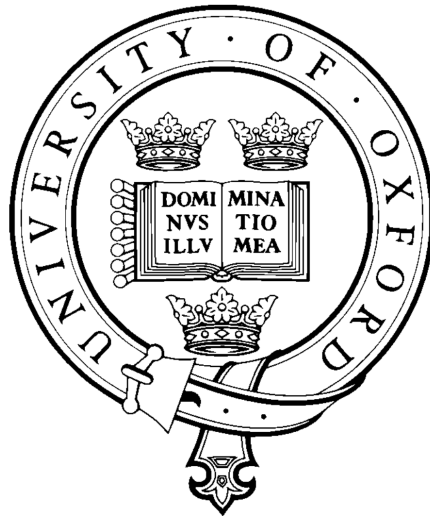


Monetary Policy, Financial Stability, and Default in Advanced and Emerging Market Economies



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Pembroke College
University of Oxford

A thesis submitted for the degree of
Doctor of Philosophy in Financial Economics

June 2022

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This thesis consists of three self-contained essays on monetary policy, financial stability, and default risk, which are applied in the context of Advanced Economies (AEs) and Emerging Market Economies (EMEs). Chapter 1 explores whether concerns for financial stability are a justification for Euro Area monetary policy to lift off the zero lower bound (ZLB) on nominal interest rates. Through the lens of an optimizing central bank, I study the consequences of a departure from the ZLB in a general equilibrium model with banks, collateral constraints, and default. Debt-deflationary forces of default sharpen the policy trade-off to central banks as they erode bank profitability and depress aggregate demand. My results thus support the argument that central banks ought to internalize the externality of their monetary policy decision on financial stability. Chapter 2 investigates the role of financial stability for monetary policy in EMEs, which are notoriously vulnerable to external shocks. Using the Mexican economy as a laboratory, I build a small open economy DSGE model with banks and firm default. I study whether a “leaning against the wind” policy can mitigate the effects of an external funding shock to the banking sector. I find that an interest rate rule augmented by a measure of expected default risk and the regulatory cost of bank capital outperforms conventional interest rate rules. This is because monetary policy takes into account financial amplification of firm default via banks’ balance sheets, which firms do not internalize. Chapter 3 uncovers whether credit risks that emanate from the corporate sector in EMEs can causally explain international capital flows. Using granular data on the universe of corporate bonds issued by non-financial firms in a large set of EMEs, I extract idiosyncratic shocks to large corporate borrowers. These shocks allow me to construct “Granular Instrumental Variables” (GIV) to identify this causal relationship. I show that corporate credit risk acts as a powerful amplifier of business cycle fluctuations in EMEs above and beyond global and sovereign risk. This thesis thus provides a novel policy implication: the interaction of private default and liquidity frictions can create important pecuniary externalities that, beyond the use of prudential regulatory measures, ought to be taken into account by monetary policy makers.

Supervisors This thesis was supervised by Dimitrios P. Tsomocos (primary supervisor) and Mungo Wilson (secondary supervisor).

Total words This thesis contains approximately 80,119 words.

Statement of authorship The work in this thesis is based exclusively on research carried out by me as a DPhil student at the University of Oxford between October 2017 and June 2022. No part of this thesis has been submitted for a degree at the University of Oxford or any other university. Chapter 1 is joint work with Dimitrios P. Tsomocos. Chapters 2 and 3 are single-authored and are fully my own work. This thesis has benefited from numerous discussions and the warm hospitality offered during my summer visits at the European Central Bank, the Bank for International Settlements, and Banco de México.

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A note to the reader The electronic version of this thesis contains hyperlinks to chapters, sections, figures, tables, equations, and references. For ease of reading, the references also contain hyperlinks to *go back* to the relevant citations in the main body.

To my family

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Acronyms

AEs Advanced Economies

BGG Bernanke, Gertler and Gilchrist

CPI consumer price index

DSGE Dynamic Stochastic General Equilibrium

ECB European Central Bank

ELB effective lower bound

EMEs Emerging Market Economies

GFC Global Financial Crisis

GIV Granular Instrumental Variables

IRFs impulse response functions

LAW leaning against the wind

NK New Keynesian

NPL non-performing loan

NPLs non-performing loans

PCA Principal Component Analysis

QE quantitative easing

SOE small open economy

UIP uncovered interest rate parity

USD US dollar

VIX CBOE volatility index

ZLB zero lower bound

Introduction

This thesis integrates theoretical and empirical research on two central questions that have engaged the debate in the field of international macro-finance over the past 15 years. The first question relates to the potential benefits of giving monetary policy makers a mandate to respond to macro-financial developments that could undermine financial stability. Chapter 1 addresses this question theoretically in the context of Advanced Economies (AEs) – specifically in the Euro Area – where monetary policy makers have faced distinct trade-offs at the zero lower bound (ZLB) on nominal interest rates. Chapter 2 applies this question in a theoretical framework to Emerging Market Economies (EMEs) where vulnerabilities to external shocks alter the costs and benefits of a financial stability mandate for central banks. The second question seeks to empirically assess the nature of these vulnerabilities in EMEs by exploring global and domestic factors that lead to volatile short-term capital movements between AEs and EMEs. Chapter 3 calls into question the predominant view that exclusively global factors shape the international architecture of capital flows. This chapter then provides evidence that domestic default risk in the corporate sector can also explain international capital flows. This thesis thus calls on monetary policy makers’ alertness to financial stability risks stemming from default and liquidity.

Motivation. This thesis is primarily motivated by two global macro-financial developments over the past 15 years: (i) the low nominal interest rate environment and (ii) the associated rise in private sector debt levels and default risk. These developments created new challenging trade-offs for monetary and regulatory policy makers around the world. Default constitutes the fulcrum of these trade-offs. It is the concept that links the conduct of monetary policy to financial stability, and that

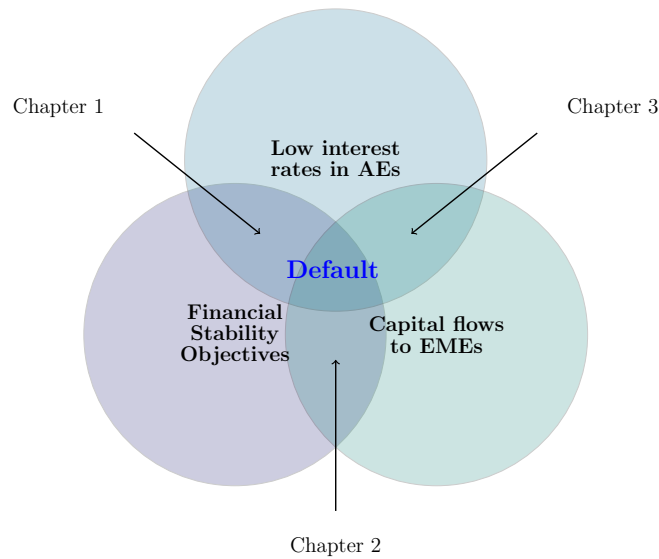


Figure A. Linkages between chapters of this thesis

gives meaning to money and credit (Goodhart & Tsomocos, 2011). The ideas presented in the following chapters, and the events that motivated them, share default as an encompassing theme as illustrated in Figure A and outlined below.

The decade following the Global Financial Crisis (GFC) set a number of precedents in the global policy arena. The advent of unconventional monetary policy, an unexplored innovation, heralded a period of persistently low nominal and real interest rates. The ZLB beyond which monetary policy was deemed to be ineffective was in many parts of the world superseded by the effective lower bound (ELB).¹ Against established beliefs, however, this accommodative monetary policy regime was not effective in reversing disinflationary pressures in AEs. Rather, the longer the low interest rate environment lasted, the more it fuelled global risk appetite. Among the consequences of risk-shifting, reminiscent of previous episodes in history, was a surge in fickle capital inflows in EMEs. Buoyant global capital markets amidst rising debt levels rekindled the debate about the adverse side effects of ultra-accommodative monetary policy.

Undoubtedly, the prolonged zero interest rate environment in AEs brought ad-

¹That is, nominal policy rates can become more negative than once was assumed without inducing cash hoarding. At the ELB, the central bank is not able to further reduce its policy rate to ease monetary policy. Hence, it must resort to unconventional measures. Note that, throughout this thesis, I use the ZLB and the ELB interchangeably to express that interest rates are either zero or negative unless otherwise stated.

verse consequences for EMEs. Low yielding safe assets in AEs enticed international investors to search for yield in riskier asset classes such as EM equity and bond markets. Propitious capital inflows were however masked by increasing vulnerabilities of EMEs to a sudden reversal of capital flows and currency devaluations (Alfaro, Asis, Chari, & Panizza, 2019; Asis, Chari, & Haas, 2021; Chari, Dilts Stedman, & Lundblad, 2021). Such a sudden reversal unfolded in May 2013 with the so called “US Taper Tantrum” when the US Federal Reserve Bank signalled an unexpected tightening in its monetary policy. The US Taper Tantrum marked a painful episode in history that uncovered the hidden dangers of “hot money” flowing into EM assets. EMEs’ vulnerability with respect to global risks surfaced again amidst the Covid-19 pandemic (Chari, Dilts-Stedman, & Lundblad, 2020) and with the Russian-led invasion of Ukrainian territory in February 2022, triggering currency swings and short-term capital outflows.

The 2020s arguably brought about a new era of monetary tightening. Yet, views on the justifications for, and thus the timing and pace of, monetary policy “normalization” were continually changing with the turn of tides. Prior to the Covid-19 pandemic, central banks in AEs were battling with public pressure to undo quantitative easing (QE) and to start to raise policy rates amidst the threat of a global search for yield to financial stability. The unexpected liquidity squeeze at the height of the pandemic postponed the debate on how to lift off from the ZLB. Concerns about default-driven disinflation reversed when global supply bottlenecks, pent-up demand, and excess liquidity fuelled inflation with the re-opening of economies. The war in Ukraine further contributed to spiking global energy and food prices, which resulted in the need for short-term action on monetary tightening.

A common theme behind these unprecedented episodes is the prevalence of default risk that is linked to growth in public and private credit (see Figure A). Historically, this phenomenon often predates financial crises (Schularick & Taylor, 2012). Before accelerating inflation started gripping the economy, structural problems in the financial system were calling into question years of ultra-accommodative monetary policy. Several culprits of disinflationary pressures were identified: high debt levels in the non-financial private sectors (Goodhart, Peiris, Tsomocos, & Wang,

2021), poor credit allocation (Acharya, Crosignani, Eisert, & Eufinger, 2020), pressure on banks to comply with prudential regulation amidst rising loan losses, and uncertainty about a sustained post-crisis recovery of the economy. Particularly in AEs, the invention of negative interest rates as a new policy tool sparked concerns about the subdued profitability of the banking sector, shifting risk preferences of banks and investors towards riskier asset classes (Bubeck, Maddaloni, & Peydró, 2020; Dell’Ariccia, Laeven, & Suarez, 2017; Martinez-Miera & Repullo, 2017), as well as a drop in deposit financing (Heider, Saidi, & Schepens, 2019), disintermediation, and dissaving. All of these risks to financial stability coincided with a boom in real estate fuelled by loose credit conditions (Jordà, Schularick, & Taylor, 2015) that remains ongoing.

In the post-GFC – and now post-Covid-19 world – an important topic of discussion for policy makers in both AEs and EMEs is the role that monetary policy plays in maintaining domestic and global financial stability. The GFC underlined the importance of safeguarding financial stability for monetary policy makers. It dismantled the classical dichotomy between monetary policy and financial stability policy put forth in the so called “neoclassical synthesis” (Mishkin, 2011). In its aftermath, regulators assiduously designed macroprudential policies to tackle the effects of systemic risk, credit growth, and procyclical movements of asset prices on overall economic performance. On paper, regulators and central banks pursue distinct objectives. At least in AEs, the latter are still following a *de jure* dual mandate of targeting inflation and stabilizing output as stipulated in their charters. Yet, in practice central banks must nowadays trade off classical monetary policy objectives against financial stability objectives (Cesa-Bianchi & Rebucci, 2017; Woodford, 2012).² Achieving financial stability however remains a more complex task than guaranteeing price stability. Unlike price stability, financial stability is more difficult to measure, model, and predict. This complicates measurement of costs and benefits of a financial stability mandate (Svensson, 2017).

²For an excellent discussion of the question whether financial stability is relevant to monetary policy making, see for example Woodford (2012). Schularick, ter Steege, and Ward (2021) provide a historical account of the effectiveness of monetary policy in leaning against the build-up of financial instabilities.

Outline. Chapter 1 of this thesis, written with Dimitrios Tsomocos, addresses the trade-off between monetary policy and financial stability objectives through the lens of monetary policy makers in AEs, specifically in the Euro Area. We analyse to what extent concerns for bank profitability could be a justification for the European Central Bank (ECB) to raise interest rates from the ZLB. In particular, we examine the consequences of what would occur if the ECB ascribed a more proactive role to financial stability in its objective function. Using a monetary general equilibrium model with incomplete markets, collateral constraints, and default in the housing market, we simulate the paths of inflation, output, bank profits, and default losses under optimal monetary and regulatory policy when the economy departs from the lower bound. Our findings do not support the argument that bank profitability will be restored upon departure from the lower bound. Instead, they highlight the dragging effect on the price level when higher debt servicing costs increase losses from default away from the lower bound. Precisely these losses from loan defaults then offset any gains stemming from banks' net interest rate margin when the economy lifts off from the lower bound. Thus, monetary policy operates beyond traditional channels, highlighting the need to take into account Fisherian debt-deflation forces. The model suggests that there are benefits to attributing a serious role to financial stability objectives in central banks' monetary policy.

Chapter 2 investigates whether these benefits also apply to EMEs. EMEs are notoriously plagued by balance of payments crises, sudden stops, and currency devaluations, which complicates the verdict. In the context of external financial shocks, I explore whether monetary policy should lean against the build-up of financial stability risks in EMEs. Taking the Mexican economy as a laboratory, I augment a Dynamic Stochastic General Equilibrium (DSGE) model of a small open economy with banks and endogenous default in the spirit of Andreev, Peiris, Shirobokov, and Tsomocos (2019) and Martínez, Peiris, and Tsomocos (2020). The model allows me to compare the performance of alternative interest rate rules applied by the central bank that react to destabilizing forces of an external shock to banks' foreign-currency denominated funding. A financial accelerator mechanism is at the heart of the propagation of these shocks. Firms do not internalize the effect

of their decision to default on aggregate outcomes. This causes financial amplification via banks' balance sheets. The model is able to capture the unfolding of a domestic financial crisis in response to a US monetary policy shock such as the US Taper Tantrum. The results underline that the propagation mechanism through default is a justification for monetary policy to react to the build-up of domestic financial imbalances to mitigate EMEs' vulnerability to external shocks.³

One common denominator of both Chapter 1 and Chapter 2 is the role of endogenous default by private agents (see Figure A). It acts as a propagating force that amplifies frictions in credit markets and leads to knock-on effects when the economy derails. The idea that corporate financial distress has a bearing on business cycles cannot be stressed enough (Gilchrist & Zakrajšek, 2012; Goodhart & Tsomocos, 2011; Suarez & Sussman, 1999). Historically, periods of excessive credit growth are a strong predictor of corporate distress and financial crises (Jordà, Schularick, & Taylor, 2011; Schularick & Taylor, 2012). Looking at corporate distress in EMEs reveals that there are two sides to this coin. To international investors, default risk in EMEs proved to be a rewarding source of yield amidst a dearth of profitable investment opportunities in asset markets in AEs in recent years. A considerable flux of foreign capital therefore made its way into EM debt markets in "good times". But abundant funding came at the expense of raising corporate leverage and currency mismatch on corporate balance sheets. Rising distress risk among EM corporates (Alfaro et al., 2019; Asis et al., 2021) has recently rekindled concerns about the "fickleness" of foreign capital (Caballero & Simsek, 2020). Since default risk may outgrow investors' risk tolerance, it could unleash an adverse feedback spiral of capital reflux. If international investors were to halt – or even reverse – their investments, their contraction in credit supply could increase firms' credit risk, exacerbate their funding costs and currency mismatch, and thus lead to further outflows out of these debt markets (Bianchi, 2011; Mendoza, 2010).

Chapter 3 investigates this theoretical mechanism empirically. In particular, I address the question of whether credit risks that emanate from the corporate sector in EMEs can explain international capital flows into and out of EM debt mar-

³This is not to say that monetary policy provides the optimal tools to address externalities arising from overborrowing in the economy. Further research is needed to assess the design of optimal macroprudential policy measures and their interaction with monetary policy in EMEs (see Martínez et al. (2020) and Andreev et al. (2019)).

kets. Overcoming the problem of endogeneity between the price of risk and capital flows is challenging. Using granular data on the universe of USD-denominated corporate bonds issued by non-financial firms in 27 EMEs and 11 tax havens, I construct “Granular Instrumental Variables” (GIV) to identify this causal effect of corporate credit risk on international capital flows following recent work by Gabaix and Koijen (2020). To that end, I exploit idiosyncratic shocks to large corporate borrowers that I extract by decomposing corporate credit spreads into their various risk components. In a static country-level panel framework, I find evidence that corporate credit risk serves as an attractor of international capital flows. Importantly, it bears significance above and beyond what global risk and US monetary policy, so-called global “push factors”, can account for. The results from a panel local projections exercise further suggest that the build-up of corporate credit risk over time can have a repelling effect on capital from abroad. Corporate credit risk therefore acts as a strong amplifier of business cycle fluctuations in EMEs.

Linkages between chapters. Several themes relevant to the study of financial stability risks emerge from the three chapters of my thesis. Any treatise of systemic risks must take into account the various interlinkages between the financial and the real sectors of the economy (Goodhart, Sunirand, & Tsomocos, 2006; Tsomocos, 2003) and the role of excessive credit growth (Jordà et al., 2011) as well as default (Goodhart & Tsomocos, 2011). Figure A highlights how default, in particular, constitutes the fulcrum of financial stability analysis in the three chapters.

Chapter 3 reinforces the corporate sector as one important source of financial fragility in addition to the banking sector stressed by Chapters 1 and 2. Chapter 2 highlights how the nexus between banks and firms gives rise to a powerful financial accelerator that works to amplify nominal (and real) shocks. Shocks to the financial system may either emanate externally or come about endogenously. While Chapter 2 deals with the response of corporate default to *external* shocks, Chapter 3 empirically investigates whether it is in fact *domestic* credit risk that can act as a “trigger” of financial destabilization. Both chapters speak to the debate about how the Global Financial Cycle (Rey, 2015) and domestic financial cycle interact to create sources of financial instability (Aldasoro, Avdjiev, Borio, & Disyatat, 2020).

Understanding whether domestic sources of risk can affect the wider financial and macroeconomic stability in both AEs and EMEs through spillovers is not least important for the design of optimal pre-emptive and reactive regulatory policies that target borrowers and lenders directly. It is also relevant for the design of optimal monetary policy and its role in “leaning against the wind”. As outlined in Chapters 1 and 2, central banks may be able to improve upon policy outcomes by internalizing some of the negative externalities of monetary policy onto the stability of both their domestic financial system as well as of more vulnerable peers. The ability to do so demands a deeper understanding of the inherent interconnections between financial intermediaries and agents on the real side of the economy.

Contributions. The research presented in this integrated thesis makes a number of key contributions to the study of monetary policy, financial stability, and default. It does so by emphasizing the various mechanisms between the nominal and real side of the economy in an integrated *general equilibrium* framework with default and liquidity.

Chapter 1 adds to the literature on financial frictions in the transmission of monetary policy by highlighting one important, but often neglected channel of propagation that links the real and nominal sector: the default channel. It does so by modelling collateral default explicitly as an *equilibrium* phenomenon that creates a powerful pecuniary externality in the housing market. This fire sale externality gives rise to Fisherian debt-deflation forces that sharpen the policy trade-off for central banks in the context of the decision to lift off from the ZLB. To provide a nuanced and novel treatise on trade-offs, we model the central bank explicitly as an optimizing agent with its objective function and policy instruments. We thereby go beyond typical ad-hoc representations of monetary authorities in general equilibrium models. We then assess the relative merit of endowing the central bank with relative preferences for policy objectives, including financial stability objectives. Our theoretical experiment not only sheds new light on default risk as a metric to be taken into account by central banks. It also underlines the importance of the Tinbergen (1956) principle, i.e. having one instrument for each externality – liquidity and default – to be internalized.

Chapter 2 contributes to the debate on whether central banks in EMEs should also lean against the wind to preempt the build-up of financial imbalances in highly vulnerable economies. Building on existing papers that stress the role of financial frictions in causing overborrowing in good times, my model proposes an alternative source of financial accelerator that stems from firms' default risk. Firms' likelihood to default is an endogenous choice that depends on the state of the business cycle. The model captures the dynamics of a typical banking crisis in EMEs, encapsulated by the case of Mexico, in response to an external shock to financial markets. It suggests that when the financial channel of external shock transmission dominates in EMEs, central banks can improve upon policy outcomes by augmenting their inflation mandate by a financial stability mandate in the presence of only one policy tool.

Chapter 3 attempts to uncover the causal relationship between domestic credit risks emanating from the corporate sector and international capital flows in EMEs. I show that corporate credit risk acts as a domestic "pull factor" of international capital flows even *after controlling* for powerful global push factors which constitute the bulk of empirical evidence (Jordà, Schularick, Taylor, & Ward, 2019; Miranda-Agrippino & Rey, 2022; Rey, 2015). My analysis thus empirically integrates two disconnected strands of empirical literature on global "push factors" and theoretical literature on domestic "pull factors" of international capital flows. To the best of my knowledge, this research is the first to exploit the full information content of corporate spreads and firm characteristics in a unique, granular cross-country dataset. Doing so allows me to make statements not only about predictive ability but the true cause-and-effect relationship. My analysis thereby provides an important laboratory for Gabaix's (2011) granular hypothesis, namely the idea that aggregate fluctuations originate in the behaviour of a handful of large "granular" players. The results also contribute to the literature in international macro-finance by highlighting that credit risk can amplify business cycle fluctuations in a quantitatively sizeable way.

Monetary policy trade-offs will likely continue to evolve as accelerating inflation following the Covid-19 pandemic heralds a new regime of higher interest rates

after more than a decade at the ZLB. New monetary and regulatory policy frameworks will undoubtedly emerge in response to multiple crises that are currently unfolding. Amidst the uncertainties of the present days, default – both private and public – will be the one certain companion of a decade yet to take shape.

CHAPTER 1

The Zero Lower Bound and Financial Stability: A New Role for Central Banks?*

with **Dimitrios P. Tsomocos**

Abstract Are critics' concerns for bank profitability a justification for the European Central Bank to raise interest rates from the (zero) lower bound (ZLB)? Using a general equilibrium model with banks, collateral constraints, and default, we analyze optimal monetary and regulatory policy upon departure from the ZLB. Rather than supporting bank profits, higher interest rates depress inflation when higher debt servicing costs increase losses from default. Precisely these losses offset any gains from banks' net interest margin. Monetary policy operates beyond traditional channels, stressing the relevance of Fisherian debt-deflation forces. They warrant incorporating financial stability objectives into central banks' objective function.

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1.1 Introduction

“I will argue that the first line of defence – macroprudential policy – remains incomplete and not fully effective in the euro area, meaning that monetary policy cannot turn a blind eye to rising financial stability risks.”

Isabel Schnabel, Member of the ECB Executive Board, December 2021

The Global Financial Crisis (GFC) triggered a paradigm shift for monetary authorities. Central banks came to acknowledge the need to align monetary policy with the financial stability objectives of macroprudential policy – improving the resilience of financial intermediaries and mitigating risks of liquidity crises and subsequent default. Notwithstanding this need, the ongoing “low for long” era of persistently low (negative) interest rates is one episode in which monetary policy objectives and financial stability objectives purportedly are at odds with each other. In particular in the Euro area, where interest rates were lowered into negative territory by the European Central Bank (ECB) in 2014, critics have voiced concerns about the adverse effects of low (and negative) policy rates on bank profitability (Bubeck et al., 2020; Heider et al., 2019) and the misalignment of the ECB’s monetary policy mandate therein. Recent inflationary pressures following the Covid-19 pandemic and rising energy prices have pushed real margins for banks and real rates for savers further into negative territory. As a result, there have been several calls for a departure from the (zero) lower bound (ZLB).²

This paper addresses one of the main arguments advanced by critics – the impact on bank profitability as an unintended consequence of monetary policy – as a justification for a departure from the ZLB.³ It does so through the lens of a consolidated monetary and regulatory authority (henceforth called the central bank) who pursues both monetary policy and financial stability objectives. We are interested in how the shift from a dual mandate to an additional financial stability mandate

²We use ZLB interchangeably to denote the zero lower bound and the effective lower bound on nominal deposit rates.

³This paper was written before the Covid-19 pandemic and the Russian invasion in Ukraine. The authors however believe the argument about financial stability trade-offs at the ZLB to still be a potent one at this time of writing as central banks are moving towards raising interest rates.

affects optimal monetary and regulatory policy and policy outcomes in the financial and private sector. In light of the recent debate between policy makers and the banking lobby, it is of particular interest to examine if different policy objectives yield alternative conclusions as to whether to raise interest rates.

We use a monetary general equilibrium model with incomplete markets and collateral default to study the consequences of the central banks' decision to lift the future policy rate from the ZLB given its objectives. Our modelling scenario allows us to answer conditional statements such as: if the ECB *did* pursue financial stability as part of its mandate, would it be optimal for the ECB to yield to its critics' argument? Would bank profitability consequently improve away from the ZLB? To make the answer to this question less obvious, we add a second salient channel through which we believe monetary policy to affect financial stability: the default channel (Geanakoplos, 2010, 2016; Hofmann & Peersman, 2017), explained below. While abandoning the ZLB in our model has the potential to restore banks' net interest margin, these gains are offset by losses from loan default when debt servicing costs increase. The resulting deflationary impact on the price level sharpens the policy trade-off faced by the central bank and its consequences for the real economy.

In theory, monetary easing at the ZLB trades off greater short- and medium-term benefits of abundant credit supply and manageable inflation against longer-run imbalances in the financial system (Cesa-Bianchi & Rebucci, 2017; Woodford, 2012). The consensus view in times of below-target inflation and subdued economic growth is to keep interest rates close to zero to prop up spending and investment. By contrast, a prudent regulator may wish to increase interest rates from the ZLB beyond the "reversal" point where monetary policy becomes contractionary for lending (Brunnermeier & Koby, 2018) to bolster banks' profit margins (Borio, Gambacorta, & Hofmann, 2017) and to disincentivize banks from investing into riskier asset classes in search for yield (Dell'Ariccia et al., 2017; Martinez-Miera & Repullo, 2017). However, higher interest rates may exacerbate the debt-servicing costs of private borrowers and decrease liquidity in a highly indebted economy (Goodhart et al., 2021). A higher probability of default beyond a threshold may trigger fire sales of assets, which could further depress prices and increase the real

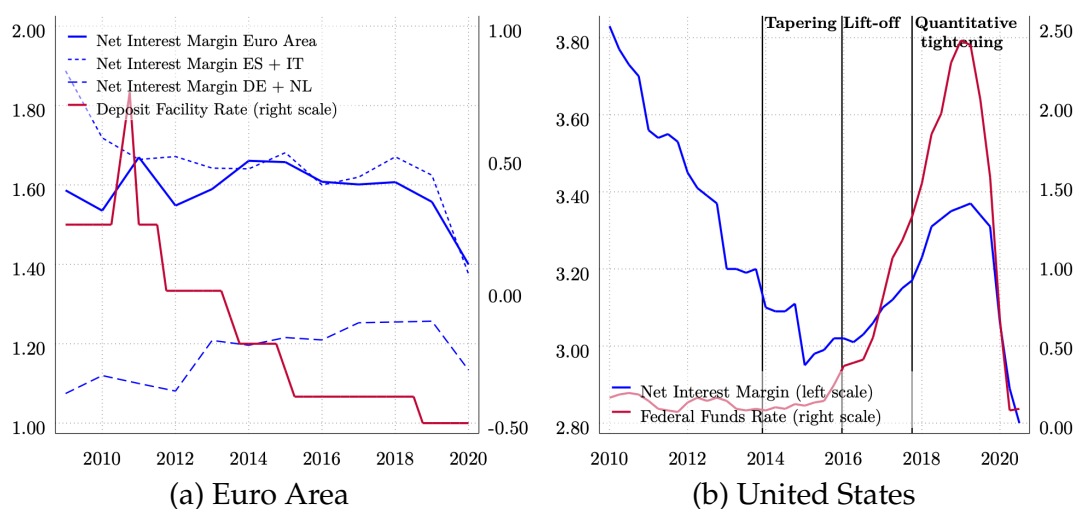


Figure 1.1. Banks' Net Interest Margin and Policy Rates (percentage points)

Note: Panel (a) plots the average net interest margin (left scale) of all Euro Area banks as well as of subgroups (Spain & Italy and Germany & the Netherlands) against the ECB's deposit facility rate (right scale). Panel (b) plots the net interest margin of all US banks (left scale) against the the effective federal funds rate (right scale). The respective policy rates are displayed as the quarterly end-of-period interest rates. Source: ECB Statistical Data Warehouse and Federal Reserve Bank of St. Louis (FRED).

burden of debt (Bianchi & Mendoza, 2020; Eggertsson & Krugman, 2012).⁴ Debt-deflation might ensue if interest rates were pushed too high too soon.⁵ The various mechanisms at work therefore make the virtues of a lift-off from the ZLB heralded by its advocates less straightforward.

Arguments in favor of a lift-off stand on ambiguous empirical grounds. Evidence of a beneficial effect of a departure from the ZLB on net interest rate margins remains an artefact of the future in the Euro Area, where policy rates still are at or below zero at the time of writing. Public attention has therefore centered on the effect of interest rate cuts rather than increases. Panel (a) of Figure 1.1 suggests that aggregate net interest margins in the Euro Area have been low but stable relative to those in the US (panel (b)) following successive policy rate cuts.⁶ Conversely,

⁴Likewise, a push of the real interest rate above the so called financial (in)stability real interest rate r^{**} could trigger debt-deflation when credit constraints become binding on the verge of default (Akinci, Benigno, Del Negro, & Queralto, 2021).

⁵Even worse, while deflation may not ensue in the current supply-driven inflationary regime, a default-driven recession could bring about long-lasting stagflation.

⁶Differences however exist between core countries (notably Germany and the Netherlands) and periphery countries. If anything, the latter have been experiencing a declining trend in net interest margins.

disaggregated data indicates that negative interest rates reduce bank net worth of high-deposit banks (Heider et al., 2019) and depress banks' equity values (Ampudia & van den Heuvel, 2019). This stands in contrast with other studies which find that banks are able to offset income losses with non-interest income (Altavilla, Boucinha, & Peydró, 2018; Lopez, Rose, & Spiegel, 2020), pass negative rates onto depositors (Altavilla, Burlon, Giannetti, & Holton, 2022) or increase corporate loan rates (Bottero, Minoiu, Peydró, Sette, Presbitero, & Polo, 2020).

Yet, the effect of a rate *cut* may not translate into a symmetric effect in response to a rate *increase*. The period of monetary policy normalization in the US between 2014 and 2020 provides an outlook. Panel (b) of Figure 1.1 indicates that the lift-off in late-2015 moved in lockstep with a sustained increase in net interest margins of US banks, albeit not commensurately. Evidence based on US data is divided: historically, banks' net interest margins have been fairly insensitive to changes in monetary policy (Drechsler, Savov, & Schnabl, 2021) but more recently, bank profitability has been affected through distortions in term premia and interest rate risk (Paul, 2022). Similarly in Japan, low interest rates do impinge on bank profitability and loan supply in the longer run (Balloch & Koby, 2019). Notwithstanding, lessons for the ECB are limited as debt overhang and zombie lending have been pervasive features of the Euro Area in recent years (Acharya et al., 2020; Acharya, Eisert, Eufinger, & Hirsch, 2019). Crucially, our theoretical experiment takes into account the effects of a lift-off when lending is subject to default and collateral values create a link between price stability and financial stability.

We consider a two-period exchange economy in the spirit of Goodhart, Tsomocos, and Vardoulakis (2010) and Tsomocos (2003) where the ZLB is the status quo in the first (predetermined) period. We then assess how the central bank's policy trade-off affects optimal policy and the future paths of inflation, the output gap, bank profitability, and default in the second period conditional on a departure from the ZLB. Our research framework allows us to explore how the relative importance of monetary policy versus financial stability objectives in the decision problem of the central bank matters. In particular, we are interested in how they affect the debt sustainability of the private sector and the profitability of the financial sector away from the ZLB. We investigate whether the relative importance of

either objective can exacerbate the debt-deflationary effect in the economy. Our numerical application of the model is motivated by the post-GFC zero interest rate environment, excess liquidity, lingering corporate distress (Acharya et al., 2020), and a supply-driven inflationary regime in the Euro Area in the post-pandemic recovery period.

Heterogeneous households in our economy trade a consumption good and housing. Cash-in-advance constraints generate a demand for money and thus a demand for loans from commercial banks. Incorporating the mortgage market provides rich implications about default for bank lending and house price dynamics. Since markets are incomplete, mortgage default emerges as an equilibrium phenomenon with real effects.⁷ Mortgage default is triggered in the second period upon realization of a supply shock in the adverse state of the world.⁸ It generates pecuniary externalities through fire sales when the housing collateral is seized and resold in the market.

In addition, there is a central bank that optimally sets the future lending facility rate on central bank loans and an ex-ante capital requirement on the commercial banks' risky assets in the face of uncertainty. As part of its monetary policy mandate, the central bank determines its monetary and regulatory policies in order to minimize (1) deviations from target inflation, and (2) the output gap. As part of its financial stability mandate, the central bank internalizes the effects of its policies on (3) bank profitability, and on (4) the price distortion resulting from the fire sale externality when mortgage default is triggered.⁹ Our measures of bank profitability and default are proxies for financial stability. Both measures affect banks' ability to fulfill their capital requirements in distinct ways in practice.¹⁰ Moreover, the central bank is concerned about bank profitability because it cares about the efficiency

⁷Market incompleteness prevents heterogeneous agents from optimally sharing risk across states of nature. Hence, they cannot design optimal contracts to rule out default in equilibrium.

⁸To be precise, we parameterize the status quo at the ZLB to match the *on-the-verge condition* of default. That is, agents are *just* able to repay their mortgage in full without defaulting.

⁹We do not derive the central bank objective function from a welfare criterion since our model with incomplete markets, heterogeneous agents, and multiple commodities generates constrained Pareto suboptimal allocations. Instead, we stipulate an ad-hoc objective function, compatible with current central bank practices, in order to focus our analysis on the resulting policy trade-offs.

¹⁰Banks' ability to retain profits as capital affects the numerator of their capital ratio. Loan defaults affect both the numerator (via loan loss provisions and write-offs) and the denominator (via risk-weighted assets).

of the monetary policy transmission mechanism. Finally, commercial banks obtain short-term loans from the central bank in addition to depositing excess reserves akin to Euro area banks. We are interested in the net interest margin between loan and deposit rates because we want to assess the monetary policy channel via bank profitability.

Four distinct general equilibrium effects characterize the findings of our benchmark numerical application when the central bank optimizes over both monetary policy and financial stability objectives. First, mortgage default generates deflationary dynamics. A departure from the ZLB impacts default and hence financial stability via two channels: the debt service channel and the collateral channel. On the one hand, a rise in short-term interest rates raises the debt servicing costs of private borrowers, thereby exacerbating their debt overhang. Higher short-term interest rates make it more difficult for households to roll over their mortgage. On the other hand, higher interest rates also depress the value of the underlying housing collateral because cash-constrained agents trade fewer consumption goods.¹¹ The fall in collateral values results in negative wealth effects. Default on long-term debt occurs endogenously when the equilibrium value of the underlying collateral falls below the value of the mortgage. The resulting fire sale externality further pushes down prices and aggregate demand. In other words, higher interest rates depress the nominal value of goods by the Quantity Theory of Money since the velocity of money remains constant in our model.¹² Default losses and deflationary pressure accompany a widening of the negative output gap.

Second, the argument that interest rates should be raised from the ZLB to restore bank profitability does not obtain in our numerical application of the model. Bank profits decrease as the economy moves away from the ZLB both in normal and adverse states. Notwithstanding the more profitable net interest margin, the increase in interest rates dampens aggregate demand for credit and exacerbates

¹¹Note that housing is a consumption good rather than an asset in the model.

¹²Given our modelling of the credit spread, one may retort that the velocity of money is a function of the interest rate and therefore pro-cyclical. Empirically, its elasticity with respect to the interest rate depends on the monetary aggregate and the currency area. We believe that making the velocity a function of the interest rate would complicate simple intuitions of the Quantity Theory of Money and not significantly modify our conclusions. We thank Charles Goodhart for raising this point.

default losses on commercial banks' balance sheet in the adverse state. The resulting reduction in bank profits reflects the knock-on effects of default onto aggregate demand when the economy departs from the ZLB.¹³

Third, the central bank's optimal state-contingent course of action as deposit rates move away from the ZLB is to set a narrower corridor between lending and deposit facility rates in good times and a wider corridor in bad times. In so doing, monetary policy becomes more "pro-cyclical" the further the economy departs from the ZLB.¹⁴ This seemingly counterintuitive result follows from the central bank's trade-offs given rational expectations about the possibility of future default and deflation. The central bank trades off setting a narrower interest rate corridor to limit credit supply that fuels default with a wider interest rate corridor that supports banks' profit margins in bad times. In particular in the adverse state, the central bank widens the interest rate corridor even further to support the bank in compensating default losses through gains in its profit margin. Higher optimal state-contingent interest rates in the default state therefore directly account for liquidity and default risk premia. The interaction of liquidity frictions and default depresses prices and economic activity even further as credit is rationed in bad times.

Finally, complementary to pro-cyclical monetary policy, the central bank aids the commercial bank by relaxing the capital constraint. The optimal capital requirement is looser as the economy moves away from the ZLB so as to compensate for the shortfall in credit extension through higher interest rates. Capital regulation is therefore *ex post* counter-cyclical. Loosely speaking, capital regulation and monetary policy intervene at different ends of the yield curve, i.e. the long end versus the short end, respectively. Thus, optimal monetary and regulatory policies may be deemed complementary (Angelini, Neri, & Panetta, 2014; Catarineu-Rabell, Jackson, & Tsomocos, 2005; Farhi & Werning, 2016; Kashyap, Tsomocos, &

¹³We leave the intriguing analytical exercise of computing a multiplier of this externality from default to future research. This also requires assessing the effect of higher interest rates on debt service as distinct from the effect on housing collateral values. We thank Oren Sussman for highlighting this distinction.

¹⁴Pro-cyclicality is defined in the sense that in good times it is optimal for the central bank to keep the lending facility rate more accommodative, i.e. *lower* (albeit with a tighter interest rate corridor). Conversely in bad times, it is optimal for the central bank to make the lending facility rate more contractionary, i.e. *higher* (albeit with a wider interest rate corridor).

Vardoulakis, 2020; Martinez-Miera & Repullo, 2019).

The findings from our simulations also speak to the debate on monetary policy versus financial stability objectives. The higher the weight that the central bank places on targeting inflation relative to other objectives, the larger is the variance between the achieved objectives – bank profitability, default, inflation, and the output gap – across states of nature. For example, if the central bank reverts to a dual mandate and neglects financial stability altogether, inflation volatility increases across states of nature. This is because the central bank does not take into account the externality that default imposes on the price level in the adverse state of nature. It therefore tightens optimal monetary policy too much under a dual mandate. Positive weights on the two financial stability objectives in the central bank’s objective function help to “smooth”, in particular, inflation and the output gap across states of nature, and hence volatility in consumption. Ultimately, whether the central bank considers financial stability or not does *not* affect the *direction* of changes in endogenous variables in equilibrium when the economy departs from the ZLB.¹⁵ The importance placed on monetary policy versus financial stability objectives only affects the *magnitude* of changes.

Note that the two policy objectives – inflation targeting and the output gap – are not derived from a model with production and nominal rigidities as in conventional dynamic macro models (Benigno & Woodford, 2005; Rotemberg & Woodford, 1997), making any welfare comparison problematic.¹⁶ Still, money non-neutrality obtains in our model. It thus reconciles the inclusion of the Taylor principle in the central bank’s objective function with the underlying frictions in DSGE models. The presence of money as a transaction technology and the institutional possibility of collateral default affect both prices and quantities through a non-trivial Quantity Theory of Money. The cash-in-advance constraint acts as a quasi-nominal rigidity because it prevents commodity markets from clearing with immediacy along with capital markets. It therefore affects prices in a “staggered” way. Hence, the financial frictions considered here lead to short-run wealth effects just as classical price rigidities do. Additionally, our equilibria are constrained

¹⁵This is not surprising since the central bank’s main objective is to smooth consumption.

¹⁶We therefore conduct a parametric analysis of the relative weights of the central bank’s policy objectives in its objective function to address the differing political economy aspects of these objectives.

Pareto suboptimal. Hence, policy intervention may improve welfare without necessarily requiring the removal of the aforementioned frictions.

(Quasi) nominal rigidities have implications for the welfare criterion implicit in the central bank objective function. In our model, the central bank accounts for the price effect of cash-in-advance constraints through an inflation target in its objective function. In addition, there is a separate price distortion that stems from the fire sale externality of collateral default. The resulting inefficiency is addressed by designing an objective function that internalizes both the effect on inflation and the pecuniary externality explicitly. The two externalities likewise justify the use of two complementary policy instrument – a monetary policy instrument and a regulatory instrument – in the spirit of Tinbergen (1956).

The paper proceeds as follows. Section 1.3 motivates our modelling of central bank policies. Section 1.4 introduces the model. Section 1.5 defines and Section 1.6 characterizes the equilibrium in the economy. Section 1.7 assesses a numerical application with two states of nature and presents the general equilibrium results when the economy lifts off from the ZLB. Section 1.9 concludes.

1.2 Related Literature

Since the GFC, a large strand of literature has emerged that assesses whether monetary policy ought to have a macroprudential role in curbing excessive credit cycles. One body of research therein investigates the role of financial stability objectives, so called “leaning against the wind (LAW)” policies, for interest rate rules in dynamic macroeconomic models (Christiano, Ilut, Motto, & Rostagno, 2011; Cúrdia & Woodford, 2010, 2016; Faia & Monacelli, 2007; Svensson, 2017; Woodford, 2012). Related to this literature are papers that explicitly derive optimal policies by minimizing a Taylor-rule type of central bank loss function augmented by a measure of financial stability (Adrian & Duarte, 2017; Aikman, Giese, Kapadia, & McLeay, 2019). The respective conclusions about whether to lean against the build-up of financial imbalances depend strongly on the model framework, the financial friction (e.g. asymmetric information resulting in agency costs, limited commitment, borrowing constraints), and the nature of the shock. However, we are not aware of attempts to capture, as a financial stability measure, the friction stemming from the

existence of default in equilibrium. If anything, previous work considers the possibility of default out of equilibrium only.¹⁷ We thus contribute to existing modelling frameworks by not only adding a pecuniary externality resulting from default but also making positive default affect banks' balance sheets in equilibrium, with nominal and real implications.

Another growing body of research analyzes the adoption of specific macroprudential policy instruments and the interaction of such instruments with monetary policy (Angelini et al., 2014; Angeloni & Faia, 2013; Beau, Cahn, Clerc, & Mojon, 2013; Benigno, Chen, Otrok, Rebucci, & Young, 2013; Cecchetti & Kohler, 2014; Kannan, Rabanal, & Scott, 2014; Nelson & Pinter, 2018; Quint & Rabanal, 2014). Our model differs from conventional approaches as we endow the central bank with both a monetary policy and a regulatory policy instrument. Both of these instruments are set optimally by the central bank rather than following a linear policy rule. This promises to deliver welfare improvements in an economy in which equilibria are constrained Pareto suboptimal.

Previous work has also examined the different policy objectives that central bankers communicate to the public and the *de facto* objectives that they follow with their policies. Both monetary policy and financial stability objectives (Friedrich, Hess, & Cunningham, 2018; Peek, Rosengren, & Tootell, 2016; Schularick et al., 2021) as well as internal balance sheet constraints (Hall & Reis, 2015; Reis, 2013) and concerns for profitability (Goncharov, Ioannidou, & Schmalz, 2022) have been identified by the literature as factors affecting the policy stance and outcome. We contribute to this debate by highlighting that different relative weights on these objectives have various effects on optimal monetary and regulatory policy as well as policy outcomes.

The literature has also recognized the importance of the ZLB on nominal interest rates as a source of non-linearity in macroeconomic models. This non-linearity may create perverse economic behavior on behalf of agents (Hakamada, 2022) and trade-offs for policy makers (Sims & Wu, 2021). Many contributions on this avenue analyze the types of shocks that push the economy into a liquidity trap at the ZLB (Eggertsson & Krugman, 2012; Kollmann, 2021) and policies that lift the

¹⁷For a detailed analysis of the role of endogenous default in macroeconomics, see Goodhart and Tsomocos (2011) and Geanakoplos (2011).

economy out of the trap. Most state-of-the-art macroeconomic models by now feature occasionally binding ZLB constraints. We acknowledge that modelling this non-linearity explicitly is outside the scope of our paper. Instead, we restrict our numerical application to equilibria at the ZLB or at positive nominal interest rates. The reason is that we are interested in the *consequences* of a lift-off from the ZLB, not in the potentially perverse incentives leading up to the decision to normalize nominal interest rates.¹⁸

Empirical evidence on financial stability implications of low interest rates is growing. Several papers investigate the risk taking channel of monetary policy (Angeloni, Faia, & Lo Duca, 2015; Dell’Ariccia et al., 2017; Ioannidou, Ongena, & Peydró, 2015) and the effects of low and negative deposit rates on bank risk taking and bank performance (Bubeck et al., 2020; Heider et al., 2019; Lopez et al., 2020). Macroprudential policies are found to be effective in curbing such risk-taking, especially in housing markets (Bergant, Acharya, Crosignani, Eisert, & McCann, 2022; Richter, Schularick, & Shim, 2018). Evidence further suggests that an increase in interest rates may impinge on financial stability through risk-shifting by shadow banks (Xiao, 2020). In addition, several papers show that so-called “zombie” lending to ailing firms in the low interest rate environment has real effects through its impact on credit supply (Balloch & Koby, 2019) and on competition and productivity (Acharya et al., 2020; Caballero, Hoshi, & Kashyap, 2008), leading to dis-inflationary pressures in the economy. Overall, a broad consensus emerges that monetary policy is not neutral vis-à-vis financial stability. This evidence provides the empirical backing for endowing our monetary authority, or central bank, with an additional financial stability mandate that considers the health of the banking sector as well as default in the mortgage market as explicit objectives.

