h,t}}{R_{\$,t}} \tag{A.32}$$

$$log\omega_t - log\bar{\omega} = \rho_\omega(log\omega_{t-1} - log\bar{\omega}) + e_{\omega,t} \tag{A.33}$$

$$log\omega^*_t = \Gamma^* log\omega_t \quad \text{for} \quad \Gamma^* > 0 \tag{A.34}$$

A.2.2 Proofs of Propositions

Steady-state

Variables without subscripts denote their steady-state values. The equations below can be used to solve for the steady-state values η, ε, and $R_\$$ as functions of the model's parameters:

$$(1-\alpha)^2\psi\eta = (Z - Z_L)(\varepsilon - 1) + \delta^{-1}Z_L(\frac{\varepsilon}{R_\$} - \beta) \tag{A.35}$$

$$(1-\alpha)^2\eta Z_L\bar{K} + (Z_L^* + Q_L^*)\bar{K} = \frac{\bar{\omega}R_\$}{\varepsilon(1-\beta R_\$)} + \frac{\bar{\omega^*}R_\$}{1-\beta^* R_\$} \tag{A.36}$$

$$\chi_m - \varepsilon\chi_m^* + \frac{\psi}{2}(1-\alpha)^2\eta^2\bar{K} = \varepsilon(R_\$ - 1)(\frac{\bar{\omega}}{\varepsilon(1-\beta R_\$)} - \frac{1}{R_\$(1-\alpha)^2\eta Z_L\bar{K})} \tag{A.37}$$

then given $\{\eta, \varepsilon, R_\$\}$ from above, the steady-state values $D_\$$, $D_\$^*$, $B_\$$, $B_\$^*$, and u satisfy

$$D_\$ = \frac{\bar{\omega}}{\varepsilon(1-\beta^* R_\$)}$$

$$D_\$^* = \frac{\Gamma^*\bar{\omega}}{1-\beta^* R_\$}$$

$$B_\$ = \frac{1}{R_\$}(1-\alpha)\eta Z_L\bar{K}$$

$$B_\$^* = \frac{1}{R_\$}(Z_L^* + Q_L^*)\bar{K}$$

$$u = \frac{1}{\beta R_\$}$$

Log-linearized equilibrium conditions

To describe the effects of the global risk shock, I employ first-order log approximations and use $\hat{\cdot}$ to denote log/level deviations from the steady-state. Then the simplified equilibrium conditions (1.25) can be written as:

$$\hat{D}_{\$,t} = \hat{\omega}_t - \frac{1}{1-\beta R_\$}[\hat{\varepsilon}_t - \beta R_\$ \mathbb{E}_t \hat{\varepsilon}_{t+1} - \beta R_\$ \hat{R}_{\$,t}] \tag{A.38}$$

$$\hat{D}^*_{\$,t} = \hat{\omega}_t + \frac{\beta^* R_\$}{1-\beta^* R_\$}\hat{R}_{\$,t} \tag{A.39}$$

$$\hat{R}_{\$,t} + \hat{B}_{\$,t} = \hat{\eta}_t \tag{A.40}$$

$$\hat{B}^*_{\$,t} = -\hat{R}_{\$,t} \tag{A.41}$$

$$\psi(1-\alpha)^2\hat{\eta}_t = (Z - Z_L)\varepsilon \mathbb{E}_t \hat{\varepsilon}_{t+1} + \delta^{-1} Z_L \frac{\varepsilon}{R_\$}\hat{\varepsilon}_t - \delta^{-1} Z_L \frac{\varepsilon}{R_\$}\hat{R}_{\$,t} \tag{A.42}$$

$$\chi^*_m \hat{\varepsilon}_t - \psi(1-\alpha)^2 \eta \bar{K} \varepsilon^{-1} \hat{\eta}_{t-1} = D_\$ \hat{D}_{\$,t} - B_\$ \hat{B}_{\$,t} - (D_\$ - B_\$) R_\$ \hat{R}_{\$,t-1} - (R_\$ - 1)(D_\$ - B_\$)\hat{\varepsilon}_t \tag{A.43}$$

$$B_\$ \hat{B}_{\$,t} + B^*_\$ \hat{B}^*_{\$,t} = D_\$ \hat{D}_{\$,t} + D^*_\$ \hat{D}^*_{\$,t} \tag{A.44}$$

$$\hat{u}_t = \hat{\varepsilon}_t - \mathbb{E}_t \hat{\varepsilon}_{t+1} - \hat{R}_{\$,t} \tag{A.45}$$