¹⁸As such, a lift-off from the ZLB in our model does not distinguish itself from an increase of policy rates from any other positive level of nominal interest rates. Rather, we characterize our numerical application as reflecting the endemic problems of the post-GFC low interest rate environment. This allows us to focus on the policy trade-offs not at the ZLB specifically but the trade-offs between stabilizing inflation and the financial system in a highly indebted economy. Hence, our analysis is also relevant to the post-pandemic period of quantitative tightening.

1.3 Central Banking in Practice and in Theory

One aspect of monetary policy that we want to understand is how the size of the interest rate corridor (i.e. the lending spread) at and away from the ZLB affects bank profitability and financial stability. Monetary policy in our model closely mimics the ECB's conventional monetary policy of supplying short-term liquidity according to a *corridor system*. The deposit rate paid on the overnight deposit facility for bank reserves constitutes the *floor* for the overnight market interest rate. The lending facility rate at which banks borrow overnight loans against eligible collateral provides a *ceiling* for the overnight market interest rate. In addition, the ECB conducts main refinancing operations (MROs) with banks borrowing at the MRO rate in the form of reverse transactions over a one-week window.¹⁹ These three instruments steer money market rates in the Euro Area within a narrow corridor, shown in Figure 1.2.²⁰

In practice, the size and the symmetry of the interest rate corridor matter. A narrower corridor implies more intermediation activity by the ECB. A wider corridor increases money market activity. Non-standard monetary policy measures have led to an asymmetric corridor in recent years, giving more importance to the deposit rate as an attractor of short-term money market rates.²¹

For the sake of simplicity we abstract from several practical features. We do not examine the effects of negative interest rates. Nor do we model explicitly the distinction between the MRO rate and the lending facility rate. Our main interest is to capture the interest rate corridor. We therefore specify (1) a deposit facility rate which the central bank pays on excess reserves deposited by the commercial bank, and (2) a lending facility rate at which the central bank lends intratemporal loans to the commercial bank. The central bank is assumed to only control the lending facility rate, i.e. the ceiling of the interest rate corridor. This allows us to condition our analysis on an exogenous departure of the deposit facility rate

¹⁹The deposit facility, the marginal lending facility, and the MROs play a non-trivial role in the ECB's short-term liquidity management (see Figure 1.B.2 in Appendix 1.B).

²⁰The Euro OverNight Index Average (EONIA) is the interbank rate at which banks lend funds to each other. It moves within the interest rate corridor.

²¹Some observers have therefore argued that the ECB has moved from a *de jure* corridor system to a *de facto floor system*. For the sake of simplicity, we ignore these technical details and focus on the official corridor system.

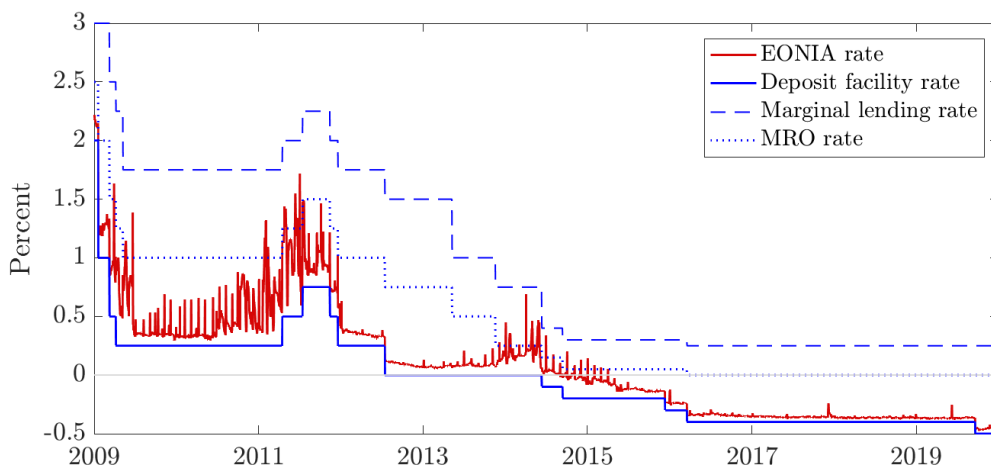


Figure 1.2. The interest rate corridor system of the ECB

Note: This figure plots the ECB’s interest rate on main refinancing operations (MRO), on the marginal lending facility, and on the deposit facility, as well as the Euro OverNight Index Average (EONIA) rate as the overnight money market rate. Source: ECB Statistical Data Warehouse.

from the ZLB in a comparative statics exercise. We assume the deposit facility rate to be predetermined because the causes for the economy to be at the ZLB lie outside the scope of our model. One reason that induces the bank in our model to deposit excess reserves rather than lend them out is that they are the only long-term investment available to the bank that is riskless. Moreover, they “absorb” part of the losses from mortgage default in the second period.

We distinguish between the deposit facility rate and the lending facility rate in order to establish the importance of the wedge between borrowing and lending rates for monetary policy transmission. Inevitably, this positive wedge generates seigniorage income for the central bank. To close the system, the seigniorage income is redistributed to households as a lump-sum transfer. It is thus considered as an expected money-financed fiscal transfer to households. This assumption is plausible since central banks redistribute profits to their shareholders, i.e. the government. We do not model a government, nor do we model the possibility of insolvency by the central bank. Instead, we assume that the central bank cares about at least breaking even (Goncharov et al., 2022; McMahon, Peiris, & Polemarchakis, 2018).

The ability of our central bank to refinance the bank is constrained by its ini-

tial stock of outside money in every period. Outside money can be thought of as initial public liabilities on the central bank's balance sheet. It differs from inside money in that it is free and clear of any debt obligation to the central bank (Gurley & Shaw, 1960). Dubey and Geanakoplos (2006) provide a compelling argument for the real-world relevance of outside money. Outside money is created by the government for example when it commissions the central bank to print money in exchange for an IOU, or when it acquires real assets, such as labor, for public investments. The common practice of perpetually rolling over IOUs then generates outside money. Outside money is necessary to ensure price level determinacy in our monetary GEI economy. Determinacy also requires that the redistribution policy of our central bank is non-Ricardian. This means that while the central bank is endowed with outside money in every period, it cannot perfectly balance its budget in every period. For prices to be determinate, we assume that the central bank rolls over its wealth from the first period into the second period and only transfers any remaining seigniorage income to households at the end of the second period.

1.4 The Model

Let there be an exchange economy with two periods $t \in T = (0, 1)$ that operates at the ZLB. Uncertainty is resolved in the second period, which consists of a finite number of states of nature, $s \in S$. The set of all states is therefore given by $s \in S^* = \{0\} \cup S$. The economy is endowed with two commodities, one perishable consumption good (potatoes) and a durable good (housing), both of which are infinitely divisible. The economy is populated by two households $i \in \{\alpha, \beta\}$, long-term borrowers and lenders who buy and sell commodities. All contracts are denominated in money which is the postulated means of exchange. Households do not trade commodities directly with each other but trade with fiat money via a commercial bank.²² The bank maximizes profits by granting loans to and taking on deposits from the households but does not discriminate between the types of households. A central bank controls liquidity in the financial system by setting the lending facility rate. It takes on excess reserve deposits from the bank and extends

²²Gains from trading with money exist because without money there is no trade in goods and no consumption smoothing. These gains rationalize positive interest rates (Dubey & Geanakoplos, 2003a).

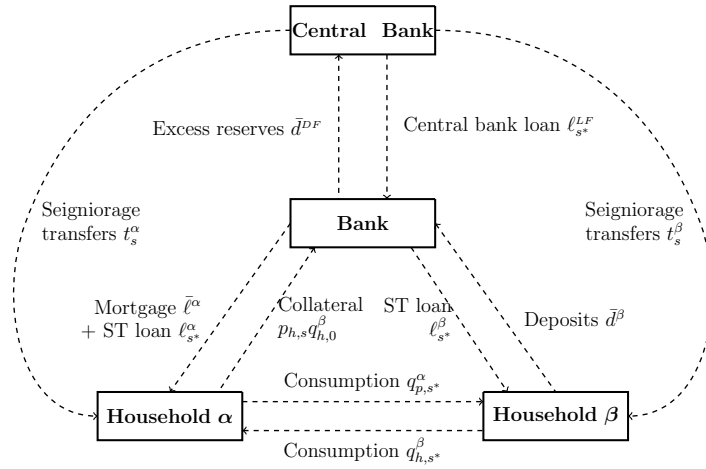


Figure 1.3. Model Setup

Note: This figure presents a stylized model overview of all optimizing agents and their respective bilateral positions or obligations with each other.

loans to the bank. The income of the central bank is distributed to households as a lump-sum payment in the second period. Figure 1.3 provides an overview.²³

There is one contract traded which is defaultable. Default is discontinuous (Geanakoplos, 2003; Geanakoplos & Zame, 2014) such that agents have no discretion over the exact amount they default on but only over whether they default or not. If they default, their collateral is seized and resold in the market at the current market price. This is the case for the collateralized non-recourse mortgage that the household enters with the bank. Finally, six different markets span each period and across periods. The intra-period markets include the market for commodities, short-term loans, and for central bank loans. The inter-period markets comprise the mortgage and consumer deposit market as well as the market for excess reserves. Markets are incomplete.²⁴

1.4.1 Households

Households hold an initial stock of money $m_{s^*}^i \geq 0$ that is free and clear of any debt obligations in each period and each state of nature. They use their monetary

²³In addition, Figure 1.B.1 in Appendix 1.B provides an overview of the sequence of events.

²⁴There exists neither a full set of state-contingent securities nor any asset in which agents can go infinitely long and short. Agents are constrained to borrow or lend, respectively.

endowment and credit from the bank to trade in the respective markets for housing and potatoes. There is a need for fiat money as a transaction technology to intermediate goods because the proceeds from selling potatoes cannot be immediately used to buy housing and vice versa. The liquidity friction thus enters in the form of a cash-in-advance constraint. The cash-in-advance constraint in the spirit of Clower (1967) and the existence of a banking sector generate a transactions demand for money (Dubey & Geanakoplos, 1992). Households differ in their endowment structure but not in their beliefs about the probability γ_s of state s occurring. Household α is endowed only with potatoes e_{p,s^*}^α in every $s \in S^*$ while household β is endowed only with housing $e_{h,0}^\beta$ at $t = 0$. Both households also have access to intra-period loans $\ell_{s^*}^i$ granted by the bank at a nominal “short-term” interest rate $r_{s^*}^{ST}$. They both receive an expected share of lump-sum seigniorage transfers t_s^i at the end of the second period.

Household α sells q_{p,s^*}^α units of potatoes to agent β and consumes the remainder of her endowment $e_{p,s^*}^\alpha - q_{p,s^*}^\alpha$ herself. In the first period, she finances the purchase of $q_{h,0}^\alpha$ units of housing with $b_{h,0}^\alpha$ units of fiat money by taking out a fixed-rate mortgage with face value $\bar{\ell}^\alpha$ at rate \bar{r}^m from the bank which is fully collateralized by the house.²⁵ Household α can also borrow short-term from the bank through an intra-period loan with face value $\ell_{s^*}^\alpha$ at interest rate $r_{s^*}^{ST}$ that she repays in full at the end of each period. At the start of the second period, household α can again decide how many units of housing q_{h,s^*}^α to buy with b_{h,s^*}^α units of fiat money.

At the end of the second period, household α chooses whether she defaults on the mortgage but she has no discretion over the amount that she defaults on. She repays the mortgage in full if the value of the housing pledged as collateral exceeds the amount of the mortgage plus interest to be repaid, i.e. $p_{h,s} q_{h,0}^\alpha \geq \bar{\ell}^\alpha$, and defaults otherwise. The bank thus receives $\min[p_{h,s} q_{h,0}^\alpha, \bar{\ell}^\alpha]$. The on-the-verge condition for default depends on the interest rate on the mortgage and prices. Let $S_g \subset S$ be the set of good states in which agent α does not default on her mortgage. For analytical tractability, households are assumed to have a constant relative risk aversion utility function of the form $u(c_s^i) = (1 - \rho)^{-1} (c_s^i)^{1-\rho} : \mathbb{R}_+ \mapsto \mathbb{R}$, $\forall s \in S^*$, and a time discount factor $0 < \beta^\alpha \leq 1$. Agent α optimizes,

²⁵Unless stated otherwise in the following, we use a bar to denote interperiod variables and a time subscript $\{0, s\}$ to denote intraperiod variables.

$$\begin{aligned} \max_{q_{p,s^*}^\alpha, b_{h,s^*}^\alpha, \ell_{s^*}^\alpha, \bar{\ell}^\alpha} U^\alpha = & u(e_{p,0}^\alpha - q_{p,0}^\alpha) + u\left(\frac{b_{h,0}^\alpha}{p_{h,0}}\right) + \beta^\alpha \sum_{s \in S} \gamma_s u(e_{p,s}^\alpha - q_{p,s}^\alpha) \\ & + \beta^\alpha \sum_{s \in S_g} \gamma_s u\left(\frac{b_{h,0}^\alpha}{p_{h,0}} + \frac{b_{h,s}^\alpha}{p_{h,s}}\right) + \beta^\alpha \sum_{s \notin S_g} \gamma_s u\left(\frac{b_{h,s}^\alpha}{p_{h,s}}\right), \end{aligned}$$

subject to the date-0 budget constraint,

$$b_{h,0}^\alpha \leq \frac{\ell_0^\alpha}{(1+r_0^{ST})} + \frac{\bar{\ell}^\alpha}{(1+\bar{r}^m)} + m_0^\alpha, \quad (\Lambda_1^\alpha)$$

where Λ^h 's are the corresponding Lagrange multipliers. In both periods, agent α cannot take out more short-term debt than she is able to repay with the proceeds of the sale of potatoes at the end of the period, independently of whether she defaults on the mortgage or not,

$$\ell_s^\alpha \leq p_{p,s} q_{p,s}^\alpha \quad \forall s \in S^*. \quad (\Lambda_2^\alpha)$$

If there is **no mortgage default**, agent α spends additional money on housing in $t = 1$ and repays the mortgage at the end of the period, subject to the budget and cash-in-advance constraints,

$$b_{h,s}^\alpha + \bar{\ell}^\alpha \leq \frac{\ell_s^\alpha}{(1+r_s^{ST})} + m_s^\alpha + t_s^\alpha, \quad \forall s \in S_g, \quad (\Lambda_3^\alpha)$$

If there is **mortgage default**, agent α does not repay the mortgage,

$$b_{h,s}^\alpha \leq \frac{\ell_s^\alpha}{(1+r_s^{ST})} + m_s^\alpha + t_s^\alpha, \quad \forall s \notin S_g, \quad (\Lambda_4^\alpha)$$

Finally, there are no short sales of goods allowed in any period and any state, $q_{p,s^*}^\alpha \leq e_{p,s^*}^\alpha, \forall s \in S^*$. All constraints (except short sale constraints) are binding because we consider an economy with fiat money. Money does not enter the utility function but only the set of affordable allocations. Thus, agents do not derive utility from holding idle cash. They either spend it or lend it out, provided that interest rates are positive.

Household β 's optimization problem differs by virtue of the endowment structure. Since he is only endowed with $e_{h,0}^\beta$ units of housing in the first period, he sells q_{h,s^*}^β units in every period and in every state of nature to buy potatoes for consumption with b_{p,s^*}^β units of fiat money from agent α . The economy is relatively more endowed with potatoes than with housing, making it relatively inexpensive for agent β to buy potatoes. He thus has an incentive to save his income, in units of fiat money, in a consumer deposit account with the bank in period $t = 0$ to be used for consumption at $t = 1$. Deposits \bar{d}^β and accrued interest at the nominal deposit rate \bar{r}^d are only settled at the end of the second period before consumption takes place. Agent β also can take out an intra-period loan $\ell_{s^*}^\beta$ in the short-term money market. Agent β optimizes,

$$\max_{q_{h,s^*}^\beta, b_{p,s^*}^\beta, \bar{d}^\beta, \ell_{s^*}^\beta} U^\beta = u\left(\frac{b_{p,0}^\beta}{p_{p,0}}\right) + u(e_{h,0}^\beta - q_{h,0}^\beta) + \beta^\beta \sum_{s \in S} \gamma_s \left[u\left(\frac{b_{p,s}^\beta}{p_{p,s}}\right) + u(e_{h,0}^\beta - q_{h,0}^\beta - q_{h,s}^\beta) \right]$$

subject to the date-0 budget constraint and cash-in-advance constraints in both periods,

$$b_{p,0}^\beta + \bar{d}^\beta \leq \frac{\ell_0^\beta}{(1 + r_0^{ST})} + m_0^\beta, \quad (\Lambda_1^\beta)$$

$$\ell_s^\beta \leq p_{h,s} q_{h,s}^\beta, \quad \forall s \in S^* \quad (\Lambda_2^\beta)$$

as well as the budget constraint at $t = 1$,

$$b_{p,s}^\beta \leq \frac{\ell_s^\beta}{(1 + r_s^{ST})} + \bar{d}^\beta (1 + \bar{r}^d) + m_s^\beta + t_s^\beta, \quad \forall s \in S, \quad (\Lambda_3^\beta)$$

Again, there are no short sales of goods allowed in any period or any state, $q_{h,0} \leq e_{h,0}$ and $q_{h,s} \leq e_{h,0} - q_{h,0}$.

1.4.2 Commercial Bank

There is one commercial bank that operates in the market for long-term consumer deposits, \bar{d}^{LT} , intra-period loans to households, $\ell_{s^*}^{ST}$, and long-term collateralized mortgages, $\bar{\ell}^{LT}$. To balance the difference in assets in liabilities at the aggregate

level, the bank also obtains funding from the central bank's lending facility in the form of an intra-period loan with face value $\ell_{s^*}^{LF}$. It pays an interest rate $r_{s^*}^{LF}$ on the intra-period loan. The bank also deposits excess reserves \bar{d}^{DF} at the central bank's deposit facility from the first to the second period at the deposit facility rate \bar{r}^{DF} . Since mortgage default makes investing in mortgages inherently risky, the excess reserves are the only risk-free long-term investment opportunity that the bank has available to save across periods.²⁶

The bank is also endowed with an amount $e_{s^*}^b$ of equity capital in all states of nature that is denominated in fiat money with a price normalized to 1. We assume that the market for equity is exogenous and the bank cannot raise more equity.²⁷ The central bank imposes a capital requirement CAR^* on the ratio of equity to risk-weighted assets that the bank has to hold in the first period. Since the amount of equity is fixed, the bank has to adjust its risk-weighted assets to fulfil the capital requirement. Risk weights $\{\omega^{ST}, \omega^{LT}\}$ are placed on short-term credit and on long-term mortgages. If the bank fails to comply with the capital requirement, it incurs a default penalty λ_0^b proportional to the discrepancy between the required and the realized capital ratio, $(CAR^* - CAR_0)$. Table 1.1 summarizes the aggregate assets and liabilities held by the bank and the respective nominal interest rates received and paid on these balance sheet items. Figure 1.4 illustrates the maturities of the respective balance sheet items.

The bank maximizes the sum of expected discounted profits $\Pi_{s^*}^b$. It implicitly earns a credit spread on its lending and borrowing activities in both periods. We can think of $\bar{r}_s^m - \bar{r}^d$ as the spread of private sector long-term loans (i.e. mortgages) over deposits that the bank earns. Similarly, $(1 + r_0^{LF})(1 + r_{s^*}^{LF}) - (1 + \bar{r}^{DF})$ is the premium paid by the bank on borrowing from the central bank over depositing excess reserves compounded over both periods. The term structure is endogenously determined and driven by liquidity premia. The bank has a quadratic objective function (i.e. mean-variance preferences), parameterized by a^b , to reflect the nature of the bank's risk aversion and the benefits of diversification stemming from

²⁶For an alternative explanation as to why banks would hold excess reserves, in a new-monetarist model by Hu (2021), positive holdings of excess reserves by banks arise in equilibrium when pledgeable assets are scarce because productivity of capital in the economy is low.

²⁷Equity can be interpreted as a form of outside money that is free and clear of any debt obligations, for example, because it is income earned from overseas subsidiaries outside our model.

Table 1.1. The bank's stylized balance sheet and interest rates

Assets	IR	Liabilities	IR
Excess reserves with CB \bar{d}^{DF}	\bar{r}^{DF}	Consumer deposits \bar{d}^{LT}	\bar{r}^d
ST loans $\ell_{s^*}^{ST}$	$r_{s^*}^{ST}$	Central bank loans $\ell_{s^*}^{LF}$	$r_{s^*}^{LF}$
LT mortgage $\bar{\ell}^{LT}$	\bar{r}^m	Equity $e_{s^*}^b$	

Note: This table presents the stylized balance sheet of the commercial bank along with the interest rates (IR) paid or received on each position.

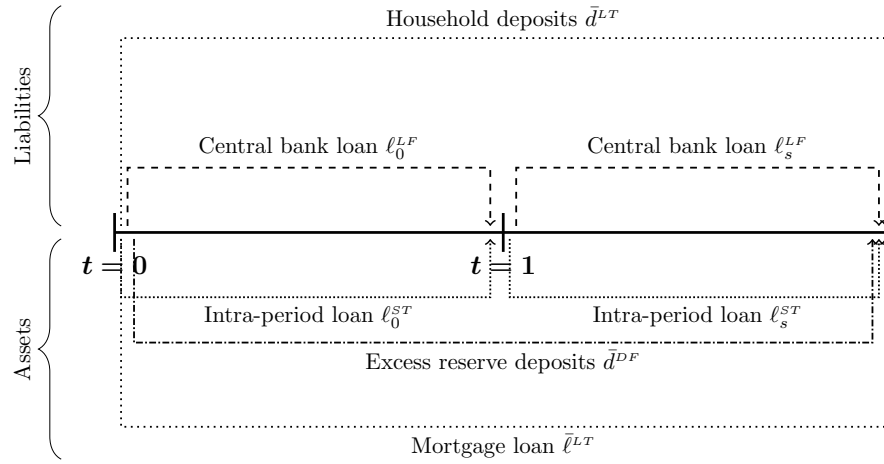


Figure 1.4. Maturity structure of the commercial bank's balance sheet

Note: This figure illustrates the maturity structure of various bilateral obligations on the balance sheet of the commercial bank. It distinguishes between *intra*-period positions (short-term) and *inter*-period positions (long-term), the latter of which span both periods $t = 0, 1$.

the bank's portfolio choice problem.²⁸ We distinguish between two different cases: the set of good states $S_g = S_g^\alpha \subset S$ in which household α does not default on her collateralized debt and the set of bad states $S_b = \{s \in S \mid s \notin S_g\}$ in which she defaults. The bank optimizes,

²⁸Using quadratic utility yields analytically tractable solutions. The convexity of the optimization problem allows us to consider interior solutions. Moreover, concave production functions may approximate the limited liability legal clause that holds for banks.

$$\begin{aligned} \max_{\ell_s^{ST}, \bar{\ell}^{LT}, \bar{d}^{DF}, \bar{d}^{LT}, \ell_s^{LF}} \mathbb{P}^b = & [\Pi_0^b - a^b(\Pi_0^b)^2] - \lambda_0^b \max[0, CAR^* - CAR_0] \\ & + \beta^b \sum_{s \in S} \gamma_s [\Pi_s^b - a^b(\Pi_s^b)^2] \end{aligned}$$

subject to its date-0 balance sheet constraint,

$$\ell_0^{ST} + \bar{\ell}^{LT} + \bar{d}^{DF} \leq \frac{\bar{d}^{LT}}{(1 + \bar{r}^d)} + \frac{\ell_0^{LF}}{(1 + r_0^{LF})} + e_0^b. \quad (\Lambda_1^b)$$

The repayment to the central bank at the end of the period must be fully covered by the receipt of short-term loans plus interest from households and the difference accrues as bank profits,

$$\ell_0^{LF} \leq \ell_0^{ST} (1 + r_0^{ST}), \quad (\Lambda_2^b)$$

$$\Pi_0^b \leq \Delta(\Lambda_2^b) = \ell_0^{ST} (1 + r_0^{ST}) - \ell_0^{LF}. \quad (\Lambda_3^b)$$

The bank's capital ratio can be no less than the regulatory capital ratio,

$$CAR^* \leq CAR_0 = \frac{e_0^b}{\omega^{ST} \ell_0^{ST} + \omega^{LT} \bar{\ell}^{LT}}. \quad (\Lambda_4^b)$$

If there is **no collateral default** by agent α at the end of period $t = 1$ in the good states $s \in S_g$, $\bar{\ell}^{LT} (1 + \bar{r}^m) \leq p_{h,s} q_{h,0}^\alpha$, the bank receives the full mortgage repayment,

$$\ell_s^{ST} + \bar{d}^{LT} \leq \frac{\ell_s^{LF}}{(1 + r_s^{LF})} + \bar{d}^{DF} (1 + \bar{r}^{DF}) + \bar{\ell}^{LT} (1 + \bar{r}_s^m) + e_s^b, \forall s \in S_g. \quad (\Lambda_5^b)$$

The repayment of the loan to the central bank must be fully covered by the receipt of short-term loans plus interest from households and the difference accrues as bank profits at the end of the final period,

$$\ell_s^{LF} \leq \ell_s^{ST} (1 + r_s^{ST}) \quad , \forall s \in S_g \quad , \quad (\Lambda_6^b)$$

$$\Pi_s^b \leq \Delta(\Lambda_6^b) = \ell_s^{ST} (1 + r_s^{ST}) - \ell_s^{LF} \quad , \forall s \in S_g \quad . \quad (\Lambda_7^b)$$

If there is **collateral default** by agent α in period $t = 1$ in the bad states $s \notin S_g$, $p_{h,s} q_{h,0}^\alpha \leq \bar{\ell}^{LT} (1 + \bar{r}^m)$, the bank instead faces the constraints,

$$\ell_s^{ST} + \bar{d}^{LT} \leq \frac{\ell_s^{LF}}{(1 + r_s^{LF})} + \bar{d}^{DF} (1 + \bar{r}^{DF}) + \bar{\ell}^{LT} (1 + \bar{r}_s^m) + e_s^b, \forall s \notin S_g \quad (\Lambda_8^b)$$

$$\ell_s^{LF} \leq \ell_s^{ST} (1 + r_s^{ST}) \quad , \forall s \notin S_g \quad , \quad (\Lambda_9^b)$$

$$\Pi_s^b \leq \Delta(\Lambda_9^b) = \ell_s^{ST} (1 + r_s^{ST}) - \ell_s^{LF} \quad , \forall s \notin S_g \quad . \quad (\Lambda_{10}^b)$$

Note that the interest rate on the mortgage in this case does not reflect the *ex ante* return, $1 + \bar{r}^m$. Instead, it reflects the *realized* interest rate, \bar{r}_s^m after taking mortgage default into account. The mortgage market clearing condition defines the effective return (see Section 1.4.4),

$$1 + \bar{r}_s^m = 1 + \bar{r}^m \quad , \forall s \in S_g \quad \text{and} \quad (\Lambda_{11}^b)$$

$$1 + \bar{r}_s^m = (1 + \bar{r}^m) \frac{p_{h,s} \frac{b_{h,0}^\alpha}{\bar{\ell}^\alpha}}{\bar{\ell}^\alpha} \quad , \forall s \notin S_g \quad , \quad (\Lambda_{12}^b)$$

In the bad states of nature, the bank does not get repaid the mortgage plus interest but instead seizes the housing collateral and resells it immediately at the prevailing market price $p_{h,s}$. Additional housing swamps the market for houses. The resulting fire sale externality decreases the market price of housing. This additional price drop is reflected in the recovery value of the mortgage, or equivalently, the effective mortgage rate \bar{r}_s^m .

1.4.3 Central Bank

The central bank takes excess reserve deposits \bar{D} from the bank at the deposit facility rate \bar{r}^{DF} . It also grants intra-period loans M_{s^*} to the bank at the lending facility rate, $r_{s^*}^{LF}$, summarized in Table 1.2. It has full discretion over setting the future, date-1 lending facility rate, r_s^{LF} , in order to maximize its objective function. Note

that at $t = 0$ the interest rate corridor between \bar{r}^{DF} and r_0^{LF} is assumed to be predetermined or “anchored” at the ZLB. The premium paid by the bank for borrowing from the central bank above and beyond what it earns on its excess reserves can be interpreted as the seigniorage income $w_{s^*}^{CB}$ that the central bank earns on its notes and coins in circulation. This central bank income is distributed to households at the end of the second period. Lastly, the central bank is also endowed with equity capital $m_{s^*}^{CB}$ in each state of nature. Equity capital is free and clear of any debt obligations, i.e. a form of outside money.

The central bank’s prime objectives combine the objectives of monetary policy – stable inflation and economic activity – with the goal of maintaining financial stability. We augment the canonical welfare loss function by two financial stability objectives in the spirit of Kotak, Ozsoylev, and Tsomocos (2017): maximizing profits of the financial sector while minimizing the aggregate loss due to default. The justification for these objectives stems from a central bank’s desire to increase the efficiency of the monetary policy transmission mechanism, to guarantee the solvency of financial intermediaries, and to minimizing the price distortion resulting from the fire sale externality of mortgage default.²⁹ To address the respective externalities, the central bank has a regulatory policy tool in addition to its monetary policy instrument at its disposal: it controls the capital requirement CAR^* that the bank has to achieve in the first period in order to avoid a violation penalty.³⁰ It thus complies with the “Tinbergen Principle” of employing as many policy instruments as targets (or externalities) exist (Tinbergen, 1956).

The real output gap is measured as the deviation of the current level of GDP from the “natural level of GDP”. We proxy the current level of GDP by the total real volume of trades in the durable and perishable goods markets in the economy. To obtain a measure of the GDP level under full capacity utilization in a model without production, we consider a version of the model in which trade in

²⁹For example, the memorandum of understanding between the Bank of England and the Chancellor in 1998 explicitly mentioned the efficiency of the financial system in the remit of the Bank of England. Similarly, the member of the Executive Board of the ECB, Isabel Schnabel (2021), has highlighted the role of financial stability in achieving price stability in various speeches.

³⁰Note that while the monetary policy instrument, i.e. the lending facility rate, is state-contingent at $t = 1$, the capital requirement is non-state contingent at $t = 0$. This reflects the observed inertia in adjusting banking regulation in contrast to monetary policy in practice.

Table 1.2. The central bank's stylized balance sheet

Assets	IR	Liabilities	IR
Loans to the bank M_{s^*}	$r_{s^*}^{LF}$	Excess reserve deposits \bar{D}	\bar{r}^{DF}
		Endowment $m_{s^*}^{CB}$	

Note: This table presents the stylized balance sheet of the central bank along with the interest rates (IR) paid or received on each position.

the economy is frictionless. In fact, money is the main friction in our model. By removing money and the cash-in-advance constraint from the model, we reduce the economy to a frictionless barter economy. Dubey and Geanakoplos (2003a) show that such a barter economy achieves the Pareto optimal outcome when there are gains to trade. By contrast, the introduction of money and a banking sector creates an inefficiency. The output gap in our model can therefore be interpreted as the distance to the Pareto optimal outcome caused by monetary frictions.³¹

Each objective $o \in \{b, d, \pi, y\}$ of financial stability and monetary policy, respectively, bears a relative weight θ_o in the objective function that will be varied in the simulation. The goal of this exercise is to understand how the relative weighing of monetary policy versus financial stability objectives affects inflation, the output gap, bank profitability, and default in the economy. At the start of the first period, the central bank maximizes total expected future "welfare", W^{CB} . It does so by choosing the date-1 nominal interest rate r_s^{LF} on central bank loans as well as the capital requirement CAR^* ,

$$\begin{aligned} \max_{r_s^{LF}, CAR^*} W^{CB} = & \underbrace{\frac{1}{2}\theta_b \sum_{s \in S} \gamma_s \Pi_s^b}_{(1)} - \underbrace{\frac{1}{2}\theta_d \sum_{s \in S} \gamma_s (\max[\bar{\ell}^\alpha - p_{h,s} q_{h,0}^\alpha, 0])^2}_{(2)} \\ & - \underbrace{\frac{1}{2}\theta_\pi \sum_{s \in S} \gamma_s (\pi_s - \pi^*)^2}_{(3)} - \underbrace{\frac{1}{2}\theta_y \sum_{s \in S} \gamma_s (y_s - y^*)^2}_{(4)} \quad (\Lambda_1^{CB}) \end{aligned}$$

³¹The existence of trade in fiat money and positive interest rates creates a wedge between buying and selling prices which hinders trade in commodities. Trade only takes place if gains to trade are sufficiently large.

Terms (1) and (2) in the equation represent the financial stability objectives, i.e. bank profitability and the aggregate loss due to default in the second period, respectively. Terms (3) and (4) represent the monetary policy objectives, inflation targeting and the output gap. The variables in these four terms comprise:

- (1) The bank's profit function Π_s^b given by (Λ_3^b) , and (Λ_7^b) .
- (2) The loss from default on the mortgage, $\max[\bar{\ell}^\alpha - p_{h,s}q_{h,0}^\alpha, 0]$ for $s \notin S_g$.
- (3) The target rate of inflation $\pi^* = 2\%$ and the expected rate of inflation defined by the change in the aggregate commodity price index, $\pi_s = p_s/p_0 - 1$, $\forall s \in S$.
- (4) Real GDP y_s , defined as the total real volume of trade in the durable and perishable goods markets in the economy in a given state,

$$y_s = \sum_{i \in \{\alpha, \beta\}} [q_{p,s}^i + q_{h,s}^i] = \sum_{i \in \{\alpha, \beta\}} \left[\frac{b_{p,s}^i}{p_{p,s}} + \frac{b_{h,s}^i}{p_{h,s}} \right] \quad \forall s \in S^*.$$

We assume that the central bank is constrained by its balance sheet because it cares about its profitability (Goncharov et al., 2022) and its solvency (Reis, 2013). It can only grant as many loans as it can finance through excess reserve deposits and its monetary endowment at the beginning of $t = 0$,

$$M_0 \leq \frac{\bar{D}}{1 + \bar{r}^{DF}} + m_0^{CB}. \quad (\Lambda_2^{CB})$$

Central bank income at the end of period $t = 0$ equals the repayment of the short-term central bank loan including interest and the funds that remained idle on the balance sheet at the start of the period,

$$w_0^{CB} = M_0(1 + r_0^{LF}) + \Delta(\Lambda_2^{CB}). \quad (\Lambda_3^{CB})$$

The loan to the bank in the next period is financed by central bank income carried over from the previous period and the monetary endowment,

$$M_s \leq r_0^{LF} M_0 + \frac{\bar{D}}{1 + \bar{r}^{DF}} + m_0^{CB} + m_s^{CB} . \quad (\Lambda_4^{CB})$$

At the end of the second period, excess reserves \bar{D} must be paid back with the repayment of the central bank loan plus interest and the funds that remained idle on the balance sheet at the start of period $t = 1$,

$$\bar{D} \leq r_s^{LF} M_s + r_0^{LF} M_0 + \frac{\bar{D}}{1 + \bar{r}^{DF}} + m_0^{CB} + m_s^{CB} \quad \forall s \in S . \quad (\Lambda_5^{CB})$$

All remaining funds after repayment of excess reserves to the bank accrue as central bank income at the end of period $t = 1$:

$$w_s^{CB} = r_s^{LF} M_s + r_0^{LF} M_0 + m_0^{CB} + m_s^{CB} - \frac{\bar{r}^{DF}}{1 + \bar{r}^{DF}} \bar{D} \quad \forall s \in S . \quad (\Lambda_6^{CB})$$

Essentially, the interest that the bank has to pay on central bank loans in period $t = 0$ over what it receives on its excess reserves is retained by the central bank as seigniorage income. A fraction x of the remaining seigniorage income w_s^{CB} is distributed as a lump-sum transfer t_s^i to households according to a predetermined share, κ , such that $t_s^\alpha = \kappa x w_s^{CB}$ and $t_s^\beta = (1 - \kappa) x w_s^{CB}$.³²

1.4.4 Market Clearing

Six markets clear for prices to be uniquely determined: the market for the consumption good, housing, intra-period loans, mortgages, excess reserves, consumer deposits, and central bank loans.

Goods market The market for the perishable good, potatoes, clears when the amount of fiat money offered for the good is exchanged for the quantity of goods sold,

$$p_{p,0} = \frac{b_{p,0}^\beta}{q_{p,0}^\alpha} \quad (MC_1) \quad p_{p,s} = \frac{b_{p,s}^\beta}{q_{p,s}^\alpha} \quad \forall s \in S \quad (MC_2)$$

³²The central bank does not redistribute the full amount of its income to households since this would render the price level indeterminate (see Bloise & Polemarchakis, 2006; Dubey & Geanakoplos, 2006).

Housing market The market for the durable good, housing, clears when the amount of fiat money offered for housing is exchanged for the quantity of housing sold,

$$p_{h,0} = \frac{b_{h,0}^\alpha}{q_{h,0}^\beta} \quad (MC_3) \quad p_{h,s} = \frac{b_{h,s}^\alpha}{q_{h,s}^\beta} \quad \forall s \in S_g \quad (MC_4) \quad p_{h,s} = \frac{b_{h,s}^\alpha}{q_{h,s}^\beta + C} \quad \forall s \notin S_g \quad (MC_5)$$

where $C = b_{h,0}^\alpha/p_{h,0}$ is the amount of housing collateral pledged per unit of the mortgage that will be seized and resold by the bank in the market if the borrower defaults at $t = 1$.

Intra-period loan market The market for intra-period loans clears when the amount of short-term loans demanded by households is exchanged for the amount of short-term credit offered by the bank,

$$1 + r_0^{ST} = \frac{\ell_0^\alpha + \ell_0^\beta}{\ell_0^{ST}} \quad \text{and} \quad (MC_6) \quad 1 + r_s^{ST} = \frac{\ell_s^\alpha + \ell_s^\beta}{\ell_s^{ST}} \quad \forall s \in S. \quad (MC_7)$$

Mortgage market The market for mortgages clears when the amount of long-term mortgages demanded by households is exchanged for the amount of long-term credit offered by the bank, $1 + \bar{r}^m = \bar{\ell}^\alpha / \bar{\ell}^{LT}$. However, because we allow for collateral default, the *ex ante* return on the mortgage does not equal its effective return in the bad states of nature $s \notin S_g$. The effective return depends on the minimal payoff of the mortgage $\min[p_{h,s} q_{h,0}^\alpha, \bar{\ell}^\alpha] = \min[p_{h,s} \frac{b_{h,0}^\alpha}{p_{h,0}}, \bar{\ell}^\alpha]$. Recall that S_g is the set of good states in which agent α does not default on the mortgage since $p_{h,s} q_{h,0}^\alpha \geq \bar{\ell}^\alpha$. The effective return is thus given by,

$$1 + \bar{r}_s^m = 1 + \bar{r}^m \quad , \forall s \in S_g \quad \text{and} \quad (MC_8)$$

$$1 + \bar{r}_s^m = (1 + \bar{r}^m) \frac{p_{h,s} \frac{b_{h,0}^\alpha}{p_{h,0}}}{\bar{\ell}^\alpha} \quad , \forall s \notin S_g \quad , \quad (MC_9)$$

where in the bad states the effective return is determined by the ratio of the salvaged value of the collateral plus interest over the total face value of the mortgage to be repaid.

Excess reserve market The market for excess reserves clears when the amount of excess reserves supplied by the bank is exchanged for the “demand” of excess reserve deposits by the central bank,

$$1 + \bar{r}^{DF} = \frac{\bar{D}}{\bar{d}^{DF}}, \forall s \in S. \quad (MC_{10})$$

Consumer deposit market The market for consumer deposits clears when the amount of long-term credit demanded by the bank is exchanged for the amount of long-term credit offered by households,

$$1 + \bar{r}^d = \frac{\bar{d}^{LT}}{\bar{d}^\beta}. \quad (MC_{11})$$

Central bank loan market The market for loans from the central bank clears when the amount of short-term credit demanded by the bank is exchanged for the amount of short-term credit offered by the central bank

$$1 + r_0^{LF} = \frac{\ell_0^{LF}}{M_0} \quad (MC_{12}) \quad 1 + r_s^{LF} = \frac{\ell_s^{LF}}{M_s}, \forall s \in S \quad (MC_{13})$$

1.5 Definition of Equilibrium

Let σ^j be the consumption and investment plans, i.e. vectors of decision variables, for each agent $j \in \{\alpha, \beta, b, CB\}$. Let $\eta = \{p_{h,s}, p_{p,s}, r_s^{ST}, \bar{r}^m, \bar{r}^d, \bar{r}^{DF}, r_s^{LF}\}$ denote the set of prices in the macroeconomy which are determined in equilibrium and which households and the bank take as given in their decision problem. Let agent j 's budget sets be given by $B^j(\eta)$. We say that the set of allocations and prices (σ^j, η) is a *monetary General Equilibrium with incomplete markets (GEI), collateral, banks, and default under optimal monetary policy and regulatory policy* iff:

- (i) $\sigma^i \in \text{Arg max}_{\sigma^i \in B^i(\eta)} \Pi^i, i \in \{\alpha, \beta\}, \sigma^b \in \text{Arg max}_{\sigma^b \in B^b(\eta)} \Pi^b$, and $\sigma^{CB} \in \text{Arg max}_{\sigma^{CB} \in B^{CB}(\eta)} W^{CB}$, that is, all households, the bank, and the central bank optimize by choosing an optimal allocation within the set of feasible allocations given their constraints,

(ii) and all markets in $(MC_1) - (MC_{13})$ clear.

Under conditions (i) - (ii), the equilibrium is characterized by rational expectations, competitive markets and market clearing. A formal proof of the existence of an equilibrium follows, *mutatis mutandis*, from Dubey and Geanakoplos (2003a), Geanakoplos and Zame (2014), and Tsomocos (2003).

1.6 Characterization of Equilibrium

This section discusses the fundamental model properties in equilibrium. We relegate proofs to Appendix 1.E. The formal proofs of the properties follow directly from Tsomocos (2003) and Romanidis and Tsomocos (2021).

To gauge how a departure of the deposit facility rate will affect equilibrium prices, allocations, and default, Propositions 1.1 and 1.2 establish how interest rate changes by the central bank affect interest rates that the financial sector charges.

Proposition 1.1 (Monetary Policy Transmission Mechanism: Channel 1). *In every state $s \in S$, the interest rate paid by households on short-term loans must equal the interest rate paid by the bank on the short-term loan with the central bank, $r_s^{ST} = r_s^{LF} \forall s \in S$.*

Proposition 1.1 implies that any change in the lending facility rate has a direct effect on households' budget constraints and consumption at $t = 1$. It is straightforward why Proposition 1.1 holds only for the transmission at $t = 1$ but not in the first period. At $t = 0$, the bank faces a "cost" to extending additional short-term credit in the form of a capital requirement. To extend more short-term credit while fulfilling the requirement, the bank would need to lower the size of mortgage loans extended. This additional cost draws a wedge between the interest rate that it pays and the interest rate that it demands on short-term credit at $t = 0$.

Proposition 1.2 (Monetary Policy Transmission Mechanism: Channel 2). *In every state $s \in S^*$, the interest rate paid by the bank on consumer deposits must equal the deposit facility rate paid by the central bank, $\bar{r}^d = \bar{r}^{DF}$.*

In the absence of default on deposits or other frictions, the wedge between the rate at which the bank borrows long-term from the household and the rate at which

it lends to the central bank must be zero. Proposition 1.2 implies that a departure of the deposit rate from the ZLB will directly pass through to the depositing household's budget constraint and consumption.

Next, Lemma 1 establishes how relative prices, real allocations, and short-term interest rates are related to each other.

Lemma 1 (Relative prices, allocations, and short-term interest rates). *In equilibrium, for agent α at $t = 1$, we have*

$$\begin{aligned} \frac{u'(e_{p,0}^\alpha - q_{p,0}^\alpha)}{u'(q_{h,0}^\beta) + \beta^\alpha \gamma_1 u'(q_{h,0}^\beta + q_{h,s}^\beta)} &= \frac{p_{p,0}}{p_{h,0}(1 + r_0^{ST})} \quad \forall s \in S_g, \\ \frac{u'(e_{p,s}^\alpha - q_{p,s}^\alpha)}{u'(q_{h,0}^\beta + q_{h,s}^\beta)} &= \frac{p_{p,s}}{p_{h,s}(1 + r_s^{LF})} \quad \forall s \in S, \text{ and} \\ \frac{\beta^\alpha \gamma_s u'(q_{h,0}^\beta + q_{h,s}^\beta)}{u'(q_{h,0}^\beta) + \beta^\alpha \gamma_s u'(q_{h,0}^\beta + q_{h,s}^\beta)} &= \frac{p_{h,s}}{p_{h,0}(1 + \bar{r}^m)} \quad \forall s \in S_g. \end{aligned}$$

Lemma 1 presents the intra- and intertemporal marginal rates of substitution of consuming the perishable and durable goods in both periods, respectively, for agent α who borrows in the short-term money market and in the long-term market for mortgages, sells the perishable good and purchases the durable good. A similar set of relations holds for agent β . Lemma 1 implies that the lending facility rate has a direct effect on households' marginal rate of substitutions and on real allocations at $t = 1$ and an indirect effect at $t = 0$.

What can we say about prices? The following propositions establish their determinacy and role.

Proposition 1.3 (Price Level Determinacy). *The presence of outside money and default guarantee that the price level is determinate.*

The intuition that outside money (Dubey & Geanakoplos, 1992, 2003a, 2003b, 2006) and default (Lin, Tsomocos, & Vardoulakis, 2016) guarantee the existence of positive nominal interest rates and price level determinacy is three-fold.³³ First, fiat

³³Note that by positive nominal interest rates we mean positive lending rates in the private sector since the nominal deposit rate is set equal to zero by assumption.

money has positive value because of its role in facilitating transactions by virtue of the transaction technology (Dubey & Geanakoplos, 1992). The cash-in-advance structure ensures that interest rates formalize the price for liquidity. Second, a positive stock of outside money free of any debt obligations, i.e. monetary endowments, makes it possible to repay interest on borrowing in excess of lending in the presence of a cash-in-advance constraint. At the end of the last period, all money must exit the economy again. In the absence of outside money, repayment of claims would not be possible and the nominal interest rate would hence be zero. A positive nominal interest rate guarantees that there exists a unique money demand which equals money supply in equilibrium. This yields a unique interest rate that clears the credit market and pins down the price level. Third, even when there is no outside money, the possibility that agents endogenously default creates a form of liquid wealth to them. This liquid wealth enables them to pay interest and thus allows for positive interest rates (Romanidis & Tsomocos, 2021).³⁴

Note that cash-in-advance and fiat money imply that aggregate income, i.e. the value of all goods sales, is linked to short-term credit extension. Both prices and quantities are therefore affected by nominal changes, i.e. changes in monetary policy. This is captured in the following two propositions.

Proposition 1.4 (Quantity Theory of Money). *In equilibrium, \forall states $s \in S^* = \{0, s, \dots, S\}$, \forall households $h \in H = \{\alpha, \beta\}$, and \forall commodities $l \in L = \{p, h\}$, it must hold that*

$$M_s^{CB} \cdot V \leq \sum_{h \in H} \sum_{l \in L} p_{s,l} q_{s,l}^h \quad \text{for } s = 0 \quad \text{and} \quad (\text{A})$$

$$(\Delta(\text{A}) + M_s^{CB}) \cdot V = \sum_{h \in H} \sum_{l \in L} p_{s,l} q_{s,l}^h \quad \forall s \in S.$$

If nominal interest rates are positive, then in equilibrium the Quantity Theory of Money must hold. The velocity of money V is then fixed at one. In each state $s \in S^*$, nominal income equals the total money stock since all the liquidity available transmits via banks to the goods market. Monetary policy therefore has real effects,

³⁴In other words, money has value whenever there is default – the possibility that not all debts are fully repaid. Hence, liquidity yields positive nominal interest rates and real effects when default is positive.

i.e. the quantity of real goods traded is endogenous with respect to the money stock. The Quantity Theory of Money therefore obtains *non-trivially*. This precisely means that changes in the money stock do not only affect prices but also change quantities, encapsulated in the following proposition.

Proposition 1.5 (Monetary Policy Non-Neutrality). *If $M_{s^*}^{CB} \geq 0$, then $\Delta M_{s^*}^{CB}$ (i.e. $\Delta r_{s^*}^{LF}$ by $(MC_{12}) - (MC_{13})$) and/or regulatory policy $\Delta CAR^* \Rightarrow \Delta \left(\sum_{l \in L} p_{s,l} \right)$ and $\Delta \left(\sum_{h \in H} \sum_{l \in L} q_{s,l}^h \right) \forall s \in S^*, \forall l \in L, \forall h \in H$.*

Proposition 1.5 states that, because monetary policy is non-neutral, changes in monetary and regulatory policy produce different prices and quantities. The existence of trade in fiat money and positive interest rates creates a wedge between buying and selling prices. This wedge hinders trade in commodities and distorts marginal rates of substitution. The resulting inefficiency is the source that makes monetary policy non-neutral.

To summarize the previous propositions, they establish that the price level is determinate. In equilibrium, nominal interest rates are positive. Because nominal interest rates are positive, monetary policy has real effects. That is, changes in the money stock affect not only prices but also quantities. Therefore, the Quantity Theory of Money holds non-trivially. The fact that it holds *non-trivially* implies that money is non-neutral.

As we stress the importance of Fisherian debt-deflation in our model throughout, we also briefly establish the Fisher effect in the next proposition.

Proposition 1.6 (Fisher effect). *In equilibrium,*

$$(1 + \tilde{r}) = (1 + \tilde{r}^m) / (1 + \pi_{h,s}^e) \quad \text{for } s \in S^g.$$

The Fisher effect obtains in the market for intertemporal loans, i.e. in the mortgage market. That is, agents in the model receive (or pay) the gross real interest rate which approximately equals the nominal intertemporal interest rate less expected

inflation rate in the housing market. Changes in prices and in the nominal interest rate induced by expected default therefore affect the real rate of interest.

We hasten to add two additional observations that stem from the novel properties of our model. The first observation relates to the central bank's balance sheet. Note that the central bank's budget constraint is determined by the set of date-0 stock of outside money in the economy. This implies that the size of monetary endowments restricts the purchasing and selling power that households have in both periods due to cash-in-advance constraints and the scarcity of collateral. Cash-in-advance constraints limit the amount of credit that households can obtain from the proceeds of their endowment sales. Because household credit is restricted via cash-in-advance, the amount of borrowing from the central bank that the commercial bank requires to fund these household loans is bounded from above. In other words, the amount of *inside money* that is created is bounded. This holds under the condition that the central bank does not redistribute its seignorage income to household in every period, i.e. under non-Ricardian policy. Hence, a finite, positive amount of outside money in the economy prevents the central bank's balance sheet from growing infinitely large (unless seignorage distribution is Ricardian).

The second observation relates to conditions under which the price level becomes indeterminate. We do not provide a formal proof of these conditions here but discuss one of them. Specifically, if the central bank redistributes its profits to households *on a per period basis*, the price level is *indeterminate*. Intuitively, the transfer of funds from the central bank to households enters the budget constraint of households. If, in the same period, households pay exactly the interest to the central bank (via the financial intermediary) which they receive back as a transfer at the end of this period, the transfer will leave the interest rate in the budget constraint undetermined. Any equilibrium can then be supported with an arbitrary vector of prices which leaves the price level indeterminate. We obtain this result numerically and refer the reader to Bloise and Polemarchakis (2006) for a formal proof. Prices in the economy can be determined only if seignorage is redistributed not *intratemporally* (period-by-period) but *intertemporally* (across periods). This is precisely the institutional feature that we assume in equations $(\Lambda_2^{CB}) - (\Lambda_6^{CB})$. Importantly, the central bank distributes seignorage income obtained from loan

issuance in the first period *only in the second period*.

A natural link then arises between central bank balance sheet management and the Fiscal Theory of the Price Level (see e.g. Buiter (2002)). Bloise and Polemarchakis (2006) highlight that the distinction between alternative redistribution policies of central bank seigniorage echoes the distinction between Ricardian and non-Ricardian policies. This is because the exact specification in both contexts has important implications for the determinacy of equilibria. In their terminology, the redistribution policy in our model is non-Ricardian. The central bank does not need to balance the accounting inflows and outflows on its balance sheet. More precisely, it carries over the surplus from the first period into the second period. It therefore does not balance its budget period-by-period.³⁵

1.7 A Numerical Application

This section explains the computational method under a set of simplifying assumptions, presents the parameterization, and discusses the numerical results.

1.7.1 Assumptions and Computational Method

The goal is to reduce the model to a manageable set of conditions that yields a numerical solution to a general equilibrium of the model. First, we limit the number of states in the second period to one good state $s = 1$ without mortgage default and one bad state $s = 2$ with default. Second, we assume that at the beginning of period $t = 0$, the central bank sets the lending facility rates on loans to the bank only for period $t = 1$ for each state of nature. It does not set the lending facility rate for $t = 0$. This type of “forward guidance” allows us to set the date-0 lending facility rate r_0^{LF} at the ZLB. Third, we set the deposit facility rate at a predetermined level close to zero to impose the ZLB onto our model. Fourth, the central bank sets the capital requirement CAR^* only for the first period. CAR^* is assumed to not be binding in the second period as banks have accumulated a capital buffer

³⁵Romanidis and Tsomocos (2021) go one step further by showing that introducing default on collateralized debt held with the central bank can resolve the problem of indeterminacy even in the absence of outside money when the central bank’s balance sheet is unrestricted.

ex ante. Finally, the central bank possesses information about all agents' optimality conditions, budget constraints, and market clearing conditions but it does not internalize all of the second order effects of its actions. We assume that the central bank internalizes the *direct* effect of setting the lending facility rate r_s^{LF} in state $s \in \{1, 2\}$ and the capital requirement CAR^* on endogenous variables in all states of nature. However, it does not internalize the *indirect* effects via other endogenous variables in the system.

The chosen setup does not yield closed-form analytical solutions for prices and quantities, and consequently, for the central bank's first order conditions. Determining the change in inflation and in the output gap in response to a change in the lending facility rate and in the capital requirement therefore poses a computational challenge. We proceed by retrieving *numerical* solutions to each partial derivative in the central bank's first order conditions. Our point of departure is the envelope theorem which, loosely speaking, allows us to only consider *direct* effects of the policy change and ignore *indirect* effects via other endogenous variables.³⁶ We use three steps in the following two sections: (1) we first solve for an initial partial equilibrium for the lending facility rates (r_1^{LF}, r_2^{LF}) and the capital requirement CAR^* without the central bank's decision problem, (2) we then use the initial equilibrium values of the endogenous variables to retrieve numerical values of the partial changes with respect to the lending facility rates from a linear system of envelope conditions, and (3) we finally solve for a general equilibrium using all optimality conditions, envelope conditions, and numerical values of the partial derivatives as starting values.³⁷

1.7.2 Parameters and Initial Equilibrium

The model is parameterized in Table 2.1 to reflect the recent low-interest rate environment in the run-up to and aftermath of the Covid-19 pandemic. The parameters are chosen to produce realistic inflation scenarios with above-target inflation in the normal or "good" state and deflation in the adverse state. As we are interested in

³⁶Please refer to Appendix 1.F for an example of the solution method and algorithm.

³⁷Our computational approach is compatible with DSGE solution methods. See for example Arellano, Maliar, Maliar, and Tsyrennikov (2016) for dynamic programming problems in the context of large-scale macroeconomic models.

the effect of monetary policy on default and prices via the collateral channel, several of the chosen parameters follow Goodhart et al. (2010) who study a similar channel in the context of the 2008 subprime mortgage crisis. Table 1.4 presents the general equilibrium values obtained under central bank optimization at the ZLB. We discuss the outcomes in both periods in turn.

At $t = 0$, the economy starts off with a small positive interest rate corridor at the ZLB akin to observed width of the interest rate corridor in the Euro Area.³⁸ Agent α (net borrower) is relatively “poorer” than agent β (net lender) in nominal terms since she is endowed with relatively cheaper perishable goods. The parameterization motivates intra-temporal borrowing from the central bank and inter-temporal depositing of excess reserves. The central bank has a sufficiently high initial endowment to lend out more short-term credit to the bank than it is able to finance through excess reserve deposits.³⁹

Two scenarios are assessed at $t = 1$. In the good state $s = 1$, endowments of goods, money, and bank capital remain constant. There is a modest rise in the price level from the first to the second period, i.e. inflation is above target at 2.6%. This rise is driven by a credit boom – albeit contained by the central bank’s monetary and regulatory policies – and overall scarcity in housing.⁴⁰ High short-term funding costs and capital requirements limit the lending capacity of the commercial bank. High short-term loan rates in turn restrict the amount of additional borrowing that agent α can take out to finance additional housing and repay her mortgage.⁴¹ Thus, agent α ’s demand for additional housing in $s = 1$ decreases because borrowing short-term credit from the bank to “roll over” her debt becomes more expensive. In light of these liquidity constraints, agent α sells less of the same endowment of potatoes and consumes more of it herself. Consequently, the price of potatoes increases. At this price, agent α can sell enough potatoes to pay back her mortgage to the bank and no mortgage default occurs. The drop in demand

³⁸Our definition of the interest rate corridor, $(r_0^{LF} - \bar{r}^{DF})$ ignores compounding, i.e. $(1 + r_0^{LF})(1 + r_s^{LF}) - (1 + \bar{r}^{DF})$. We still use the former definition for the ease of exposition.

³⁹One may think of the high initial monetary endowment of the central bank as a capital injection or legacy debt of the government (see Goodhart et al. (2021)).

⁴⁰Recall that the stock of housing in the economy does not replenish in the second period. Hence, there is an intertemporal trade-off between consuming and selling housing in the first and second period that affects relative prices and trade.

⁴¹Recall that households cannot immediately use the proceeds from their endowment sales to buy goods due to cash-in-advance. They hence borrow short-term credit from the bank.

Table 1.3. Parameterization of exogenous variables

Real Endowments	Money Endowments	CB Parameters	Other Parameters
$e_{p,0}^\alpha = 10.0$	$m_0^\alpha = 5.0$	$\bar{r}^{DF} = 0.0\%$	$\beta^\alpha = 0.99$
$e_{p,1}^\alpha = 10.0$	$m_1^\alpha = 5.0$	$r_0^{LF} = 1.0\%$	$\beta^\beta = 0.99$
$e_{p,2}^\alpha = 3.0$	$m_2^\alpha = 1.0$	$\kappa = 0.6$	$\beta^b = 0.99$
$e_{h,0}^\beta = 5.05$	$m_0^\beta = 1.0$	$\varkappa = 0.59$	$\gamma_1 = 0.9$
$e_0^b = 5.0$	$m_1^\beta = 1.0$	$y_1^* = 6.49$	$\gamma_2 = 0.1$
$e_1^b = 5.0$	$m_2^\beta = 1.0$	$y_2^* = 3.39$	$\sigma = 1.525$
$e_2^b = 2.0$	$m_0^{CB} = 80$	$\pi^* = 2.0\%$	$a^b = 0.0045$
	$m_1^{CB} = 0.1$	$\theta_\pi = 1$	$x = 0.01$
	$m_2^{CB} = 0.1$	$\theta_d = 0.001$	
		$\theta_b = 0.001$	
		$\theta_\theta = 0.001$	
		$\omega^{ST} = 0.3$	
		$\omega^{LT} = 1.0$	

Note: This table presents the parameterization of all exogenous variables. Table 1.A.1 in Appendix provides an overview of all variable definitions.

Table 1.4. Initial equilibrium

Prices	Quantities	Money spent	ST credit	LT credit	CB variables
$p_{p,0} = 6.04$	$q_{p,0}^\alpha = 6.01$	$b_{h,0}^\alpha = 54.72$	$\ell_0^\alpha = 36.28$	$\bar{\ell}^\alpha = 15.65$	$M_0 = 89.03$
$p_{p,1} = 11.13$	$q_{p,1}^\alpha = 4.53$	$b_{h,1}^\alpha = 34.89$	$\ell_1^\alpha = 50.47$	$\bar{\ell}^{LT} = 14.38$	$M_1 = 64.45$
$p_{p,2} = 24.46$	$q_{p,2}^\alpha = 1.28$	$b_{h,2}^\alpha = 29.48$	$\ell_2^\alpha = 31.40$	$\bar{d}^\beta = 18.00$	$M_2 = 31.08$
$p_{h,0} = 37.50$	$q_{h,0}^\beta = 1.50$	$b_{p,0}^\beta = 36.28$	$\ell_0^\beta = 54.72$	$\bar{d}^{LT} = 18.00$	$\bar{D} = 9.03$
$p_{h,1} = 31.34$	$q_{h,1}^\beta = 1.11$	$b_{p,1}^\beta = 50.47$	$\ell_1^\beta = 34.89$	$\bar{d}^{DF} = 9.03$	$w_1^{CB} = 87.91$
$p_{h,2} = 10.92$	$q_{h,2}^\beta = 1.24$	$b_{p,2}^\beta = 31.40$	$\ell_2^\beta = 13.55$		$w_2^{CB} = 83.91$
$r_0^{ST} = 2.70\%$			$\ell_0^{LF} = 83.52$		$\pi_1 = 2.57\%$
$r_1^{ST} = 12.12\%$			$\ell_1^{LF} = 64.80$		$\pi_2 = -0.16\%$
$r_2^{ST} = 12.25\%$			$\ell_2^{LF} = 34.19$		$y_1 = 5.65$
$r_1^{LF} = 12.12\%$					$y_2 = 2.52$
$r_2^{LF} = 12.25\%$					$\Pi_1^0 = 13.42$
$\bar{r}^d = 0.0\%$					$\Pi_2^0 = 10.06$
$\bar{r}_1^m = 8.78\%$					$CAR^* = 12.20\%$
$\bar{r}_2^m = 10.75\%$					

Note: This table presents the initial general equilibrium values of all endogenous variables obtained under the parameterization in Table 2.1, i.e. when the economy is at the ZLB ($\bar{r}^{DF} = 0.0\%$). Table 1.A.1 in Appendix 1.A provides an overview of all variable definitions.

for housing in turn makes houses relatively cheaper. Agent β sells less housing in state $s = 1$ relative to $t = 0$ and buys the relatively more expensive potatoes. Facing the same high interest rate for short-term credit, he uses the anticipated income transfer and savings deposits to afford potatoes.

In the adverse state $s = 2$, occurring with only a 10% probability, an adverse supply shock hits. Agent α suffers a loss in her endowment of potatoes $e_{p,2}^\alpha$ and money m_2^α – a negative wealth effect – relative to the previous period and state $s = 1$. She therefore sells only a fifth of what she sold in the first period, which results in inflation in potato prices. To afford the relatively more expensive potatoes given a small money endowment at $s = 2$, agent β now sells more of his leftover stock of housing than he otherwise would have. House prices fall by more from the previous period relative to the good state. The decline in house prices unfolds up to a critical point, where the value of housing that agent α initially pledged as collateral at $t = 0$ just equals the value of the mortgage to be repaid. If the nominal recovery value of collateral fell below the face value of the mortgage, this would trigger default on the mortgage and foreclosure of the collateral. In other words, we parameterize the status quo at the ZLB to match the *on-the-verge condition* of default. The effects of positive default in equilibrium will become clear in the simulations in the following section.

Note also how market incompleteness plays into the adverse scenario. Facing a negative supply shock tomorrow, both rich and poor agents want to consume less today and save more for tomorrow to insure against the shock. However, due to incomplete markets, agents cannot fully insure. Notwithstanding, agent α can default on the mortgage in the second period, which in a way provides “insurance”. Agent α therefore naturally consumes more at date-0 by taking out a higher mortgage in anticipation that she can default tomorrow. The crux is that, although she does internalize that she loses the housing collateral upon default, she does not take into account the fire sale externality when the collateral is resold in the market. She therefore borrows more than is socially optimal given the possibility of default.

Even absent positive default losses in the bad state in our initial equilibrium at the ZLB, falling prices raise the real burden of debt which leads to a further decline in prices – a debt-deflation “spiral” ensues in the spirit of Fisher (1933). While agent α may be thought to benefit from higher potato prices, the decline in the relative price of housing depresses demand for potatoes due to the downturn in the housing market. Overall aggregate demand falls.

The commercial bank, in turn, faces a shock to its equity endowment in the bad state. This can be thought of as the bank losing access to equity markets or facing a prohibitive external financing premium in downturns. Although all outstanding obligations are settled on the bank's loan portfolio and no default occurs at the ZLB, the bank still suffers from the negative effect of depressed aggregate demand on demand for short-term credit. Consequently, bank profits turn out lower relative to the good state.

What do these dynamics in the second period imply for the central bank's objectives, *ceteris paribus*? First, bank profitability is relatively higher in the good state compared to the bad state. High levels of trade and credit extension as well as high returns on the mortgage boost bank profits. By contrast in the bad state, although the bank does not earn negative profits and become insolvent, it still suffers from subdued credit demand.

Second, the rate of inflation exceeds the target level of 2% by 0.6 percentage points in the good state but falls short of it by 2.2 percentage points in the bad state. Inflation dynamics in both states of nature depend on the relative weights of perishable and durable goods in the consumer price index. We assume that the consumer price index (CPI), p_s , takes the simple form $p_s = \varkappa p_{p,s} + (1 - \varkappa)p_{h,s}$ for $s \in S = \{1, 2\}$ where we place a weight of $\varkappa = 0.6$ on the consumption good. The aggregate supply shock in the bad state unleashes Fisherian debt-deflationary forces through an aggregate demand channel in the absence of a productive sector.⁴² By virtue of the Fisher effect, the combination of deflation and high real short-term interest rates explains why the nominal short-term rate on loans, optimally set by the central bank and passed through to consumers, must rise in the second period. In other words, the central banks' optimal state-contingent policy rates account for default and liquidity risk premia. This leads to relatively high nominal interest rates even, *or* in particular, in the adverse state.

Finally, the output gap is negative in both the good and the bad state of nature. This is due to the fact that we have parameterized the natural level of output to

⁴²We acknowledge that the results are sensitive to the weight on the price of the perishable good in the CPI. Comparing weights with those published by the Office for National Statistics (2018), we think that our chosen weight is still conservative.

reflect the total volume of trade that would be achieved in a barter economy without financial frictions. Since our economy achieves at most a constrained Pareto suboptimal result due to the frictions embedded in it, the output gap will always be negative. The goal of the central bank then is to minimize deviations of actual from potential output by bringing the economy closer to first best.

1.7.3 General Equilibrium with Optimal Policy

Given the simplified two-period model with two states of nature and our initial equilibrium, we now investigate (1) how a departure of the deposit facility rate from the ZLB affects equilibrium prices, allocations, and default levels, and (2) how the relative importance of monetary policy and financial stability objectives affects the equilibrium.

We run simulations by exogenously varying the deposit facility rate, \bar{r}^{DF} , and the accompanying interest rate on central bank loans in the first period, r_0^{LF} by increments of 20 basis points at each iteration. That is, we simulate the model over a grid of different widths and levels of the interest rate corridor between the rate at which the commercial bank borrows and the rate at which it lends to the central bank in the first period. Equipped with the simulated equilibrium values, we analyze (1) how each of the four central bank objectives – bank profits, default, inflation, and the output gap – is affected by the change in the interest rate corridor, and (2) how optimal capital regulation CAR^* at $t = 0$ and the optimal state-contingent lending facility rates r_s^{LF} at $t = 1$ change with the size of the corridor.

In the following figures, we plot our variables of interest as a function of \bar{r}^{DF} and r_0^{LF} , i.e. as a function of the date-0 interest rate corridor. The resulting surfaces over the interest rate grid are characterized by a blue diagonal “threshold” line. This threshold marks the separation between the feasible equilibria that we are interested in on the right hand side (RHS) where $\bar{r}^{DF} \leq r_0^{LF}$, i.e. where the bank has an incentive to lend out loans to households rather than to deposit its funds with the central bank. We therefore focus on the RHS of the threshold and trace the slope of the blue line as the deposit facility rate \bar{r}^{DF} increases. Table 1.5 summarizes the direction of changes of endogenous variables as the economy moves along the

Table 1.5. Impact of an exogenous lift-off from the ZLB

Variable	$t = 0$	$s = 1$	$s = 2$
Excess reserves/ deposit facility \bar{D}	–		
Mortgage loan $\bar{\ell}^\alpha$	+		
Price of housing p_{h,s^*}	–	+	–
Price of potatoes p_{p,s^*}	–	+	–
Quantity of housing sold q_{h,s^*}^β	+	–	–
Quantity of potatoes sold q_{p,s^*}^α	–	+	+
Private short-term credit ℓ_s^{ST}	–	0	–
Money supply/ lending facility M_{s^*}	–	+	–
Short-term household loan rate r_0^{ST}	+		
Optimal lending facility rate r_s^{LF}		–	+
Capital requirement CAR^*	–		
Bank profits Π_s^b		–	–
Loss given default			+
Inflation π_s		+	–
Output (gap) y_s		–	–

Note: This table summarizes marginal positive (+) and negative (–) changes of endogenous variables in equilibrium with respect to an exogenous increase in the deposit facility rate \bar{r}^{DF} from the ZLB in period $t = 0$ and states $s = 1, 2$. The symbol “0” indicates no change.

blue line, i.e. as \bar{r}^{DF} and r_0^{LF} increase commensurately. We discuss them below in the context of the central bank trading off its objectives.

Figures 1.5 and 1.6 illustrate the main results of the simulation for the four central bank objectives. Overall, the popular claim that bank profitability will increase as we depart from the ZLB does not obtain. Bank profits suffer from the lift-off in both states of nature (Figure 1.5 panel (a)). Default is the primary driver of this outcome. Losses due to mortgage default materialize in bad times following a departure from the ZLB (Figure 1.5 panel (c)). They also steadily increase with the size of the interest rate corridor.⁴³

Two effects drive the reduction in bank profits. First, as debt service increases away from the ZLB, agents face problems rolling over their debt through short-term loans ℓ_s^{ST} .⁴⁴ The problem is that both their overall debt service increase and at the same time the value of housing collateral falls as cash-constrained agents trade less. This lowers the recovery value of the mortgage. Consequently losses

⁴³Even at the ZLB, as the interest corridor widens, higher lending spreads are passed on to households, thus increasing their debt service and default risk.

⁴⁴See Figure 1.C.1 in Appendix 1.C for additional results.

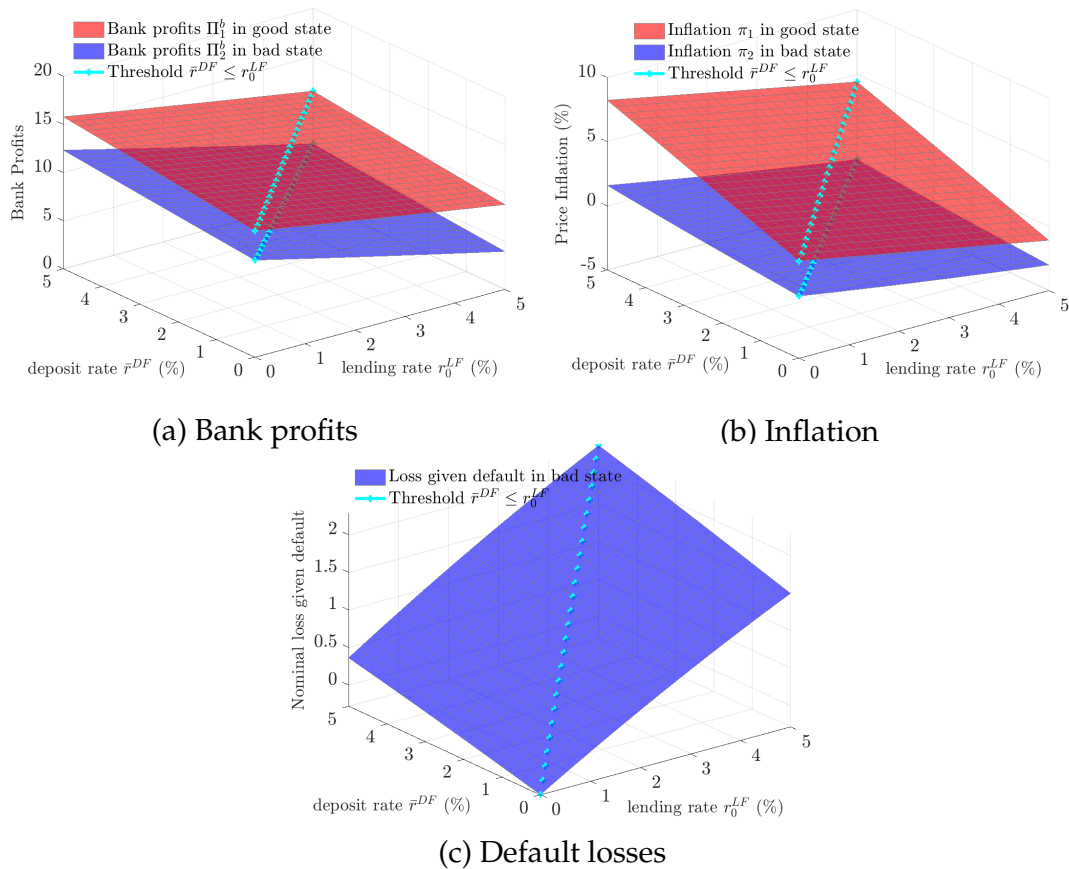


Figure 1.5. Bank profits, inflation, and loss due to mortgage default conditional on the interest rate corridor.

Note: This figure shows comparative statics with respect to the interest rate corridor between the central bank’s lending facility and deposit facility, i.e. r_0^{LF} and \bar{r}^{DF} at $t = 0$. The feasible levels of bank profits, inflation, and default losses are displayed in panels (a)-(c), respectively, in the good state $s = 1$ (red) and in the bad state $s = 2$ (blue) conditional on different widths of the interest rate corridor as determined along the horizontal axes. The threshold line (light blue) separates feasible equilibria on the RHS from infeasible equilibria on the LHS.

due to default increase in the adverse state. Second, higher funding costs across the entire maturity spectrum – think of it as an upward shift in the yield curve – also depress the demand for short-term credit. Therefore, both less credit demand and higher default losses bear on banks’ balance sheet. Bank profits fall by almost twice the loss from mortgage default, reflecting the knock-on effect via aggregate demand.

Note that even in the good state, the hypothetical gains in bank profits that we would expect to see when moving away from the ZLB do not materialize. Figure

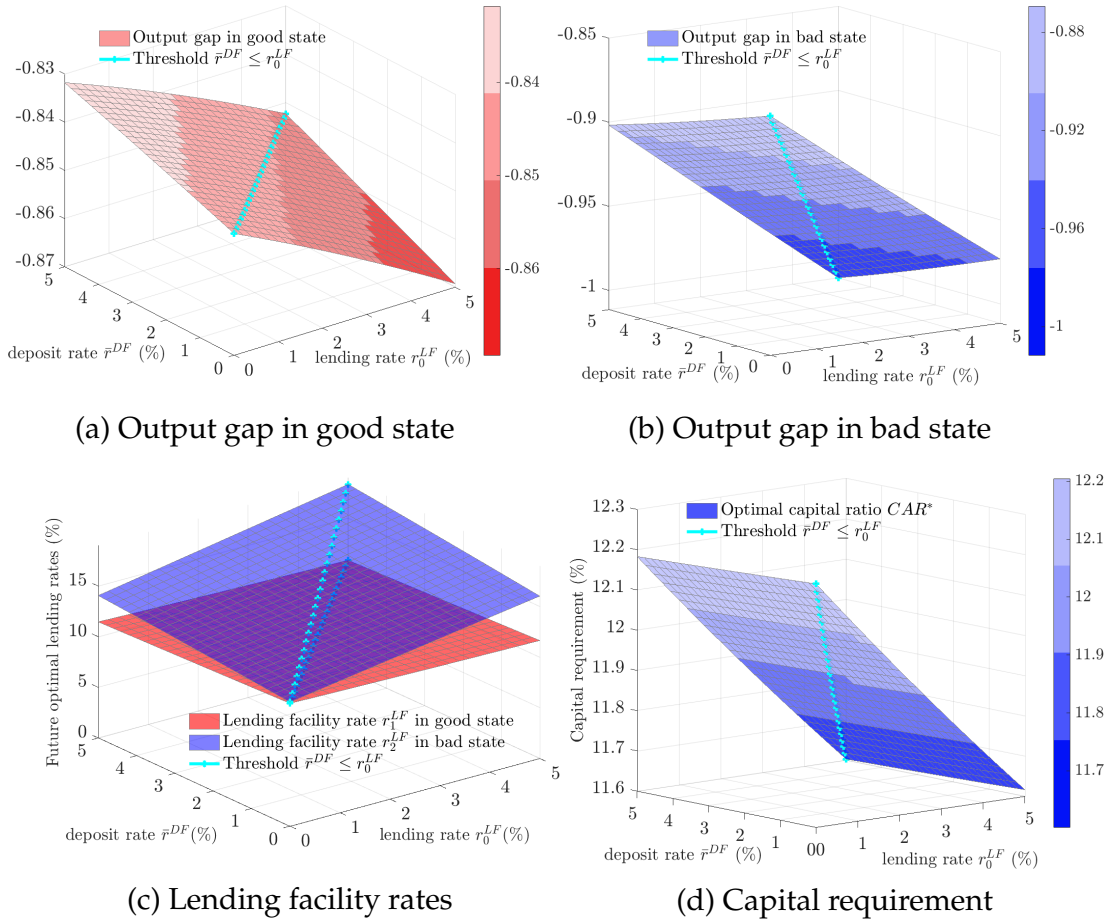


Figure 1.6. Output gap, optimal policy rates and capital ratio conditional on the interest rate corridor.

Note: This figure shows comparative statics w.r.t. the interest rate corridor between the central bank's lending facility and deposit facility, i.e. r_0^{LF} and \bar{r}^{DF} at $t = 0$. The feasible levels of the output gap are displayed in panels (a)-(b), respectively, in the good state $s = 1$ (red) and in the bad state $s = 2$ (blue) conditional on different widths of the interest rate corridor as determined along the horizontal axes. Panel (c) displays the results of the same exercise for the optimal state-contingent lending facility rates and panel (d) for the capital requirement. The threshold line (light blue) separates feasible equilibria on the RHS from infeasible equilibria on the LHS.

1.6 panels (c)-(d) illustrate the optimal policy decisions that are at the heart of this counterintuitive result. It shows that the optimal future corridor between deposit and lending facility rates should be *narrower* in good times and *wider* in economic downturns the further away the economy is from the ZLB.⁴⁵

⁴⁵Another way of interpreting the fall in the optimal lending facility rate at $s = 1$ and its rise at $s = 2$ is that the central bank attempts to flatten the yield curve in good times while it tries to steepen the yield curve in bad times.

Why does the central bank act in such a “procyclical” manner? The intuition follows from the model’s assumption that the central bank has rational expectations about the likelihood of future default and deflation. If the economy is expected to fare well, it will set the corridor between the lending facility rate and the deposit facility rate at a narrower level (lower r_1^{LF}) to counter the adverse effect of a lift-off on credit extension to disincentivize banks from extending more credit.⁴⁶ This tighter policy interest rate corridor fully transmit to loan spreads as laid out in Proposition 1.1. The commercial bank’s interest rate margin therefore actually shrinks. Conversely, if the economy is expected to slump in the face of the adverse supply shock, the central bank will want to raise the lending facility rate (higher r_2^{LF}) so as to support commercial banks’ profit margin in bad times. Higher optimal state-contingent interest rates in the default state therefore directly account for liquidity and default risk premia. The interaction of liquidity frictions and default depresses prices and economic activity even further as credit is rationed in bad times.

Why is it *optimal* for the central bank to tighten the interest rate corridor by *lowering* the lending facility rate in good times seemingly against conventional wisdom? Essentially, the central bank trades off (in expectation) setting a tighter interest rate corridor to limit credit *supply* that fuels default in good times with a wider interest rate corridor that supports banks’ profit margins in bad times. It thus sets ex-ante “pro-cyclical” monetary policy. Particularly in the bad state, raising the optimal lending facility rate, and thus the interest rate corridor, is the outcome of an intricate trade-off between promoting bank profitability on the one hand while keeping the mortgage credit boom contained on the other hand. In so doing, the central bank effectively weighs up the cost that higher short-term interest rates depress demand for short-term credit and agents’ ability to roll over their mortgage debt. Thus, there is an additional tension *between* the two financial stability objectives: supporting bank profits on the one hand while keeping default risk limited.⁴⁷

⁴⁶Taking the counter-example, if the policy rate in the good state would increase by more than one for one with \bar{r}^{DF} , credit supply in the economy would expand up to a socially suboptimal level at date-0 that would feed back into default losses in the bad state. Thus, the marginal effect on private short-term credit in Table 1.5 would be positive rather than unchanged at the margin.

⁴⁷Characterizing this trade-off through optimal weights on central bank objectives unfortunately lies outside the scope of this paper. We leave it to future research to quantify the sensitivity to optimal weights in a calibrated macro model.

Note also that the central bank does not only face this trade-off between states of nature but also *intertemporally*. Since it seeks to smooth welfare across periods, it seeks to affect leverage through date-1 containment measures already at date-0 so as to minimize welfare losses at date-1 in expectation.

Complementary to the pro-cyclical monetary policy, the central bank however aids the commercial bank by relaxing the capital constraint (Figure 1.6 panel (d)). The optimal capital requirement is looser as the economy moves away from the ZLB so as to compensate for the shortfall in credit extension through higher interest rates. Capital regulation is therefore *ex post* counter-cyclical. If you will, capital regulation and monetary policy in our model intervene at different ends of the yield curve, i.e. the long end versus the short end, respectively. Thus, optimal monetary and regulatory policies may be deemed complementary (Angelini et al., 2014; Catarineu-Rabell et al., 2005; Farhi & Werning, 2016; Kashyap et al., 2020; Martinez-Miera & Repullo, 2019).

What is the impact of these policies on inflation? The central bank is not successful in moving closer to target inflation (Figure 1.5 panel (b)). Inflation in the good state climbs from 2.6% to up to 4.4% as the economy departs from the ZLB. Deflation in the bad state is further exacerbated from -0.2% down to -1.7%. Default acts as a drag on the price level via Fisherian debt-deflation. Deflation also further increases the real burden of debt. In fact, as we will see, if the central bank does not internalize the effect of default in its objective function, deflation will be even worse in the default state. The results pose a puzzle: Why can the central bank not bring inflation to target in the good state of nature? Again at the heart of this result is the trade-off between supporting the health of the banking sector and limiting default on the one hand while keeping prices in check on the other hand. The central bank tries to smooth default across states of nature, which inevitably also affects its ability to bring down inflation in good times.

The rise in default and deflation in the bad state depress output by the quantity theory of money as illustrated in Figure 1.6. The negative output gap widens in both states of nature as the economy departs from the ZLB. The interaction of low fire-sale prices of housing collateral and high lending rates leads to more de-

pressed output and prices in crises times.⁴⁸ Why does output also fall in the good state of nature? The drop in economic activity results from second-order effects of default losses. As agents have rational expectations about future default in bad times, they adapt their date-0 choices to smooth consumption across states. In addition, a higher level of interest rates away from the ZLB reduces credit extension and thereby attenuates economic activity. By the Quantity Theory of Money in Proposition 1.4, the monetary contraction resulting from the lift-off reduces not only prices but also changes allocations. Thus, trade in goods falls as the economy lifts off.

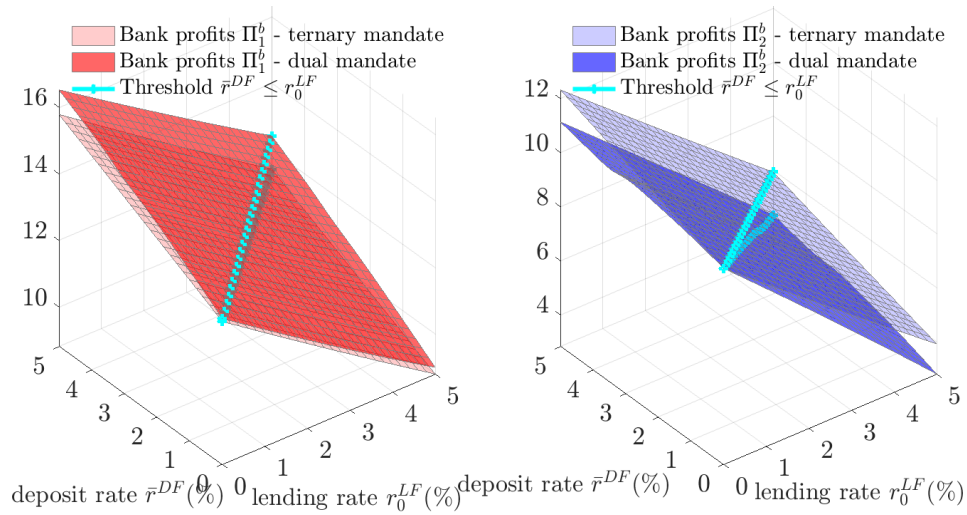
1.7.4 Optimal Policy under Different Weights on Central Bank Objectives

In our benchmark equilibrium, we impose equal weights on each of the four central bank objectives. In the following analysis, we examine what happens when zero weights are placed on financial stability objectives. That is, we consider optimal monetary policy changes when the central bank adheres to its dual mandate of targeting inflation and the output gap. We compare the effects of a lift-off under a dual mandate to those under an additional financial stability mandate. Figures 1.7 and 1.8 compare the equilibrium levels of bank profits, default losses, inflation, and the output gap under the benchmark weights. The equilibrium levels are obtained under zero weights on financial stability objectives, i.e. $\theta_b = \theta_d = 0$ in the objective function in (Λ_1^{CB}) .⁴⁹ We denote the two cases as a ternary mandate versus a dual mandate for ease of exposition.

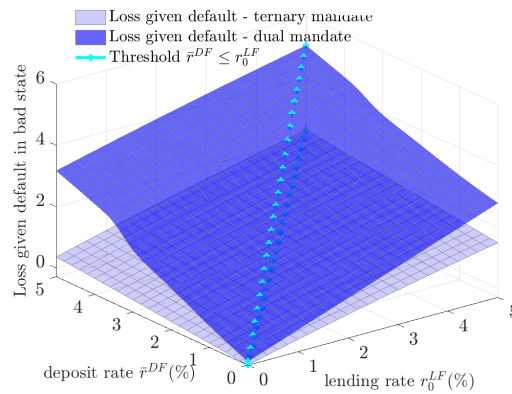
Under a dual mandate, bank profits are higher in good times but lower in bad times compared to profits under a ternary mandate (Figure 1.7 panel (a)-(b)). This is the case at any level of interest rates and any size of the interest rate corridor away from the ZLB. Default losses surge when the central bank does not directly factor financial stability considerations into its decision (Figure 1.7 panel (c)). The central bank fails to reach its inflation target in both states of nature even more so

⁴⁸See Guembel and Sussman (2010) for a similar result in the context of collateralized interbank markets.

⁴⁹For computational reasons, we set the weight on financial stability objectives close to but not exactly zero. Note also that, although we remove one of the central bank's targets, we do not remove the endogenous regulatory instrument from the model in the simulation.



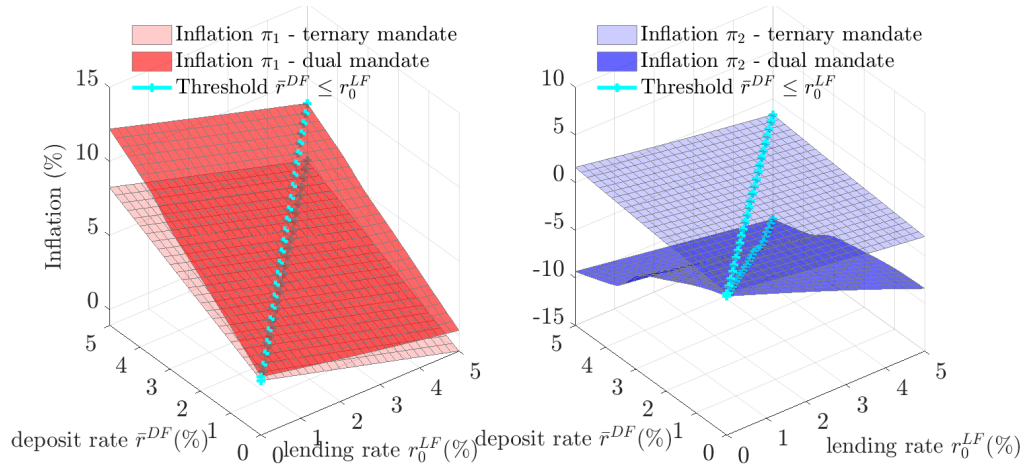
(a) Bank profits in good state (b) Bank profits in bad state



(c) Default losses in bad state

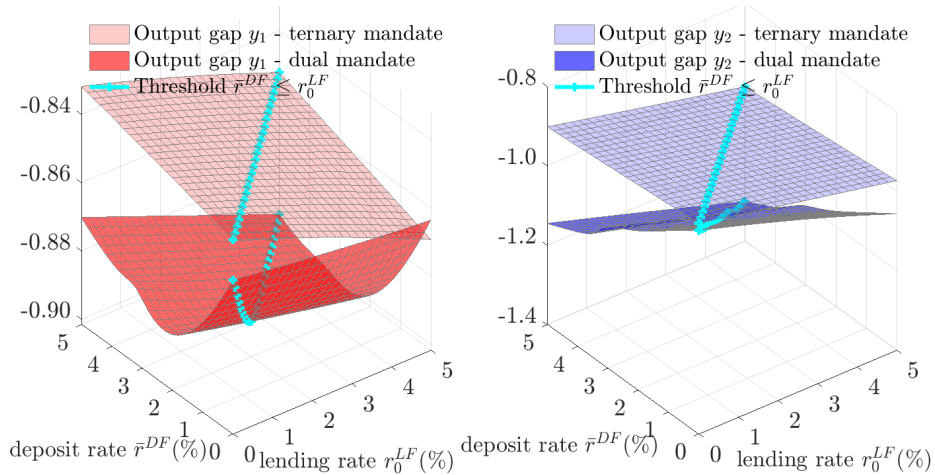
Figure 1.7. Bank profits and loss due to default conditional on the interest rate corridor and central bank objectives.

Note: This figure shows comparative statics with respect to the interest rate corridor between the central bank's lending facility and deposit facility, i.e. r_0^{LF} and \bar{r}^{DF} at $t = 0$. The feasible levels of bank profits in the good state $s = 1$ (red) and in the bad state $s = 2$ (blue) as well as of default losses in the bad state $s = 2$ (blue) are displayed in panels (a)-(c), respectively, conditional on different widths of the interest rate corridor as determined along the horizontal axes. The figures distinguish between equilibria under a dual mandate (solid plane) and under a ternary mandate (transparent plane) with positive weight on financial stability objectives. The threshold line (light blue) separates feasible equilibria on the RHS from infeasible equilibria on the LHS.



(a) Inflation in good state

(b) Inflation in bad state



(c) Output gap in good state

(d) Output gap in bad state

Figure 1.8. Inflation and output gap conditional on the interest rate corridor and central bank objectives.

Note: This figure shows comparative statics w.r.t. the interest rate corridor between the central bank's lending facility and deposit facility, i.e. r_0^{LF} and \bar{r}^{DF} at $t = 0$. The feasible levels of inflation and the output gap in the good state $s = 1$ (red) and in the bad state $s = 2$ (blue) are displayed in panels (a)-(d), respectively, conditional on different widths of the interest rate corridor as determined along the horizontal axes. The figures distinguish between equilibria under a dual mandate (solid plane) and under a ternary mandate (transparent plane) with positive weight on financial stability objectives. The threshold line (light blue) separates feasible equilibria on the RHS from infeasible equilibria on the LHS.

under a dual mandate (Figure 1.8 panels (a)-(b)). Similarly, the negative output gap widens further in both good and adverse states under a dual mandate (Figure 1.8 panel (c)-(d)). Thus, a dual mandate increases the variance of consumption across normal and crises times and fares even worse in absolute terms in stabilizing economic activity across states.

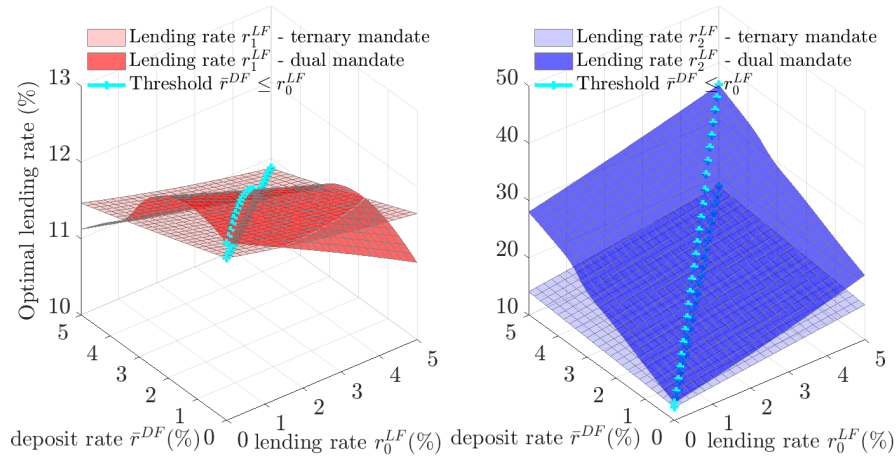
Note that the divergence in bank profits, default losses, inflation and the output gap across the ternary versus dual mandate emerges *only as the economy departs from the ZLB*. At the ZLB where $\bar{r}^{DF} = r_0^{LF} = 0$, the central bank achieves similar levels of its objectives regardless of whether it neglects financial stability considerations.⁵⁰ This result substantiates the idea that default is the driving force behind the adverse consequences of a lift-off. It is the channel that sharpens the policy trade-off to the central bank.