Proof of Proposition.1

Suppose the share of dollar invoicing is fixed to a constant, then $\hat{\eta}_t = 0$. Solving the equations, we can express the log-linearized variables as functions of $\hat{\omega}_t$. First, when $\hat{\omega}_t > 0$, the dollar appreciates:

$$\hat{\varepsilon}_t = \frac{1}{R_\$}[(1 - \beta R_\$ + 3(1-\beta^* R_\$) - (\beta^* - \beta))(1 + \frac{\beta^2 \rho_\omega^2}{4 - 2\beta\rho_\omega}) + \rho_\omega]\hat{\omega}_t + \Lambda_1 \tag{A.46}$$

where $\Lambda_1 \equiv \hat{\varepsilon}_{t-1} - (\beta^* - \beta)\hat{\omega}_{t-1} + \sum_{i=1}^{\infty}(\frac{\beta}{2})^i[\frac{1}{R_\$}(1 - \beta R_\$ + 3(1-\beta^* R_\$))\sum_{j=0}^{i}\rho_\omega^j e_{\omega,t+i-j} - (\beta^* - \beta)\sum_{j=0}^{i-1}\rho_\omega^j e_{\omega,t+i-j}]$ includes past and error terms. Since $[(1 - \beta R_\$ + 3(1-\beta^* R_\$) - (\beta^* - \beta))(1 + \frac{\beta^2\rho_\omega^2}{4-2\beta\rho_\omega}) + \rho_\omega]$ is positive, the exchange rate is proportional to $\hat{\omega}_t$. Similarly, the dollar interest rate decreases in response to the global risk shock as shown in the equation below:

$$[\frac{1}{1-\beta^* R_\$}+\frac{1}{1-\beta R_\$}]\hat{R}_{\$,t}=-[2-\frac{R_\$}{1-\beta R_\$}(\beta^*-\beta)]\hat{\omega}_t+\Lambda_1 \tag{A.47}$$

where $\Lambda_2 \equiv \frac{R_\$}{1-\beta R_\$}[(\beta^*-\beta)\{(\frac{1}{2\beta}(1+\frac{\beta}{\beta^*}-R_\$)\hat{\omega}_{t-1}-\frac{R_\$}{2\beta}(1+\frac{\beta}{\beta^*})\hat{\omega}_{t-1}\}+\frac{1}{2\beta}(1+\frac{\beta}{\beta^*})\{-(\frac{1}{2}(1+\frac{\beta}{\beta^*})+\frac{1}{R_\$})\hat{\varepsilon}_{t-1}+\hat{\varepsilon}_{t-2}\}]$.

Since the cost of dollar borrowing becomes cheaper, EM exporters borrow more in dollars: $\hat{B}_{\$,t}=-\hat{R}_{\$,t}$. Since returns to safe dollar claims go down, $\hat{D}_{\$,t}$ and $\hat{D}^*_{\$,t}$ increase. Since the dollar appreciates and the dollar rate decreases, we can also prove that the UIP premium, $\hat{u}_t$, goes up. With the fixed share of dollar invoicing, EM exporters cannot increase dollar borrowing as much as they want, because they need more of dollar collateral which cannot increase further without increasing the share of dollar invoicing. Therefore, EM depositors turn to U.S. exporters when their demand for safe dollar claims cannot be satisfied enough by saving domestically. It means an increase in the foreign asset accumulation, $\hat{FA}_{\$,t}$, which is the same as the net exports net the cost of dollar invoicing.

Proof of Proposition.2

Now suppose EM exporters can choose the share of dollar invoicing, η_t, endogenously ($\hat{\eta}_t \neq 0$). In this case, from the equilibrium conditions, the dollar share of invoicing can be written as a function of $\hat{\omega}_t$:

$$\frac{1}{R_\$}(1-\beta R_\$)[\frac{2-R_\$}{1-\beta^* R_\$}+\frac{1+\beta R_\$}{1-\beta R_\$}(R_\$-1)]\hat{\eta}_t$$
$$=\frac{1}{1-\frac{\beta\rho_\omega}{2}}[\frac{1}{R_\$}(1-\beta R_\$+3(1-\beta^* R_\$))\rho_\omega-(\beta^*-\beta)] \tag{A.48}$$
$$\times[(\frac{1+\beta R_\$}{1-\beta R_\$}+\frac{1}{1-\beta^* R_\$}(1+\frac{\beta\rho_\omega}{2})+\frac{\beta}{2(1-\beta^* R_\$}]]\hat{\omega}_t+\Lambda_3$$

where Λ_3 includes past and error terms. Thus, $\hat{\eta}_t$ increases in $\hat{\omega}_t$.

Since EM exporters invoice more of their exports in dollars, their capacity for dollar borrowing goes up, as they can create more dollar collateral. Therefore, EM exporters' dollar borrowing increase further, dampening the decrease in the dollar interest rate. This is followed by a larger increase in depositors' holdings of safe dollar claims. In this case, EM depositors fly less to the U.S. treasury assets, thereby dampening the appreciation of the dollar and the increases in foreign assets and net exports, compared to Case I.