How do the optimal choices of the policy instruments affect this outcome? Figure 1.9 presents the comparison between a dual and a ternary mandate for the optimal level of lending facility rates in both states of nature and the optimal capital requirement. Under the dual mandate, the central bank sets the lending facility rate higher in both the good state and the adverse state compared to the ternary mandate. When neglecting default altogether, the central bank fails to take into account the effect of higher interest rates on agents' ability to roll over their short-term debt and service their long-term debt. This begs the question: what makes it optimal for the central bank to set state-contingent lending facility rates so prohibitively high to fight inflation (deflation) and subdued economic activity?

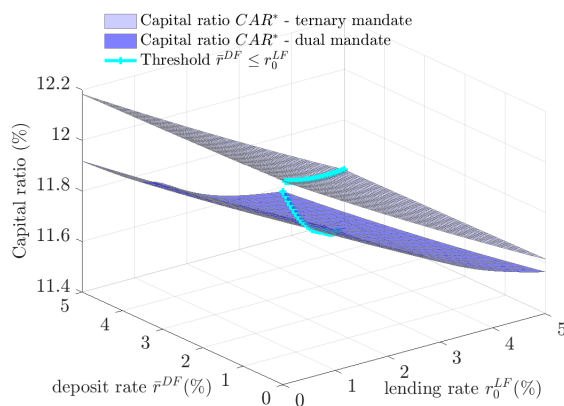
Recall that under a dual mandate, the central bank does not directly take into account that higher interest rates exacerbate the pecuniary externality of default on the price level. When the central bank expects an adverse supply shock to hit the endowment of the poor agent in the bad state, the central bank will want to support the poor by changing relative prices in the economy. In the adverse state, the supply shock pushes up the price of the relatively scarcer good (potatoes), making the indebted agent relatively poorer in absolute wealth terms.⁵¹ Because markets

⁵⁰Recall that we parameterize the model so as to match the *on-the-verge* condition of default at the ZLB, i.e. the point at which agents *just* repay their mortgage in full.

⁵¹Recall that heterogeneous households differ in their individual endowments of the two consumption goods, potatoes and housing.



(a) Policy rate in good state (b) Policy rate in bad state



(c) Capital ratio at $t = 0$

Figure 1.9. Optimal lending facility rates and capital requirement conditional on the interest rate corridor and central bank objectives.

Note: This figure shows comparative statics w.r.t. the interest rate corridor between the central bank's lending facility and deposit facility, i.e. r_0^{LF} and \bar{r}^{DF} at $t = 0$. The optimal levels of the lending facility rates in the good state $s = 1$ (red) and in the bad state $s = 2$ (blue) at $t = 1$ as well as the optimal capital requirement are displayed in panels (a)-(c), respectively, conditional on different widths of the interest rate corridor as determined along the horizontal axes. The figures distinguish between equilibria under a dual mandate (solid plane) and under a ternary mandate (transparent plane) with positive weight on financial stability objectives. The threshold line (light blue) separates feasible equilibria on the RHS from infeasible equilibria on the LHS.

are incomplete, the central bank can possibly improve upon the constrained sub-optimal allocations by affecting relative prices. It hence raises the policy rate to reduce house prices to support the poorer, indebted agent. This is in line with its objective of lowering inflation (a composite price index) and closing the output gap by stimulating trade. In so doing, the central bank however fails to realize that higher interest rates aggravate default losses and the resulting price externality. Recall that the central bank is assumed to be “boundedly rational” in the sense that it fails to take into account the second order effects of its actions. Hence, it achieves the very opposite by raising the lending facility rate too high in both states of nature.

Note that even in the good state the central bank does not manage to move inflation closer to target inflation under a dual mandate. Inflation increases while the negative output gap widens dramatically (see Figure 1.8 panel (a) and (c)). Two effects drive this result. First, from the central bank’s standpoint, it makes sense in an overheated economy to contract monetary policy so as to push down aggregate demand. However, the wider interest rate corridor under a dual mandate (Figure 1.9 panel (a)) paired with an even looser capital requirement (panel (c)) give too much incentive for banks to extend more credit. Thus, it increases credit *supply*. Second, the prospect of spiraling default losses in bad times also changes date-0 consumption choices of households. Since borrowers (lenders) cannot fully insure when markets are incomplete, they over-borrow (over-save) so as to compensate for the expected shortfall in consumption in bad times. This behavior leads to higher credit *demand* under a dual mandate than would be the case if default losses could be contained. Taken together, optimal policy under the dual mandate leads to more credit that drives inflation in the good state than would be the case under a ternary mandate.

In sum, under a ternary mandate, optimal monetary policy is still pro-cyclical in the sense that the optimal interest corridor is tighter in good times relative to downturns and interest rates are generally higher in downturns. However, it is less so than under a dual mandate. A dual mandate strongly exacerbates the pro-cyclicality of monetary policy in bad times, i.e. it induces a monetary contraction when the economy is faring badly.

Figure 1.9 panel (c) further underlines how the dual mandate falls short of employing policy instruments effectively to achieve the central bank's inflation and output objectives. The optimal *ex post* capital requirement is even looser under a dual mandate because the central bank does not internalize that a relaxation increases mortgage extension and consequently default. From an efficiency standpoint, this suggests that an additional instrument (the capital requirement) for an additional externality (fire-sale driven default) is only helpful if central banks optimize over an additional objective (the financial stability mandate) that is addressed through the instrument. As a mere bystander, the capital requirement may otherwise be futile, or in the worst case, do more harm as a means to the wrong end.

We finally check whether the *direction* of the lift-off effect from the ZLB on any of the endogenous variables changes depending on whether the central bank places relatively more weight on monetary policy versus financial stability objectives. In other words, conditional on a lift-off taking place, are there circumstances under which relative central bank preferences determine whether we observe an increase or a decrease in an observable? In unreported simulations, we establish that the relative weighing of monetary policy versus financial stability objectives, at least for small changes in weights, does not affect the *direction* of changes of endogenous variables with respect to a positive change in \bar{r}^{DF} . Therefore, whether the central bank cares more about monetary policy objectives relative to financial stability objectives, within small margins, does not affect the judgement call as to whether to depart from the ZLB or not.

Nevertheless, Figures 1.8 to 1.9 and additional simulations indicate that the *magnitude* of changes in the targeted objectives with respect to a change in the width of the interest rate corridor is larger when the central bank cares less about financial stability. An augmented mandate therefore smoothes the large effects that a lift-off from the ZLB has, in particular, on inflation and the output gap, and hence on volatility in consumption across states of nature. Moreover, a financial stability mandate mitigates the pro-cyclicality of monetary policy under a dual mandate to some extent. Relative to a dual mandate, it calls for a narrower policy corridor between borrowing and lending rates in good times and a narrower corridor in crises times.

In sum, whether the central bank considers financial stability or not does not change the direction that a departure from the ZLB means for optimal monetary and regulatory policy *instruments*. Yet, the magnitude of effects on policy *targets* – inflation, the output gap, bank profits, and default – is substantially affected by the choice and relevance of objectives of the central bank. Hence, monetary and financial stability policy are complements rather than substitutes.

1.8 Discussion

How does the main result of optimal pro-cyclical monetary policy square with the conventional view that central banks ought to set monetary policy rates counter-cyclically, accommodating in bad times and tightening in good times? Our simplified model with a perfectly competitive banking sector abstracts from many other real world frictions that affect the efficiency of the transmission mechanism – e.g. imperfect competition in the banking sector, informational frictions, and departures from rational expectations. Yet, it offers a first tentative take on the importance of modelling liquidity and default jointly to capture an at times neglected debt-deflation mechanism. It also stresses the role of default and financial intermediaries in complicating the transmission mechanism of monetary policy. This complexity can lead to seemingly counterintuitive results when trade-offs arise not only between monetary policy and financial stability objectives but also between mitigating default while supporting bank profitability. Provided that the health of the financial sector contributes to financial stability, central banks must strike a balance between countering economic downturns on the real side of the economy while guaranteeing the efficient transmission of their policies on the financial side of the economy. A procyclical tightening of the interest rate corridor in good times but supportive widening in bad times may strike this balance in the presence of liquidity and default risk premia. Our results thus offer a tentative argument for shifting attention not only to the level of interest rates but also the *size* of the interest rate corridor *conditional* on the level.

Contextualizing the results in the recent public debate, optimal pro-cyclical monetary policy is the result of a trade-off between stagflation in the good state

and debt-deflation in the adverse state.⁵² If the central bank were to act countercyclically, it would risk suppressing economic activity in the good state. It would thereby further exacerbate stagnation while not keeping supply-driven inflation under control. Conversely, in the adverse state, it would risk driving banks to the brink of collapse from default losses.

Assuming incomplete markets in this setting does not only lend itself to the study of default as an equilibrium phenomenon. It also gives meaning to central bank actions in a constrained Pareto suboptimal setting. Central banks may Pareto improve upon outcomes by affecting relative prices – and hence allocations by the Quantity Theory of Money – through their policy choices. By regulating liquidity in a liquidity-constrained economy, central banks effectively rein in money non-neutrality.

Our simplified model is amenable to studying more closely the role of macroprudential policies as a separate policy instrument to address externalities onto financial stability. Notwithstanding computational limitations to obtaining *optimal* levels of these instruments, there is scope to further explore the countercyclical nature of capital regulation. Future research should address the sensitivity of our results with respect to changes in the weights on risk-weighted assets in the definition of the capital ratio. It could also explore the benefits and costs of loan-to-value ratios in the mortgage market. This could yield further implications for the effectiveness of following the Tinbergen (1956) principle in the context of our model.

In sum, the presence of default in crises times exacerbates debt-deflationary forces in the economy. These forces prevent the central bank from bringing inflation to target in both states of nature, given the trade-offs between financial stability and monetary policy objectives that it faces. The output gap widens and bank profits fall as the economy departs from the ZLB. The question remains whether the failure to reach its inflation target could be mitigated by attaching more weight to the inflation objective in the central bank's objective function. We leave the determination of optimal relative policy weights from first principles to future research.

⁵²We want to stress here once again that the decision to lift off the ZLB is external to our numerical exercise and hence the central bank's decision set. Conditional on having to lift off, the central bank opts to minimize the fallout from credit-driven stagflation through a tighter, more prohibitive corridor in the stagflation state but a wider corridor in a default-driven recession.

1.9 Conclusion

This paper proposes a monetary general equilibrium model with a financial sector, a central bank, incomplete markets, collateral constraints, and default to analyze (a) how monetary policy and financial stability objectives affect optimal policies, and (b) how a departure of interest rates from the ZLB affects bank profitability, default, inflation, and economic activity when the central bank considers (i) only monetary policy objectives or (ii) also financial stability objectives. We add to the debate on whether the ECB should yield to its critics' claim that the low-for-long era has squeezed banks' profit margins and imperilled financial stability. We thereby give a tentative take on the normative question of whether the ECB ought to better align its policy mandate with financial stability objectives.

We draw several lessons from simulating the paths of inflation, the output gap, bank profitability, and default for various sizes of the interest rate corridor at and away from the ZLB. First, our findings do not corroborate the claim that bank profitability will be restored away from the ZLB. Instead, they highlight the need to take into account an additional salient channel of monetary tightening – the default channel. Any potential gains in banks' net interest margins from departing from the ZLB are more than offset by larger default losses on banks' loan portfolios due to higher debt servicing costs of the private sector. Second, a departure from the ZLB exacerbates default losses and default-induced debt-deflation when the price externality from default causes knock-on effects on aggregate demand. Finally, a dual mandate absent financial stability objectives increases the variance in targeted policy outcomes across states of nature. Pursuing financial stability objectives on top of the dual mandate makes optimal monetary policy less pro-cyclical.

Our findings question the arguments brought forward by popular advocates of a departure from the ZLB. We highlight the need to take the risk of a Fisherian debt-deflation seriously and consider debt levels in optimal monetary policy setting. We learn that it is pivotal to let the central bank control a regulatory policy instrument if it pursues goals to stabilize the financial system. Yet, our model does not provide insights into the *endogenous* decision to depart from the ZLB. Further research is warranted as to which endogenous mechanisms make it optimal for the central bank to abandon the lower bound.

Appendices of Chapter 1

Appendix 1.A List of variables

Table 1.A.1. Overview of model variables

e_{p,s^*}^α	: Endowment of the perishable good, potatoes p , of agent α in state $s \in S^*$
$e_{h,0}^\beta$: Endowment of durable good, housing h , of agent β in period $t = 0$
q_{p,s^*}^α	: Quantity of perishable good p offered for sale by agent α in $s \in S^*$
q_{h,s^*}^β	: Quantity of the durable good h offered for sale by agent β in $s \in S^*$
b_{h,s^*}^α	: Quantity of money spent by agent α to buy housing h in state $s \in S^*$
b_{p,s^*}^β	: Quantity of money spent by agent β to buy potatoes p in state $s \in S^*$
m_s^i	: Monetary endowment of household $i \in \{\alpha, \beta\}$ in state $s \in S^*$
p_{p,s^*}	: Price of potatoes p in state $s \in S^*$
p_{h,s^*}	: Price of housing h in state $s \in S^*$
$r_{s^*}^{ST}$: Short-term loan rate demanded by the commercial bank in state $s \in S^*$
\bar{r}^m	: Long-term mortgage rate demanded by the commercial bank
\bar{r}^d	: Long-term deposit rate offered by the commercial bank
ℓ_s^i	: Face value of intra-period borrowing by agent $i \in \{\alpha, \beta\}$ in state $s \in S^*$
β^i	: Subjective discount factor of agent $i \in \{\alpha, \beta\}$
$\gamma_{s^*}^i$: Subjective probability of agent $i \in \{\alpha, \beta\}$ of state $s \in S$ occurring
$\bar{\ell}^\alpha$: Face value of mortgage borrowing paid by agent α at $t = 1$
\bar{d}^β	: Deposits by agent β held with the commercial bank at $t = 0$
t_s^i	: Seignorage transfer to household $i \in \{\alpha, \beta\}$ at $t = 1$ in state $s \in S$
$\Pi_{s^*}^b$: Profit per period of the commercial bank in state $s \in S^*$
a^b	: Risk aversion coefficient of the commercial bank
$\ell_{s^*}^{ST}$: Total amount of short-term loans granted by the bank in state $s \in S^*$
$\bar{\ell}^{LT}$: Total amount of long-term loans granted by the commercial bank at $t = 0$
\bar{d}^{DF}	: Excess reserves deposited by the bank with the central bank at $t = 0$
\bar{d}^{LT}	: Face value of long-term deposits borrowed by the bank from household β to be repaid at $t = 1$
$\ell_{s^*}^{LF}$: Face value of short-term loan by the bank from the central bank in $s \in S^*$
$e_{s^*}^b$: Equity endowment of the commercial bank in state $s \in S^*$
\bar{r}^{DF}	: Deposit facility rate paid by the central bank on excess reserves deposited by the commercial bank
$r_{s^*}^{LF}$: Interest rate on central bank loans paid by the bank in $s \in S^*$
θ_o	: Weight put on policy objective $o \in \{b, \lambda, i, y\}$ in the CB's objective function
π_s	: Rate of inflation in state $s \in S$
π^*	: Target rate of inflation
y_s	: Level of GDP proxied by the aggregate volume of trade in $s \in S$
y_s^*	: Natural level of output achieved in a frictionless barter economy in $s \in S$
$M_{s^*}^{CB}$: Total credit granted by the central bank in the form of repo loans in $s \in S^*$
\bar{D}	: Borrowing of excess reserve deposits by the central bank in $s \in S^*$
w_s^{CB}	: Seignorage income earned by the central bank in $s \in S^*$
κ	: Share of seignorage transfer to the relatively "poorer" household α at $t = 1$

Appendix 1.B Additional Figures

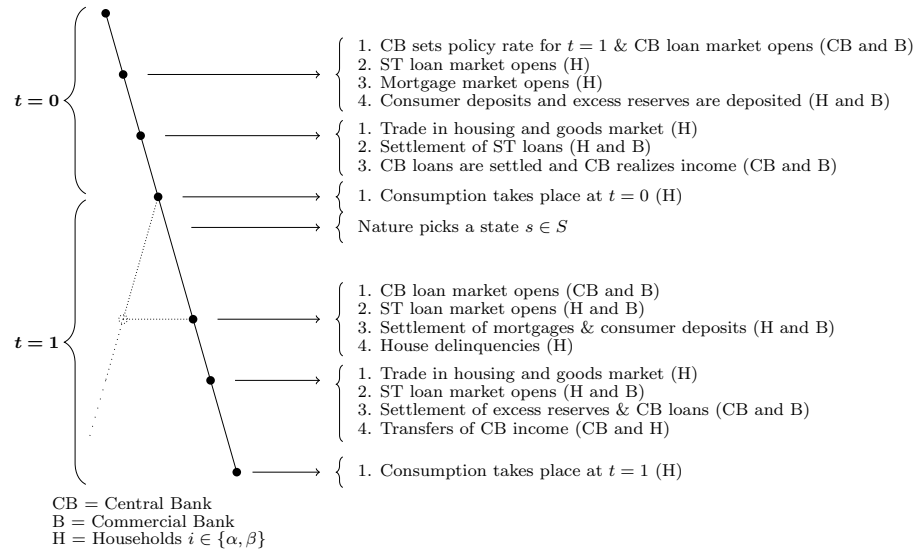


Figure 1.B.1. Model Timeline

Note: This figure displays a stylized timeline containing the sequence of events across the two periods $t = 0, 1$ and states of nature $s \in S$. Each node represents a set of events taking place simultaneously.

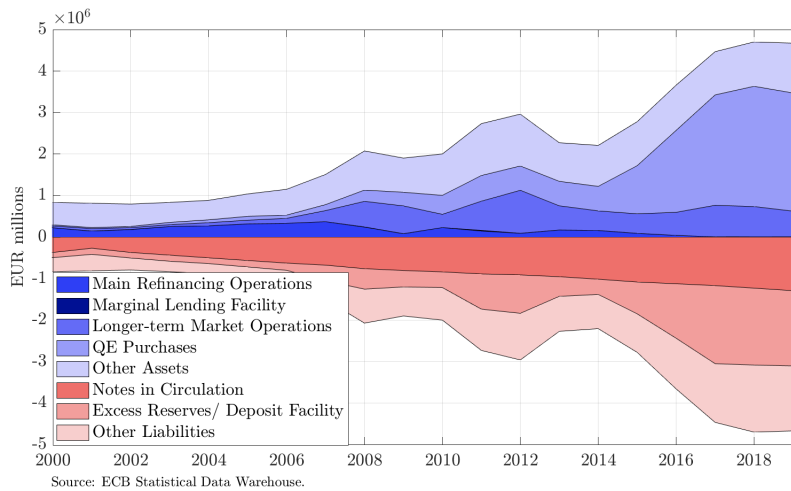


Figure 1.B.2. The ECB's consolidated balance sheet

Note: This figure presents the European Central Bank's (ECB) consolidated balance sheet. Data is retrieved from the ECB's Statistical Data Warehouse. Asset purchases not covered in this paper constitute the bulk of the balance sheet. However, a non-negligible share of positions is taken up by "traditional" lending and depositing arrangements with banks as in the model at hand, e.g. main refinancing operations and longer-term market operations, as well as excess reserves.

Appendix 1.C Additional Results

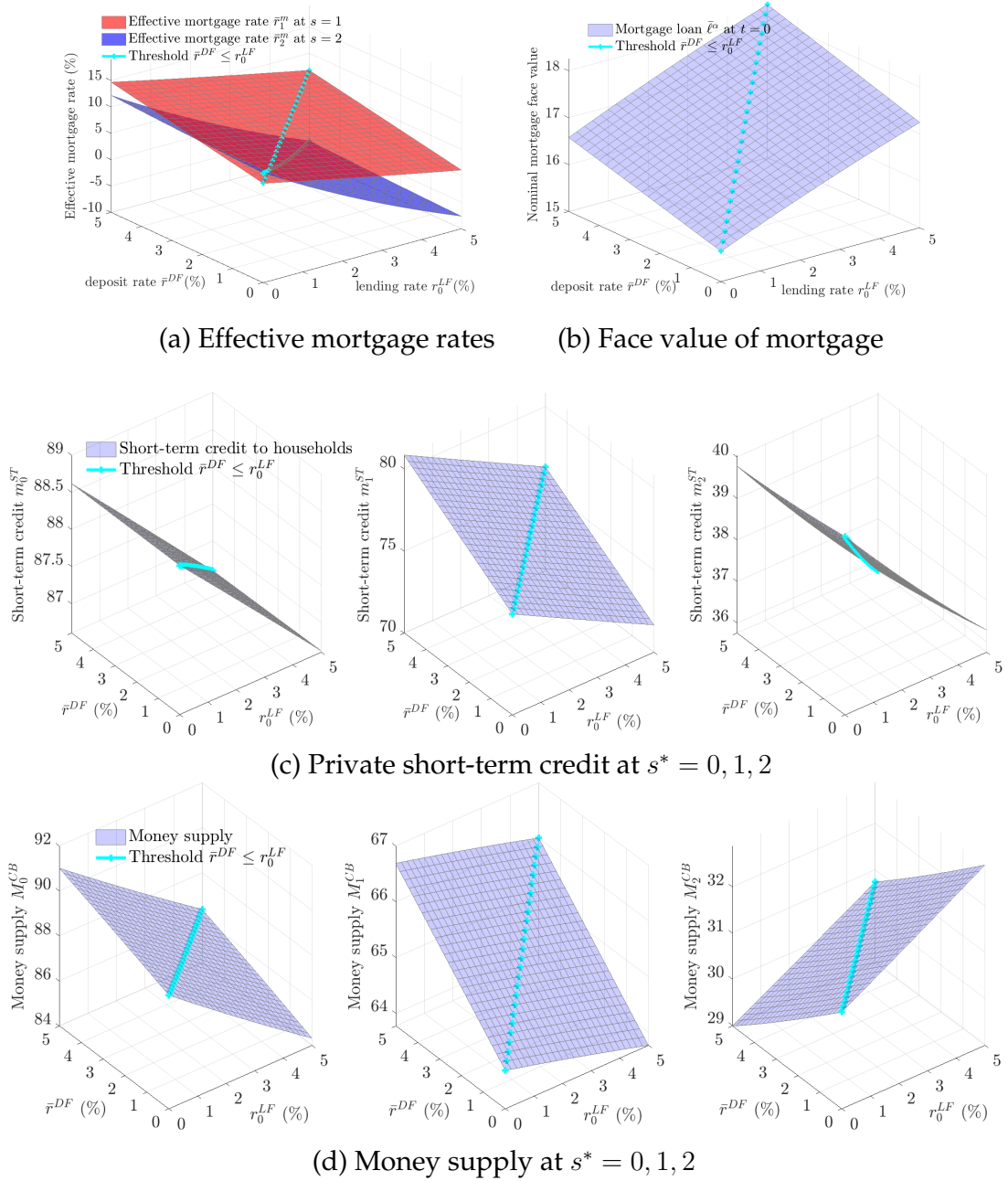


Figure 1.C.1. Mortgage market, short-term credit, and money supply conditional on the interest rate corridor.

Note: This figure shows the results of comparative statics with respect to the interest rate corridor between the central bank's lending facility and deposit facility, i.e. r_0^{LF} and \bar{r}^{DF} at $t = 0$. Panel (a) displays the feasible levels of the *realized* mortgage rate in the good state $s = 1$ (red) and in the bad state $s = 2$ (blue) conditional on different widths of the interest rate corridor as determined along the horizontal axes. Panels (b)-(d) displays the results of the same exercise for the mortgage face value, private short-term credit to households, and money supply by the central bank at $t = 0$, in the good state $s = 1$, and in the bad state $s = 2$, respectively. The threshold line (light blue) separates feasible equilibria on the RHS from infeasible equilibria on the LHS.

Appendix 1.D The Natural Level of Output

To obtain an estimate for the natural level of output in our endowment economy, we change our model to a barter economy without frictions stemming from money, default, and cash-in-advance constraints. In such a model, households trade directly with each other, obliterating the need for a financial sector and a central bank who injects money in the economy. The two optimization problems of households $i \in \{\alpha, \beta\}$ therefore simplify substantially. Agents are endowed with the same amounts of the durable and perishable consumption goods as in the GEI economy. Agent α chooses how many units $q_{p,s}^\alpha$ of the perishable good to sell. Agent β decides how many units $q_{h,s}^\beta$ of the durable good to sell in each state of nature. Prices are determined in equilibrium when the markets for both goods clear. There is no need for money as a transaction technology and hence no interest rate.

In the absence of frictions, the optimization problem of **household α** is given by

$$\max_{q_{p,s}^\alpha, q_{h,s}^\beta} U^\alpha = u(e_{p,0}^\alpha - q_{p,0}^\alpha) + u(q_{h,0}^\beta) + \beta^\alpha \sum_{s \in S} \gamma_s \left[u(e_{p,s}^\alpha - q_{p,s}^\alpha) + u(q_{h,0}^\beta + q_{h,s}^\beta) \right]$$

subject to

$$p_{h,0} q_{h,0}^\beta \leq p_{p,0} q_{p,0}^\alpha \quad (\Gamma 1^\alpha)$$

$$p_{h,1} q_{h,1}^\beta \leq p_{p,1} q_{p,1}^\alpha \quad (\Gamma 2^\alpha)$$

$$p_{h,2} q_{h,2}^\beta \leq p_{p,2} q_{p,2}^\alpha \quad (\Gamma 3^\alpha)$$

The optimization problem of **household β** is given by:

$$\max_{q_{p,s}^\beta, q_{h,s}^\alpha} U^\beta = u(q_{p,0}^\alpha) + u(e_{h,0}^\beta - q_{h,0}^\beta) + \beta^\beta \sum_{s \in S} \gamma_s \left[u(q_{p,s}^\alpha) + u(e_{h,0}^\beta - q_{h,0}^\beta - q_{h,s}^\alpha) \right]$$

Subject to

$$p_{p,0} q_{p,0}^\alpha \leq p_{h,0} q_{h,0}^\beta \quad (\Gamma 1^\beta)$$

$$p_{p,1} q_{p,1}^\alpha \leq p_{h,1} q_{h,1}^\beta \quad (\Gamma 2^\beta)$$

$$p_{p,2} q_{p,2}^\alpha \leq p_{h,2} q_{h,2}^\beta \quad (\Gamma 3^\beta)$$

Solving for the equilibrium allocations yields an optimal set of quantities traded, $q_{h,s}^{\alpha*}$ and $q_{p,s}^{\beta*}$. Given the same set of endowments of potatoes and housing presented in Section 1.7.2, the natural level of output is defined as the total volume of trade in each state of nature:

$$y_s^* = q_{h,s}^\alpha + q_{p,s}^\beta \quad \text{for } s \in S = \{1, 2\}$$

Solving the above program yields $y_1^* = 6.4909$ and $y_2^* = 3.3939$.

Appendix 1.E Proofs of Propositions

We present here the proofs that rely on agents' optimality conditions.

Proof of Proposition 1.1 From the two simplified first order conditions (FOCs) of the commercial bank,

$$\begin{aligned}\beta^b \gamma_1 (r_1^{ST} - r_1^{LF}) [1 - 2a^b \Pi_1^b] &= 0 \\ \beta^b \gamma_2 (r_2^{ST} - r_2^{LF}) [1 - 2a^b \Pi_2^b] &= 0\end{aligned}$$

we immediately see that either $r_s^{LF} = r_s^{ST}$ or $[1 - 2a^b \Pi_s^b] = 0$ for $s \in [1, 2]$. However, zero future marginal profits would imply in the following FOC,

$$(1 + r_0^{LF})(1 - 2a^b \Pi_0^b) - (1 + \bar{r}^d) \beta^b \left[\gamma_1 (1 + r_1^{LF})(1 - 2a^b \Pi_1^b) + \gamma_2 (1 + r_2^{LF})(1 - 2a^b \Pi_2^b) \right] = 0$$

that also period-0 marginal profits would need to be zero. This in turn would mean by the following FOC

$$\begin{aligned}(1 + r_0^{LF})(1 - 2a^b \Pi_0^b) - (1 + \bar{r}_1^m) \beta^b \gamma_1 (1 + r_1^{LF})(1 - 2a^b \Pi_1^b) \\ - (1 + \bar{r}_2^m) \beta^b \gamma_2 (1 + r_2^{LF})(1 - 2a^b \Pi_2^b) + \omega^{LT} CAR_0 \Lambda_4^b = 0\end{aligned}$$

that either the capital requirement or the Lagrange multiplier would need to be zero. A zero Lagrange multiplier would imply by complementary slackness that the capital requirement would not bind. Since we rule out non-binding and zero capital requirements, the only way for all optimality conditions to hold is that $r_s^{LF} = r_s^{ST}$ for $s \in [1, 2]$. This can be easily generalized to $s \in S^*$.

Proof of Proposition 1.2 The result that $\bar{r}^{DF} = \bar{r}^d \quad \forall s \in S^*$ follows immediately from the FOCs of the commercial bank. Eliminating the Lagrange multipliers in the FOCs of the commercial bank by substitution, and subtracting the resulting equations

$$(1 + r_0^{LF})(1 - 2a^b \Pi_0^b) - (1 + \bar{r}^d) \beta^b \left[\gamma_1 (1 + r_1^{LF})(1 - 2a^b \Pi_1^b) + \gamma_2 (1 + r_2^{LF})(1 - 2a^b \Pi_2^b) \right] = 0$$

$$(1 + r_0^{LF})(1 - 2a^b \Pi_0^b) - (1 + \bar{r}^{DF}) \beta^b \left[\gamma_1 (1 + r_1^{LF})(1 - 2a^b \Pi_1^b) + \gamma_2 (1 + r_2^{LF})(1 - 2a^b \Pi_2^b) \right] = 0$$

immediately results in $\bar{r}^{DF} = \bar{r}^d \quad \forall s \in S^*$ which must hold in equilibrium if household β rationally optimizes. This can be generalized to a finite number of states $s \in S^*$. \square

Proof of Proposition 1.6 From the market clearing conditions and household α 's FOCs, simply note that,

$$\frac{\beta^\alpha \gamma_s u'(q_{h,0}^\beta + q_{h,s}^\beta)}{u'(q_{h,0}^\beta) + \beta^\alpha \gamma_s u'(q_{h,0}^\beta + q_{h,s}^\beta)} = \frac{(1 + \bar{r}^m)}{p_{h,s}/p_{h,0}} \quad \forall s \in S_g$$

where the LHS equals the intertemporal marginal rate of substitution between consuming housing tomorrow versus today, which we define as the gross real interest rate $(1 + \tilde{r})$. The RHS equals the ratio of the gross intertemporal nominal interest rate to the gross rate of inflation of house prices. \square

Notes on Proposition 1.3 We start by noting that the central bank's balance sheet constraint in the first period is given by equation (Λ_2^{CB})

$$M_0 \leq \frac{\bar{D}}{1 + \bar{r}^{DF}} + m_0^{CB}$$

which must be binding in equilibrium. Substituting the market clearing conditions (MC_{10}) and (MC_{12}) and rearranging, we get

$$\frac{\ell_0^{LF}}{(1 + r_0^{LF})} - \bar{d}^{DF} = m_0^{CB}$$

We then use the budget constraint of the commercial bank given by equation (Λ_5^b) and plug market clearing conditions (MC_6) , (MC_8) , and (MC_{11}) into it

$$\begin{aligned} \ell_0^{ST} + \bar{\ell}^{LT} + \bar{d}^{DF} - \frac{\bar{d}^{LT}}{(1 + \bar{r}^d)} - \frac{\ell_0^{LF}}{(1 + r_0^{LF})} - e_0^b &= 0 \\ \frac{\ell_0^\alpha + \ell_0^\beta}{(1 + r_0^{LF})} + \frac{\bar{\ell}^\alpha}{(1 + \bar{r}^m)} + \bar{d}^{DF} - \bar{d}^\beta - \frac{\ell_0^{LF}}{(1 + r_0^{LF})} - e_0^b &= 0 \end{aligned}$$

Rearranging this and plugging it into the central bank's budget constraints above, we get

$$\frac{\ell_0^\alpha}{(1+r_0^{LF})} + \frac{\bar{\ell}^\alpha}{(1+\bar{r}^m)} + \frac{\ell_0^\beta}{(1+r_0^{LF})} - \bar{d}^\beta = m_0^{CB} + e_0^b$$

Noting that we can substitute household α 's budget constraint in (Λ_1^α) into the first two terms above and household β 's budget constraint in (Λ_1^β) into the middle two terms, we get

$$\begin{aligned} p_{h,0}q_{h,0}^\beta - m_0^\alpha + p_{p,0}q_{p,0}^\alpha - m_0^\beta &= m_0^{CB} + e_0^b \\ \Rightarrow p_{h,0}q_{h,0}^\beta + p_{p,0}q_{p,0}^\alpha &= m_0^\alpha + m_0^\beta + m_0^{CB} + e_0^b \end{aligned}$$

The price level is pinned down by the existence of outside money in the economy. The central bank's budget constraint is determined by the available monetary endowments in the first period. Similar results can be derived for the second period. Moreover, the Quantity Theory of Money holds since the circulation of money in the economy directly affects prices and allocations. \square

Appendix 1.F Numerical Solution Method

The “Envelope Theorem Approach”

In this appendix, we sketch the basic approach that we take in order to retrieve numerical solutions to the partial derivatives – the changes of endogenous variables with respect to a change in the lending facility rates r_1^{LF} , r_2^{LF} , and the capital requirement CAR_0 in the optimization problem of the central bank – presented in Section 1.4.3. Our point of departure is the envelope theorem.

Loosely speaking, the envelope theorem for unconstrained optimization can be summarized as follows. For a function $f(x, p)$ with an endogenous variable x and a parameter p that we want to maximize, we retrieve a unique solution $x^*(p)$ for which the function achieves a maximum $f^*(p) = f(x^*(p), p)$. If we want to find the derivative of the value function f^* with respect to the parameter p , then we must only consider the *direct* effect of the parameter on the function, holding the value of x fixed at its optimal level $x^*(p)$. We can neglect the *indirect* effect that results from the change in the optimal value of x caused by a change in the parameter p . Formally,

$$\frac{d}{dp}f(x^*(p), p) = \frac{\partial}{\partial p}f(x^*(p), p) + \underbrace{f'(x^*(p), p) \frac{\partial x^*(p)}{\partial p}}_{=0}$$

where the indirect effect $f'(x^*(p), p) \frac{\partial x^*(p)}{\partial p}$ is zero. A similar reasoning applies to constrained optimization problems. We leave a more formal treatment to economics textbooks. The basic idea in the context of our model is to treat the lending facility rates r_1^{LF} and r_2^{LF} as parameters and the endogenous variables in (Λ_1^{CB}) as value functions, i.e. as functions that depend on other endogenous variables that are already optimized in equilibrium.

Let’s take loans from the central bank, ℓ_s^{LF} , as an example. We want to know how central bank lending to the bank in equilibrium changes when the lending facility rate changes, i.e. $\partial \ell_s^{LF} / \partial r_s^{LF}$. Intuitively, if the cost of refinancing of banks changes, this will affect their supply of credit to households, which will in turn affect households’ trade behavior via cash-in-advance constraints, and ultimately their consumption. The loan from the central bank, ℓ_s^{LF} , is therefore an (implicit) function f of the lending facility rate and of other endogenous variables in the system, subsumed in the vector \mathbf{X}_s^* , which are in turn functions of the lending facility rate and endogenous variables (abbreviated by “...” for convenience), i.e.,

$$\begin{aligned} \ell_s^{LF}(r_s^{LF}, \dots) &= f\left(r_s^{LF}, m_s^{ST*}(r_s^{LF}, \dots), \ell_s^{\alpha*}(r_s^{LF}, \dots), \ell_s^{\beta*}(r_s^{LF}, \dots), \dots\right) \\ &\equiv f\left(r_s^{LF}, \mathbf{X}_s^*(r_s^{LF}, \dots)\right) \end{aligned}$$

Evoking the envelope theorem, we are not interested in the indirect effect of the

lending facility rate via other endogenous variables,

$$\frac{d}{dr_s^{LF}} f\left(r_s^{LF}, \mathbf{X}_s^*(r_s^{LF}, \dots)\right) = \frac{\partial}{\partial r_s^{LF}} f\left(r_s^{LF}, \mathbf{X}_s^*(r_s^{LF}, \dots)\right) + f'\left(r_s^{LF}, \mathbf{X}_s^*(r_s^{LF}, \dots)\right) \underbrace{\frac{\partial \mathbf{X}_s^*}{\partial r_s^{LF}}}_{=0}$$

but only in the direct effect $\partial \ell_s^{LF*} / \partial r_s^{LF}$. We can then apply the chain rule to all optimality conditions, i.e. all first order conditions of all agents and market clearing conditions. All optimality conditions must hold in equilibrium. They must still hold in equilibrium after a change in the lending facility rate has taken place. Therefore, all changes in endogenous variables with respect to a change in the lending facility rate must add up to zero for a given set of optimal endogenous variables, \mathbf{X}_s^* .

We illustrate our approach in the following example. We plug the market clearing conditions into one of the first order conditions of household α ,⁵³

$$u'(e_{p,0}^\alpha - q_{p,0}^\alpha) - \frac{p_{p,0}}{p_{h,0}(1+r_0^{ST})} \left[u'(q_{h,0}^\beta) + \beta^\alpha \gamma_1 u'(q_{h,0}^\beta + q_{h,1}^\beta) \right] = 0$$

Applying the chain rule, we write the above optimality condition as a sum of partial changes with respect to the lending facility rates r_1^{LF} and r_2^{LF} . Invoking the envelope theorem, we neglect all indirect effects via other endogenous variables in the system:

$$\begin{aligned} & -u''(e_{p,0}^\alpha - q_{p,0}^\alpha) \frac{\partial q_{p,0}^\alpha}{\partial r_1^{LF}} - \frac{p_{p,0}}{p_{h,0}(1+r_0^{ST})} \left[u''(q_{h,0}^\beta) \frac{\partial q_{h,0}^\beta}{\partial r_1^{LF}} + \beta^\alpha \gamma_1 u''(q_{h,0}^\beta + q_{h,1}^\beta) \left(\frac{\partial q_{h,0}^\beta}{\partial r_1^{LF}} \right. \right. \\ & \left. \left. + \frac{\partial q_{h,1}^\beta}{\partial r_1^{LF}} \right) \right] - \left[u'(q_{h,0}^\beta) + \beta^\alpha \gamma_1 u'(q_{h,0}^\beta + q_{h,1}^\beta) \right] \left[\frac{1}{p_{h,0}(1+r_0^{ST})} \frac{\partial p_{p,0}}{\partial r_1^{LF}} \right. \\ & \left. - \frac{p_{p,0}}{(p_{h,0})^2(1+r_0^{ST})} \frac{\partial p_{h,0}}{\partial r_1^{LF}} - \frac{p_{p,0}}{p_{h,0}(1+r_0^{ST})^2} \frac{\partial r_0^{ST}}{\partial r_1^{LF}} \right] = 0 \end{aligned}$$

We repeat these steps for all first order conditions of agent α , agent β , and the commercial bank, and also with respect to the capital requirement CAR^* . We thus obtain a system of equations that are *linear* in partial derivatives. In theory, the endogenous variables that serve as coefficients on the partial derivatives to be solved for can be considered as “exogenous” because they are already optimized in our initial partial equilibrium. Note that all period-0 and period-1 variables

⁵³For both households α and β we assume CRRA utility of the form $u(c_s^i) = (1-\rho)^{-1}(c_s^i)^{1-\rho}$ with the first and second derivatives given by $u'(c_s^i) = (c_s^i)^{-\rho}$, $u''(c_s^i) = (-\rho)(c_s^i)^{-\rho-1}$. Moreover, we neglect income transfers from the central bank to households for now in order to make the problem more tractable.

change both in response to r_1^{LF} , r_2^{LF} , and CAR^* . Plugging all of these equations and the original optimality condition into a computer program, one can jointly solve for numerical values of all endogenous variables and all partial derivatives. The latter are inserted into the two FOCs of the central bank. Thus, we apply the following algorithm.

- (1) Make an initial guess of the *partial equilibrium* without monetary and regulatory policy.
- (2) Solve for a partial equilibrium excluding the central bank using the initial guess.
- (3) Solve the system of *envelope conditions* using values of the partial equilibrium to retrieve values for the partial derivatives.
- (4) Solve the system of envelope conditions and the partial equilibrium conditions *jointly* until convergence.
- (5) Plug numerical values of partial derivatives into the CB's FOCs as starting values.
- (6) Solve for a *general equilibrium*.
- (7) Iterate until convergence.

The shortcoming of the “envelope theorem approach” is that we have to draw on a number of strong assumptions. First, we assume that the initial partial equilibrium is already a general equilibrium such that all optimality conditions are fulfilled. However, we think that using computational methods to iteratively improve on the initial partial equilibrium will bring us closer to the true general equilibrium. Of course any equilibrium is local in nature and depends on the initial calibration used.

Second, unless we make additional assumptions about the rationality of the central bank and its information set, the dimension of the system of simultaneous linear and non-linear equations would explode. We therefore assume that the central bank cannot understand the *indirect* effects of change in the lending facility rate on all endogenous variables in the system. It can only gauge the *direct* effects on the optimality conditions on which it has perfect information. Lastly, we abstract from strategic behavior. Households and the bank take the central bank's actions as given.

In conclusion, we believe that this approach is most flexible to being tailored to economic behavior under different assumptions about the beliefs of the central bank. It makes it possible to retrieve numerical values to solve for first order conditions of the central bank, and, possibly endogenously solve for a general equilibrium. However, we realize that an adequate initial equilibrium that serves as starting values is crucial to finding a solution. This makes the computational process more tedious and time-consuming.

The Role of Financial Stability for Monetary Policy in Emerging Market Economies*

Abstract Emerging Market Economies (EMEs) are exceptionally exposed to currency fluctuations that create domestic financial imbalances and vulnerabilities to external financial shocks. The question as to whether central banks in EMEs should adopt “leaning against the wind” (LAW) policies to combat financial stability risks is therefore more complex. Using the Mexican economy as a laboratory, I build a small open economy New-Keynesian model with banks and endogenous firm default. I compare the performance of alternative monetary policy rules that react to the destabilizing forces of an external funding shock to banks’ balance sheet. My findings support an interest rate rule augmented by the credit spread, which is a summary statistic of firm default risk and the regulatory cost of bank capital. A LAW policy rule reduces the volatility in response to an external financial shock on both the real and financial side of the economy. This is because monetary policy tightens initially, so as to stabilize the exchange rate, but eases in the medium term, so as to alleviate funding conditions.

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2.1 Introduction

Should monetary policy lean against financial imbalances to mitigate risks to financial stability? The trade-offs of leaning against the wind (LAW) policies have been studied extensively for Advanced Economies (AEs) (Cesa-Bianchi & Rebucci, 2017; Cúrdia & Woodford, 2016; Gourio, Kashyap, & Sim, 2018; Svensson, 2017; Woodford, 2012) but less so for Emerging Market Economies (EMEs) (Aoki, Benigno, & Kiyotaki, 2018; Bianchi & Mendoza, 2020; Ghosh, Ostry, & Chamon, 2016). EMEs differ from AEs in important ways, making the effects of LAW policies more complex. Historically, the “original sin” of not being able to freely borrow in local currency abroad (Eichengreen & Hausmann, 1999) has made EMEs inherently vulnerable to “fickle” capital flows. These capital flows have led to overborrowing in foreign currency in good times and balance-of-payments crises when shocks hit (Caballero & Simsek, 2020; Mendoza, 2010). Taking Mexico as an example, Figure 2.1 illustrates how in particular the financial and non-financial corporate sectors have held a substantial proportion of debt in foreign currency over the past decade. EMEs are hence dependent on investors’ assessment of default and liquidity risks to safeguard international funding. Their vulnerability to capital flow reversals and currency devaluations raises the need to understand how frictions in financial markets affect the transmission of external shocks and domestic monetary policy.

Taking the Mexican economy as a laboratory, this paper explores whether there are benefits of reacting to financial stability risks for monetary policy in EMEs. I first investigate the mechanism through which an external shock to financial intermediaries’ funding propagates through the domestic economy under a conventional inflation targeting rule. I then compare the performance of alternative interest rate rules² to shed light on the normative question of whether central banks in EMEs ought to lean against the build-up of financial stability risks.³ To that end, I augment a small open economy (SOE) New Keynesian (NK) DSGE model by adding a banking sector and introducing endogenous default in the corporate

²Using the terminology of Schularick et al. (2021), I focus on systematic LAW policy rules (S-LAW) that require central banks to respond to financial imbalances using fixed rules as opposed to discretionary LAW policies actions (D-LAW).

³Put differently, the question arises how central banks should respond to the domestic financial cycle in light of the Global Financial Cycle (Aldasoro, Avdjiev, et al., 2020; Rey, 2015).

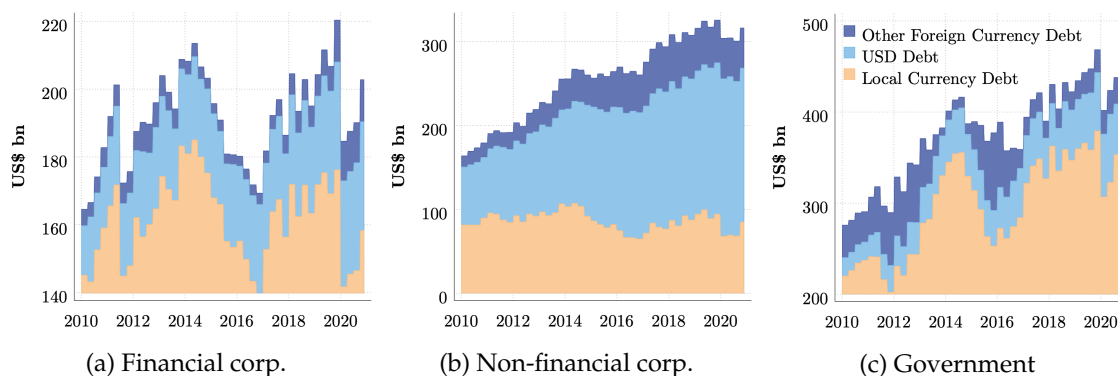


Figure 2.1. Currency composition of Mexican debt by sector

Note: This figure presents a decomposition of Mexican debt issued by the financial and non-financial corporate sectors and the government sector, respectively, (in US\$ bn) into its currency components. The data is based on the quarterly global debt monitor of the Institute of International Finance (IIF).

loan market. The innovation of this paper is to propose a firm-bank nexus that yields financial amplification and creates a non-trivial trade-off for monetary policy makers in the face of currency mismatch and default.