A.3 A Global Risk Shock

The VIX, used as a measure of the global financial cycle in the literature including di Giovanni et al. (2021), Kalemli-Ozcan et al. (2020), and Kalemli-Ozcan and Varela (2022), reflects the market's expectation of 30-day forward-looking volatility. Therefore, an increase in this index indicates an expectation of high market volatility over the next 30 days. In the literature addressing the global financial cycle, an increase in the VIX is interpreted as an increase in global risk.

In this paper, I directly introduce an exogenous shock to the dollar's convenience yield, representing the surge in global risk, and term it a "global risk shock." This shock is caused by an exogenous increase in global risk, leading to a rise in the convenience yield of the dollar due to an increased global demand for holding the safe-haven currency. Hence, during a global risk shock, global savings in dollars increase, a phenomenon referred to by Kekre and Lenel (2021) as a "flight to safety." They also designate this global risk shock as a "safety shock."

Figure A.5 illustrates the rationale behind proxying the global risk shock as an increase in the convenience yield of safe dollar assets in a theoretical model and an increase in the VIX in empirical analyses. When we take a close look at two significant crises, first the 2008 global financial crisis and then the 2020 pandemic crisis, a notable pattern emerges. We observe a substantial increase in the VIX during these periods, coinciding with a decline in the spread between three-month Treasury bills and three-month AA commercial paper.[2] This dynamic suggests that in times of heightened global risk, there is an increased demand for safe dollar assets, leading to a reduction in the yield offered on these assets. This reduction implies a rise in

[2]Following Kekre and Lenel (2021), the convenience yield on safe dollar assets is proxied by the three-month spread. Data is obtained from the FRED database.

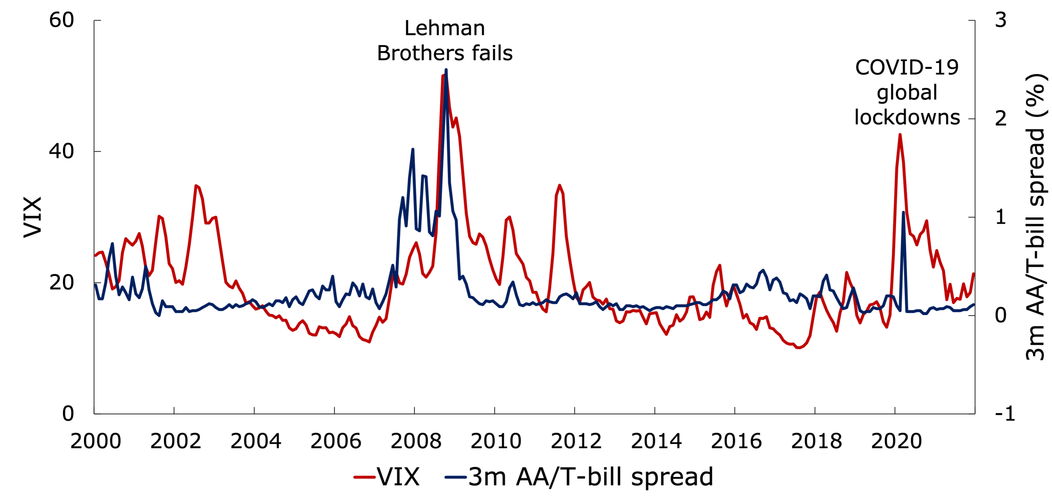

Figure A.5: VIX and a Global Risk Shock

the convenience yield of safe dollar assets. Therefore, in this paper, I refer to a global risk shock as an exogenous increase in the convenience yield on safe dollar assets in theory, and an increase in the VIX empirically.