The effect of the US “Taper Tantrum” on the Mexican economy serves as a relevant case to illustrate the nature of this trade-off. Motivated by the unexpected rise in US yields in May 2013, I limit my attention to the effects of an exogenous shock to the interest rate paid on foreign debt. The shock triggers an exchange rate depreciation and restricts banks’ ability to meet foreign currency debt.⁴ In a world of large capital flows and nominal price rigidities, how should an EME like Mexico with an open capital account respond to US monetary tightening? Drawing on the seminal contributions by Mundell (1963) and Fleming (1962), conventional wisdom has it that countries should let their exchange rate depreciate freely. The corresponding domestic monetary expansion stimulates exports, thereby offsetting downward pressure on export demand from the center country (the trade channel).⁵ Domestic monetary policy thus retains its independence and effectiveness under floating exchange rates.

⁴In an additional exercise, I also consider an external shock the country risk premium paid on banks’ external debt. This shock may e.g. represent changes in global investors’ risk appetite in the spirit of the Global Financial Cycle (Miranda-Agrippino & Rey, 2020; Rey, 2015). The two shocks yield similar qualitative results.

⁵Additionally, consumption of domestic goods relative to imported goods becomes more attractive, boosting domestic demand (the expenditure switching channel).

The insightful empirical work by Rey (2013, 2015) questions this view: floating exchange rates cannot perfectly insulate EMEs with free capital mobility from the Global Financial Cycle and hence from US monetary policy. When domestic asset markets are very sensitive to the Global Financial Cycle, an exchange rate depreciation weakens domestic balance sheets, reduces collateral values, and triggers deleveraging. The effect of these adverse *financial spillovers* counters the traditional shock absorbing property of the nominal and real exchange rate. Gourinchas (2018) argues that moderate financial spillovers are not sufficient to overturn the Mundellian trilemma: a domestic monetary expansion may still be optimal in the face of a US monetary contraction. Yet, if financial spillovers are exceedingly strong, the central bank's optimal response is to mimic the Federal Reserve by responding with a domestic *tightening* in order to stabilize the exchange rate. The trilemma thus reduces to a dilemma: under free capital mobility, monetary policy is dictated by the Global Financial Cycle – or US monetary policy – regardless of the exchange rate regime.⁶ This paper analyzes the central bank's trade-off between macroeconomic and financial stability objectives in the presence of strong financial spillovers.⁷

Conditional on this premise, how much monetary tightening is "appropriate"? The presence of default and banks in my model gives rise to an *additional* trade-off for monetary policy. When the external shock hits, the strong passthrough of exchange rate depreciation to inflation requires a central bank who follows a rules-based inflation-targeting approach to react strongly by hiking the policy rate. On the one hand, too sharp of a hike in financial conditions can push heavily levered firms to the brink of default, leading to a rise in non-performing loans on banks' balance sheet. Financial amplification can depress economic activity even further. Because a sharp hike also shuts down the traditional trade channel of external adjustment, the fallout in economic activity gets reinforced. Thus, the cost of leaning against the wind by tightening too strongly could be to exacerbate a financial crisis rather than mitigate it (Schularick et al., 2021). Conversely, if the central bank reacts too little to the deterioration in the purchasing power of its currency, it can fail

⁶Conversely, Obstfeld (2015) argues that "independent monetary policy is feasible for financially open EMEs, but limited in what it can achieve".

⁷"Spillovers" are defined in the sense that currency movements spill over to agents' balance sheets, thus affecting their borrowing capacity.

to stabilize the exchange rate sufficiently to prevent capital outflows. The resulting high inflation and difficulty to meet foreign-currency debt can lead to an equivalent economic downturn depending on the strength of the trade channel.⁸ Hence, the pecuniary externality of default (Bianchi & Mendoza, 2020), which firms do not internalize, gives justification for the central bank to internalize the effect of its monetary policy decision onto the level of default in the economy through a LAW interest rate rule.⁹

I find support for extending the central bank's mandate by a LAW policy. An interest rate rule augmented by the credit spread, a proxy for macro-financial risk, outperforms the status quo inflation-targeting rule and the Taylor rule in terms of volatility in consumption, output, and investment. It also achieves lower non-performing loan (NPL) levels. The credit spread is the wedge that banks earn on their risky loan portfolio. It is a forward-looking summary statistic of both expected default and the banks' risk of violating the capital requirement. The main cost of adopting a LAW interest rate rule in my model is that lower initial inflation comes at the expense of deflation in the medium to longer run. Although this finding is puzzling, the benefits of a LAW policy do not come at the expense of lower economic activity in contrast to what cost-benefit analyses for AEs suggest (Svensson, 2017). Conversely, I find that the Taylor rule exacerbates the negative output gap, inflation, and investment in the long run. This is consistent with the stylized fact that the "divine coincidence" does not obtain in EMEs.¹⁰

Beyond the assessment of LAW policy, this paper offers a framework to analyze the transmission of external financial shocks to the real sector in the presence of financial frictions. On the macroeconomic side, I use a canonical SOE-NK model à la Galí and Monacelli (2005). On the financial side, I introduce default

⁸Given the importance of exchange rate stabilization, targeted FX interventions by the central bank could be a more efficient instrument than conventional monetary policy (Ottonello, 2021). Yet, FX interventions are a viable option only if the central bank is endowed with sufficient reserves. Monetary policy remains the last line of defence.

⁹One shortcoming of a rules-based approach is that it imposes a linear relationship to address non-linear amplification. I leave the more complex task of modelling a social planner who accounts for non-linearities in an open economy model with endogenous default to future research.

¹⁰In contrast to EMEs, AEs may benefit from the divine coincidence (Blanchard & Galí, 2007). Under fairly restrictive assumptions in the NK model, the divine coincidence implies that stabilizing inflation automatically stabilizes the output gap and vice versa. The divine coincidence however fails in practice, even more so in EMEs, as perceived by central banks.

by firms on unsecured credit as in Andreev et al. (2019) and Martínez et al. (2020). Shocks in international financial markets are transmitted to the real economy via a perfectly competitive banking sector. Banks accumulate capital out of retained earnings subject to a capital adequacy requirement akin to Gerali et al. (2010). The cost of regulatory compliance enters credit spreads, which creates an additional feedback between banks' balance sheet and the business cycle.¹¹

The existence of default in the economy generates a financial accelerator mechanism in the spirit of Bernanke, Gertler and Gilchrist (BGG) (1999). Endogenous developments in credit markets adversely propagate to the real economy via banks' balance sheet. Following Shubik and Wilson (1977), firms choose to renege on a fraction of their outstanding loan obligation to the bank. However, they incur a cost for renegotiating the terms of their loan for the following period. The cost is a function of aggregate credit conditions (Andreev et al., 2019; Goodhart, Peiris, & Tsomocos, 2018). Firm default rates therefore move endogenously over the business cycle.¹² An economic boom endogenously fuels default because it makes renegotiation less costly. The borrowing and default decisions of firms amplify the effect of the negative external shock as banks incur loan losses and credit contracts. Households suffer from this indirectly through their savings in the form of deposits and directly through subdued labor demand.

The simulations of the calibrated model capture the financial transmission channel of foreign monetary policy in small open economies similar to Aoki et al. (2018) and as empirically documented by Morais, Peydró, Roldán-Peña, and Ruiz-Ortega (2019) for Mexico. An adverse external shock to the interest rate paid by banks on foreign debt generates an initial spike in inflation and a drop in output as expected. The central bank responds by raising the monetary policy rate in the first two quarters. The resulting surge in firm defaults after the shock triggers a prolonged credit crunch. Banks shrink their balance sheet as foreign funding dries up and NPLs impair their loan portfolio. Although the central bank manages to stabilize inflation under the inflation-targeting interest rate rule, the economy enters a prolonged default-driven recession. By contrast, under the LAW policy rule, the

¹¹A policy rule that captures both excessive credit and capital shortfall can be justified on the grounds of evidence that credit growth is an important predictor of financial crises (Jordà et al., 2011; Schularick & Taylor, 2012).

¹²Loosely speaking, default works as an "insurance" for firms against business cycle fluctuations.

central bank reacts more forcefully upon impact of the shock. It tightens monetary policy more aggressively to counter the adverse effect of exchange rate depreciation on inflation and aggregate demand. But it also follows up by countercyclical monetary easing in the medium term in contrast to standard interest rate rules. These measures mitigate the adverse effect of the shock on NPL losses and contain the contraction in bank credit.

This paper contributes to our understanding of policy responses to external financial shocks through two important model features: default and banks. First, note that the idea of augmenting a standard Taylor rule by a measure of credit spreads is not new. Other papers model financial frictions that draw a wedge between borrowing and lending rates to which monetary policy ought to react (Cúrdia & Woodford, 2010, 2016; Mimir & Sunel, 2019). Yet, the types of financial frictions tend to abstract from default as an equilibrium phenomenon that causes deadweight losses.¹³ In these settings, credit risk does not arise from the decisions of optimizing agents but from exogenous distortions. By contrast, in my model, credit spreads emerge from the strategic default decisions of firms, as well as from the regulatory cost faced by banks. Because agents do not internalize the effect of their decisions, there are pecuniary externalities that give justification for policy makers to intervene.

Second, augmenting the Mundell-Fleming framework with default and banks allows financial stability to impact upon macroeconomic stability, creating the type of boom and bust cycles observed in EMEs (Reinhart & Reinhart, 2009). In the presence of financial frictions and a strong pass-through of currency movements to prices, the Mundellian trilemma reduces to a dilemma (Rey, 2015). A floating exchange rate alone is not sufficient to boost economic activity through the trade channel in response to US monetary tightening. Currency depreciation adversely affects macroeconomic stability when external shocks get amplified through banks' balance sheets and firms' risk-taking. Stabilizing inflation requires stabilizing the exchange rate, thus forgoing the beneficial effect of a sustained depreciation on exports.¹⁴ The financial channel of exchange rate adjustment there-

¹³Instead they highlight barriers to efficient financial intermediation.

¹⁴In the extreme case of perfect exchange rate pass-through, inflation and the exchange rate become isomorphic as nominal anchors.

fore makes it all the more pertinent (i) to model internationally active banks in the context of external financial shocks and (ii) to analyze whether LAW policies that address financial vulnerabilities of intermediaries may improve upon standard prescriptions.

Note that the presence of banks and currency mismatch in the model alone likely would not generate the type of “strong” financial spillovers (Gourinchas, 2018) needed to break the Mundellian trilemma. Banks could offset the loss in foreign funding by switching to domestic deposits. The financial accelerator between the real and the financial sector is at the heart of the required feedback. Default adds another layer of complexity to the central bank’s trade-off. Introducing both default in the productive sector and maturity mismatch on banks’ balance sheets generates amplification in two opposite directions: forceful tightening benefits banks initially but it also exacerbates firm delinquencies, increases debt deflation, and depresses economic activity. This second round effect counters the beneficial effect of currency stabilization on banks’ balance sheets. Assessing the extent to which default changes the hawkishness of the policy response relative to the Mundellian prescription will require a quantitative assessment of the model, ideally estimated on Mexican NPL data, going forward.

The paper proceeds as follows. Section 2.2 places the paper into the existing literature. Section 2.3 presents a case study of the effect of the US Taper Tantrum on the Mexican economy to delineate the monetary policy trade-off at hand. Section 2.4 outlines the model including the behavior of all agents and the monetary policy rule. Section 2.5 presents the calibration. Section 3.6 explains the expected external shock transmission channel and demonstrates the results for a shock to the foreign interest rate. Section 2.7 discusses limitations to the analysis and future avenues. Section 2.8 concludes.

2.2 Related Literature

This paper relates to several strands of literature, including a growing body of work on LAW monetary policy, on EMEs’ vulnerabilities to external shocks, and on endogenous default as a driver of price dynamics.

LAW policy rules. Since the Global Financial Crisis (GFC), a sizeable body of work has explored the performance of (ad hoc) LAW policy rules that respond to risks originating in financial frictions. In the context of AEs, Cúrdia and Woodford (2010) find that a forward-looking Taylor rule augmented by the credit spread may perform better depending on the cause of changes in credit spreads. In the context of EMEs, Mimir and Sunel (2019) show that an interest rate rule augmented by a measure of financial distortion – e.g. the level of credit, asset prices, real exchange rate, or credit spreads – achieves a higher level of welfare than an optimized Taylor rule.¹⁵ Other policy rules augmented by a Merton-type measure of distance to default (Garcia, Gray, Luna, & Restrepo, 2011) and firm delinquencies (Roldán-Peña, Torres-Ferro, & Torres García, 2017) come closer to my proxy of default risk in the central bank’s policy rule. Similar to my findings, Garcia et al. (2011)’s LAW policy rule reduces volatility in both inflation and output. Neither of these semi-structural models however provides an intuition of the trade-offs at play. By contrast, I model the source of default risk in the economy, which allows me to trace its transmission channels explicitly.

Evidence on use and effectiveness of LAW. Ghosh, Ostry, and Qureshi (2017) document that policy makers in EMEs tend to use a mix of different prudential measures including countercyclical monetary tightening to combat an overheating economy during capital inflow surges. Are such LAW measures effective at taming domestic credit cycles? For a long-run panel of AEs, Schularick et al. (2021) find that discretionary LAW policies, i.e. those that are not rules based, may trigger financial crises rather than prevent them when asset valuations are elevated and credit is excessive. Looking instead at EMEs, the evidence is limited. Empirical studies indicate that sterilized FX interventions may be effective at mitigating capital flow volatility as surveyed by Ghosh et al. (2016). While there is some evidence that EM central banks respond to *currency* imbalances in practice (Mohanty

¹⁵Other papers that augment the Taylor rule by some measure of financial distortion or imbalance relevant to their specific modelling framework include Christiano et al. (2011), Christiano, Motto, and Rostagno (2010), Cúrdia and Woodford (2016), and Faia and Monacelli (2007), Woodford (2012) among others.

& Klau, 2005), there is little evidence whether they react to *credit* imbalances.¹⁶ My analysis offers insights into the usefulness of looking at domestic indicators of credit risk as an early warning sign of financial imbalances.

Financial channel of exchange rates. My paper also relates to a body of work that revisits the Mundell-Fleming tenet of floating exchange rates serving as a shock absorber when there are financial spillovers from AEs to EMEs (Aoki et al., 2018; Basu, Boz, Gopinath, Roch, & Unsal, 2020; Rey, 2013, 2015). Gourinchas (2018) argues that the optimal monetary policy response to a US monetary policy shock under a floating exchange rate depends on the strength of the financial channel of exchange rates. My analysis assumes that this financial channel, in the words of Gourinchas (2018), leads to “perverse” transmission of monetary policy: a domestic *tightening* of monetary policy is *expansionary*. That is, the depreciation of the domestic exchange rate is so strong as to tighten domestic banks’ balance sheets, inducing a credit crunch and a period of deleveraging. Only a forceful monetary contraction can stabilize the exchange rate and rein in on a domestic financial crisis. My analysis goes one step further than Gourinchas (2018) by considering how monetary policy can improve upon policy outcomes by internalizing the source of amplification of financial spillovers, i.e. default risk.

Other policy instruments. Monetary policy under a floating exchange rate alone may however not be able to absorb the adverse effects of external financial shocks (Rey, 2015). Domestic credit booms in EMEs are often driven by capital inflow surges by foreign financial intermediaries rather than by a purely domestic expansion. Proposals to address domestic credit booms have therefore stressed the role of macroprudential policies (Gelos, Gornicka, Koepke, Sahay, & Sgherri, 2022; Martínez et al., 2020), FX interventions (Alla, Espinoza, & Ghosh, 2019; Ghosh et al., 2016) and capital flow management measures (Basu et al., 2020). These measures may be more effective at taming domestic credit cycles in light of the Global

¹⁶Sustained exchange rate appreciation often coincides with rising credit imbalances and leverage in the banking sector (Bruno & Shin, 2015a, 2015b). Targeting currency imbalances may therefore be argued to be isomorphic to targeting credit imbalances. Note however that credit imbalances may be easier to target in practice because it is easier to monitor them and trace their origins.

Financial Cycle (Rey, 2015). My paper remains silent on the use of *regulatory* measures to preempt against or react to external financial shocks. Instead, I focus on the *macroprudential role of monetary policy* in small open economies. Monetary policy, in particular, may be in a tight spot to act upon shocks because regulatory policy measures are usually more sticky and take longer to implement. Ultimately, however, efficiency gains may be higher if monetary policy were to be complemented by targeted macroprudential policies in the spirit of the Tinbergen (1956) principle (Goodhart, Kashyap, Tsomocos, & Vardoulakis, 2012; Gourio et al., 2018; Kashyap, Tsomocos, & Vardoulakis, 2014).

Financial amplification in SOEs. A number of papers study external financial shocks to EMEs in small open economy models, some of which do not explicitly model financial intermediaries. Cuadra and Menna (2019) use a wedge between borrowing and lending rates in reduced form to rationalize the expansionary effect of capital inflows on EMEs during good times. However, their model is devoid of financial amplification in response to capital outflows. Gertler, Gilchrist, and Natalucci (2007) model a financial accelerator à la BGG to study the Asian Financial Crisis. As is common for the BGG type of models, the link between borrower balance sheets and credit conditions creates room for amplification without the need for an explicit financial intermediation sector. Aoki et al. (2018) analyze monetary and regulatory responses to external shocks by incorporating a standard agency problem in the banking sector. Mimir and Sunel (2019) model a credit friction in the market for foreign debt to investigate optimal LAW policy rules, none of which however relate to default risk. Both Aoki et al. (2018) and Mimir and Sunel (2019) feature a banking sector with perfect consumption insurance as in Gertler and Kiyotaki (2010) that is vulnerable to external shocks. These models however do not provide scope for endogenous default as a source of amplification. In my model, the rise in non-performing loans (NPLs) on banks' balance sheet exacerbates credit conditions and alters firms' incentives to default endogenously.

Pecuniary externalities. The study of private default in international financial stability analysis in EMEs is important not least because default changes collateral values and real allocations, and thus affects prices in a non-trivial way (Goodhart &

Tsomocos, 2011; Peiris & Tsomocos, 2015). Fisherian debt-deflation forces are also at play in small open economy models of sudden stops by Mendoza (2010) and Bianchi (2011). At the heart of these type of models is an occasionally binding collateral constraint that only leads to sharp capital reversals and deep recessions in high-leverage states. The binding collateral constraints unleashes Fisherian debt-deflation in response to shocks. These events are rare because agents accumulate precautionary savings to insure against these stops (Mendoza, 2010). My model does not feature an occasionally binding borrowing constraint because loans are unsecured. Nevertheless, a pecuniary externality of strategic default arises. The fact that the decision to default is directly affected by monetary policy through the credit spread gives justification for a LAW policy rule from a political economy perspective. That is, central banks, unless taking into account financial stability, may exacerbate the pecuniary externality from firm default.

Default. My approach to modelling partial default as a strategic decision by agents follows closely the seminal work of Shubik and Wilson (1977) which was extended by Dubey, Geanakoplos, and Shubik (2005) and subsequently employed by Goodhart, Shubik, and Tsomocos (2013), Goodhart et al. (2006), and Peiris and Tsomocos (2015), Tsomocos (2003) in finite horizon and by Goodhart et al. (2018) and De Walque, Pierrard, and Rouabah (2010) in infinite horizon. Clerc et al. (2015) implement this approach in a model with banks and multiple layers of default. Note that the financial accelerator of BGG involves a similar mechanism as the aforementioned models. Yet, their financial friction is built on an agency problem justified in partial equilibrium. While in BGG default can be ruled out in equilibrium through the design of optimal contracts, default in Clerc et al. (2015) and in my analysis arises endogenously as an equilibrium phenomenon. Andreev et al. (2019, 2020) and Martínez et al. (2020) incorporate both partial default and collateral default in a small open economy NK model estimated for the Russian and Chilean economies, respectively. They demonstrate that a model with endogenous default is better able to fit the data than a model with exogenous default. However, they focus on commodity price and productivity shocks and assume that households invest in foreign bonds. Instead, I explore an external financial shock to banks

which propagates and amplifies through their balance sheets.¹⁷ Recent work by Peiris, Sokolova, and Tsomocos (2019) attempts to micro-found the renegotiation cost of partial default in a finite-horizon open economy model of sovereign default. Since an application of this approach is outside the scope of my model, I use a simple expression for the renegotiation cost of default as a function of aggregate credit conditions. This simplification allows me to obtain an intuitive expression for the credit spread that aids the interpretation of transmission channels.

2.3 The US Taper Tantrum: the Mexican Experience

The effect of the US Taper Tantrum on the Mexican economy serves as an important case in point to illustrate the mechanisms of the model.¹⁸ The context is symptomatic of crises episodes in many EMEs. In May 2013, the US Federal Reserve announced its downscaling of asset purchases, which took financial markets by surprise. The Fed's actions sent a strong signal to international investors about the expected higher path of short-term interest rates. Consequently, waves of capital outflows rattled through EMEs after several buoyant years of capital inflows, relatively cheap international financing, and EM currency appreciation. Many EM currencies depreciated sharply against the US dollar (USD). To disentangle the mechanism through which an adverse shock to banks' external funding in foreign currency propagates through the model economy, it is instructive to distinguish between three interdependent channels that operate in the short and medium term: the exchange rate channel, the policy rate channel, and the default risk channel. Figure 2.2 illustrates these channels.

The exchange rate channel. Consider a contractionary shock to US monetary policy. By the uncovered interest rate parity (UIP), the domestic currency depreciates against the foreign currency for a given domestic interest rate. This was the case for the Mexican peso which depreciated by more than 5% against the US dollar within the first month after the Fed's announcement (panel (a)). In many

¹⁷Modelling representative firms and banks, unlike Andreev et al. (2019), allows me to focus on the intuition and role of the bank lending channel in the transmission of shocks.

¹⁸The taper tantrum is an adequate example for an exogenous shock to international loan and bond flows to EMEs. It has been the episode with the highest sensitivity of capital flows to US monetary policy since the GFC as estimated by Avdjiev, Gambacorta, Goldberg, and Schiaffi (2020).

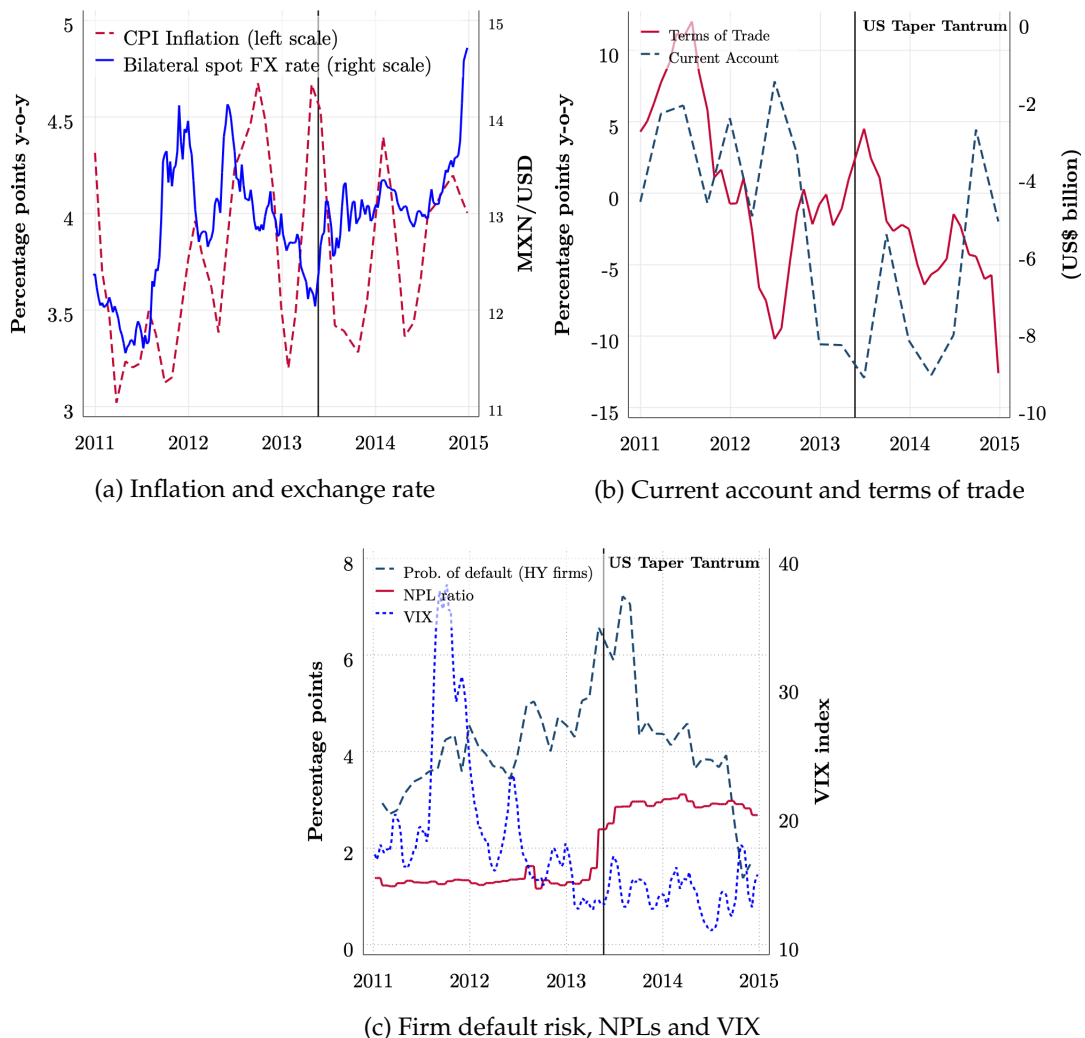


Figure 2.2. Mexican financial and macro indicators around the US Taper Tantrum

Note: Panel (a) shows the year-on-year percentage change in the consumer price index (CPI) and the MXN/USD spot exchange rate. Panel (b) shows the current account and the year-on-year percentage change in the terms of trade index. Panel (c) shows Moody's expected default frequency – a measure of the probability of default – over a 1-year horizon, averaged across listed financial and non-financial firms in Mexico. It also shows the non-performing loan (NPL) ratio of unsecured bank credit and the CBOE volatility index, smoothed over a 30-day rolling window. See Table 2.A.1 in Appendix 2.A for data sources and measurement details.

real-world episodes as in my model, this depreciation triggers a surge in inflation as imported goods become more expensive, all else equal. Inflation in Mexico peaked around the tantrum and continued wiggling around above target levels in the year thereafter (panel (a)). The depreciation also results in a deterioration in the terms of trade, as was the case for Mexico in the two years following the

US Taper Tantrum (panel (b)). The resulting outflow of capital pushes the current account into surplus which depresses consumption, investment, and GDP. While the Mexican current account deficit did not turn into surplus, it was still markedly reduced by the outflow of capital in the third quarter of 2013 (panel (b)).

The policy rate channel. Monetary policy makers simultaneously intervene in response to the shock. Note that a number of central banks in EMEs are bound by their legal mandates to stabilize the economy by (exclusively) stabilizing inflation.¹⁹ Such is the case, for example, for Banco de México which aims to guarantee the purchasing power of the peso. A simple policy rule that responds exclusively to inflation, however, means that central banks in EMEs must raise nominal interest rates in times of capital outflows if the exchange rate passthrough to inflation is very strong.²⁰ Contractionary monetary policy may further depress investment and output. This generally makes it difficult for central banks in EMEs to stabilize both inflation and output at the same time. The “divine coincidence” breaks down.

The default risk channel. How do these developments affect firm solvency and bank balance sheets? Central banks in EMEs may face a trade-off between monetary policy and financial stability objectives at this point. They must take into account that any change in the policy rate does not only propagate via the cost of funding from banks to the real economy but also affects corporate distress. Higher interest rates increase the cost of debt incurred by firms. In addition, the contractionary effect on corporate earnings reduces firms’ capacity to service debt. Banks may contract their balance sheets in the face of a foreign funding shortfall. Tight aggregate credit conditions exacerbate the likelihood of firm defaults which increases the default premium paid on corporate debt. Tighter monetary policy also decreases the liquidity in the economy, *ceteris paribus*, making it more difficult for banks to weather losses from defaulting loans.

¹⁹Central banks in EMEs whose legal frameworks stipulate price or monetary stability as their primary objective (without further mention of growth, employment, or economic development) include e.g. Banco de México, Banco Central do Brasil, Banco Central de Chile, Banco Central de Reserva del Perú, the Reserve Bank of South Africa, and Bank Indonesia as of January 2020.

²⁰See Gourinchas (2018) for an analysis of the optimal course of action under different strengths of the financial channel in response to an external shock.

Panel (c) in Figure 2.2 illustrates this point. The probability of default of particularly risky Mexican firms peaked in 2013. The fact that the CBOE volatility index (VIX), a measure of global risk, remained largely unaffected by the taper tantrum suggests that the rise in default risk in the private sector was likely brought about by domestic amplification. The share of NPLs in gross unsecured loans held by banks increased by almost a percentage point over the course of the following year. The decline in debt levels in the financial and non-financial private sector after 2013 (Figure 2.1 panel (a)-(b)) further suggest that an episode of strong delevering followed the years after the tantrum.

How do higher default rates affect inflation? On the one hand, a higher probability of default beyond a crucial point may trigger fire sales of assets. The resulting Fisherian debt-deflation forces depress prices and increase the real burden of debt (Eggertsson & Krugman, 2012; Goodhart et al., 2010; Korinek & Mendoza, 2014; Mendoza, 2010). On the other hand, higher domestic default rates may accelerate international capital flight, depreciate the exchange rate further, and thereby raise the price level. The respective effects on inflation and output therefore operate in opposite directions. The evolution of inflation (Figure 2.2 panel (c)) does not rule out the possibility that debt-deflationary forces through higher default risk may have been at play in Mexico.²¹ A closer investigation is needed to understand the interaction of monetary policy with the interest rate, exchange rate, and default risk channel. Different monetary policy rules may be optimal for the central bank when this interaction is taken into account.

Finally, note that the assumption that banks rather than firms are directly exposed to shocks to international capital flows is reasonable for the case of Mexico. The Mexican banking sector is dominated by foreign affiliates of international banks which increases its vulnerability to shocks from abroad (Levin-Konigsberg, López, López-Gallo, & Martínez-Jaramillo, 2017).²² This is in line with evidence by

²¹This drop in inflation must be taken with a grain of salt because commodity prices, and specifically energy prices in Mexico, plunged in 2014, possibly putting downward pressure on inflation.

²²In Mexico, 80% of the financial system's assets are held by the seven largest banks of which five are domestic subsidiaries of foreign global banks. Formally, domestic subsidiaries of foreign banks are legally independent entities. However, they are still tightly connected and steered by their parent bank (Levin-Konigsberg et al., 2017).

Bruno and Shin (2015b) who document the existence of a cross-border transmission channel of financial conditions through bank capital flows.

2.4 The Model

My small open economy framework follows closely the models by Galí and Monacelli (2005) and Gertler et al. (2007) with nominal price rigidities. The real side of the economy is comprised of representative households and domestic firms. On the financial side, domestic banks intermediate funds between households and firms, governed by a consolidated monetary (and macroprudential) policy maker, henceforth called the “central bank”. Conventional NK features enter through the retail firm sector. There is also a reduced-form foreign sector and foreign investors that import goods from and lend to banks in the home economy, respectively. Figure 2.B.1 in Appendix 2.B provides an overview.

Domestic households save, work, and consume domestic (H) and foreign (F) final goods. Domestically produced goods and imported goods are imperfect substitutes. The domestic production sector is characterized by competitive capital producers (c), competitive wholesale producers (w), and monopolistically competitive retailers (r). Capital producers combine undepreciated capital from wholesale producers and final goods into new capital that is resold to wholesale goods producers at the beginning of every period. Wholesale goods producers use capital and labor as inputs to produce wholesale goods. They do not hold sufficient funds to afford the purchase of capital. They therefore borrow unsecured inter-period loans from domestic banks (b). Under certain conditions, it may be viable for wholesale goods producers to renege on their obligation to repay their loan in full. They may choose to (partially) default on their loan but incur a default cost that endogenously depends on aggregate credit conditions. Finally, wholesale goods are slightly differentiated and repackaged by retailers into final goods which are consumed domestically and exported abroad. Nominal price stickiness enters via the retail sector. All firms are owned by households.

Households deposit their savings with domestic banks under certainty of being repaid. Banks use these risk-free domestic deposits, deposits from foreign investors, and accumulated bank capital to finance unsecured loans to wholesale

producers. They use end-of-period profits to build up their bank capital stock. The foreign interest rate that banks pay on foreign debt is subject to an exogenous shock that can be thought of as a US monetary policy shock. The supply of foreign deposits is subject to another disturbance that gives rise to a country risk premium. Banks also need to fulfil a capital adequacy requirement. Any deviations from the regulatory level incur a cost. This cost lowers end-of-period profits and hence future bank capital.

The risk-free interest rate on domestic deposits is determined by the policy rate set by the central bank. Four different interest rate rules are considered in the determination of the policy rate. The LAW interest rate rules aim at mitigating the adverse effects of external shocks on the domestic economy and financial system.

2.4.1 Households

Let there be a continuum of representative households with measure unity in the domestic economy. Each household supplies labor to wholesale producers and consumes a final composite consumption good. Households receive any non-negative dividends from firms in a lump-sum fashion by virtue of their ownership stake. The representative household derives utility from consumption c_t and leisure $(1 - h_t)$. Domestically produced and imported final goods are imperfect substitutes such that households consume a positive amount of both goods. More precisely, they consume an aggregate composed of both goods according to the following technology,²³

$$c_t = Z(c_t^H)^{1-\xi}(c_t^F)^\xi \quad (2.1)$$

where Z is a constant that I calibrate for computational reasons.²⁴ The share of each good in the consumption basket is governed by $\xi = (1 - n)\omega$ with $\xi > 0$. Households place a relative weight $0 < \omega < 1$ on home goods in the basket which represents the degree of home bias in household preferences. n governs the size of the domestic economy on the continuum $[0, 1]$ of the world population. The

²³In the following, unless otherwise stated, lowercase letters denote real variables expressed in terms of the domestic consumer price index (CPI), P_t , while upper case letters denote nominal variables.

²⁴I calibrate $Z = (1 - \xi)^{-(1-\xi)}\xi^{-\xi}$.

economy is completely open when $\omega = 1$ such that households only consume a negligible share of domestic goods. As the domestic economy becomes smaller relative to the rest of the world, $n \rightarrow 0$, $\xi = \omega$.

Let P_t^H and P_t^F denote prices of home and foreign goods denominated in domestic currency. They are aggregates of a continuum of differentiated home and foreign good varieties, respectively. Further, let p_t^H and p_t^F denote their real counterparts, deflated by the CPI, P_t . Gross domestic inflation is then given by $\pi_t^H = p_t^H/p_{t-1}^H \pi_t$. Note that domestic price inflation is not equivalent to CPI inflation, $\pi_t = P_t/P_{t-1}$, the latter being a composite of prices for domestic and foreign goods. The Law of One Price is assumed to hold for each final good in every period.²⁵ Let S_t be the nominal exchange rate of the foreign currency in domestic currency units. The real exchange rate of the foreign currency in terms of real home goods is therefore given by $s_t = S_t P_t^*/P_t$. The foreign currency denominated CPI, P_t^* , is assumed to be exogenous and normalized to one. Finally, let us define the terms of trade as the price of imports relative to exports, $\mathcal{T}_t = P_t^F/P_t^H$, i.e. the amount of imports the economy can purchase per unit of exports. A deterioration in the terms of trade for the domestic economy implies an improvement in the terms of trade for the foreign economy and vice-versa.

The demand for home and foreign goods, respectively, is obtained from households minimizing expenditures subject to the consumption aggregator (2.1),

$$c_t^H = (1 - \xi) \frac{c_t}{p_t^H} \quad \text{and} \quad c_t^F = \xi \frac{c_t}{s_t} \quad (2.2)$$

Moreover, cost minimization yields the relationship between the domestic price index and the real exchange rate,

$$p_t^H = s_t^{-\frac{\xi}{1-\xi}} \quad (2.3)$$

²⁵This may, for example, rest on the assumption that home and foreign households have identical preferences such that firms sell goods to home and foreign buyers at the same price, i.e. $\frac{P_t^H}{P_t^F} = \frac{P_t^{H*}}{S_t P_t^{F*}} = \frac{P_t^H}{S_t P_t^{F*}}$. The LOOP may break down, for example, in an environment of sticky prices and local currency pricing whereby relative prices cannot change in the short run in response to real shocks, i.e. $P_t^H \neq S_t P_t^{H*}$.

In addition to choosing between the consumption good and leisure, households also save some of their net worth in the form of domestic currency deposits with domestic financial intermediaries. Let d_t denote the real balance of these deposits. Households receive a risk-free nominal rate of return r_t^d on their deposits. Note that households cannot directly invest in foreign bonds or hold deposits with foreign banks because they lack expertise to do so.²⁶ They maximize lifetime utility under CRRA preferences,

$$\max_{c_t, h_t, d_t} E_{t-1} \sum_{i=0}^{\infty} \beta^i \left[\frac{1}{(1-\sigma)} (c_{t+i} - \alpha_h c_{t+i-1})^{1-\sigma} - \frac{\chi}{(1+\varphi)} h_{t+i}^{(1+\varphi)} \right] \quad (2.4)$$

by choosing consumption c_t , hours worked h_t , and how much to save in real deposits d_t . E_t denotes the time t expectations operator conditional on information up to and including time t . α_h governs the degree of habit formation, χ is the relative utility weight of labor, and $\varphi > 0$ pins down the Frisch elasticity of labor supply. The maximization of (2.4) is subject to the real balance sheet constraint,

$$c_t + d_t = w_t h_t + \frac{(1+r_{t-1}^d)}{\pi_t} d_{t-1} + \Pi_t \quad (2.5)$$

Consumption and deposits are financed by labour income, existing deposits plus interest from the previous period, and real dividends from firms Π_t . The maximization of (2.4) subject to (2.5) yields standard first order conditions with respect to c_t , h_t , and d_t , respectively,

$$\Lambda_t = (c_t - \alpha_h c_{t-1})^{-\sigma} - \beta \alpha_h E_t (c_{t+1} - \alpha_h c_t)^{-\sigma} \quad (2.6)$$

$$w_t = \frac{\chi h_t^\varphi}{\Lambda_t} \quad (2.7)$$

$$\Lambda_t = \beta E_t \left[\frac{\Lambda_{t+1}}{\pi_{t+1}} (1+r_t^d) \right] \quad (2.8)$$

The Lagrange multiplier Λ_t , given by equation (2.6), defines the marginal utility of consuming an additional unit of income. Equation (2.7) equates the marginal

²⁶Moreover, households' desire to hold foreign debt may be nil since the domestic economy provides a higher real return than abroad.

disutility of an additional hour worked to the shadow value of real wages. Finally, equation (2.8) defines the Euler equation for the risk-free asset.

2.4.2 Firms

Capital Goods Producers

As in Gerali et al. (2010), I introduce capital goods producers rather than endowing households with capital and modelling a rental market. This modelling device allows me to obtain a market price for capital that pins down the value of the collateral against which wholesale goods producers borrow loans from banks.²⁷ Perfectly competitive capital goods producers buy undepreciated capital $(1 - \delta)k_t$ from the previous period at price Q_t from wholesale producers and domestic final goods i_t at price P_t^H from retailers. They turn undepreciated capital and final goods into new capital but face adjustment costs for the latter. Let $q_t = Q_t/P_t$ denote the real price of capital. Capital goods producers choose investment i_t to maximize,

$$\max_{i_t} E_{t-1} \sum_{j=0}^{\infty} \beta^j \Lambda_{t-1,t+j} \left[q_{t+j} (k_{t+j} - (1 - \delta)k_{t+j-1}) - p_{t+j}^H i_{t+j} \right] \quad (2.9)$$

The law of motion of capital takes the form,²⁸

$$k_t = (1 - \delta)k_{t-1} + \left[1 - \frac{\tau_I}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t \quad (2.10)$$

where δ is the rate of depreciation of capital and i_t denotes time t gross investment. Capital accumulation incurs quadratic adjustment costs where τ_I determines the magnitude of the cost incurred when the gross growth rate in investment deviates from one. In the steady state, when investment is constant, adjustment costs are zero. Maximizing (2.9) with respect to (2.10) yields the "Q-investment" relationship,

²⁷If we were to rule out the existence of capital producers, households would need to own capital and rent it out to wholesale producers at a rental rate R^k . To justify the existence of firms borrowing from banks, one would assume e.g. that firms need to finance a share of working capital by taking on loans such as in Millard, Varadi, and Yashiv (2018). This would only lead to added complication of the model.

²⁸Note that I use the *end-of-period stock* timing convention.

$$p_t^H = q_t \left[1 - \frac{\tau_I}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 - \tau_I \left(\frac{i_t}{i_{t-1}} - 1 \right) \frac{i_t}{i_{t-1}} \right] + E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} q_{t+1} \tau_I \left(\frac{i_{t+1}}{i_t} - 1 \right) \left(\frac{i_{t+1}}{i_t} \right)^2 \quad (2.11)$$

Wholesale Producers

Representative wholesale producers produce wholesale goods using labor and capital as input which they finance by borrowing unsecured loans from banks. A key friction of this model is the possibility of (partial) default by wholesale producers. Wholesale firms are short-lived along the lines of Clerc et al. (2015) and Andreev et al. (2020). The finite planning horizon is a straightforward way to rationalize firm exit conditional on default.²⁹ This is because all firms exit by assumption after two periods.³⁰ In the first period, wholesale producers borrow unsecured real loans, b_t , from domestic banks at a nominal interest rate, r_t^b , to buy capital for production in the next period at price q_t ,

$$q_t k_t = p_t^H b_t \quad (2.12)$$

where the real value of the loan is adjusted by p_t^H to express it in units of the domestic consumption bundle. In the second period, firms receive an aggregate productivity shock A_t which follows an AR(1) process. After the realization of the shock, wholesale producers determine how much labour, h_t , to hire.³¹ Firms employ a constant returns to scale technology using labor and capital as inputs to produce wholesale goods,

$$y_t^w = A_t k_{t-1}^\alpha h_t^{1-\alpha} \quad (2.13)$$

²⁹Other authors such as Ottonello and Winberry (2020) address the task of modelling firm exit conditional on default by assuming firm heterogeneity which generates a distribution of firms that default and those that continue to exist infinitely.

³⁰Note that the finite horizon assumption can be extended to an infinite horizon in a straightforward way without affecting the optimality conditions.

³¹The intertemporal disconnect between the decision to rent capital and to hire labor does not materially affect the conclusions drawn in section 3.6. The assumption of a sequential nature is arguably plausible to the extent that physical capital as a factor of production is the first investment that young firms make. See for example Kang and Pflueger (2015) for a similar OLG structure whereby the firm's capital structure is determined in the previous period.

When profits from selling wholesale goods to retailers are ultimately realized, wholesale producers have the choice to pay back the loan to domestic banks in full or default on a fraction, θ_t , of the loan. However, if they choose to partially or fully default, they incur a cost of renegotiating their debt to obtain a haircut from the bank. For every dollar of the loan plus interest defaulted on $\theta_t b_{t-1}(1 + r_{t-1})$ – henceforth called the loss given default – they incur a proportional renegotiation cost, Ω_t , that lowers their overall profits. This non-pecuniary cost may be thought of as summarizing the payments to lawyers for renegotiation, fines, reputational damage, and foregone future financing opportunities. Domestic banks only hold a limited claim on the existing wealth of the firm since borrowing is unsecured. They therefore cannot open bankruptcy proceedings and liquidate assets. Firms have an incentive to successfully negotiate their debt burden in order to liquidate assets and pay dividends to their owners before ceasing to exist at the end of their life-time. Note that the fraction defaulted on is a choice variable to firms. In equilibrium, firms trade off the marginal benefit from defaulting against the marginal cost of defaulting by choosing the default rate. Default is therefore *strategic*. This modelling approach of default follows the seminal work of Shubik and Wilson (1977) which was extended by Dubey et al. (2005) and subsequently employed by Andreev et al. (2020), Goodhart et al. (2013), and Goodhart et al. (2006), Tsomocos (2003).

Wholesale producers maximize real profits discounted by households' stochastic discount factor, $\beta\Lambda_t$, in the second period by choosing factor inputs, domestic borrowing, and the default rate on domestic loans,³²

$$\max_{k_t, h_t, b_t, \theta_t} E_{t-1} \beta \Lambda_t \Pi_t^w \quad (2.14)$$

where real profits, distributed as dividends to households, are given by,

³²I use the timing convention at time t rather than $t + 1$ for computational reasons related to the stochastic simulation.

$$\begin{aligned} \Pi_t^w = & p_t^w y_t^w - w_t h_t - p_t^H (1 - \theta_t) b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \\ & - \frac{p_t^H \Omega_t}{(1 + \psi)} \left[\theta_t b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \right]^{(1+\psi)} + q_t (1 - \delta) k_{t-1} \end{aligned} \quad (2.15)$$

The last term in expression (2.15) denotes the proceeds from selling undepreciated capital back to capital producers. Note that the repayment of the loan and renegotiation costs are adjusted by p_t^H to express these financial flows in terms of the domestic consumption bundle. Taking the total renegotiation cost term under closer inspection,

$$\frac{p_t^H \Omega_t}{(1 + \psi)} \left[\theta_t b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \right]^{(1+\psi)}$$

we can observe that the parameter ψ governs the elasticity of the renegotiation cost term – a pecuniary cost – with respect to the loss given default. The size of the renegotiation cost is endogenously determined through the coefficient Ω_t on the loss given default,

$$\Omega_t = \Omega \frac{\Delta}{\Delta_t} \quad (2.16)$$

where variables without a time subscript denote steady state values. Following Goodhart et al. (2018) and Andreev et al. (2020), the macro variable Δ_t is a function of the default rate (first term) and of the aggregate credit-to-GDP ratio (second term),

$$\Delta_t = \left(\theta_t \right)^\gamma \frac{\left(b_{t-1} (1 + r_{t-1}^b) / \pi_t \right)^v}{(y_t^H)^v} \quad (2.17)$$

where the parameters $\gamma > 0$ and $v > 0$ govern the elasticities of the macro variable with respect to the default gap versus the credit and output gap (or jointly the credit-to-GDP gap), respectively. Note that the renegotiation cost decreases as the credit-to-GDP gap increases. On the one hand, an economic expansions should aid in bolstering economic profits and reducing firms' probability of default. On the other hand, credit expansions often coincide with a loosening of credit standards resulting in higher NPL losses ex post. The macro variable Δ_t captures this trade-

off. Moreover, the renegotiation cost increases as the deviation of the default rate from its steady state value increases. The rationale is that as more firms default on their debt, it becomes easier for firms to negotiate the terms of their debt with banks. Banks become negligent in renegotiating debt contracts when dealing with more default cases. Importantly, firms do not internalize their contribution to the aggregate credit conditions.