A.4 Dynamic Responses

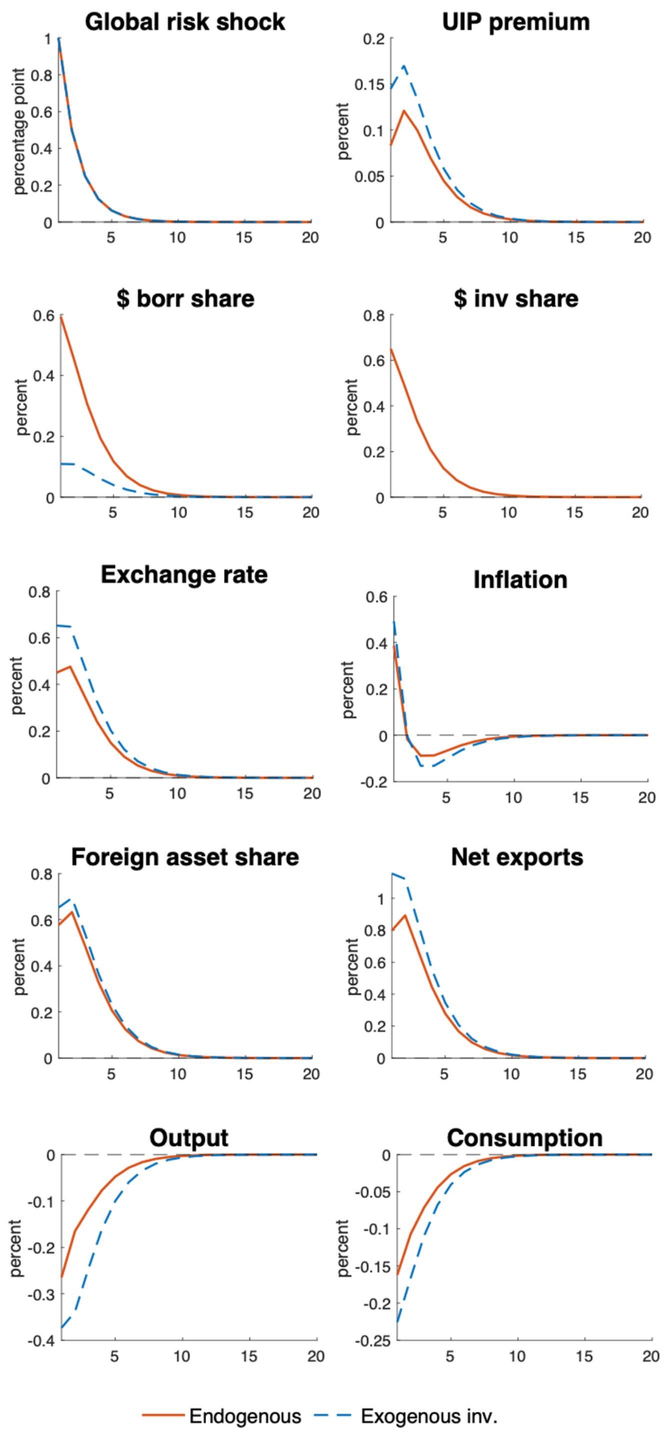

Figure A.6: Impulse Responses of the EM to a Global Risk Shock

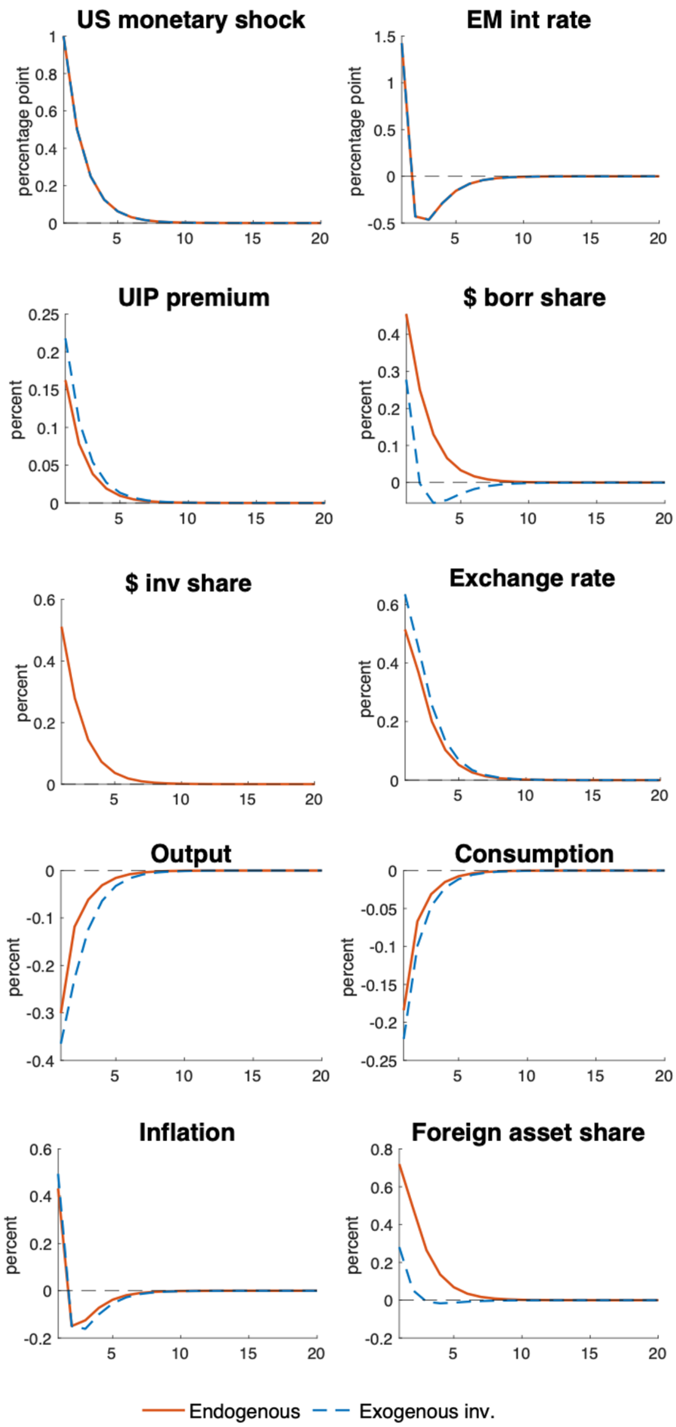

Figure A.7: Impulse Responses of the EM to a U.S. Monetary Tightening

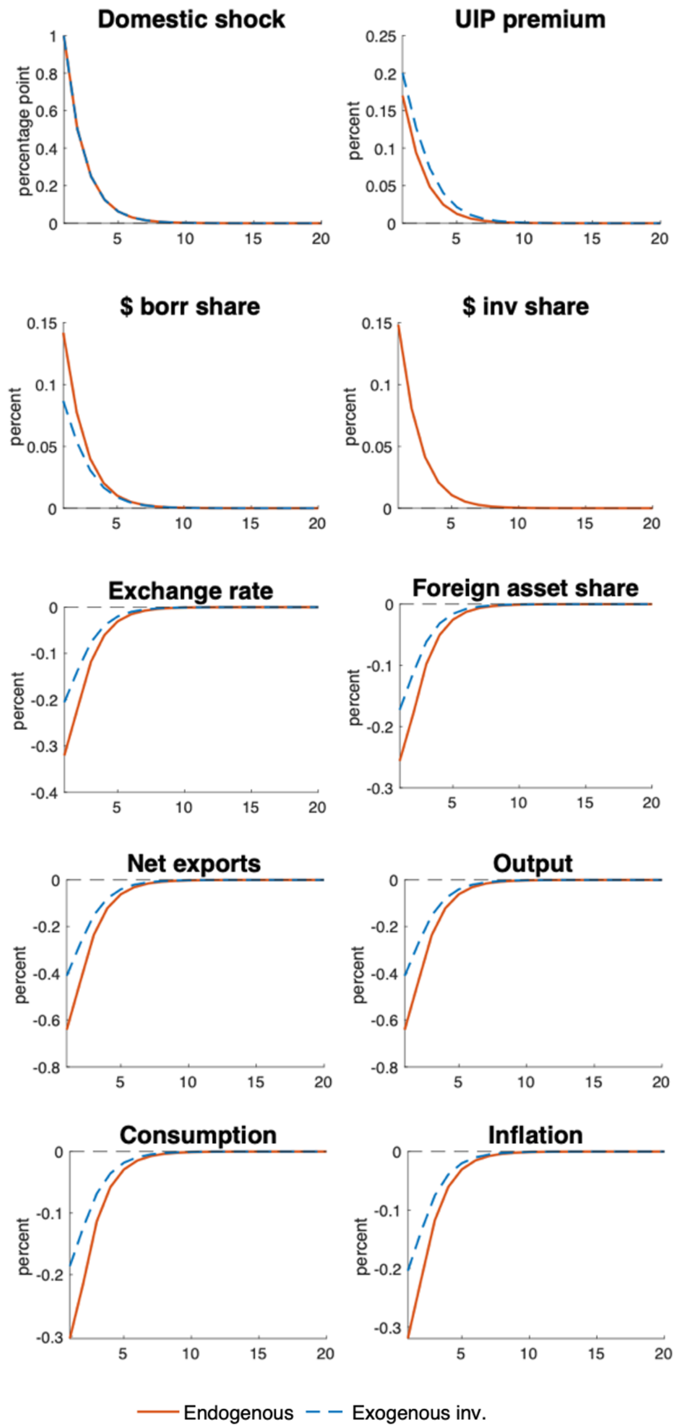

Figure A.8: Impulse Responses of the EM to a Domestic Monetary Tightening

Appendix B: Chapter 2 Appendix

B.1 Summary Statistics and Regression Results - Full

Table B.1: Summary Statistics of Main Regression Variables - Extended

	Mean	Median	Min	Max	Std. Dev.	Obs
Dependent Variables						
Total corporate loan growth (%)						
Advanced Countries	17.07	18.74	-710.44	977.18	154.28	323
Emerging Markets	21.62	12.82	-532.78	567.80	123.46	236
Total corporate loan level (logged , USD)						
Advanced Countries	1.49	1.71	-713.18	546.86	209.85	333
Emerging Markets	0.98	1.05	-5.83	5.08	2.01	243
Independent Variables						
(Country-year level variables)						
MPI_all						
Advanced Countries	2.10	2	0	8	1.81	345
Emerging Markets	3.23	3	0	12	2.41	255
MPI_lender						
Advanced Countries	1.71	2	0	6	1.33	345
Emerging Markets	2.73	2	0	10	1.92	255
MPI_borrower						
Advanced Countries	0.39	0	0	2	0.65	345
Emerging Markets	0.51	0	0	2	0.74	255
CFM						
Advanced Countries	0.03	0	0	1	0.18	345
Emerging Markets	0.20	0	0	1	0.40	255
Policy rate (%)						
Advanced Countries	3.03	2.51	-0.09	13.5	2.55	345
Emerging Markets	6.27	3.32	-0.09	183.2	13.14	243
GDP growth (%)						
Advanced Countries	2.37	2.54	-9.58	10.65	2.87	345
Emerging Markets	3.28	3.81	-16.43	14.19	4.09	255
(Country level variables)						
Foreign Share						
Advanced Countries	0.78	0.86	0.28	1	0.21	344
Emerging Markets	0.78	0.93	0.28	1	0.23	255
(Year level US variables)						
US expansion	0.67	1	0	1	0.47	345
US shadow funds rate (%)	1.46	1.35	-2.74	6.24	2.65	345

Notes: The table presents summary statistics for all observations from 2000-2014. Sources are Dealscan, IMF database and FRED. "MPI_all" is an index of all macroprudential policies, "MPI_lender" indexes lender-targeted policies, and "MPI_borrower" indexes borrower-targeted policies. "CFM" is an index of capital flow management policies, constructed by the author based on "IMF 2019 taxonomy of capital flow management measures." "Foreign Share" denotes the share of foreign loans in total corporate loans.

Bibliography

Aiyar, S., W. Calomiris, and T. Wieladek, "Does Macro-Prudential Regulation Leak? Evidence from a UK Policy Experiment," *Journal of Money, Credit and Banking*, 2014, *46(s1)*, 181–214.

Akinci, O. and A. Queralto, "Exchange Rate Dynamics and Monetary Spillovers with Imperfect Financial Markets," *NYFed Staff Report*, 2021.

Amiti, M., O.Itskhoki, and J. Konings, "Dominant Currencies: How Firms Choose Currency Invoicing and Why It Matters," *NBER Working Paper 27926*, 2020.

Aoki, K., G. Benigno, and N. Kiyotaki, "Monetary and Financial Policies in Emerging Markets," *Working Paper*, 2016.

Barbiero, O., "The Valuation Effects of Trade," *Job Market Paper*, 2020.

Bengui, J. and J. Bianchi, "Capital Flow Management when Capital Controls Leak," *15th Jacques Polak Annual Research Conference*, 2014.