The optimization of (2.14) with respect to k_t , b_t , and θ_t subject to (2.13) and (2.15) yields the following “capital return relationship”,

$$E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} \left[\frac{\alpha p_{t+1}^w y_{t+1}^w}{q_t k_t} + R_{t+1}^k (1 - \delta) - (1 + r_t^b) \right] = 0 \quad (2.18)$$

The first term on the RHS represents the expected productive return on investment in capital. The second term is the gross real capital gain $R_{t+1}^k = q_{t+1}/q_t$ net of depreciation. Hence, in equilibrium the gross nominal borrowing rate must equal the sum of the expected productive return and the expected asset return.

Retailers

A continuum of monopolistically competitive retail firms, indexed by $i \in (0, 1)$, buy wholesale goods, y_t^w , from domestic wholesale producers.³³ Let $p_t^H(i) = P_t^H(i)/P_t$ be the price of individual retail goods deflated by the domestic CPI. Retailers simply incur the relative wholesale price, p_t^w/p_t^H , as marginal cost. The differentiated goods, $y_t^H(i)$, are then repackaged into a final consumption good, y_t^H , using a CES technology ($\epsilon > 0$),

$$y_t^H = \left(\int_0^1 y_t^H(i)^{\frac{\epsilon-1}{\epsilon}} di \right)^{\frac{\epsilon}{\epsilon-1}} \quad (2.19)$$

The cost minimization problem of the retailer results in a downward-sloping demand curve for each retail good:

³³I abstract from imported intermediate goods for the sake of simplicity. Note however that empirical evidence suggests that a majority of exporting firms uses imported intermediate inputs from abroad in the production of final goods, in particular in less developed countries (Kugler & Verhoogen, 2009). This reduces the value-added content of exports.

$$y_t^H(i) = \left(\frac{p_t^H(i)}{p_t^H} \right)^{-\epsilon} y_t^H \quad (2.20)$$

The demand for the i^{th} retail good thus depends on its relative price and the elasticity of substitution ϵ . It is proportional to aggregate domestic output y_t^H . The aggregate domestic price index p_t^H as a function of retail goods prices $p_t^H(i)$ is given by,

$$p_t^H = \left(\int_0^1 p_t^H(i)^{1-\epsilon} di \right)^{\frac{1}{1-\epsilon}} \quad (2.21)$$

Nominal stickiness in the economy enters through the retail sector. Retailers incur Rotemberg (1982) quadratic adjustment costs for changing their price in every period. The overall size of these costs is governed by the parameter τ_p . Retailers choose their price $p_t^H(i)$ to maximize real profits,

$$\max_{p_t^H(i)} E_{t-1} \sum_{j=0}^{\infty} \beta^j \Lambda_{t+j} \left[p_t^H(i) y_t^H(i) - p_t^w y_t^H(i) - \frac{\tau_p}{2} \left(\frac{p_t^H(i)}{p_{t-1}^H(i)} - 1 \right)^2 p_t^H y_t^H \right] \quad (2.22)$$

subject to the demand relation in (2.20). In equilibrium, all retailers behave identically, produce the same output, and charge the same price. This gives rise to the non-linearized Phillips curve,

$$(\epsilon - 1) = \frac{\epsilon}{z_t} - \tau_p (\pi_t^H - 1) \pi_t^H + \tau_p \beta E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} (\pi_{t+1}^H - 1) \pi_{t+1}^H \left(\frac{p_{t+1}^H y_{t+1}^H}{p_t^H y_t^H} \right) \right] \quad (2.23)$$

where $z_t = p_t^H / p_t^w$ is the gross mark-up that retail firms earn.

2.4.3 Foreign Behavior

An amount of the final consumption good produced by domestic retailers is exported abroad. I follow Gertler et al. (2007) in assuming that the foreign demand for domestically produced final goods takes the form,

$$c_t^{H*} = \left[\xi \left(\frac{P_t^{H*}}{P_t^*} \right)^{-\vartheta} y_t^* \right]^\varrho (c_{t-1}^{H*})^{1-\varrho} \quad (2.24)$$

where P_t^{H*} is the foreign price of domestically produced goods denoted in foreign currency, P_t^* is the foreign CPI, and y_t^* is foreign production. ξ is the elasticity of substitution between domestic and foreign goods, which is included for computational reasons. There is inertia in foreign demand for domestic goods, expressed by $(c_{t-1}^{H*})^{1-\varrho}$ and scaled by the parameter ϱ . The nominal price of foreign final consumption goods P_t^{F*} denominated in foreign currency is taken as exogenous. Since the domestic economy is small relative to the foreign economy (or the rest of the world), it is reasonable to assume an export demand curve of the above form. I further assume that the supply of imported foreign goods to the domestic economy is infinitesimally small since the domestic economy is small relative to the foreign economy.

Foreign output and the interest rate on foreign debt, r_t^{d*} , are assumed to follow an autoregressive exogenous process,

$$\log(y_{t+1}^*) = (1 - \rho_y)y_t^* + \rho_y \log(y_t^*) + \epsilon_{y,t+1} \quad (2.25)$$

$$\log(r_{t+1}^{d*}) = (1 - \rho_{r^*})r_t^{d*} + \rho_{r^*} \log(r_t^{d*}) + \epsilon_{r^*,t+1} \quad (2.26)$$

with zero mean and constant variance innovations. This gives room to analyze the effects of external shocks to foreign demand and to the foreign interest rate, as becomes relevant below.

2.4.4 Banks

There is a continuum of infinitely lived, perfectly competitive banks which operate in the market for domestic and foreign deposits as well as the market for domestic loans to firms. Banks are risk-neutral. They accumulate bank capital, k_t^b , over time by retaining earnings in order to fulfil their capital requirement. They incur a quadratic cost whenever their leverage ratio or “capital-to-asset ratio”, k_t^b/b_t , deviates from a pre-specified regulatory capital adequacy ratio CAR^* . The law of motion of bank capital is given by,

$$k_t^b = (1 - \delta^b) \frac{k_{t-1}^b}{\pi_t} + \Pi_t^b \quad (2.27)$$

where Π_t^b are the real cash flows earned by banks in a given period. δ^b governs the degree to which resources are used up in the capital accumulation process.³⁴ Note that capital is not a choice variable for banks. Banks do not pay out any dividends to shareholders but instead reinvest all their profits. Banks finance unsecured loans, b_t , to wholesale producers through capital and deposits borrowed in domestic currency from domestic households, d_t , at the domestic deposit rate, r_t^d , and in foreign currency from investors abroad, d_t^* at the foreign interest rate r_t^{d*} . Corporate loans are subject to limited liability and default risk. Banks face the following real balance sheet constraint in every period,

$$b_t = d_t + s_t d_t^* + k_t^b \quad (2.28)$$

In every period, banks realize the returns net of default from their lending business and repay deposits plus interest to households and international investors. They also extend new loans and take on new deposits as well as accumulate capital. Their objective is to choose unsecured lending and deposits to maximize the discounted sum of real cash flows,

$$\max_{b_t, d_t, d_t^*} E_{t-1} \sum_{i=0}^{\infty} \beta^i \Lambda_{t+i} \Pi_{t+i}^b \quad (2.29)$$

subject to the per period balance sheet constraint in (2.28) and the real cash flow or “profit” function,

$$\begin{aligned} \Pi_t^b = & (1 - \theta_t) \frac{(1 + r_{t-1}^b)}{\pi_t} b_{t-1} - b_t - \frac{(1 + r_{t-1}^d)}{\pi_t} d_{t-1} + d_t \\ & - s_t \Psi_t \frac{(1 + r_{t-1}^{d*})}{\pi_t} d_{t-1}^* + s_t d_t^* + \left(k_t^b - \frac{k_{t-1}^b}{\pi_t} \right) - \frac{\tau_b}{2} \left(\frac{k_t^b}{b_t} - CAR^* \right)^2 k_t^b \end{aligned} \quad (2.30)$$

Banks discount real cash flows with the stochastic discount factor of house-

³⁴Another interpretation offered by De Walque et al. (2010) is that δ^b represents the fraction of capital put into an insurance fund managed by a public authority.

holds, their owners.³⁵ Recall that $(1-\theta_t)$ is the fraction of the defaulted loan that the bank recovers from wholesale producers, i.e. the haircut. Then $\theta_t b_{t-1}(1+r_{t-1})/\pi_t$ is the real *loss given default* or, loosely speaking, the non-performing loan (NPL) loss incurred by the bank.

Banks are exposed to two external shocks – a shock to the foreign interest rate, $r_t^{d^*}$, and a shock to the country risk premium, Ψ_t , both of which are paid on foreign deposits.³⁶ The foreign interest rate follows an autoregressive process,

$$\log(r_{t+1}^{d^*}) = (1 - \rho_{r^*})r^{d^*} + \rho_{r^*} \log(r_t^{d^*}) + \epsilon_{r^*,t+1} \quad (2.31)$$

with $\epsilon_{r^*,t+1} \sim \mathcal{N}(0, \sigma_r^2)$. $\epsilon_{r^*,t}$ are the innovations to the foreign interest rate that are explored in the quantitative analysis. Following Schmitt-Grohé and Uribe (2003), the country risk premium Ψ_t on foreign debt is a function of total net foreign indebtedness d_t^* and a small, random disturbance to capital flows, $\xi_{d,t}$,

$$\Psi_t = \exp\left(\iota(d_t^* - d^*)\right)\xi_{d,t} \quad (2.32)$$

where the parameter ι captures the foreign debt elasticity of the country risk premium. The shock process takes the form,

$$\log(\xi_{d,t+1}) = \rho_d \log(\xi_{d,t}) + \epsilon_{d,t+1} \quad (2.33)$$

with $\epsilon_{d,t+1} \sim \mathcal{N}(0, \sigma_d^2)$. Note that the country risk premium is zero in the steady state, i.e. $\Psi_t = 1$. A small positive shock to the foreign interest rate or to the country risk premium is a simple way to model sudden capital outflows. Qualitatively, outcomes in response to the two shocks should be similar. Yet, the interpretation of the two shocks differs. A shock to the foreign interest rate can for example result from changes in US monetary policy, which alters the attractiveness of investing in

³⁵Assuming that banks discount by the stochastic discount factor of households although the latter do not reap any dividends from banks is no reason for concern. If banks could earn more profits in equilibrium than are necessary to accumulate capital, they would certainly distribute these as dividends to households. However, perfect competition ensures that they are not making any additional profits in equilibrium.

³⁶See, for example, Alla et al. (2019) for a case where a shock to the risk premium can break the divine coincidence and therefore necessitates a second policy instrument.

EMEs. A shock to the country risk premium in turn may reflect a high perception of counterparty risk in the EMEs by foreign investors.

From the first order conditions of (2.29) with respect to b_t and d_t , we obtain an expression for the spread between the loan rate and the domestic deposit rate, i.e. the *credit spread*,

$$r_t^b - r_t^d = E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} \frac{1}{\pi_{t+1}} \left(\theta_{t+1} (1 + r_t^b) \right) - \tau_b \left(\frac{k_t^b}{b_t} - CAR^* \right) \left(\frac{k_t^b}{b_t} \right)^2 \quad (2.34)$$

The first term on the RHS reflects the risk of default that draws a wedge between the lending and borrowing rate. The second term implies that violations of the minimum regulatory capital ratio increase this wedge. In other words, a leverage ratio above the regulatory level increases the wedge. The further banks deviate from regulatory compliance, the larger the interest rate margin needs to be in order to generate sufficient profits to build up equity capital. Note also that due to the cost of violating prudential regulation, banks cannot simply overcompensate losses on the intensive margin of their loan portfolio by increasing the extensive margin. Banks trade off taking on more leverage on the extensive margin with paying higher violation charges. Hence, the penalty from violating the capital requirement provides a backstop that prevents credit spreads from spiralling prohibitively high.

From the first order conditions with respect to d_t and d_t^* , the classical uncovered interest rate parity (UIP) condition obtains,

$$E_t \beta \frac{\Lambda_{t+1}}{\pi_{t+1}} \left[(1 + r_t^d) - \Psi_{t+1} (1 + r_t^{d*}) \frac{S_{t+1}}{S_t} \right] = 0 \quad (2.35)$$

The UIP incorporates the country risk premium to account for the risk of capital outflows. On average, the expected deviation of the exchange-rate adjusted foreign cost of funding from the domestic risk-free rate must net out to zero.

2.4.5 Aggregation

Idiosyncratic behavior only enters through the retail goods sector. From the retail producers' optimization problem, we already know that all firms set the same price under Rotemberg quadratic adjustment costs. This gives rise to the New

Keynesian Phillips curve in equation (2.23). Aggregating over all retail firms, we get the following aggregate profit function,

$$\Pi_t^r = p_t^H y_t^H - p_t^w y_t^H - \frac{\tau_p}{2} (\pi_t^H - 1)^2 p_t^H y_t^H \quad (2.36)$$

The domestic final goods sector faces the aggregate resource constraint,

$$\begin{aligned} y_t^H = & c_t^H + c_t^{H*} + i_t + \delta^b \frac{k_{t-1}^b}{\pi_t} + \frac{\tau_p}{2} (\pi_t^H - 1)^2 y_t^H + \frac{\tau_b}{2} \left(\frac{k_t^b}{b_t} - CAR^* \right)^2 k_t^b \\ & + \frac{\Omega_t}{(1 + \psi)} \left[\theta_t b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \right]^{(1+\psi)} \end{aligned} \quad (2.37)$$

where y_t^H is domestic output, c_t^H is consumption of domestic final goods, c_t^{H*} is exports of domestic final goods abroad, and i_t is investment of domestic final goods for the production of capital. Depreciation of bank capital enters as a deadweight cost. The last three terms capture adjustment costs faced by retail firms and banks, as well as default costs incurred by wholesale producers.

2.4.6 Central Bank

The central bank sets the short-term monetary policy rate r_t which transmits one-for-one to the short-term risk-free rate in bank deposits, i.e. $r_t = r_t^d$. This means that there is a direct monetary policy transmission channel via banks to households in the absence of any frictions in the market for deposits. The central bank sets the policy rate in response to changes in key observable macroeconomic variables according to a simple and implementable interest rate rule (Schmitt-Grohé & Uribe, 2007). I distinguish between four different rules according to which the central bank sets the monetary policy rate. I include interest rate smoothing in each of these rules.

Status quo rule: Inflation

$$(1 + r_t) = (1 + r)^{(1-\phi_r)} (1 + r_{1,t-1})^{\phi_r} \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi (1-\phi_r)} \xi_{r,t} \quad (2.38)$$

where r is the steady-state policy rate. π_t is the net CPI inflation rate and $\bar{\pi}$ is the corresponding steady-state value. ϕ_r is the parameter that determines the degree of interest rate smoothing, allowing for some degree of persistence in the interest rate rule $0 < \phi_r < 1$. ϕ_π captures the reaction of the interest rate to deviations from steady state inflation with $\phi_\pi > 1$.

Taylor rule: Inflation and output gap

$$(1 + r_t) = (1 + r)^{(1-\phi_r)}(1 + r_{2,t-1})^{\phi_r} \left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi(1-\phi_r)} \left(\frac{y_t^H}{y^H}\right)^{\phi_y(1-\phi_r)} \xi_{r,t} \quad (2.39)$$

where the fraction of y_t^H and its steady state value y^H define the output gap. ϕ_y governs the responsiveness of the interest rate to the output gap with $\phi_y > 0$.

Next, suppose the central bank acts as a “benevolent social planner” who tries to internalize the first and second order effects of its monetary policy decision on financial stability.³⁷ What is the justification to do so? A pecuniary externality arises from the fact that wholesale firms do not take into account the negative effect that their default decision has on banks’ balance sheet and the price level. Tighter funding conditions in bad times alter the default decision of productive firms, resulting in adverse consequences for the economy. The objectives of stabilizing inflation and output alone may yield an interest rate decision that exacerbates the pecuniary externality of default. Hence, there is a need to mitigate the effect of the interest rate decision on losses arising from firm default. I augment the interest rate rule by the credit spread $\omega_t \equiv r_b - r_d$ obtained in equation (2.34), i.e. the spread that banks earn by extending risky loans to firms.

LAW rule: Inflation and credit spread

$$(1 + r_t) = (1 + r)^{(1-\phi_r)}(1 + r_{3,t-1})^{\phi_r} \left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi(1-\phi_r)} \left(\frac{\omega_t}{\omega}\right)^{\phi_\omega(1-\phi_r)} \xi_{r,t} \quad (2.40)$$

³⁷I leave it to future research to derive the optimal simple rule from the welfare criterion of a social planner.

where ω is the credit spread in steady state.³⁸ ϕ_ω determines the degree to which the interest rate responds to deviations of the credit spread from the steady state value.

The credit spread is found to be the most suitable proxy for macro-financial risk that impinges on financial stability. It combines a forward-looking measure of the NPL ratio with a current measure of equity capital shortfall. The credit spread can be interpreted as a “summary statistic” of both the cost arising from firm default and from regulatory compliance. Importantly, it achieves the lowest volatility in key macroeconomic variables in the stochastic simulation. An important difference exists between my measure of the credit spread and the Taylor-rule augmenting credit spreads in Cúrdia and Woodford (2010, 2016). While their measure captures the exogenous distortion arising from inefficient financial intermediation, the credit spread in my LAW policy rule represents the pecuniary externality from decisions by optimizing agents. This pecuniary externality leads to real inefficiencies. Moreover, in the spirit of *leaning against the wind*, the credit spread ω_t in equation (2.34) is truly forward looking.

LAW-Taylor rule: Inflation, output gap, and credit spread

$$(1 + r_t) = (1 + r)^{(1-\phi_r)} (1 + r_{4,t-1})^{\phi_r} \left(\frac{\pi_t}{\bar{\pi}}\right)^{\phi_\pi(1-\phi_r)} \left(\frac{y_t^H}{y^H}\right)^{\phi_y(1-\phi_r)} \left(\frac{\omega_t}{\omega}\right)^{\phi_\omega(1-\phi_r)} \xi_{r,t} \quad (2.41)$$

This specification unites all three objectives under one LAW interest rate rule. In each of the four policy rules, $\xi_{r,t}$ is a monetary policy shock that follows an AR(1) process.

In separate simulations, I also conduct the analysis with other proxies for financial stability that capture the extensive margin of default, for example the NPL ratio, the aggregate loss given default, and total credit. These alternative proxies are found to improve upon the status-quo rule and the Taylor rule as well. Yet, they result in greater volatility in macroeconomic outcomes relative to the LAW policy rule augmented by the credit spread. The “ex-post” nature of NPLs may

³⁸Note that I consider a steady state in which default is positive and hence the credit spread is positive (see Appendix 2.D).

play a role in their relatively worse performance. The credit spread serves as a better indicator of financial imbalances because it combines both a forward-looking measure of default and a current indicator of balance sheet health, i.e. equity capital shortfall. As the next Section makes clear, augmenting the monetary policy decision rule by the credit spread is therefore welfare enhancing in relative terms.

2.5 Calibration

I choose the calibration partly to simplify the task of finding an analytical steady state, to align the parameters with a number of moments in Mexican data, and to match common parameter values in the literature. Steady state derivations and values are presented in Appendix 2.D. The discount factor of households is chosen to be $\beta = 0.98$ to achieve a steady state quarterly real deposit rate of $r^d = 2.04\%$. This approximately matches the annual real interest rates in Mexico over the period from 2000 to 2020. The inter-temporal elasticity of substitution of households is set to 2.0 in line with the literature. Habit persistence is set to zero in the calibrated model to focus on a simplified steady state.³⁹ The relative utility weight of labor is $\xi = 0.46$ to fix steady state hours worked at $h = 1.0$. The inverse Frisch elasticity of labor supply is set to $1/3$, a value commonly used in the business cycle literature. The elasticity of substitution between home and foreign goods is $\xi = 0.3$, following Cuadra and Menna (2019). The rate of depreciation of physical capital, $\delta = 0.025$, the investment adjustment cost parameter, $\tau_I = 5.0$, and the effective capital share, $\alpha = 1/3$ are common values in the literature.

The three elasticities that determine the size of the renegotiation cost, ψ, γ, v , are aligned with the estimated values for the Russian economy in Andreev et al. (2020).⁴⁰ The elasticity of substitution between varieties is chosen to imply a mark-up of $z = 1.1$. The elasticity in export demand, $\vartheta = 1.0$, the share of foreign output in export demand, $1 - \rho = 0.25$, and the Rotemberg adjustment cost parameter, $\tau_p = 30.0$, are adopted from Gertler et al. (2007). The bank capital depreciation rate is set to $\delta^b = 0.03$ to match an average NPL ratio of 2.8% in Mexico. The capital requirement follows the Mexican minimum requirement of 8% plus an additional

³⁹Habit persistence may be added at a later stage to match the data in the estimation.

⁴⁰Ideally, these parameters should be estimated with Mexican data using Bayesian methods, for example as in Andreev et al. (2020).

Table 2.1. Parameterization and calibration

Parameter	Description	Source/Target
Households		
β	0.98	Quarterly discount factor
α_h	0	Habit persistence
$1/\sigma$	2.0	Relative risk-aversion
χ	0.46	Relative utility weight of labor
φ	0.33	Inverse Frisch elasticity of labor supply
ξ	0.3	Elasticity of substitution between home and foreign goods
Capital firms		
δ	0.025	Rate of depreciation of physical capital
τ_I	5.0	Investment adjustment cost parameter
Wholesale firms		
α	0.33	Effective capital share
ψ	2.0	Elasticity of renegotiation cost
γ	1.1	Sensitivity of renegotiation cost w.r.t. θ
v	1.3	Sensitivity of renegotiation cost w.r.t. aggregate credit
Retailers		
ϵ	11.0	Elasticity of substitution between varieties
τ_p	30.0	Rotemberg adjustment cost parameter
Foreign sector		
ϑ	1.0	Elasticity in export demand
$1 - \varrho$	0.25	Share of foreign output in export demand
Banks		
δ_b	0.015	Bank capital depreciation rate
τ_b	11.5	Bank capital adjustment cost parameter
CAR^*	0.105	Bank capital adequacy ratio
ι	0.005	Elasticity of country risk premium
Central bank		
ϕ_π	1.5	Weight on inflation in MonPol rule
ϕ_y	0.5	Weight on output in MonPol rule
ϕ_r	0.8	Weight on interest smoothing in MonPol rule
ϕ_ω	1.5	Weight on credit spread in MonPol rule
Shocks		
ρ_a	0.9	Persistence of TFP shock
ρ_d	0.9	Persistence of country risk premium shock
ρ_y	0.9	Persistence of foreign demand shock
ρ_{r^*}	0.9	Persistence of foreign interest shock
ρ_r	0.9	Persistence of monetary policy shock

Note: This table presents the model calibration for a non-stochastic steady state with default.

capital buffer. The bank capital adjustment cost parameter, $\tau_b = 11.5$, is taken from Gerali et al. (2010).

The weight on inflation in the monetary policy rule is chosen to correspond to a more than one-to-one increase in the interest rate in response to an increase in inflation. The weights on output and interest rate smoothing are similar to the optimal weights under an augmented Taylor Rule in response to a country risk premium shock found by Mimir and Sunel (2019). The weight on the financial stability externality, i.e. the credit spread, is positive. The central bank will want to increase the policy rate following a rise in credit spreads to counter the credit boom and resulting default losses. Finally, all shocks are assumed to have sufficient persistence but should ideally be estimated based on Mexican data. Future work will need to address the limitations of the chosen calibration as discussed in the next section.

2.6 Results

This section outlines the transmission mechanism of a positive exogenous shock to the foreign interest rate r_t^{d*} and presents the impulse responses obtained from the simulation of the calibrated model. I assume that the shock persists as a first-order autoregressive process with a coefficient of 0.9. I relegate a summary of the equilibrium conditions to Appendix 2.C.⁴¹

2.6.1 Expected External Financial Shock Transmission

I first conjecture how the shock to the foreign interest rate paid by banks on foreign debt propagates through the real and financial sector. Figure 2.3 displays the stylized shock transmission mechanism. For ease of exposition, I shall refer to the shock as a foreign monetary policy shock to Mexico, originating in the US. Suppose the US Federal Reserve unexpectedly raises the federal funds rate. International investors will find it relatively more profitable to invest in the US since yields are expected to rise. Consequently funds flow out of Mexico (and from other EMEs) to the US. The Mexican peso depreciates against the USD by the UIP condition in (2.35). The weaker peso however stimulates exports which, *ceteris*

⁴¹Appendix 2.E provides additional results for the country risk premium shock.

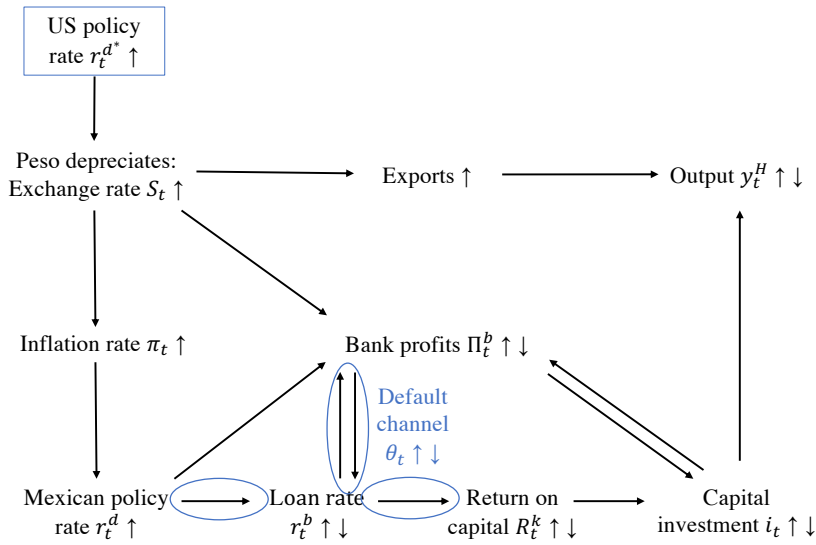


Figure 2.3. Stylized monetary policy transmission mechanism

Note: This figure illustrates the propagation mechanism of an external monetary policy shock that ripples through the domestic economy.

paribus, increases output (the trade channel). At the same time, the weaker peso makes imports more expensive for households and causes CPI inflation to rise. The central bank, who follows an inflation-targeting rule under the status quo, will consequently increase the policy rate by more than one-to-one with inflation.

On the financial side of the economy, the important question is how a higher policy rate, in theory, is expected to affect bank net worth. Importantly, the loan rate does not simply increase one for one with the policy rate. Recall that two components determine the spread between the loan rate and the deposits rate $\omega_t \equiv r_t^b - r_t^d$ in (2.34): (1) the fraction of the loan, θ_t , that firms choose to default on, and (2) how far away the bank is from the regulatory capital requirement $\frac{k_t^b}{b_t} - CAR^*$, i.e. the size of adjustment costs that it incurs for bringing its capital ratio to target. Thus, whether the credit spread that the bank earns increases or decreases depends on its exposure to NPLs and on how closely it can meet the capital requirement.

The loan rate in turn affects the return on capital and production that wholesale producers must earn to reap profits. The capital return relationship in (2.18) shows that a higher cost of funding can only be absorbed by wholesale producers if they can raise their productive return on capital $\alpha p_{t+1}^w y_{t+1}^w / q_t k_t$ or achieve higher capital gains R_{t+1}^k from holding capital as an asset. The return on capital affects

capital investment by capital producers. It in turn indirectly feeds back to banks via demand for credit and the repayment of claims.

As highlighted in Figure 2.3, default plays a key role because it partly determines the positive credit spread. Default also affects the return on production that wholesale firms earn. Finally, it affects the degree of credit losses that banks suffer on their loan portfolio, and whether they decide to cut back on lending. The strategic decision to default in turn depends on aggregate credit conditions via the renegotiation cost of default. Higher credit supply increases the losses from NPLs, all else equal. Due to the two-way causality between bank credit supply and default, it is not entirely obvious how NPLs and loans will move in response to an external shock. I therefore investigate next to what extent this transmission mechanism manifests in the stochastic simulation and what we can learn about the interaction of default and the health of the banking sector.

2.6.2 Status Quo Rule: Responses to an External Shock

To understand whether the conjectured transmission channels materialize in the model simulations, first consider the impulse response functions (IRFs) under the status quo interest rate rule that addresses inflation stabilization only. Figure 2.4 presents the relative IRFs for selected endogenous variables with respect to a one unit exogenous increase in the foreign interest rate r_t^{d*} under the *status-quo inflation targeting rule*. That is, they display the percentage response in the selected variables to a 100 basis point increase in the foreign interest rate. The IRFs are obtained using a first-order linear approximation around the non-stochastic steady state.⁴² The derivations of an analytical solution to the non-stochastic steady state are presented in Appendix 2.D and the steady state values in Table 2.D.1.

The shock transmission proposed in Figure 2.3 can be traced out in the IRFs in Figure 2.4. On the real side of the economy (top two rows), the positive shock to the foreign interest rate indeed triggers a sharp depreciation of the real exchange rate which raises exports as expected. Consumption however falls since the strong depreciation of the peso lowers the purchasing power of households. Output

⁴²The approximation does not capture non-linear behavior such as precautionary savings. Larger departures from the steady state moreover mean that the conditions for borrowing constraints to bind in the steady state may not hold anymore.

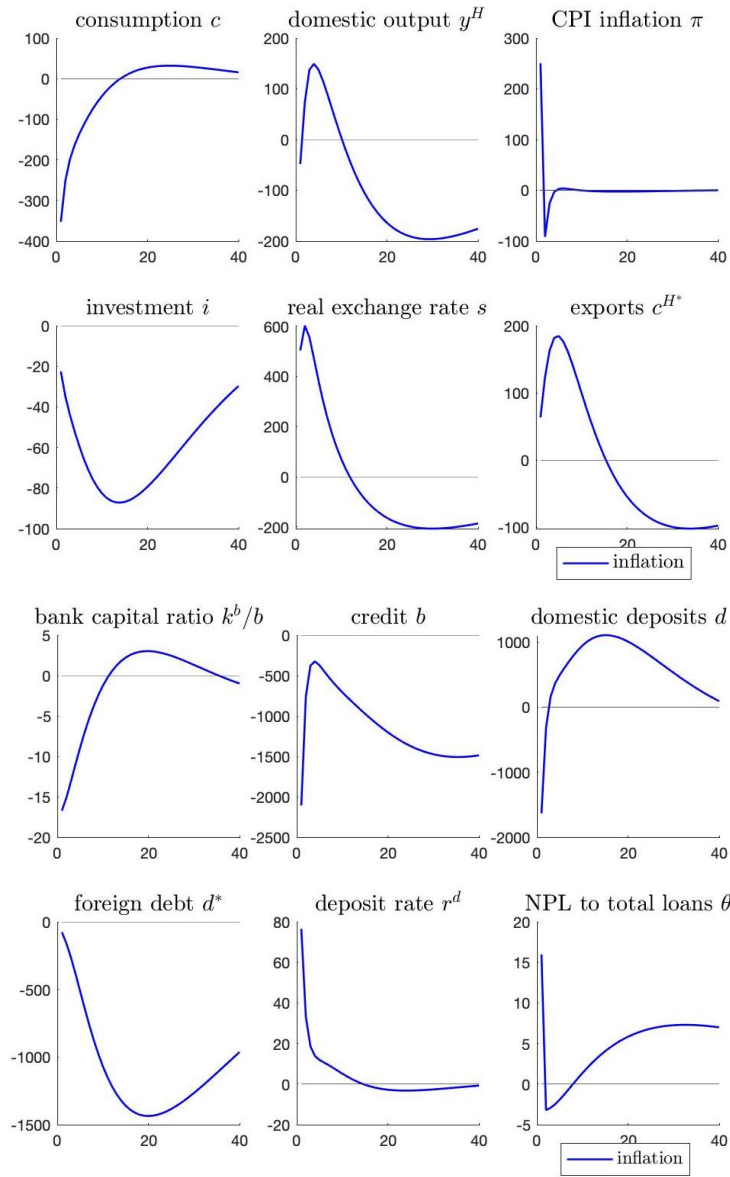


Figure 2.4. Status quo rule in response to a shock to the foreign interest rate r_t^{d*} .

Note: This figure presents the relative impulse response functions in absolute deviations from steady state of selected endogenous variables with respect to a 100 basis point increase in the foreign interest rate r_t^{d*} under a status quo inflation targeting policy rule.

drops initially because higher exports cannot compensate for subdued demand in domestic goods. Investment in capital suffers from this economic downturn. Moreover, the high real exchange rate makes imported goods more expensive for households. This is reflected by the spike in inflation in the first quarter. These observations are consistent with evidence by Avdjiev, Bruno, Koch, and Shin (2019)

who find that the financial channel of exchange rate adjustments prevails over the trade channel in EMEs when the USD strengthens. That is, a weaker domestic currency vis-à-vis the USD is associated with reduced cross-border bank flows and real domestic investment. Along these lines, Figure 2.4 indicates that a weakening of the peso depresses rather than supports investment when US monetary policy tightens.

The IRFs on the financial side of the economy (bottom two rows) corroborate that this effect operates via the balance sheet of banks as suggested by Avdjiev et al. (2019). As expected, capital outflows ensue in response to a positive foreign interest rate shock. Foreign deposits drop sharply, not only at the outset but also over time. Under the status quo rule, the central bank responds to the surge in inflation by raising the policy rate by almost 80 basis points in the first quarter. A higher deposit rate would usually be expected to stimulate saving of household wealth, *all else equal*. The IRF of domestic deposits however indicates quite the opposite. Deposits drop sharply in the first quarter. This drop points towards a supply-side driven reason – the contraction of banks’ balance sheet as the central bank tightens monetary policy. In particular, credit supply is sharply reduced due to higher firm default levels. As NPLs accrue on banks balance sheets in the first quarter, their capital ratio falls below the regulatory requirement. Hence, they reduce their lending activity and shrink their balance sheet. As the credit crunch ensues, the marginal benefit of defaulting falls. This brings down NPL levels.

What triggers the surge in NPLs upon impact? The initial fall in output and hence demand for wholesale goods leads to a fall in profits generated from sales of wholesale goods. To compensate for this profit loss, wholesale producers decide to cash in a share of the loan instead of repaying it. Default is hence induced by the economic downturn. Apart from the ensuing credit crunch, a second force that reduces NPL losses in the second quarter is the surge in inflation in the first quarter. By the Fisher equation, inflation reduces the real cost of debt financing. A lower real interest rate attenuates the need to default on a large fraction of the loan. Therefore, firms choose to default less in the second quarter on debt previously entered into.

2.6.3 LAW Policy Rules: Responses to an External Shock

Next, I compare the relative IRFs in response to the same shock to r_t^{d*} across the four different policy rules: (i) status quo inflation-targeting rule, (ii) Taylor rule, (iii) LAW rule, and (iv) LAW-Taylor rule. Figure 2.5 presents the results

First, consider the IRFs under (i) the status quo rule (solid blue line) to the IRFs under (ii) the Taylor rule (solid red line). The two interest rate rules are expected to achieve quantitatively different responses. In the context of AEs, the divine coincidence implies that stabilizing inflation stabilizes output automatically under certain regularities, and hence the Taylor rule is optimal (Blanchard & Galí, 2007). Real world episodes suggest that the divine coincidence however does not hold in the context of EMEs, where the financial channel of exchange rate adjustment interferes. EMEs often observe surging inflation and a contraction in economic activity in response to an adverse external shock to capital flows. This stylized fact obtains in Figure 2.5 for both the status quo inflation targeting rule and the Taylor rule. In support of the breakdown of the divine coincidence, the fall in output and the spike in inflation are more pronounced under a Taylor rule. Inflation returns sooner to its steady state level under inflation targeting. These differences are quantitatively distinguishable even absent precise estimates from a model estimated on data. The results thus confirm that the divine coincidence fails to hold in my model.

On the financial side of the economy, dynamic responses are generally also very different under the two interest rate rules. A simple inflation targeting rule outperforms the Taylor rule in each aggregate variable considered in terms of their volatility. The NPL ratio rises by less initially and remains at a lower level in the longer run when the central bank only stabilizes inflation. The credit crunch is exacerbated when the central bank follows a Taylor rule. This is because monetary policy (r^d in the bottom row) is too tight for too long under a Taylor rule.⁴³

What happens if the central bank adopts a LAW policy rule that is augmented by the credit spread (blue dotted line)? The short-term effects of the shock on

⁴³A qualification of this result is in place. Note that the Taylor rule in this calibration is not optimized over a grid search in the sense of optimal simple rules proposed by Schmitt-Grohé and Uribe (2007). Doing so may improve upon outcomes. However, the large quantitative differences in Figure 2.5 suggest that pure inflation stabilization will still likely be more efficient.

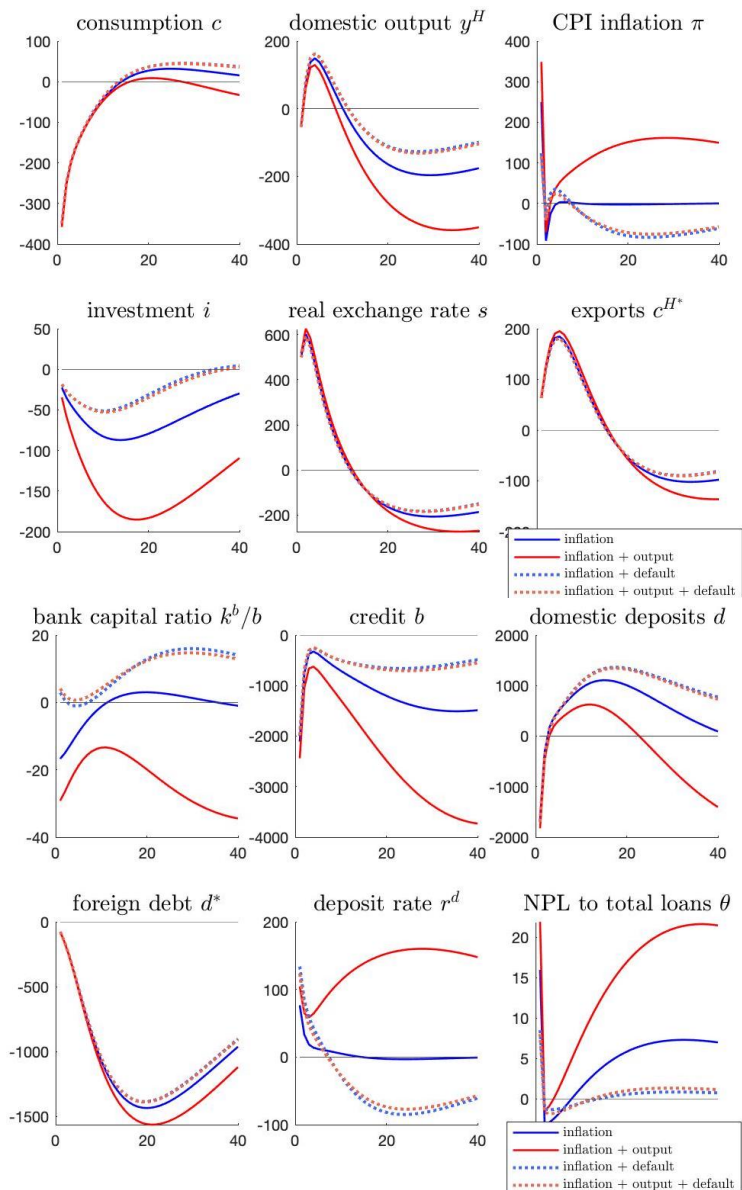


Figure 2.5. Comparison of IRF under policy rules in response to a shock to the foreign interest rate r_t^{d*} .

Note: This figure presents the relative impulse response functions in absolute deviations from steady state of selected endogenous variables with respect to a 100 basis point increase in the foreign interest rate r_t^{d*} under four different policy rules: (i) status quo inflation-targeting rule, (ii) Taylor rule, (iii) LAW rule, and (iv) LAW-Taylor rule.

the real exchange rate, exports, consumption, and output are quantitatively very similar to other interest rate rules. However, the LAW policy rule achieves more favourable outcomes in these key macro variables in the longer run. Moreover,

investment falls by less in the medium to long run. Inflation rises only by 1.3 percentage points from its steady state value initially. However, persistent deflation ensues in the longer run.

The improved health of the real economy through the LAW policy rule benefits the reduction in NPLs by design. In the short-run, default losses are less pronounced because the policy rate is raised even higher than under the status quo inflation-targeting rule and the Taylor rule upon impact. The policy rate is then subsequently lowered below the steady state level in a countercyclical manner to combat the recession. The long-run NPL ratio falls almost to its steady state value by virtue of more accommodative monetary policy after several quarters. Accommodative monetary policy is able to revert the economy back to a stable trajectory as it counters the initial contraction in credit. On this trajectory, deflation is manageable and default does not prompt a stronger debt-deflation. As a result of less severe default losses, banks are able to build up their capital base to raise their capital adequacy ratio above the regulatory level. Banks do not have to shrink their balance sheet as drastically as when the central bank does not incorporate the credit spread in its monetary policy rule.

Note that changing the interest rate rule leaves external capital flows largely unaffected. At most, the outflow of capital from Mexico to the US is a bit less pronounced under a LAW policy rule in the longer run. Due to the reduced form modelling device of the foreign economy, there is little direct interaction between capital flows and default channel. The bulk of indirect amplification stems from the effect of capital outflows on the exchange rate and thus on banks' balance sheet contraction.

What are likely causes of the failure to stabilize inflation in the medium to long term under a LAW policy rule? The real rate of return and the rate of default stabilize at their steady state levels in the longer run. As the central bank lowers the policy rate below the steady state level, a period of deflation ensues by the Fisher equation. However, the stable real rate also aids investment in stabilizing much faster under a LAW policy rule. The interim downward pressure on the price level is therefore inconsequential.

Finally, under a LAW-Taylor rule, similar results obtain as under a LAW rule without the output gap. Only the policy rate and the long-run NPL ratio are slightly lower if inflation and default are considered in the monetary policy rule.⁴⁴

2.7 Discussion

Comparing the IRFs with the theoretical transmission channel confirms the existence of a financial channel of exchange rate adjustment that is amplified via banks' balance sheets in the model. The shock triggers a strong real depreciation which stimulates exports. But the trade channel is not strong enough. Inflation spikes and output falls as expected in EMEs. A persistent credit crunch ensues in response to a surge in the NPL ratio. The LAW interest rate rule performs better in terms of most macroeconomic outcomes of interest – consumption, investment, output, and lending. It reduces the volatility in key variables on both the real and financial side of the economy. The only exception is inflation, which returns sooner to its steady state value under the status-quo inflation-targeting rule (by design).

Overall, the results suggest that a LAW policy rule augmented by the credit spread still leads to a forceful initial reaction in the interest rate to the external financial shock. This yields the same fallout in real activity in the short run. While a LAW policy rule therefore cannot mitigate the adverse effects on the domestic economy upon impact, it can dampen the medium to longer term dragging effect of the domestic financial crisis onto economic activity.

The magnitude of capital outflows remains largely invariant to the type of policy rule. A lower default rate is associated with a slightly faster return of capital outflows to steady state but the magnitudes are very subtle. Capital outflows are unaffected by the scale of default most importantly because the model lacks an explicit feedback mechanism with the rest of the world (which is modelled in reduced form). Default risk may bite precisely when it affects the willingness of foreign financiers to lend to the domestic economy. A way to address such a feedback mechanism would involve modelling the foreign financial sector explicitly. A

⁴⁴The lack of differences between these interest rate rules may stem from the fact that the calibration is not optimally chosen to maximize welfare. Further research is needed to estimate the parameters underlying the interest rates rules.

portfolio choice problem that lets both banks (or firms) and foreign financiers optimally choose the currency composition of their debt (Gabaix & Maggiori, 2015) could capture the interaction of currency mismatch with default risk. This could refine the financial channel of exchange rate adjustment and provide a powerful source of amplification to match observed capital flight episodes.

A word of caution with regards to the results is in place. Several assumptions are required to simplify the task of finding a steady state analytically (see Appendix 2.D). The calibration is chosen to match only a subset of relevant moments in Mexican data. In particular, the results are sensitive to the chosen elasticities in the debt renegotiation cost. Several parameter values, including these elasticities, have been found by the literature to be adequate for EMEs. A more bottom-up approach to calibration would estimate these parameters using granular data on Mexican defaults to match Mexico's sectoral structure and external positions. Synergies in the data exercise in Chapter 3 could be exploited to estimate default-related elasticities. Specifically, data on credit spreads and probabilities of default for Mexican non-financial firms could be exploited to estimate ψ , γ , and ν . Even more adequate, the model could be estimated on Mexican data using Bayesian methods to enable a quantification of the results and conduct counterfactual welfare analysis under different policies.⁴⁵

Another limitation in this paper relates to the coefficients in the monetary policy rules not being optimally chosen. The optimal simple rule method following Schmitt-Grohé and Uribe (2007) provides an approach to finding optimal coefficients. As applied e.g. by Mimir and Sunel (2019), this method can be used to compare optimal coefficients and different monetary policy rules under different external shocks. This is one of the next steps to further quantify the results of the simulations.

Finally, my model does not feature a regulator with discretionary choices over a policy instrument. Nor does it consider a reaction function or decision rule whereby the capital requirement endogenously responds to shocks. Instead, the regulatory policy instrument is taken to be an exogenous capital adequacy requirement to focus our attention exclusively on monetary policy and the role of

⁴⁵See for example Andreev et al. (2020) and Martínez et al. (2020) for applications to the Russian and Chilean economies.

financial stability therein. This brings us back to the more fundamental debate since the GFC: should monetary policy makers internalize the negative effects of their monetary policy decision onto the financial system? Or is it upon regulators to do so using appropriate, and possibly more targeted tools? Follow the Tinbergen (1956) principle, one would require one endogenous policy *instrument* for each externality to be addressed – or for each policy objective to be pursued. A complete analysis of the normative question set out in this paper therefore necessitates also modelling regulatory policy endogenously, and to investigate the interaction thereof with monetary policy (see for example Martínez et al. (2020)).