Bianchi, J., "Overborrowing and systemic externalities in the business cycle," *American Economic Review*, 2011, *101(7).*

Bocola, L. and G. Lorenzoni, "Financial Crises, Dollarization, and Lending of Last Resort in Open Economies," *National Bureau of Economic Research Working Paper Series*, 2017, *w23984.*

Boz, E., C. Casas, G. Georgiadis, G. Gopinath, H. L. Mezo, A. Mehl, and T. Nguyen, "Patterns in Invoicing Currency in Global Trade," *IMF Working Paper*, 2020, *20/126.*

Brunnermeier, M. and Y. Sannikov, "International Credit Flows and Pecuniary Externalities," *American Economic Journal: Macroeconomics*, 2015, *7(1)*, 297–338.

Bruno, V., I. Shim, and H.S. Shin, "Comparative Assessment of Macroprudential Policies," *Journal of Financial Stability*, 2017, *28*, 183–202.

Cerutti, E., S. Claessens, and L. Laeven, "The Use and Effectiveness of Macroprudential Policies: New Evidence," *Journal of Financial Stability*, 2017, *28*, 203–224.

Cespedes, L. F., R. Chang, and A. Velasco, "Financial intermediation, real exchange rates, and unconventional policies in an open economy," *Journal of International Economics*, 2017, *108*, S76–S86.

Chari, A. and P.B. Henry, "Risk Sharing and Asset Prices: Evidence from a Natural Experiment," *The Journal of Finance*, 2004, *59(3)*, 1295–1324.

Christiano, L., M. Eichenbaum, and S. Rebelo, "When is the government spending multiplier large?," *Journal of Political Economy*, 2011, *119(1)*, 78–121.

Claessens, S., S. Ghosh, and R. Mihet, "Macroprudential Policies to Mitigate Financial System Vulnerabilities," *Journal of International Money and Finance*, 2013, *39*, 153–185.