With this in mind, my model is amenable to being augmented by a regulatory policy rule that responds to financial imbalances in a counter-cyclical fashion. Specifically, the assumption that banks accumulate bank capital for prudential purposes leaves scope to explore the effects of the interaction between the monetary policy instrument (the policy rate) and the regulatory policy instrument (*CAR*) in response to external shocks.

2.8 Conclusion

This paper asks whether it can be welfare-enhancing for monetary policy in EMEs to respond to financial stability risks in light of EMEs' financial vulnerabilities to external shocks. I compare the performance of alternative “leaning-against-the-wind” (LAW) interest rate rules that react to the destabilizing forces of an external funding shock to the banking sector. The effect of the US taper tantrum on the Mexican economy serves as a useful case to illustrate the propagation of such a shock. I embed standard inflation-targeting and Taylor rules as well as a LAW policy rule in a small open economy New-Keynesian DSGE model with a banking sector and endogenous firm default. The borrowing and default decisions of firms amplify the effect of the negative shock to bank's foreign funding sources.

Although the model is fairly stylized and parameters are not estimated, the simulations capture well the financial channel of exchange rate adjustment in small open economies in response to a US monetary policy shock. The model produces a depreciation of the exchange rate, a spike in inflation, and a drop in output, akin to observed past episodes in many EMEs such as the US taper tantrum. Rising

NPL levels and outflows of foreign funds from banks' balance sheets explain a prolonged credit crunch in the economy. The existence of firm default in equilibrium creates a link between real production and financial intermediaries through which monetary policy transmits.

I find support for a LAW policy rule augmented by the credit spread as a proxy for macro-financial risks. This rule outperforms conventional interest rate rules in terms of volatility in consumption, output, and investment. By responding to the forward-looking credit spread, the central bank thus internalizes both changes in expected default on bank balance sheets and in banks' risk of regulatory violations following a credit crunch. It therefore responds more forcefully through monetary tightening upon impact of the shock but follows up by countercyclical monetary easing in the medium term. These measures mitigate the adverse effect of the shock on NPL losses and contain the contraction in bank credit. My findings moreover confirm the stylized fact that the "divine coincidence" does not obtain in EMEs in practice.

Ultimately, financial amplification in EMEs may even be stronger when default risk and currency mismatch interact with the willingness of foreign financiers to provide credit. Endogenous capital flow volatility may necessitate the adoption of alternative regulatory instruments when monetary policy alone cannot absorb external financial shocks. Future research should therefore address complementing *optimal* LAW monetary policies with *targeted* regulatory instruments.

Appendices of Chapter 2

Appendix 2.A Details on Data

Table 2.A.1. Data sources of key Mexican macroeconomic and financial indicators

Variable	Source	Description
Sectoral debt statistics	Institute of International Finance (IIF), Quarterly Global Debt Monitor	Quarterly, debt issued by the financial and non-financial corporate sectors and the government sector (in US\$ bn) by currency in Mexico.
Annual CPI inflation	Instituto Nacional de Estadística Geografía e Informática	Year-on-year percentage change in the monthly Consumer Price Index (CPI)
MXN/USD spot exchange rate	FRED, Federal Reserve Bank of St. Louis	Daily, not seasonally adjusted, Board of Governors of the Federal Reserve System (US), Mexican Pesos to U.S. Dollar Spot Exchange Rate [DEXMXUS]
Terms of Trade Inflation	Banco de México	Year-on-year percentage change in the monthly Terms of Trade Price Index, seasonally adjusted (1980=100)
Current Account	International Monetary Fund, International Financial Statistics (IFS)	Quarterly, in US\$ mn.
VIX	FRED, Federal Reserve Bank of St. Louis	Daily, Chicago Board Options Exchange, CBOE Volatility Index [VIX-CLS]
Probability of default (high yield firms)	Moody's CreditEdge	Daily/monthly expected default frequencies (EDFs) at the firm level, averaged across issuers with a high-yield Moody's issuer rating
Non-performing loan (NPL) ratio	Banco de México	Monthly, non-performing unsecured credit to total unsecured credit, in percentage terms
Real interest rate	International Monetary Fund, International Financial Statistics (IFS), and data files using World Bank data on the GDP deflator	Annual, computed as the lending interest rate adjusted for inflation as measured by the GDP deflator.

Note: This table presents data sources from which the series displayed in the figures are retrieved. Most data series are based also on author's computations to aggregate across different frequencies for the purpose of illustration.

Appendix 2.B Model Overview

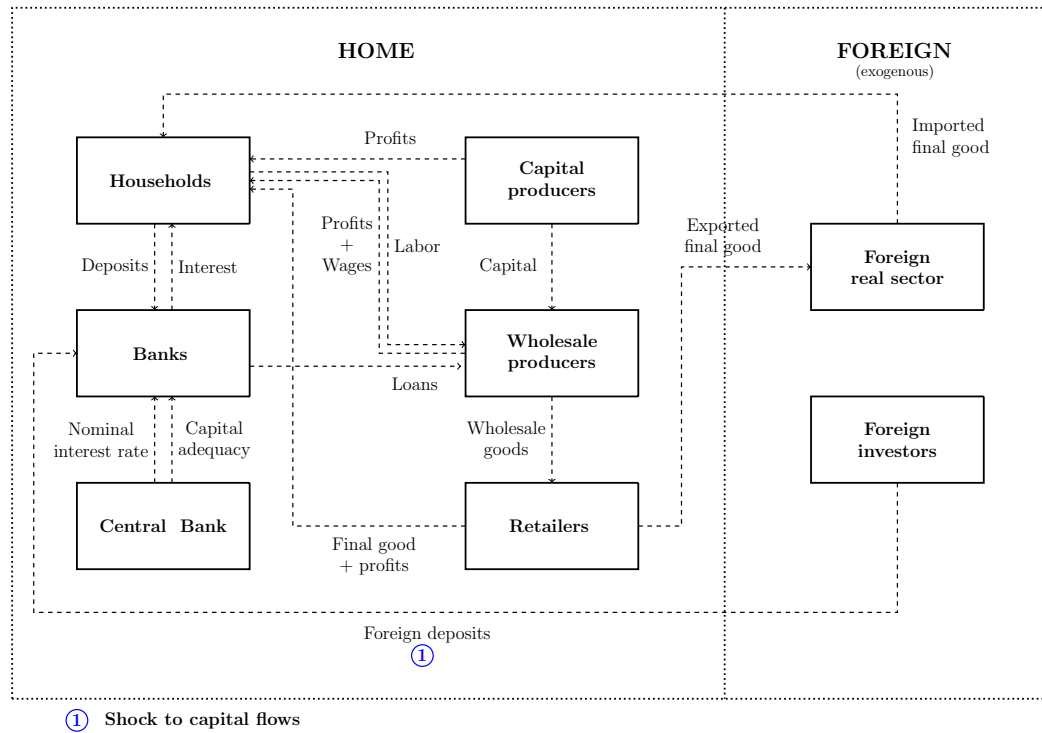


Figure 2.B.1. Overview of the model economy

Note: This figure presents a stylized overview of the model. Note that the benchmark analysis assumes a fixed, exogenous capital adequacy ratio imposed by the central bank.

Appendix 2.C Full Set of Equilibrium Conditions

Households	
Budget constraint	$c_t + p_t^H d_t = w_t h_t + p_t^H \frac{(1 + r_{t-1}^d)}{\pi_t} d_{t-1} + \Pi_t$
Marginal utility	$\Lambda_t = (c_t - \alpha_h c_{t-1})^{-\sigma} - \beta \alpha_h E_t (c_{t+1} - \alpha_h c_t)^{-\sigma}$
Real wage	$w_t = \frac{\chi h_t^\varphi}{\Lambda_t}$
Euler equation, risk-free asset	$\Lambda_t = \beta E_t \left[\frac{\Lambda_{t+1} p_{t+1}^H}{\pi_{t+1} p_t^H} (1 + r_t^d) \right]$
Consumption aggregate	$c_t = Z (c_t^H)^{1-\xi} (c_t^F)^\xi$
Domestic price index	$p_t^H = s_t^{-\frac{\xi}{1-\xi}}$
Total demand	$c_t = p_t^H c_t^H + s_t c_t^F$
Demand of home goods	$c_t^H = (1 - \xi) \frac{c_t}{p_t^H}$
Demand for foreign goods	$c_t^F = \xi \frac{c_t}{s_t}$
Real exchange rate	$s_t = \frac{S_t P_t^*}{P_t} = \frac{S_t P_t^{F*}}{P_t} \quad \text{with} \quad P_t^{F*} = P_t^* = 1$
Capital producers	
Law of motion of capital	$k_t = (1 - \delta) k_{t-1} + \left[1 - \frac{\tau_I}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t$
Q-investment relation	$p_t^H = q_t \left[1 - \frac{\tau_I}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 - \tau_I \left(\frac{i_t}{i_{t-1}} - 1 \right) \frac{i_t}{i_{t-1}} \right] + E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} q_{t+1} \tau_I \left(\frac{i_{t+1}}{i_t} - 1 \right) \left(\frac{i_{t+1}}{i_t} \right)^2$
Capital producer profits	$\Pi_t^c = q_t (k_t - (1 - \delta) k_{t-1}) - p_t^H i_t$
Wholesale goods producers	
Borrowing constraint	$q_t k_t = p_t^H b_t$
Production function	$y_t^w = A_t k_{t-1}^\alpha h_t^{1-\alpha}$
Wholesale producer profits	$\Pi_t^w = p_t^w y_t^w - w_t h_t - p_t^H (1 - \theta_t) b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} - \frac{p_t^H \Omega_t}{(1 + \psi)} \left[\theta_t b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \right]^{(1+\psi)} + q_t (1 - \delta) k_{t-1}$
FOC labor	$w_t = p_t^w \frac{(1 - \alpha) y_t^w}{h_t}$
FOC capital	$\mu_t^w = E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} \left[\frac{\alpha p_{t+1}^w y_{t+1}^w}{q_t k_t} + \frac{q_{t+1}}{q_t} (1 - \delta) \right]$
FOC debt	$\mu_t^w = E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} \frac{1}{\pi_{t+1}} \frac{p_{t+1}^H}{p_t^H} \left[(1 - \theta_{t+1}) (1 + r_t^b) + \Omega_{t+1} \theta_{t+1} (1 + r_t^b) \left[\theta_{t+1} b_t \frac{(1 + r_t^b)}{\pi_{t+1}} \right]^\psi \right]$
FOC default	$1 = \Omega_t \left[\theta_t b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \right]^\psi$
Renegotiation cost relation	$\Omega_t = \Omega \frac{\Delta}{\Delta_t}$

$$\text{Renegotiation cost component} \quad \Delta_t = \frac{(\theta_t)^\gamma (b_{t-1}(1+r_{t-1}^b)/\pi_t)^v}{(y_t^H)^v}$$

Retail goods producers

$$\begin{aligned} \text{Phillips Curve} \quad & (\epsilon - 1) = \epsilon \frac{p_t^w}{p_t^H} - \tau_p (\pi_t^H - 1) \pi_t^H \\ & + \tau_p \beta E_t \left[\frac{\Lambda_{t+1}}{\Lambda_t} (\pi_{t+1}^H - 1) \pi_{t+1}^H \left(\frac{p_{t+1}^H y_{t+1}^H}{p_t^H y_t^H} \right) \right] \\ \text{Retail producer profits} \quad & \Pi_t^r = p_t^H y_t^H - p_t^w y_t^H - \frac{\tau_p}{2} (\pi_t^H - 1)^2 p_t^H y_t^H \end{aligned}$$

Foreign demand

$$\text{Foreign demand for home goods} \quad c_t^{H*} = \left[\xi \left(\frac{P_t^{H*}}{P_t^*} \right)^{-\vartheta} y_t^* \right]^\rho (c_{t-1}^{H*})^{1-\rho}$$

Banks

$$\begin{aligned} \text{Law of motion of bank capital} \quad & k_t^b = (1 - \delta^b) \frac{k_{t-1}^b}{\pi_t} + \Pi_t^b \\ \text{Balance sheet constraint} \quad & b_t = d_t + S_t d_t^* + k_t^b \\ \text{Country risk premium} \quad & \Psi_t = \exp(\iota(d_t^* - d^*)) \xi_{d,t} \\ \text{Bank profits} \quad & \Pi_t^b = (1 - \theta_t) \frac{(1 + r_{t-1}^b)}{\pi_t} b_{t-1} - b_t - \frac{(1 + r_{t-1}^d)}{\pi_t} d_{t-1} \\ & + d_t - S_t \Psi_t \frac{(1 + r_{t-1}^{d*})}{\pi_t} d_{t-1}^* + S_t d_t^* \\ & + \left(k_t^b - \frac{k_{t-1}^b}{\pi_t} \right) - \frac{\tau_b}{2} \left(\frac{k_t^b}{b_t} - CAR^* \right)^2 k_t^b \\ \text{Credit spread} \quad & \omega_t \equiv r_t^b - r_t^d = E_t \beta \frac{\Lambda_{t+1}}{\Lambda_t} \frac{1}{\pi_{t+1}} \left(\theta_{t+1} (1 + r_t^b) \right) \\ & - \tau_b \left(\frac{k_t^b}{b_t} - CAR^* \right) \left(\frac{k_t^b}{b_t} \right)^2 \\ \text{UIP condition} \quad & E_t \beta \frac{\Lambda_{t+1}}{\pi_{t+1}} \left[(1 + r_t^d) - \Psi_{t+1} (1 + r_t^{d*}) \frac{S_{t+1}}{S_t} \right] = 0 \end{aligned}$$

Aggregate constraints

$$\begin{aligned} \text{Aggregate resource constraint} \quad & y_t^H = c_t^H + c_t^{H*} + i_t + \delta^b \frac{k_{t-1}^b}{\pi_t} + \frac{\tau_p}{2} (\pi_t^H - 1)^2 y_t^H \\ & + \frac{\tau_b}{2} \left(\frac{k_t^b}{b_t} - CAR^* \right)^2 k_t^b + \frac{\Omega_t}{(1 + \psi)} \left[\theta_t b_{t-1} \frac{(1 + r_{t-1}^b)}{\pi_t} \right]^{(1+\psi)} \\ \text{Aggregate profits} \quad & \Pi_t = \Pi_t^c + \Pi_t^w + \Pi_t^r \end{aligned}$$

Central Bank

$$\begin{aligned} \text{Augmented interest rate rule (4)} \quad & (1 + r_t) = (1 + r)^{(1-\phi_r)} (1 + r_{t-1})^{\phi_r} \cdot \left(\frac{\pi_t}{\bar{\pi}} \right)^{\phi_\pi (1-\phi_r)} \\ & \cdot \left(\frac{y_t}{\bar{y}} \right)^{\phi_y (1-\phi_r)} \cdot \left(\frac{\omega_t}{\bar{\omega}} \right)^{\phi_\omega (1-\phi_r)} \epsilon_{r,t} \end{aligned}$$

Shocks

Productivity shock	$\log(A_{t+1}) = (1 - \rho_a)A + \rho_a \log(A_t) + \epsilon_{a,t+1}$
Country risk premium shock	$\log(\xi_{d,t+1}) = \rho_d \log(\xi_{d,t}) + \epsilon_{d,t+1}$
Foreign output shock	$\log(y_{t+1}^*) = (1 - \rho_y)y^* + \rho_y \log(y_t^*) + \epsilon_{y,t+1}$
Foreign interest rate shock	$\log(r_{t+1}^{d*}) = (1 - \rho_{r^*})r^{d*} + \rho_{r^*} \log(r_t^{d*}) + \epsilon_{r^*,t+1}$
Domestic monetary policy shock	$\log(\xi_{r,t+1}) = (1 - \rho_r)\xi_r + \rho_r \log(\xi_{r,t}) + \epsilon_{r,t+1}$

Appendix 2.D The Non-Stochastic Steady State with Positive Default

Before dropping all time subscripts in steady state, note that steady state inflation is assumed to be zero, i.e. gross inflation (both domestic and CPI) equals one $\pi^H = \pi = 1$. Moreover, I set hours worked to one, $h = 1$, foreign deposits to zero, $d^* = 0$, the capital ratio to the regulatory level, $k^b/b = CAR^*$, and foreign output to one, $y^* = 1$, to simplify the steady state. Note also that for the time being I calibrate $\sigma = 1$ and $\alpha_h = 0$ to reduce the problem to log utility without habit formation.

Households Households' budget constraint reduces to,

$$c = w + r^d d + \Pi^w + \Pi^r \quad (2.D.1)$$

From households' Euler equation and FOCs, we get

$$\beta = \frac{1}{1 + r^d} \quad (2.D.2)$$

and

$$\begin{aligned} c^{-\sigma} &= \frac{\chi}{w} \\ \Leftrightarrow \chi c^\sigma &= (1 - \alpha) p^w y^w \\ \Leftrightarrow \chi c^\sigma &= (1 - \alpha) \frac{\epsilon - 1}{\epsilon} p^H k^\alpha \end{aligned} \quad (2.D.3)$$

Moreover, the expenditure minimization problem of households,

$$\begin{aligned} \min c - p^H c^H + s c^F \\ \text{s.t. } c &= Z(c^H)^{1-\xi} (c^F)^\xi \end{aligned} \quad (2.D.4)$$

implies,

$$c = p^H c^H + s c^F \quad (2.D.5)$$

$$p^H c^H = (1 - \xi) c \quad (2.D.6)$$

$$s c^F = \xi c \quad (2.D.7)$$

where $s = SP^{F^*}/P$. Plugging the two demand equations into the technology function yields the relationship between the domestic price index and the real exchange rate,

$$p^H = s^{-\frac{\xi}{1-\xi}} \quad (2.D.8)$$

In order to get an expression for Z , plug (2.D.6) and (2.D.7) into (2.D.4),

$$c = Z \left((1 - \xi) \frac{c}{p^H} \right)^{1-\xi} \left(\xi \frac{c}{s} \right)^\xi$$

$$\Leftrightarrow (1 - \xi)^{-(1-\xi)} \xi^{-\xi} = Z \left(\frac{1}{p^H} \right)^{1-\xi} \left(\frac{1}{s} \right)^\xi$$

Thus, I calibrate Z as,

$$(1 - \xi)^{-(1-\xi)} \xi^{-\xi} = Z$$

Moreover, balanced trade implies,

$$p^H c^{H*} = s c^F$$

$$\Leftrightarrow s \xi y^* = \xi c \quad (2.D.9)$$

$$\Leftrightarrow s y^* = c \quad (2.D.10)$$

Plugging (2.D.10) into (2.D.8),

$$(p^H)^{-\frac{1-\xi}{\xi}} = \frac{c}{y^*} \quad (2.D.11)$$

Capital producers From the physical capital accumulation equation, we get a target value for the depreciation rate,

$$\delta = \frac{i}{k} \quad (2.D.12)$$

From the Q-investment relationship, we get $q = p^H$. Moreover, steady state profits are zero, $\Pi^c = 0$.

Wholesale goods producers Since the real price of capital is p^H , the budget constraint of firms boils down to,

$$k = b \quad (2.D.13)$$

Noting that the steady state mean of the productivity shock is zero in the log, i.e. $A = 1$,

$$y^w = k^\alpha \quad (2.D.14)$$

Combining (2.D.14) and (2.D.13),

$$y^w = k^\alpha = b^\alpha = y^H$$

From the FOC w.r.t h , we get

$$w = (1 - \alpha)p^w y^w \quad (2.D.15)$$

The FOC w.r.t k and b combined with (2.D.14) yield,

$$\begin{aligned} \frac{\alpha p^w y^w}{p^H k} + (1 - \delta) &= (1 + r^b) \\ \Leftrightarrow \alpha \frac{p^w}{p^H} k^{\alpha-1} &= (1 + r^b) - (1 - \delta) \\ \Leftrightarrow k &= \left[\frac{\epsilon}{\epsilon - 1} \frac{(1 + r^b) - (1 - \delta)}{\alpha} \right]^{\frac{1}{\alpha-1}} \end{aligned} \quad (2.D.16)$$

The FOC w.r.t θ in real terms results in,

$$1 = \Omega \left[\theta b (1 + r^b) \right]^\psi \quad (2.D.17)$$

The renegotiation cost in steady state is therefore,

$$\Omega = \left[\theta b (1 + r^b) \right]^{-\psi} \quad (2.D.18)$$

Using these results in the real profit function and simplifying,

$$\begin{aligned} \tilde{\Pi}^w &= p^w y^w - w - (1 - \theta) p^H b (1 + r^b) - \frac{p^H \Omega}{(1 + \psi)} \left[\theta b (1 + r^b) \right]^{(1+\psi)} + q(1 - \delta)k \\ &= [(1 + r^b) - (1 - \delta)] p^H k - (1 - \theta) p^H b (1 + r^b) - \frac{\theta p^H b (1 + r^b)}{(1 + \psi)} + p^H (1 - \delta)k \\ &= (1 + r^b) p^H k - (1 + r^b) p^H b + \frac{\psi}{1 + \psi} \theta p^H b (1 + r^b) \end{aligned} \quad (2.D.19)$$

Noting that $k = b$ in steady state,

$$\tilde{\Pi}^w = \frac{\psi}{1 + \psi} \theta p^H k (1 + r^b) \quad (2.D.20)$$

Retailers The New Keynesian Phillips curve under $\pi^H = 1$ yields an expression for the mark-up z charged by retailers above marginal cost,

$$z = \frac{p^H}{p^w} = \frac{\epsilon}{\epsilon - 1} \quad (2.D.21)$$

We use this result to get an expression for steady state retail profits,

$$\begin{aligned} \tilde{\Pi}_t^r &= (p^H - p^w)y^H \\ &= \left(p^H - \frac{\epsilon - 1}{\epsilon}p^H\right)y^H \\ &= \frac{1}{\epsilon}p^Hy^H. \end{aligned} \quad (2.D.22)$$

Therefore, profits are positive in steady state.

Foreign behavior. I normalize the price of the foreign CPI to one, $P_t^* = 1$, such that in steady state the demand for exports of domestic goods is,

$$\begin{aligned} c^{H*} &= \left[\xi \left(\frac{P^{H*}}{P^*}\right)^{-\vartheta} y^*\right]^\varrho (c^{H*})^{1-\varrho} \\ \Leftrightarrow \frac{c^{H*}}{y^*} &= \xi \left(\frac{P^H}{SP^*P}\right)^{-\vartheta} \\ \Leftrightarrow \frac{c^{H*}}{y^*} &= \xi \left(\frac{p^H}{s}\right)^{-\vartheta} \\ \Leftrightarrow \frac{c^{H*}}{y^*} &= \xi \frac{s}{p^H} \end{aligned} \quad (2.D.23)$$

where the last line follows from assuming $\vartheta = 1$ and $sP^{H*} = p^H$. Thus, the ratio of Mexican exports to US GDP depends on the real exchange rate and the domestic price index.

Banks The bank capital accumulation equation is given by,

$$k^b = (1 - \delta^b)k^b + \tilde{\Pi}^b \quad (2.D.24)$$

Assuming that foreign debt is zero, $d^* = 0$, the balance sheet constraint is given by,

$$\begin{aligned} b &= d + k^b \\ \Leftrightarrow d &= (1 - CAR^*)b \end{aligned} \quad (2.D.25)$$

In other words, the deposit-to-loans ratio equals one minus the regulatory capital ratio. Noting that the country risk premium is one in steady state (i.e. the exponent of zero) and there is no change in the nominal exchange rate, the UIP reduces to,

$$(1 + r^d) - (1 + r^{d*}) = 0 \quad (2.D.26)$$

The expression for the interest rate spread reduces to,

$$r^b - r^d = \beta\theta(1 + r^b) \quad \text{if } \theta \neq 0 \quad (2.D.27)$$

Using the fact that $r^d = r^{d*}$ and assuming that $k^b/b = CAR^*$ in steady state, the real profit function obtains as

$$\begin{aligned} \tilde{\Pi}^b &= (1 - \theta)(1 + r^b)b - b - (1 + r^d)d + d \\ \tilde{\Pi}^b &= (r^b - \theta(1 + r^b))b - r^d d \end{aligned}$$

If $\theta \neq 0$,

$$\begin{aligned} \tilde{\Pi}^b &= \left(r^b - \frac{1}{\beta}(r^b - r^d) \right) b - r^d d \\ \Leftrightarrow \tilde{\Pi}^b &= (r^d - r^b)r^d b + r^d k^b \end{aligned} \quad (2.D.28)$$

Equation (2.D.28) implies through the bank capital accumulation equation,

$$\begin{aligned} \delta^b k^b &= (r^d - r^b)r^d b + r^d k^b \\ \Leftrightarrow \frac{\beta\theta(1 + r^b)r^d}{(r^d - \delta^b)} &= CAR^* \end{aligned} \quad (2.D.29)$$

Aggregate constraints The firm profits that enter households' budget constraint when there is zero default are given by,

$$\begin{aligned} \Pi &= \Pi^c + \Pi^w + \Pi^r = \frac{1}{\epsilon} p^H y^H + (r^d - r^b)r^d b + r^d k^b \\ &= \frac{1}{\epsilon} p^H k^\alpha + \delta^b CAR^* k \end{aligned} \quad (2.D.30)$$

The aggregate resource constraint under the assumption that $\theta \neq 0$ is given by,

$$\begin{aligned} y^H &= c^H + c^{H*} + i + \delta^b k^b + \frac{\Omega}{(1 + \psi)} \left(\theta b(1 + r^b) \right)^{(1 + \psi)} \\ \Leftrightarrow y^H &= c^H + c^{H*} + i + \delta^b k^b + \frac{\theta b(1 + r^b)}{(1 + \psi)} \end{aligned} \quad (2.D.31)$$

where the second line follows from using the FOC w.r.t. θ .

Pre-multiplying both sides by p^H and using the expression for the consumption bundle (??) and for exports (2.D.23),

$$\begin{aligned}
p^H y^H &= p^H c^H + p^H c^{H^*} + p^H i + p^H \delta^b k^b + p^H \frac{\theta b(1+r^b)}{(1+\psi)} \\
\Leftrightarrow p^H y^H &= c - s c^F + s y^* + p^H i + p^H \delta^b k^b + p^H \frac{\theta b(1+r^b)}{(1+\psi)}
\end{aligned} \tag{2.D.32}$$

Using the expression for investment and the balanced trade condition, the aggregate resource constraint thus reduces to,

$$\begin{aligned}
p^H k^\alpha &= c + p^H \delta k + p^H \delta^b k^b + p^H \frac{\theta b(1+r^b)}{(1+\psi)} \\
\Leftrightarrow p^H k^\alpha &= c + p^H \delta k + p^H \delta^b CAR^* k + p^H \frac{(r^d - \delta^b) CAR^* k}{(1+\psi)r^d \beta}
\end{aligned} \tag{2.D.33}$$

Now we have **four equations in three unknowns** given by c , k , and p^H ,

$$c^\sigma \chi = (1 - \alpha) \frac{\epsilon - 1}{\epsilon} p^H k^\alpha \tag{2.D.34}$$

$$c = p^H \left(k^\alpha - \delta k - \delta^b CAR^* k - \delta^b CAR^* k - \frac{(r^d - \delta^b) CAR^* k}{(1+\psi)r^d \beta} \right) \tag{2.D.35}$$

$$\alpha \frac{\epsilon - 1}{\epsilon} k^{\alpha-1} = (1 + r^b) - (1 - \delta) \tag{2.D.36}$$

$$(p^H)^{-\frac{1-\xi}{\xi}} = \frac{c}{y^*} \tag{2.D.37}$$

Solving for k ,

$$k = \left[\frac{\epsilon}{\epsilon - 1} \frac{(1 + r^b) - (1 - \delta)}{\alpha} \right]^{\frac{1}{\alpha-1}}$$

Plugging p^H and k into (2.D.35),

$$\begin{aligned}
c &= \left(\frac{c}{y^*} \right)^{\frac{\xi}{\xi-1}} \left(k^\alpha - \delta k - \delta^b CAR^* k - \delta^b CAR^* k - \frac{(r^d - \delta^b) CAR^* k}{(1+\psi)r^d \beta} \right) \\
c^{-\frac{1}{\xi-1}} &= \left(\frac{1}{y^*} \right)^{\frac{\xi}{\xi-1}} \left(k^\alpha - \delta k - \delta^b CAR^* k - \delta^b CAR^* k - \frac{(r^d - \delta^b) CAR^* k}{(1+\psi)r^d \beta} \right)
\end{aligned}$$

Finally, we can use the expression for c to calibrate χ in equation (2.D.34).

Figure 2.D.1. Steady state values

Variable & Value	Description
c	1.47 Total domestic consumption
c^H	1.21 Consumption of domestic good
c^F	0.30 Consumption of foreign good
p^H	0.85 Deflated price index of domestic good
p^F	1.0 Deflated price index of foreign good
p^{H*}	0.58 Deflated price index of domestic good in foreign currency
P^*	1.0 Foreign Consumer Price Index
π	1.0 Consumer Price Index inflation
π^H	1.0 Domestic Price Index inflation
w	1.05 Real wage
h	1.0 Hours worked
Π^c	0.0 Profits of capital producers
Π^w	0.14 Profits of wholesale producers
Π^r	0.16 Profits of retail goods producers
Π^b	0.01 Profits of banks
k	8.43 Physical capital stock
i	0.21 Investment in physical capital
q	0.85 Real price of physical capital
A	1.0 Productivity level
y^w	2.03 Real wholesale output
p^w	0.77 Real price of wholesale goods
θ	0.027 Default rate
Ω	17.51 Scale of renegotiation cost
Δ	0.13 Macro variable component of renegotiation cost
R^k	1.0 Gross asset return on holding capital
y^H	2.03 Real final goods output
z	1.1 Mark-up
c^{H*}	0.52 Exports of domestic good
y^*	1.0 Foreign output (long run mean)
k^b	0.88 Stock of bank capital
b	8.43 Real loans to wholesale firms
d	7.53 Real domestic deposits
d^*	0.0 Real foreign deposits
s	1.47 Real exchange rate
r^d	0.020 Interest rate on domestic deposits
r^{d*}	0.020 Interest rate on foreign deposits
r^b	0.0482 Interest rate on loans
k^b/b	0.105 Bank capital ratio
ψ	1.0 Country risk premium

Note: This table summarizes the steady state characterized by positive default in equilibrium and obtained under the additional assumptions as outlined in this Appendix and in Section 2.5.

Appendix 2.E Simulations under Different Shocks

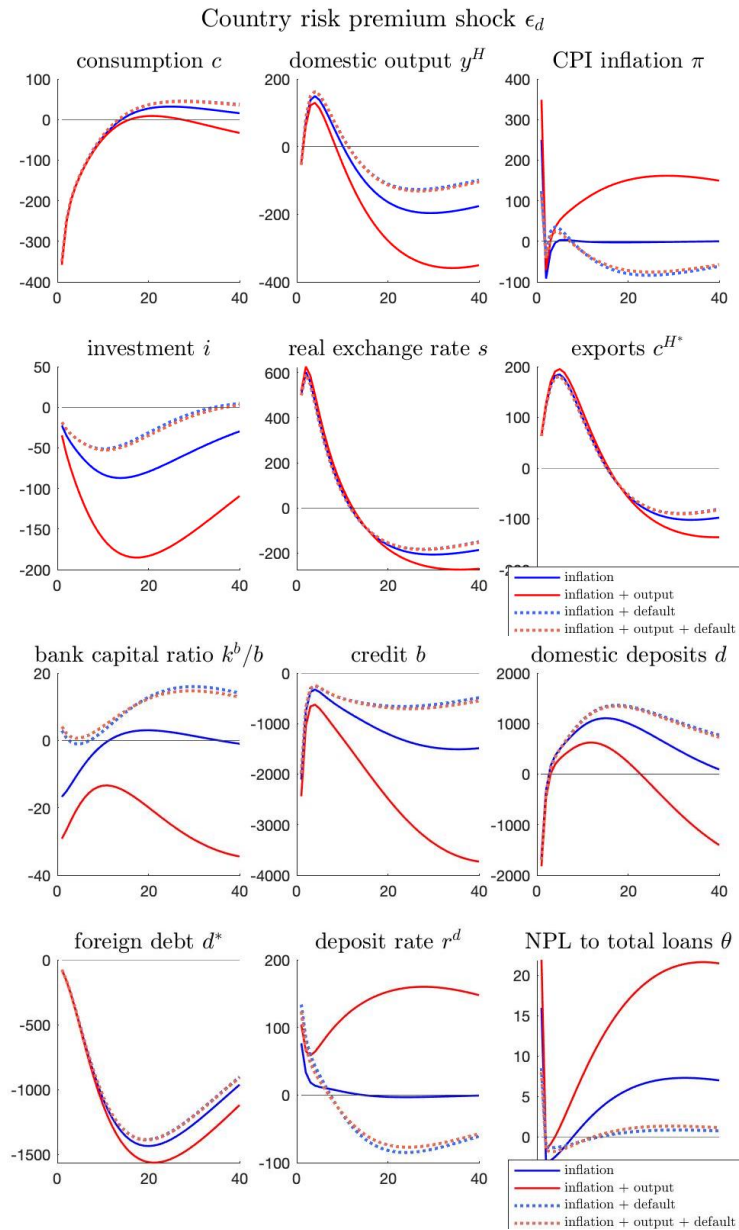


Figure 2.E.1. Comparison of IRF under policy rules in response to a shock to the country risk premium Ψ_t .

Note: This figure presents the relative impulse response functions in absolute deviations from steady state of selected endogenous variables with respect to a 100 basis point increase in the country risk premium under four different policy rules: (i) status quo inflation-targeting rule, (ii) Taylor rule, (iii) LAW rule, and (iv) LAW-Taylor rule.

Corporate Credit Risk and Capital Flows in Emerging Market Economies*

Abstract Foreign-currency denominated international bonds have become an increasingly popular financing instrument for many emerging market (EM) firms. Credit risks that are associated with such securities could simultaneously serve as an attracting and a repelling factor to capital from abroad. Using the universe of corporate bonds issued by non-financial firms in 27 EM countries and 11 tax havens, I show that credit spreads on corporate bonds can explain international capital flows. Importantly, they do so above and beyond well-known drivers of capital flows such as global risk, US monetary policy, and EM sovereign risk. I exploit idiosyncratic shocks to large bond issuers to construct granular instrumental variables (GIVs) to identify the causal effect of domestic corporate credit risk on capital flows. In a static country panel framework, I find robust evidence that EM corporate credit risk serves as an attractor of international capital flows. The results of a dynamic panel local projections exercise further suggest that the build-up of corporate credit risk over time can unleash capital flow reversals, deteriorate the terms of trade, lower output, and raise unemployment. My findings thus reconcile the empirical and theoretical literature on push and pull factors of international capital flows.

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3.1 Introduction

Foreign-currency denominated corporate bond issuance has surged to unprecedented levels in emerging market economies (EMEs) over the past decade (see panel (a) Figure 3.1). This has attracted large capital inflows into emerging debt markets, raising concerns about a potential sudden reversal, or “sudden stop”, of capital flows in response to either external shocks or growing corporate leverage and instability in the domestic financial system.² The latter could eventually lead to a reassessment and repricing of credit risk by international bond investors. A sudden tightening of credit conditions in international debt markets could not only increase the risk of insolvency of EM corporates. It could also precipitate a drop in the exchange rate which would further exacerbate the funding situation for firms holding unhedged foreign currency debt.³

It is therefore important to understand whether, in addition to acting as a “pull factor” of international capital, corporate credit risk can also unleash capital flow reversals, thus reinforcing domestic business cycles (Mendoza, 2010). Using a unique and rich cross-country panel of EM firms and their corporate bonds, I show that corporate credit risk can serve as a driver of capital flows into and out of EMEs. Importantly, this causal relationship obtains after controlling for the presence of strong global forces that have been found to be leading “push factors” of capital flows. My paper thus contributes to our understanding of the *domestic* origins of financial instabilities and business cycle fluctuations in EMEs. These domestic factors offer a complementary explanation to the Global Financial Cycle (Rey, 2015) known to be a pivotal motor of international capital flows.⁴

Identifying the causal relationship between the price of risk and international capital flows is notoriously challenging. The riskiness of corporate debt is determined, apart from factors fundamental to a firm, by the availability of credit. EMEs

²Concerns for EMEs’ hidden debt risk (Avdjiev, Chui, & Shin, 2014; Das, Kalemli-Özcan, Puy, & Varela, 2020) have been fuelled most recently by the global Covid-19 pandemic. Both anecdotal evidence and data point towards worsening corporate leverage and currency mismatch (Forni & Turner, 2021).

³Evidence that EM firms do not perfectly hedge their foreign currency exposure is rather anecdotal.

⁴I do not hypothesize ex-ante that domestic credit risk could be a more powerful trigger of capital flow reversals than sovereign credit risk or external factors, or even a trigger at all. Instead, I investigate whether corporate credit risk can serve as an additional driver of changes in capital flows above and beyond what sovereign and global risk can account for.

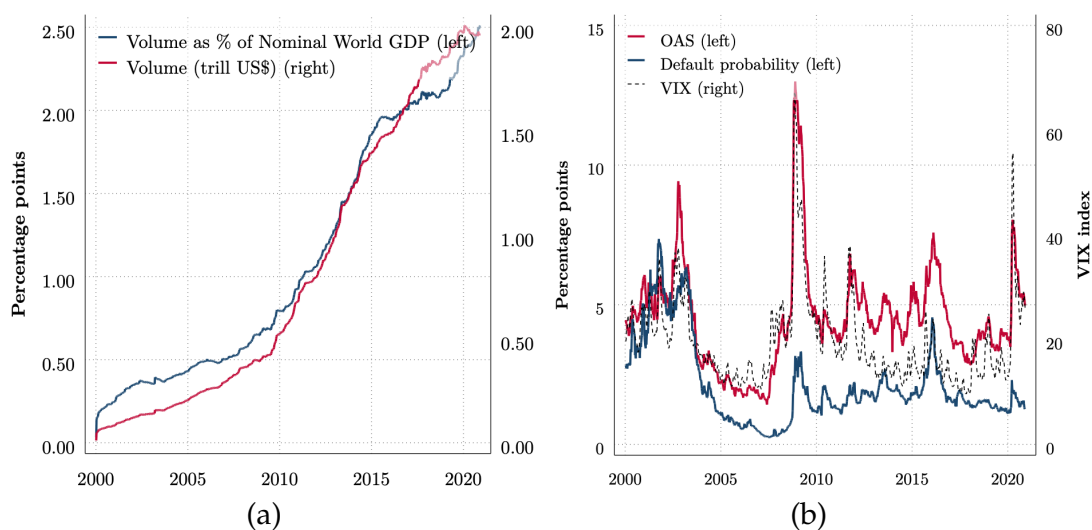


Figure 3.1. Corporate bond volume, credit spreads, fundamental default probability, and global risk (VIX)

Note: The left panel shows the sum total of notional USD-volume of corporate bonds issued by non-financial firms in my wider sample of 43 EMEs and traded on the secondary market at a given point in time. The secondary market traded volume is broadly representative of the primary market issuance. The right panel shows the weekly option-adjusted corporate bond spread (OAS) and Moody’s expected default frequency – a measure of the probability of default – over a 1-year horizon, averaged across firms across countries. The VIX is the CBOE volatility index, smoothed over a 30-day rolling window.

are exceptionally exposed to foreign investors’ willingness to invest in domestic debt markets. This vulnerability demands a risk premium which is determined by foreign demand for EM debt. Credit risk is therefore endogenous to capital flows.⁵ Yet at the same time, it is precisely this premium, along with positive (negative) prospects of economic growth, that attract (deter) foreign capital. Added to that are global factors, unrelated to a domestic economy’s fundamentals, that may confound the relationship between the domestic business cycle and international capital flows. Global risk (Forbes & Warnock, 2012; Fratzscher, 2012), subsumed under the so-called Global Financial Cycle (Rey, 2015), US monetary policy (Bruno & Shin, 2015a; Ghosh, Qureshi, Kim, & Zalduendo, 2014; Jordà et al., 2019; Miranda-Agrippino & Rey, 2020), and global interest rates (Akinci, 2013) feature prominently among such factors. Panel (b) of Figure 3.1 illustrates this point. Corporate credit spreads, corporate fundamentals, and global risk endogenously

⁵The remainder of this paper will focus on the fast-moving component of capital flows, i.e. portfolio flows that are more “fickle” with respect to changes in risk.

comove over the sample period.

One may imagine an ideal setting in which one observes both the demand for corporate debt by international investors as well as the supply of debt by domestic firms and its price. A high-frequency financial shock that is exogenous to both of these components as well as to global factors could be used to cleanly identify elasticities. Absent such a laboratory, the available data does not allow me to distinguish demand from supply. I therefore remain agnostic about the supply of corporate debt. Instead, I focus on how differences in the size of corporate borrowers can be exploited to extract information from granular prices – credit spreads – about their aggregate impact for identification.

To that end, I make three contributions to our understanding of the possible direction of causality between credit risk and capital flows. First, I collect a rich, cross-country microeconomic dataset spanning the universe of EM corporate bonds. I restrict my attention to USD-denominated corporate bonds issued by non-financial firms incorporated in 27 EMEs and 11 tax havens and traded in international secondary markets over the period from January 2000 to November 2020. I match bond-level data with issuer-level data on firm fundamentals as well as (high-frequency) country-level data on institutional investors' portfolio flows.⁶ Using the matched sample of around 3,200 bonds, I decompose the weekly time-series of credit spreads into several risk components. This decomposition allows me to extract idiosyncratic, firm-specific shocks that are orthogonal to firm- and country fundamentals as well as to global risk. It is the compensation that investors demand in excess of any expected losses for bearing a firm's default risk. I find that, when aggregated across EMEs, this aggregate shock component strongly positively covaries with the "excess bond premium" (EBP) estimated by Gilchrist and Zakrajšek (2012) for the US over the period from 2000 up until 2009. However, this strong correlation falls from 60% to 22% for the period from 2010 up until the Covid-19 crisis. This observation warrants confidence that the firm-specific shocks to credit spreads in EMEs are not simply driven by a common global factor that is not captured by my spread model.

⁶Mutual funds' portfolio flows account for the lion's share of flows into EM debt markets. They are a suitable indicator for capital flow activity alongside low-frequency macroeconomic measures of gross capital flows. See Koepke and Paetzold (2020) for a comparison of measures of capital and portfolio flows and their characteristics.

Second, with this observation in mind, I exploit the full heterogeneity in bond and firm characteristics to make statements about the granular effects of bond issuers' credit risk onto macroeconomic outcomes.⁷ Having obtained idiosyncratic shocks to firms' credit risk, I construct "Granular Instrumental Variables (GIV)" (Gabaix & Koijen, 2020) that allow me to overcome the problem of endogeneity between credit risk and capital flows. The intuition behind GIV is that shifts in credit risk that are idiosyncratic to "big players" such as large borrowers can affect macroeconomic outcomes in a meaningful way. Since corporate bond issuers in EMEs are generally large corporations found to have systemic impact (Alfaro et al., 2019; Calomiris, Larrain, Schmukler, & Williams, 2022; Grigoli, Luttini, & Sandri, 2021), I argue that aggregate fluctuations may have granular origins (Gabaix, 2011) in large corporate bond issuers. Firms' idiosyncratic shocks can then identify that credit risk – when stripped of all confounding effects of country-specific and global risk – can indeed drive capital flows into and out of the economy. From an asset pricing perspective, firm-specific risk cannot be fully diversified away in a granular economy characterized by a fat-tailed firm-size distribution. It bears a common component with systematic risk (Herskovic, Kelly, Lustig, & Van Nieuwerburgh, 2020) and hence influences international investors' perception of economy-wide risk. This property, not captured by traditional asset pricing theory in which firms are atomistic, strengthens the validity of the instrument in affecting aggregate credit risk.

In simple terms, the GIV summarizes any variation in credit risk of particularly large firms that is not explained by the *average* firm. The GIV thereby also controls for sovereign risk under the assumption that a large firm is equally exposed to sovereign risk as the average firm. To the best of my knowledge, my paper is the first to study the *causal* effect of corporate credit risk on capital flows while controlling for potential spillovers from the sovereign bond market and external factors. Other studies (Akinci, 2013; Caballero et al., 2019) analyze the ability of aggregate credit spreads to predict future economic activity in EMEs. However, their

⁷While others embark on similar endeavors with respect to studying corporate bond spreads in EMEs (e.g. Caballero, Fernández, & Park, 2019; Cavallo & Valenzuela, 2009), they either *aggregate* micro-measures across firms to study macroeconomic outcomes, or they study how macroeconomic factors affect microeconomic measures pertaining to corporate bonds.

methodologies rely on assumptions on the causal ordering of shocks in structural VAR frameworks.⁸

Third, unlike previous papers, I extend the sample of corporate bonds to also cover bonds issued by offshore subsidiaries in tax havens. Recent compelling evidence by Coppola, Maggiori, Neiman, and Schreger (2021) and Avdjiev et al. (2014) suggests that EM corporates have issued a sizeable fraction of their foreign-currency denominated debt via offshore subsidiaries in tax havens over the past decade. To the extent that not all of these funds are channelled into real activity, offshore issuance of bonds may pose underestimated risks to financial stability. Neglecting offshore bonds could bias the effect of credit risk on capital flows as both credit risk of the subsidiary firm and portfolio flows into and out of tax havens would not be captured.

My findings support the hypothesis that credit risk is indeed a relevant factor that explains capital flows. The results of the instrumented country panel regressions yield a strong relationship, both in terms of significance and magnitude, controlling for other domestic and global factors. The direction of the effect in the baseline model indicates that a rise in credit risk *attracts* international capital and therefore raises net capital inflows. This observation is in line with the literature on “pull factors” of international capital flows which suggests that domestic factors attract capital inflows in good times. The relationship holds up to a set of robustness checks.

The positive association between credit risk and capital flows begs the question whether the effect could be asymmetric depending on the state of the economy as well as the degree of leverage and currency mismatch on corporate balance sheets (Kalemli-Özcan, Liu, & Shim, 2021). Specifically, corporate credit risk could strike precisely when firms are the most vulnerable to a funding cost reversal, for example when firms cannot meet obligations in foreign currency by liquidating assets in local currency (Chui, Fender, & Sushko, 2014). To shed light on whether currency mismatch could pivot this relationship, I interact the credit risk measure with large real effective exchange rate depreciations. The results provide tentative

⁸Statistically speaking, these frameworks test for Granger causality in the sense that *X predicts Y*. This is not to be mistaken with a true “cause-and-effect” relationship that the GIV approach attempts to uncover by instrumenting an exogenous relationship.

evidence that international investors are more likely to retract capital if they expect firms to not be able to meet their funding needs due to rising currency mismatch and leverage.