Corsetti, G. and P. Pesenti, "The Simple Geometry of Transmission and Stabilization in Closed and Open Economics [with Comments]," *NBER International Seminar on Macroeconomics*, 2007, pp. 65–127.

Das, M., G. Gopinath, and S. Kalemli-Ozcan, "Preemptive Policies and Risk-Off Shocks in Emerging Markets," *Working paper*, 2023.

Dedola, L, P. Karadi, and G. Lombardo, "Global implications of national unconventional policies," *Journal of Monetary Economics*, 2013, *60*, 66–85.

Dell'Ariccia, G., D. Igan, L. Laeven, and H. Tong, "Policies for Macrofinancial Stability: How to Deal with Credit Booms," *IMF Staff Discussion Note*, 2012, *12/06.*

Devereux, M. and C. Engel, "Monetary Policy in the Open Economy Revisited: Price Setting and Exchange Rate Flexibility," *Review of Economic Studies*, 2003, *70*, 765–84.

di Giovanni, J., S. Kalemli-Ozcan, M. Fatih Ulu, and Y. S. Baskaya, "International Spillovers and Local Credit Cycles," *The Review of Economic Studies*, 2021, *forthcoming.*

Egorov, K. and D. Mukhin, "Optimal Policy under Dollar Pricing," *American Economic Review*, 2023.

Engel, C., "Equivalence Results for Optimal Pass-Through, Optimal Indexing to Exchange Rates, and Optimal Choice of Currency for Export Pricing," *Journal of European Economic Association*, 2006, *4(6)*, 1249–60.

_ , "Exchange rates, interest rates, and the risk premium," *American Economic Review*, 2016, *106* (436-474).

_ **and S. Wu**, "Liquidity and exchange rate: an empirical investigation," *Working Paper*, 2020.

Friberg, R. and F. Wilander, "The Currency Denomination of Exports - A Questionnaire Study," *Journal of International Economics*, 2011, *78(1)*, 54–69.

Gali, J., "Monetary Policy, Inflation and the Business Cycle: An Introduction to the New Keynesian Framework," *Princeton University Press*, 2008.

Gertler, M. and N. Kiyotaki, "Financial Intermediation and Credit Policy in Business Cycle Analysis," *Handbook of Monetary Economics*, 2010.

_ **and** _ , "Financial Intermediation and Credit Policy in Business Cycle Analysis," *Handbook of Monetary Economics*, 2010, *Elsevier.*

_ **and P. Karadi**, "A model of unconventional monetary policy," *Journal of Monetary Economics*, 2011, *58*, 17–34.

Gilmore, S. and F. Hayashi, "Emerging Market Currency Excess REturns," *American Economic Journal: Macroeconomics*, 2011, *3(4)*, 85–111.

Goldberg, L. S. and C. Tille, "Vehicle Currency Use in International Trade," *Journal of International Economics*, 2008, *76(2)*, 177–192.

Gopinath, G., "The International Price System," *Jackson Hole Symposium Proceedings*, 2016.

_ **and J. Stein**, "Banking, Trade, and the Making of a Dominant Currency," *Working Paper*, 2019.

_ **, E. Boz, C. Casas, F. J. Diez, P. O. Gourinchas, and M. Plagborg-Moller**, "Dominant Currency Paradigm," *American Economic Review*, 2020, *110 (3)*, 677–719.

_ **, O. Itskhoki, and R. Rigobon**, "Currency Choice and Exchange Rate Pass-through," *American Economic Review*, 2010, *100(1)*, 306–336.

Gourinchas, P., H. Rey, and N. Govillot, "Exorbitant privilege and exorbitant duty.," *IMES Discussion Paper Series*, 2010, *10-E-20.*

Greenwood, R., S. Hanson, and J. Stein, "A Comparative-Advantage Approach to Government Debt Maturity," *Journal of Finance*, 2015, *LXX(4)*, 1683–1722.

Hamilton, J. D., "Why you should never use the Hodrick-Prescott filter," *Review of Economics and Statistics*, 2018, *100(5)*, 831–843.

Hardy, B., "Foreign currency borrowing, balance sheet shocks, and real outcomes," *BIS Working Papers*, 2018, *758.*

Hassan, T.A., "Country Size, Currency Unions, and International Asset Returns," *Journal of Finance*, 2013, *68(6)*, 2269–2308.

Ito, T., S. Koibuchi, K. Sato, and J. Shimizu, "Invoice Currency Choice and Exchange Rate Risk Management in Japanese Firms' Trade Network: "RIETI Survey on Japanese Overseas Subsidiaries2010," *RIETI Discussion Paper*, 2011, *11-J-070.*

Javadekar, A., S. Tomar, and G. Udupa, "Dollar Liquidity, Trade Invoicing and Real Effects: Evidence from India," *SSRN*, 2021.

Jiang, Z., A. Krishnamurthy, and H. Lustig, "Dollar safety and the global financial cycle," *Working paper*, 2020.

— , — , **and** — , "Beyond incomplete spanning: convenience yields and exchange rate disconnect," *Working paper*, 2021.

Jimenez, G., S. R. G. Ongena, J. Peydro, and J. S. Salas, "Macroprudential Policy, Countercyclical Bank Capital Buffers and Credit Supply: Evidence from the Spanish Dynamic Provi- sioning Experiments," *European Banking Center Discussion Paper*, 2012.

Kalemli-Ozcan, S. and L. Varela, "Five Facts about the UIP Premium," *NBER Working Paper*, 2022, *28923*.

— **, X. Liu, and Ilhyock Shim**, "Exchange Rate Fluctuations and Firm Leverage," *IMF Working Paper*, 2020, *No. 2020/283*.

Kalemli-Ozcan, Sebnem, "U.S. Monetary Policy and International Risk Spillovers," *Jackson Hole Symposium*, 2020.

Kekre, R. and M. Lenel, "The Flight to Safety and International Risk Sharing," *NBER Working Paper 29238*, 2021.

Keller, L., "Capital Controls and Risk Misallocation: Evidence From a Natural Experiment," *SSRN*, 2019.

Korinek, A., "Excessive dollar borrowing in emerging markets: balance sheet effects and macroeconomic externalities," *IMF Economic Review*, 2011, *59(3)*, 523–561.

— **and D. Sandrii**, "Capital controls or macroprudential regulation?," *Journal of International Economics*, 2016, *99*, S27–S42.

Krishnamurthy, A. and A. Vissing-Jorgensen, "The Aggregte Demand for Treasury Debt," *Journal of Political Economy*, 2012, *120(2)*, 233–267.

Lim, C. H., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel, and X. Wu, "Macroprudential Policy: What Instruments and How Are They Used? Lessons from Country Experiences," *IMF Working Papers*, 2011, *11/238*.

Maggiori, M., "Financial Intermediation, International Risk Sharing, and Reserve Currencies.," *American Economic Review*, 2017, *107(10)*, 3038–71.

Mendoza, E., "Sudden stops, financial crises, and leverage," *American Economic Review*, 2010, *100(5)*, 1941–1966.

Mukhin, D., "An Equilibrium Model of the International Price System," *Working Paper*, 2020.

Nagel, S., "The Liquidity Premium of Near-Money Assets," *Quarterly Journal of Economics*, 2016, *131(4)*, 1927–1971.

Nuguer, V., "Financial intermediation in a global environment," *International Journal of Central Banking*, 2016, *12*, 291–345.

Ostry, J. D., A. R. Ghosh, M. Chamon, and M. S. Qureshi, "Tools for managing financial-stability risks from capital inflows.," *Journal of International Economics*, 2012, *88(2)*, 407–421.

Salomao, J. and L. Varela, "Exchange rate exposure and firm dynamics," *Warwick Economics Research Papers*, 2018, *1157.*

_ **and** _ , "Exchange rate exposure and firm dynamics," *Warwick Economics Research Papers*, 2018, *1157.*

Schmitt-Grohe, S. and M. Uribe, "Prudential Policy for Peggers," *Technical report, National Bureau of Economic Research*, 2012.

Stein, J. C., "Monetary Policy as Financial Stability Regulation," *Quarterly Journal of Economics*, 2012, *127(1)*, 57–95.

Stock, J. H. and M. W. Watson, "Business Cycle Fluctuations in U.S. Macroeconomic Time Series," *Handbook of Macroeconomics*, 1999, *2.A*, 3–64.

Sunderam, A., "Monetary Creation and the Shadow Banking System," *Review of Financial Studies*, 2015, *28(4)*, 939–977.

Ueda, K., "Banking globalization and international business cycles," *Journal of International Economics*, 2012, *86*, 1–16.

Valchev, R., "Bond convenience yields and exchange rate dynamics," *American Economic Journal: Macroeconomics*, 2020, *12*, 124–166.

Vayanos, D., "Flight to Quality, Flight to Liquidity, and the Pricing of Risk," *NBER Working Paper 10327*, 2004.

Wu, J. C. and F. Xia, "Measuring the Macroeconomic Impact of Monetary Policy at the Zero Lower Bound," *Journal of Money, Credit and Banking*, 2016, *48(2-3)*, 253–291.

Zhang, L. and E. Zolit, "Leaning Against the Wind: Macroprudential Policy in Asia," *IMF Working Papers*, 2014, *14/22.*

Zhang, T., "Monetary Policy Spillovers through Invoicing Currencies," *Working Paper*, 2020.