Theories of sudden stops argue that it is the very *build-up* of domestic credit risk over time that can trigger capital flow reversals. I therefore further analyze my hypothesis in a panel local projections framework with instrumental variables (panel IV-LP) following Jordà (2005).⁹ This method allows me to investigate the dynamic response of capital flows and other monthly indicators of real economic activity to accumulated credit risk over a longer horizon. Identification again relies on the GIV. The impulse responses highlight that credit risk, when built up over time, can unleash powerful adverse dynamics onto the real economy. Net capital flows decrease, the terms of trade deteriorate, industrial production falls by 6.6 percentage points, and the unemployment rate rises by up to 1.3 percentage points over a two-year horizon in response to a 100 basis point exogenous widening of credit spreads. Hence, while the static regression setting can capture the positive relationship between credit risk and capital inflows, the dynamic panel IV-LP setting uncovers the adverse feedback that prolonged domestic financial imbalances in the non-financial sector inflict on capital outflows and the wider economy. A prolonged build-up of credit risk therefore amplifies business cycle fluctuations.

Finally and more generally, my paper adds to a growing research agenda on the granular corporate origins of macroeconomic fluctuations in EMEs. While a vast body of research on capital flow volatility in EMEs has focused on the sovereign nexus (Aguiar & Gopinath, 2006; Arellano, 2008; Mendoza & Yue, 2012; Yue, 2010), this paper explores the corporate nexus (Bianchi, 2011; Mendoza, 2010). Historically, capital flow reversals have often occurred alongside sovereign default on foreign-currency denominated bonds.¹⁰ Since the Global Financial Crisis (GFC), governments in EMEs have therefore tried to remedy problems associated with currency mismatch by issuing relatively more local currency debt (see Figure 3.C.2

⁹See also Jordà et al. (2015) and Ramey and Zubairy (2018).

¹⁰Examples of recent sovereign defaults include Barbados (2018), Jamaica (2013, 2010), Nicaragua (2008, 2003), Argentina (2001), Turkey (1999), Russia (1998).

in Appendix 3.A) (Carstens & Shin, 2019).¹¹ At the same time, international appetite for EM corporate bonds has been fuelled by ultra-low interest rates in advanced economies (Calomiris et al., 2022). It is for these reasons that nowadays one may attribute an increasing role to EM corporate debt markets as a source of financial instability and business cycle fluctuations. Much about the domestic sources and mechanisms of macro-financial risks in EM debt markets as well as their triggers (Avdjiev et al., 2014) remains to be understood and explained. Amidst the strain on corporate balance sheets and global investor wariness induced by the Covid-19 pandemic, my paper adds to our understanding of how one specific source of risk – corporate default – may contribute to overall macroeconomic and financial instability. Knowledge thereof can guide policy makers in designing appropriate preemptive policies (e.g. capital controls, macroprudential policies, taxes) and reactive policies (e.g. foreign reserve interventions, corporate relief programs) capable of easing the strain on the economy (Basu et al., 2020).

This paper proceeds as follows. Section 3.2 places the paper into the existing literature. Section 3.3 details the data and presents descriptive statistics. Section 3.4 discusses the methodological issues related to potential endogeneity between corporate risk and capital flows. Section 3.5 explains the basic intuition of the GIV approach and outlines the identification strategy. Section 3.6 presents results of the static and dynamic regression models. Section 3.7 outlines robustness checks. Finally, Section 3.8 concludes.

3.2 Related Literature

This paper relates to several strands of literature. The endogenous relationship between credit risk and capital flows builds on theoretical work on sudden stops by Mendoza (2010) and Bianchi (2011). Mendoza (2010) explains the occurrence of deep recessions after sudden stops through the build-up of leverage during expansions. Sudden stops are only triggered in high-leverage states in which agents' collateral constraint binds. Because credit constraints link bond issuance to market-

¹¹As illustrated in Figure 3.C.2 in Appendix 3.A, the non-financial corporate (NFC) sector still holds substantially more foreign currency debt relative to local currency debt than the government sector. See also Caballero et al. (2019) for a breakdown of bond debt into domestic and external debt based on more granular data.

determined prices, firms overborrow in good times (Bianchi, 2011). Agents cannot insure against Fisherian debt-deflation dynamics, or fire sale spirals (Caballero & Simsek, 2020) triggered by exogenous shocks. This explains why capital flows into EMEs are so “fickle” (Caballero & Simsek, 2020). These credit market frictions are the fulcrum of my hypothesis whereby high credit risk in bond markets, due to leverage and currency mismatch, unleashes capital outflows.

The issue of capital flow reversals follows from a more fundamental and longer-lasting debate in the literature about the costs and benefits of capital account openness and financial integration.¹² Benefits may stem from international risk sharing (Coeurdacier, Rey, & Winant, 2020; Kalemli-Ozcan, Sørensen, & Yosha, 2001), portfolio diversification (Lewis & Liu, 2015), and allocative efficiency (Gourinchas & Jeanne, 2006; Hoxha, Kalemli-Ozcan, & Vollrath, 2013), although found to be small in welfare analysis. Costs may arise from monetary policy spillovers (Gourinchas, 2018), household indebtedness (Mian, Sufi, & Verner, 2017), and leverage in domestic asset markets, in particular the housing market (Ferrero, 2012), which create vulnerabilities to financial crashes. Further, Gourinchas and Rey (2014) argue that part of the changes in a country’s net foreign asset position reflect valuation changes resulting from exchange rate movements. Capital flows therefore represent capital gains and losses on external positions, and hence wealth transfers mostly from poor to rich countries. As a result, capital flows to EMEs that reflect valuation changes may be deemed more harmful than propitious. Notwithstanding the ambiguous evidence, there is reason to believe that capital flows bear benefits by decoupling business cycles as regulation among banks becomes more harmonized (Kalemli-Ozcan, Papaioannou, & Peydró, 2013) and by promoting economic growth as firms are better able to access external finance through integrated financial markets (Alfaro, Chanda, Kalemli-Ozcan, & Sayek, 2004, 2010). Within the scope of this paper, I do not explore the costs and benefits of net capital *inflows*. Instead I contribute to the existing evidence on the potentially harmful effects of net capital *outflows* that are unleashed by a negative credit risk shock.¹³

¹²See Passari and Rey (2015) for a survey of the literature.

¹³Looking at *gross* as opposed to *net* capital flows would likely yield more nuanced conclusions. Yet, as outlined in Section 3.3, the data in this analysis does not allow me to explore this distinction.

In recent years, corporate spreads have received increasing attention as a predictor of business cycle fluctuations. Gilchrist and Zakrajšek (2012) are among the first to comprehensively document the high information content of corporate bond spreads for aggregate outcomes in the context of the US economy. They show that the aggregated residual component of credit spreads – after accounting for firms’ fundamental default risk – can serve as a significant and robust predictor of business cycle fluctuations. To the best of my knowledge, I am the first to apply a similar bottom-up approach of disentangling credit risk to a rich panel of EMEs in an open-economy context. Several papers investigate the macroeconomic effects of corporate credit spreads in Western Europe (De Santis, 2016; Gilchrist & Mojon, 2018), and of sovereign credit spreads (Akinci, 2013) and corporate credit spreads (Caballero et al., 2019) on business cycle fluctuations in emerging markets, albeit in a less granular fashion. I contribute to this strand of literature in two ways. The common denominator of existing studies is that they construct *aggregate* indicators of credit spreads and risk premia rather than studying the *granularity* of their underlying data. Instead, I explicitly exploit the heterogeneity in credit spreads and volume of debt across borrowers for identification. Moreover, while other researchers only establish the predictive power of credit spreads, I go one step further by identifying the *causal* link between credit spreads and changes in aggregate capital flows. Both of these extensions exploit the richness of the data across borrowers and countries. Hence, they allow me to study the information content of credit spreads at the firm level and at a higher frequency.

Another strand of literature seeks explanations for the recent surges in capital inflows into emerging debt markets. Chang, Fernández, and Gulan (2017) show theoretically that a fall in the world interest rate – as observed over the past decade – leads EME firms to pivot from bank financing to bond financing as the former becomes relatively more expensive when there is an equity shortfall.¹⁴ Calomiris et al. (2022) document that the surge in bond issuance since the GFC has been driven in part by the issuance of large USD-denominated corporate bonds and by global investors’ search for yield in riskier asset markets. Two factors have increased both demand for and supply of large bonds. First, bonds with a volume of at least

¹⁴Bank credit and bond financing may however be imperfect substitutes as they serve different short-term and long-term financing needs.

USD 500 are index-eligible and hence highly desired by institutional investors.¹⁵ Second, institutional investors have been attracted by both the highly liquid nature of these index traded bonds and their role in facilitating benchmark trading. Evidence by Raddatz, Schmukler, and Williams (2017) find that inclusion of companies into benchmark bond and equity indices affects mutual funds' country allocations and hence portfolio flows into these markets as well as exchange rates. Despite these scale effects, I consider both index-eligible and smaller-denomination bonds to exploit the full heterogeneity in the size distribution of corporate borrowers for identification.

Several papers shed light on the granular origins of credit risk in EM corporates. Asis et al. (2021) find a positive distress risk premium in EM equities that is driven by global factors such as US monetary policy and global liquidity risk. Similarly, Cavallo and Valenzuela (2009) find in a sample of EM bonds that macroeconomic variables as well as global factors drive variation in spreads. This certainly poses concerns about endogeneity in our context which I address in my identification strategy. Alfaro et al. (2019) document that corporate default risk is positively correlated with firm leverage and firm size in EMEs in the post-GFC period. Importantly, they find that idiosyncratic shocks to the sales growth of large firms positively correlate with GDP growth. This finding indicates systemic importance of large firms. These granular origins of aggregate fluctuations (Gabaix, 2011) build the backbone of my identification strategy.

The notion that "large players" – be it firms, sectors, or countries – may affect aggregate outcomes is exploited for identification in recent work by Gabaix and Koijen (2020). In their "granular instrumental variable" (GIV) approach, they formalize the idea of using idiosyncratic shocks to large players to purge off common shocks that may affect aggregate variables. This allows them to clearly identify the causal effect of these players on aggregate outcomes. GIVs have been adopted most recently in several papers in international macroeconomics and finance. Camanho, Hau, and Rey (2022) use GIVs constructed through idiosyncratic shocks to large mutual funds' portfolio rebalancing to identify the elasticity of supply

¹⁵This institutional feature has enticed large corporates to issue more external debt at the expense of hoarding large amounts of cash.

of foreign exchange. Aldasoro, Beltrán, Grinberg, and Mancini-Griffoli (2020) exploit idiosyncratic shocks to country-level cross-border bank flows to identify the causal effect of bank inflows on domestic macro-financial conditions. Galaasen, Jamilovgurd, Juelsrud, and Rey (2020) show, using GIVs, that idiosyncratic loan-level risk is not diversified away through aggregation in banks' portfolios and can spill over to other borrowers via banks' balance sheets. Kwak (2021) constructs GIVs to identify spillovers from the corporate into the sovereign bond market in the Euro area during the European sovereign debt crisis.

Recent comprehensive cross-country evidence by Coppola et al. (2021) suggests that capital flows into offshore tax havens can be a sizeable share of nationality-based external debt. Avdjiev et al. (2014) document that repatriation of funds from offshore subsidiaries to domestic firms can occur via three main channels: as within-company flows, between-company flows, and as corporate deposits. Not all of these flows may translate into real activity but instead may represent financial operations. Measuring debt by residency rather than by nationality of the issuer's ultimate parent can therefore mask important origins of risks to financial and macroeconomic stability. I hence take a more holistic approach by considering internationally traded bonds that are issued both by domestic firms and by offshore subsidiaries of EM parent companies.

Research on the link between corporate and sovereign risk is still in its infancy. It is well known that sovereign credit risk premia endogenously comove with the USD exchange rate as global investors make portfolio choices based on dollar returns (Hofmann, Shim, & Shin, 2020). Corporate borrowers are more insulated from such currency movements as they mostly borrow in hard currencies. However, there may exist spillovers from sovereign into corporate bond markets via at least two channels: the banking sector and state ownership of corporations. Using Italian firm-level data, Moretti (2020) finds that banks with higher sovereign debt holdings exhibit higher loan losses in their corporate debt portfolios. Broner, Martin, Pandolfi, and Williams (2021) and Pandolfi and Williams (2020) find positive spillovers from EM sovereigns to government-related and financial firms through higher growth in income, employment, and dividends relative to tradable firms. By contrast, an equivalent case for reverse causality can be made through the im-

pact of changes in tax revenues on sovereigns, as evidenced by Kwak (2021) for the European sovereign debt crisis of 2008-2012. I argue below that the GIV approach to identification controls for these confounding effects by exploiting firm-specific shocks that are uncorrelated with common shocks to a country's sovereign risk.

3.3 Data

Since the GFC, a large share of investment and expenditures by EM corporates has been financed through the issuance of internationally traded corporate bonds denominated in foreign currency. This paper analyzes credit risk in a panel representing the *universe* of USD-denominated corporate bonds across a panel of firms from several EMEs.¹⁶ To this end, I obtain and match a rich dataset at four different levels of granularity: bond-, firm-, country-, and global-level.

Countries The set of EMEs selected into the sample is justified on the grounds of two criteria. First, I select countries included by leading global equity and bond index providers whose benchmark indices are closely tracked by global investors. Second, I include additional countries classified on the grounds of determinants of economic development such as GDP per capita, exports of diversified goods and services, and integration into the global financial system. My sample therefore comprises most of the countries included in the MSCI Emerging Market Index and the JP Morgan Corporate Emerging Market Bond Index suite, as well as several additional countries classified as “Emerging Market and Middle-Income Economies” by the International Monetary Fund (2021). Table 3.A.1 in Appendix 3.A provides a detailed list of classifications.

Bond spreads and characteristics. I retrieve time-series as well as cross-sectional data on bond characteristics from Bloomberg.¹⁷ I limit the sample to bonds that

¹⁶I leave it to future research to complement data on the universe of *USD-denominated* bonds with data on the universe of *local* currency bonds.

¹⁷While there are other commercial databases available (e.g. Thomson Reuters Datastream, Cbonds, Morningstar), Bloomberg offers a broad global coverage of corporate bonds and relevant pricing sources as well as meta data on the issuing company and parent company. This warrants confidence that the resulting sample is representative and indeed spans the universe of corporate bonds in EMs.

are (i) active or matured, traded any day between 1 January 2000 and 1 December 2020, (ii) denominated in USD, (iii) issued by non-financial firms, (iv) issued by *onshore* issuers in one of 43 EMEs or by *offshore* subsidiaries in one of 11 tax havens, (v) subject to a fixed coupon schedule, and (vi) have a remaining term to maturity of at least one year. The criteria in (i)–(iv) yield a sample of 6,006 bonds spanning 43 EMEs for which the time-series of credit spreads is reliably available. Filters (v)–(vi) will be applied to the sample in the estimation.

The limited bond coverage across EMEs before 2000 restricts the sample period to 2000–2021. I limit my analysis to only USD-denominated bonds. Since 2008, the bulk of new issuances of corporate bonds has been denominated in foreign currency.¹⁸ EM corporates tend to prefer issuing debt in foreign currency – as opposed to sovereigns – since these markets are usually more liquid and hence more attractive for international investors. The liquidity of USD-denominated bond markets allows me to obtain reliable time series of credit spreads on bonds that are frequently traded. Moreover, focusing on USD-denominated bonds limits the influence of currency mismatch faced by international investors’ as a confounding latent factor in the analysis.

Following recent evidence by Coppola et al. (2021) on the systematic obfuscation of large-scale bond issuance through foreign subsidiaries in tax havens, I also collect information on bonds issued by firms domiciled in tax havens whose next-of-kin parent company is incorporated in an EME.¹⁹ I select eleven tax havens following Coppola et al. (2021) that exhibit at least five bonds issued on behalf of firms with parents incorporated in EMEs across the sample period. These tax havens include the Bahamas, Bermuda, British Virgin Islands, Cayman Islands, Curacao, Hong Kong, Ireland, Jersey, Luxembourg, Netherlands, and Panama. Table 3.A.2 in Appendix 3.A presents an overview of the number and cumulative notional volume of bonds in the sample, split between onshore and offshore issuance. Appendix 3.C.2 provides additional information on bond characteristics in the cross-section of onshore-offshore issuances.

¹⁸More than 60 % of issuances have been denominated in USD (Caballero et al., 2019; Calomiris et al., 2022).

¹⁹The share of bonds issued via tax havens is sizeable for some countries, including Brazil, Russia, and China.

Table 3.1. Corporate bonds – Summary statistics

	Mean	SD	Min	Median	Max
No. of bonds per firm/week	7.64	8.37	1.00	4.00	41.00
Bond volume (mil)	649.70	498.46	5.00	500.00	4,115.28
Maturity at issue (years)	11.70	7.83	1.50	10.00	50.00
Term to maturity (years)	7.36	6.67	0.50	5.50	42.55
S&P Issuer Rating	BBB-		D	BBB-	AAA
OAS spread (bsp)	401.95	581.23	-16,786.50	262.67	19,064.08
Duration (years)	4.92	3.45	-0.02	4.19	22.12
Coupon rate (%)	6.42	2.28	0.00	6.25	13.75
Callable bonds (%)	0.33	0.47			

Note: Sample period: 2000/01/07 – 2020/11/27; Bond-week observations=1,084,333; Number of bonds=4,668; Number of firms = 1,281; Number of countries=30. The sample statistics are based on trimmed data.

To obtain a reliable measure of credit risk for the sample of bonds, I obtain week-end option-adjusted spreads (OAS) and option-adjusted effective duration from Bloomberg. In most basic terms, an OAS is the spread over an issuer’s spot rate curve, i.e. the theoretical yield on a zero-coupon Treasury security.²⁰ Equivalently, the option-adjusted effective duration is the sensitivity of the bond’s yield to a shift in the entire yield curve. OAS have the advantage of harmonizing yields across bonds of various different cash flow characteristics, particularly across heterogeneous countries.²¹ They take into account embedded options in bonds such as early redemption and hence make spreads more comparable.

Table 3.1 presents summary statistics for the sample of bonds. Overall, the distribution of bond characteristics exhibits considerable heterogeneity. The median firm has four bonds outstanding at a given point in time with a considerable pos-

²⁰Formally, let $r_{k,t}^j$ and r_t denote the yield curves of bond k of firm j with maturity M and of the safe asset, respectively. An OAS $S_{k,t}^j = r_{k,t}^j - r_t$ is the solution to

$$\underbrace{p_{k,t}}_{\text{bid price}} = \sum_{n=1}^N \underbrace{\prod(n)}_{\text{Pr. of } n^{\text{th}} \text{ path}} \sum_{\tau=t}^M \frac{\overbrace{C_{k,\tau}(n)}^{\text{cash flow}}}{1 + r_{\tau} + r_{k,t}}$$

²¹See for example Caballero et al. (2019) and Cavallo and Valenzuela (2009) who use OAS in a similar cross-country context and Anderson and Cesa-Bianchi (2020) who use OAS in a US context.

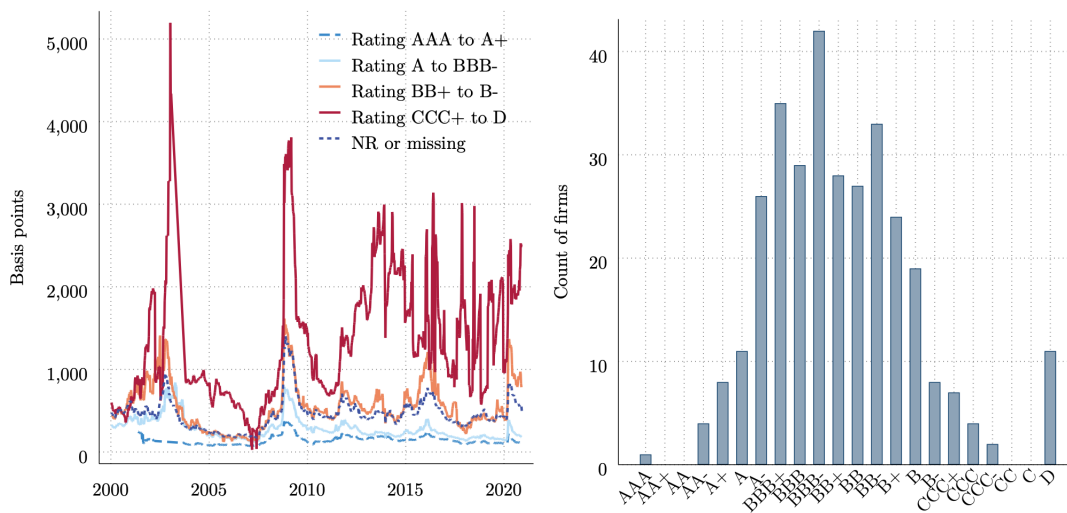


Figure 3.2. Credit spreads by rating category and the distribution of ratings

Note: The left panel shows the arithmetic average of the option-adjusted spread (OAS) series for a given selection of rating categories of the S&P issuer rating. The right panel shows the frequency of average S&P ratings of firms computed over the sample period. Data availability of issuer ratings limits the bonds and firms underlying these statistics to a subset of the sample.

itive skew towards a few firms with a large set of bonds outstanding. The distribution of notional bond volume is similarly skewed, ranging from USD 5 million to USD 4.1 billion. The median bond volume centers on the threshold of USD 500 million at which bonds become eligible for inclusion in leading emerging market bond indices. Note that the tails of the distribution of OAS spreads are quite long, owing to the computation of the model-based measure.²² A sizeable fraction of 33% of bonds feature an embedded call option.

The firms in my sample cover the full spectrum of issuer credit ratings ranging from defaulting issuers with a D-rating to high-quality AAA-rated issuers. The median rating is just above the cut-off from investment-grade to high-yield rating where many firms tend to cluster (Acharya, Banerjee, Crosignani, Eisert, & Spigt, 2021). Figure 3.2 presents a fairly bell-shaped distribution of S&P issuer ratings for the firms in the sample. The sample of EME credit ratings therefore appears fairly representative of the global distribution of ratings. Note however that a considerable right tail of bonds is in default (D-rating). Moreover, Figure 3.2 shows

²²In other words, the OAS is not the observed spread that investors incur. Instead it is a theoretical measure of credit risk once the embedded option is taken into account. Hence the possibility of negative OAS.

Table 3.2. EM corporations – Summary statistics

	Mean	SD	P25	Median	P75
EDF 1-Year (%)	1.997	4.504	0.086	0.430	1.814
Altman's Z-score	2.340	2.707	1.172	1.902	2.920
Debt/Equity	1.46e+05	3.334e+06	49.195	86.957	149.796
Earnings per share (bn)	3.045	136.702	0.000	0.000	0.000
Total assets (bn)	8.349	19.557	0.751	2.311	7.495
Market capitalization (bn)	5.161	24.139	0.215	1.069	4.137
Equity (bn)	4.315	11.318	0.422	1.349	4.166
Sales (bn)	5.151	13.359	0.325	1.042	3.797

Note: Sample period: 2000/01/07 – 2020/11/27; Firm-week observations=204,331; Number of firms = 692; Number of countries=27. The sample statistics are based on winsorized data at the top and bottom 1% within a given country. If a given company is privately held by a publicly traded parent company, the balance sheet information of the parent company is used for the computation of statistics.

that credit spreads are much larger and more volatile in the worst high-yield rating categories as expected.

Firm fundamentals. To employ an adequate measure of expected default of the bond issuer, I follow the literature and obtain daily series of expected default frequencies (EDFs) of publicly listed firms from Moody's KMV CreditEdge database.²³ The calculation of the EDF takes a firm's market value of assets, its asset volatility, and leverage as inputs in a proprietary Merton-type model. It then converts the resulting *distance to default* into a probability of default over a 12-month period. It is therefore a timely market-based measure of credit risk based on observable information.²⁴

In addition to the expected default data, I obtain quarterly balance sheet infor-

²³The bulk of the literature relies on measures derived from some variant of the Merton model, which has been subject to vast criticism (Bharath & Shumway, 2008). Other model-free measures such as option-implied default risk can be constructed (Culp, Nozawa, & Veronesi, 2018), yet they tend to be more demanding in terms of the granularity and coverage of data.

²⁴Let V be the market value of assets, σ_V be the asset volatility, and D be the default point. Then, in an abuse of notation, the distance to default, DD , is roughly defined as:

$$DD = \frac{V - D}{V \cdot \sigma_V}$$

mation from Bloomberg. Table 3.2 reports information on the distribution of firm size and key financial indicators. The median firm faces a probability of default over a one-year horizon, as implied by Moody's EDF measure, of 0.43% and an Altman's Z-score of 1.9.²⁵ Note that the median Z-score is just above the threshold of 1.8 which is commonly referred to as the score below which a company is close to bankruptcy. Equally striking is the degree of leverage that the median firm takes up, with a right skew towards excessively large multiples of debt to equity. Profitability as indicated by the 12-month trailing earnings per share similarly exhibits a very large variance and right skew. The median-sized firm comprises about USD 2.3 billion in total assets and has a market capitalization of USD 1.1 billion. Unsurprisingly, EM corporations are also quite large by measures of equity and sales, in line with stylized facts documented by Alfaro et al. (2019).

Bond information is then matched with firm identifiers from Moody's KMV in a three-step procedure: (i) matching by (unique) Bloomberg ID and ISIN of the issuer, jointly and individually, (ii) matching by unique Bloomberg ID and ISIN of the parent company, and (iii) matching by equity ticker symbol of subsidiary and parent company, respectively, using a matching algorithm outlined in Appendix 3.B. The matched sample comprises 1,346 firms in 30 countries.

As we shall see in Section 3.5, one necessary condition for the GIV to be a valid instrument is that the distribution of firm size is sufficiently "granular". That is to say that activity must be concentrated in a handful of particularly large firms. If all firms were uniformly of the same size – as is the conventional assumption in representative agent frameworks – the lack of "large firm shocks" with systemic impact would compromise the relevance of the instrument. Figure 3.3 shows the share of firms in a country's aggregate equity market capitalization (panel (a)) and their relative share of total assets (panel (b)) across the firm-size distribution. The figure suggests that the largest 20th percentile of firms, as measured both by market capitalization and by total assets, takes up a much larger share of aggregate

²⁵As an indicator of whether a firm is close to becoming insolvent, Altman's Z-score is computed by Bloomberg based on leverage, liquidity, profitability, solvency, and activity characteristics obtained from balance sheet information.

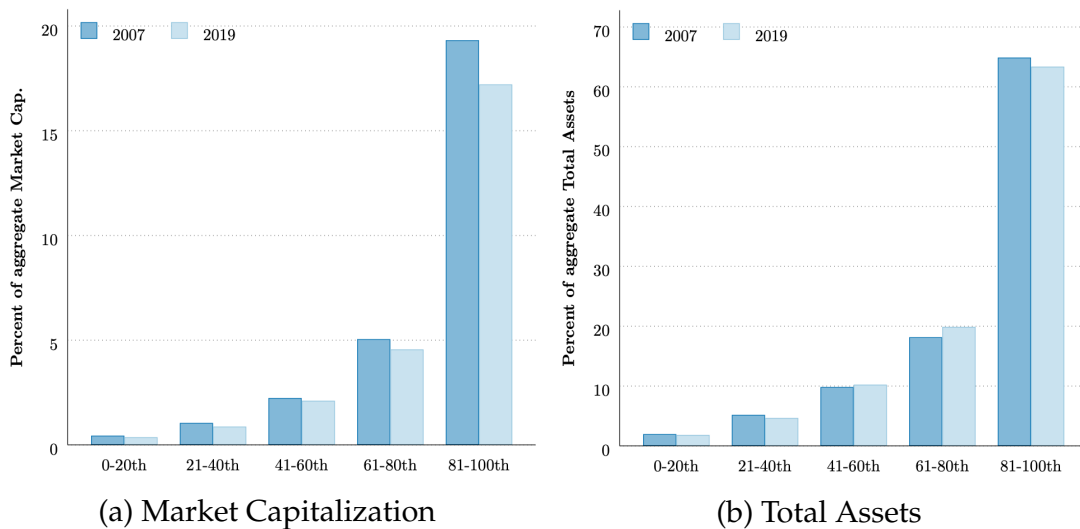


Figure 3.3. Concentration of shares across the firm size distribution over time

Note: The figures plot the concentration of equity market capitalization (panel (a)) and total assets (panel (b)) across the size distribution of non-financial firms. The quantiles are computed based on a firm’s position in the *sample* distribution within a country, not in the *population* distribution. The shares (in %) are computed as the average share of a firm’s market capitalization in the total market capitalization of a country (data source: IIF) and the average share of a firm’s total assets in the sum of total assets *in the sample*, respectively, over the reference years 2007 and 2019. The statistics are averaged across 15 and 18 countries, respectively.

market capitalization than smaller firms.²⁶ Comparing the shares in 2007 versus 2019 further suggests that this “granularity” is relatively stable over time.

A further condition for the GIV to be a “strong” instrument is that the variable to be instrumented – the credit spread – exhibits sufficient heterogeneity across the size distribution of firms. That is, larger firms in the market for debt must clearly distinguish themselves from smaller firms in the degree of credit risk. Figure 3.4 provides confidence that this condition is met. It shows the distribution of the level of OAS (top panel) as well as the volatility in the time-series of OAS (bottom panel) for each firm according to its place in the size distribution, measured by (the

²⁶Caution is warranted in interpreting absolute numbers in Figure 3.3 as the data used to compute these statistics comes from two different sources. I obtain annual data on a country’s aggregate stock market capitalization from the IIF. By contrast, weekly data on market capitalization of the firms included in my sample comes from Bloomberg. Since my sample only comprises listed companies with substantial USD-denominated bond issuance in international debt markets, other public companies that do not issue in these markets are not captured in the firm size distribution in the figure. Moreover, listed *financial firms* such as banks are excluded from my sample. Thus, while the largest 20% of firms take up only about 20% of total market capitalization, among the subset of these firms in the total population of listed firms they likely have a larger market share.

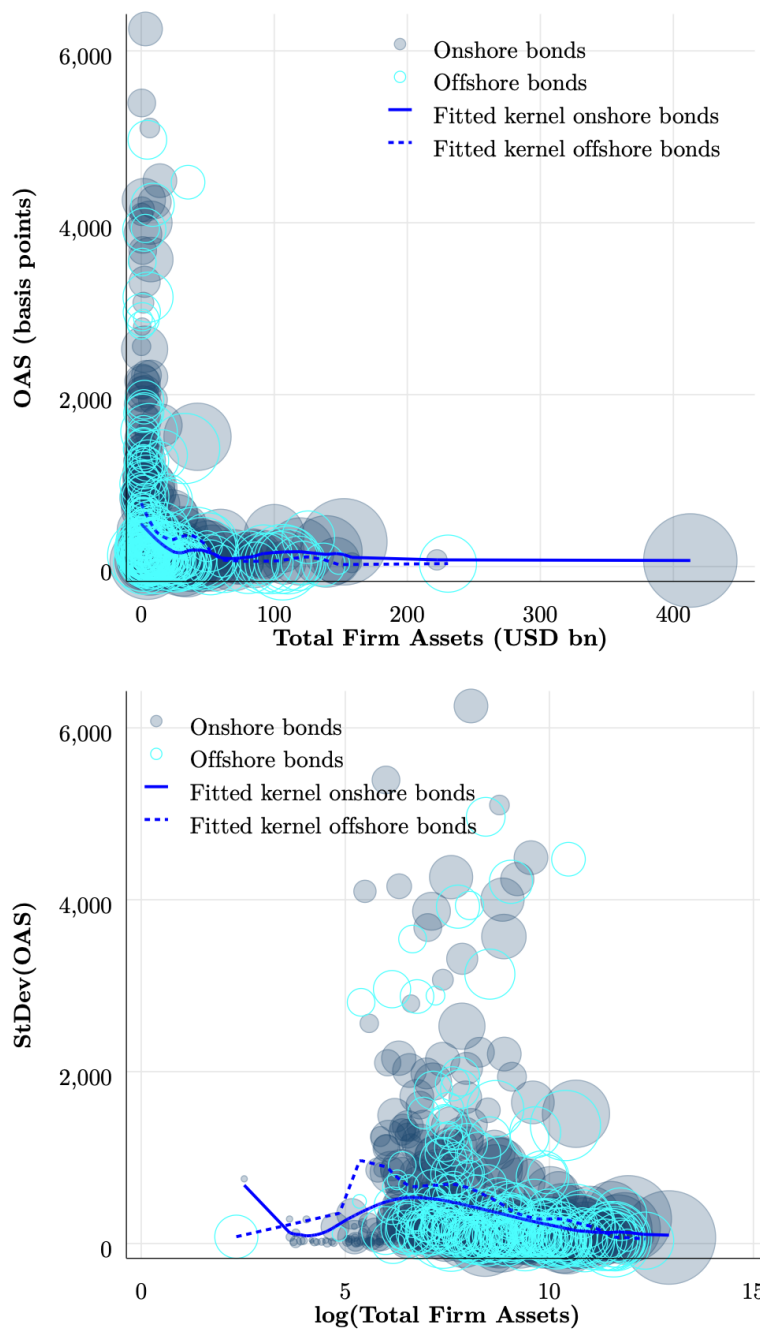


Figure 3.4. Heterogeneity in credit spreads and in volatility across the firm-size distribution

Note: The top panel presents the average option-adjusted spread (OAS) observed for each firm over the sample period for a given firm size as measured by total assets. The average OAS are computed for both onshore and offshore issuances. The observations are weighted by the average volume of bonds of a given firm, with larger circles indicating greater notional USD-volume. The bottom panel presents the volatility in the time-series of OAS of each firm over the sample period across the firm size distribution, scaled by the logarithm of total assets. Both plots include the fitted line of a non-parametric Kernel regression for both onshore and offshore issuances.

logarithm of) total assets. As indicated by the non-parametrically fitted relationship between credit risk and firm size, large firms tend to exhibit smaller and less volatile credit spreads on average. They also issue bonds larger in volume than their peers, denoted by the larger size of circles. These observations suggest that there is sufficient heterogeneity across the firm-size distribution to exploit variation in firm-specific shocks to credit risk

Figure 3.4 also distinguishes between bonds that have been issued onshore or offshore via a subsidiary. Simple eye-balling does not yield any substantial difference between the risk-size relationship. Yet, the non-parametrically fitted relationship suggests that bonds issued offshore tend to demand a slightly higher and more volatile credit spread, especially for firms smaller than the median firm.

Capital and portfolio flows. Country-level data on net capital flows comes from two sources.²⁷ As the closest high-frequency proxy to inflows and outflows to and from international bond markets, I obtain portfolio “country-flow data” from EPFR Global’s proprietary database.²⁸ EPFR Global collects and aggregates weekly data on portfolio investment flows from a large sample of global institutional investors covering more than 14,000 equity funds and 7,000 bond funds with more than USD 42 trillion assets under management. Country coverage is determined by funds’ mandate to invest in a specific geographical location. Aggregate portfolio flows are calculated based on changes in country allocations of funds. As argued by Chari et al. (2020), EPFR’s country flows are free from valuation effects and represent real quantities precisely because they are computed based on aggregate re-allocations at the fund level.

The EPFR data spans 32 EMEs in my sample. The flow measure is disaggregated into allocations to bond and equity markets which is a clear advantage compared to other flow measures for the purpose of my analysis. It conveniently controls for confounding effects between bond and equity markets which aggregate

²⁷The desire to have a high-frequency measure of capital flows restricts the choice of variables to those that measure *net* capital flows. Data on *gross* debt portfolio flows starting in 09/2002 are only available at a quarterly frequency from the IMF Balance of Payments statistics.

²⁸I focus on debt portfolio flows to isolate direct effects of credit risks in corporate bond markets onto portfolio flows into these markets. Forbes and Warnock (2014) document that most episodes of extreme capital flows around the world are debt- rather than equity-led.

portfolio flow measures cannot account for. The data however comes with several caveats. For one, the time series of country flows only starts in 2004 whilst bond and firm data is available from 2000. Moreover, for some smaller EMEs, the time series starts only in the second half of the sample. This is only partially problematic because some countries do not exhibit bond coverage as early as 2000 (see Table 3.A.2 in Appendix 3.A). Finally, EPFR data represents *net* flows as opposed to *gross* flows. That is, changes in liabilities are netted against changes in assets.

The Institute of International Finance (IIF) offers an alternative to EPFR bond flows with its measure of debt portfolio flows. It covers 25 EMEs at a weekly frequency starting in 2005 and at a monthly frequency as early as 2000 for some countries.²⁹ To maximize the coverage along both the time and country dimension as well as exploit the highest frequency available in the static country regression, I use weekly EPFR flows in my baseline regression model to identify the causal effect at the weekly frequency. However, I use the monthly IIF flows in the dynamic local projections analysis when estimating impulse responses of monthly indicators of macroeconomic activity, given its longer series at the monthly frequency.

In addition to country-level portfolio and capital flows, I also obtain country-level index series of the JP Morgan suite of Emerging Market Bond Indices (EMBI) and the Corporate Emerging Market Bond Indices (CEMBI). The EMBI comprises public debt securities at the municipal and federal level. It serves as a suitable proxy for sovereign risk at the country level to account for residual spillovers into corporate bond markets. As its corporate equivalent, the CEMBI includes a large portfolio of USD-denominated and internationally traded corporate bonds with a volume of at least USD 500 million. It is therefore a relevant benchmark index relative to which to assess the variation in OAS spreads in a given country.

Global factors. Finally, I obtain time-series on global factors from Bloomberg and FRED, including the Chicago Board Options Exchange's CBOE volatility index (VIX), the 10-year US Treasury yield, and the US Baa spread. All of these measures

²⁹In a horserace, Koepke and Paetzold (2020) show that IIF and EPFR data have significant predictive content for portfolio flows based on the IMF's Balance of Payments Statistics (BoPS).

have been frequently used as a proxy for the Global Financial Cycle.³⁰ Specifically, the VIX is widely used as a measure of global risk aversion (Di Giovanni, Kalemli-Özcan, Ulu, & Baskaya, 2022). Shocks to the US Baa spread are found by Akinci (2013) to account for a considerable share of variation in economic activity in EMEs.

3.4 Discussion of Endogeneity

In light of the link between the Global Financial Cycle and the domestic financial cycle in EMEs (Aldasoro, Avdjiev, et al., 2020), valid concerns about endogeneity arise. It is broadly agreed that global developments have come to predominantly steer short- to medium-term changes in the current account and exchange rates in EMEs. Yet, domestic developments have been found to impact – rather than just to react to – capital flows as well, and thus need to be considered with equal importance.

The key challenge to identifying the causal effect of credit risk on capital flows involves overcoming the potential risk of reverse causality. On the one hand, as this paper argues, a causal nexus may be drawn from credit spreads to capital flows when the underlying risk that is priced by international investors stems from the default risk of an investment. Positive, yet compressed credit spreads attract capital from abroad in good times. These inflows fuel corporate leverage but also maturity mismatch on firms' balance sheets as firms borrow in foreign currency. As fundamental default risk crosses the threshold of investors' risk tolerance, risk is repriced, capital flows halt or reverse, and the exchange rate depreciates by the uncovered interest rate parity (UIP) condition. Additional currency mismatch further feeds into firms' default risk which increases credit spreads. A feedback loop may arise in which higher credit spreads not only bring capital flows to a halt but also trigger their reversal as international investors reassess their risk exposure in these markets.

³⁰Additional measures could include the first principal component of capital flows across countries (Cerutti, Claessens, & Rose, 2019), a monthly indicator derived from global risky asset prices (Miranda-Agrippino & Rey, 2020), or a measure of global "flights-to-safety" that capture the co-movement between risky and safe asset returns across developed markets (Ahmed, Hofmann, & Schmitz, 2021). I focus on those indicators of global risk that are readily available at a weekly frequency.

On the other hand, a case can be made that it is in fact capital flows that determine credit spreads in EM bond markets. The influx of cheap financing in good times compresses credit spreads as funding is abundant and firms find it easy to refinance their debt. As a result, the domestic currency appreciates. When global external factors trigger capital outflows, funding falls short of investment needs, the domestic economy contracts, and the local currency depreciates. The resulting currency mismatch and dry-up of liquidity increase risk premia demanded by investors. The direction of causality may thus run from capital flows via the exchange rate to corporate credit spreads. Quantities may be driving prices rather than the reverse. The question as to which direction of causality prevails is deeply rooted in the debate about whether the Global Financial Cycle is the dominant force, above and beyond domestic financial developments, that determines business cycle fluctuations in EMEs (Rey, 2015).

The existing literature circumvents the problem of endogeneity by addressing the *predictive* rather than the *causal* effect of credit spreads on domestic economic activity. Statistically speaking, these frameworks test for Granger causality in the sense that X *predicts* Y. This is not to be mistaken for a true “cause-and-effect” relationship that the GIV approach attempts to uncover by using an exogenous relationship as instrument. Akinci (2013) and Caballero et al. (2019) follow the approach of Gilchrist and Zakrajšek (2012) by using structural VAR models to analyze whether sovereign and corporate credit spreads can forecast domestic economic activity. These approaches however have two features that make them ill-suited for the purpose of my analysis. First, they rely on assumptions about the recursive ordering of key macroeconomic and financial variables in the structural VAR model to identify the effect of spreads on macroeconomic aggregates. The validity of these assumptions relies on macroeconomic variables being more slow-moving than financial variables. Hence, the former lag behind the latter. This arguably plausible assumption is exploited for identification. Second, they employ low-frequency data at the quarterly level. Both of these features would not be able to address the faster-moving nature of capital flows that I examine. Capital flows – to the extent that they are portfolio flows – and credit risk may react to each other in a nearly simultaneous manner. It would therefore be fatal to draw strong assump-

tions on the recursive ordering of these variables in a structural VAR approach. While quarterly data is suitable to predict business cycle movements, short-term fluctuations in capital flows would be smoothed out if the data were measured at a quarterly frequency. It is for these reasons that I employ a more granular approach to identification which exploits the full heterogeneity in credit spreads across firms and across countries at a weekly frequency to overcome endogeneity.

3.5 Identification of the Causal Effect

The purpose of the empirical analysis is to present a novel way to identify the causal effect of credit spreads on international capital flows, or more precisely, on the change in the stock of international capital invested in the domestic corporate bond market. To that end, I exploit firm-specific shocks to heterogeneous firms which borrow in international debt markets. These shocks allow me to construct a measure that picks up exogenous variation specific to large borrowers relative to variation of the *average* borrower. Intuitively, this measure is purged of any shocks that affect all firms, and hence the average firm. This section first outlines the basic intuition of GIVs (Gabaix & Koijen, 2020) under some simplifying assumptions and subsequently applies the approach to overcome the issue of endogeneity between credit risk and capital flows.

3.5.1 Understanding Granular Instrumental Variables (GIV)

The idea that aggregate outcomes have granular origins through the activities of a limited number of large entities – where entities are broadly defined – serves as a natural starting point for the construction of instruments for identification of causal links. Such instruments exploit entity-specific events that are orthogonal to what is happening to “everyone else” (Gabaix, 2011). In basic terms, the GIV is a summary statistic of idiosyncratic shocks to large players such as firms, industries, or countries. It is a construct of differences between size-weighted and unweighted aggregates of these firm-specific shocks. If we can credibly believe that shocks to large firms are truly idiosyncratic to these firms and hence exogenous, we can sum over all of these shocks to obtain an “aggregate exogenous shock” at a given point in time. Yet, it may still be the case that some systematic latent factor

affects all of these firms in the same way. We therefore do not simply sum over the firm-specific shocks but instead take the difference of the sum of size-weighted individual shocks to the shocks faced by the *average* firm. If latent common factors affect all firms roughly equally, this will purge the summary statistic of any systematic components.

Importantly, firms must be sufficiently large – otherwise their shocks will simply be averaged out. This heterogeneity in the size distribution of firms at the micro-level can be exploited for identification of macro-elasticities. Hence, a key condition for the validity of GIVs is that these large players account for a sizeable share of economic activity such that they can plausibly affect aggregate outcomes. Corporate bond markets in EMEs are dominated by a handful of large corporations that are able to access international funding (see Figure 3.3 and Alfaro et al. (2019)). Moreover, credit risk is distributed heterogeneously across the firm-size distribution (see Figure 3.4). This condition is therefore likely to be met.

To convey the basic intuition in reduced form, suppose we want to identify the elasticity α of some country-specific endogenous macro variable F_t to domestic firms' aggregate credit spread S_t . Let F_t be the net capital flow to this country such that,

$$F_t = \alpha S_t + \epsilon_t \quad (3.5.1)$$

where ϵ_t denotes an aggregate shock to country c .³¹ Suppose that the aggregate credit spread – for example the spread on a country-level corporate bond index – is a weighted average of the credit spread $s_{j,t}$ of individual firms j , i.e. $S_t = \sum_j s_{j,t} \cdot w_j$. The weights w_j are the contribution to, or share of, each individual firm j 's spread in the country's aggregate measure.³² The share can represent, for example, the weight on each bond in the country's benchmark bond index, discussed below. For now, we operate under the strong assumption that individual credit spreads $s_{j,t}$ have the same sensitivity to a common shock η_t across all firms,

$$s_{j,t} = \lambda \eta_t + u_{j,t} \quad (3.5.2)$$

³¹I henceforth omit country subscripts for notational convenience.

³²For simplicity, suppose for now that weight w_j is time-invariant. I will later relax this assumption.

where λ denotes the loading on the common shock. For ease of exposition, assume $\lambda = 1$ and that the loading is time-invariant. We may also think of a vector of common shocks η_t and loadings Λ which will be useful for illustration in the application. Importantly, $u_{j,t}$ is the unobserved, idiosyncratic shock to an individual firm j that affects the firm's observed credit spread. We assume that the idiosyncratic shock is orthogonal to both the common shock to firms η_t and the aggregate country-level shock ϵ_t , i.e. $E[u_{j,t}\eta_t] = E[u_{j,t}\epsilon_t] = 0$. How shall we conceive of these shocks? Take the example of Brazilian firms. We may think of η_t as a negative funding shock in debt markets which hits all firms' funding conditions equally and ϵ_t as domestic macroeconomic news. In addition, there may be idiosyncratic reasons that induce, say, Telekom Brazil to reduce the riskiness of its debt in excess of what would be expected based on the common shock alone. This "idiosyncratic reason", for example stemming from a recent change in management, is unlikely to be correlated with the common shock η_t and the aggregate shock ϵ_t . Yet, because Telekom Brazil is a large player in the Brazilian corporate sector, idiosyncratic changes in its credit risk may have aggregate effects.

The key issue with identification in this setting is that we cannot recover α in (3.5.1) directly with OLS because it is likely that the aggregate shock to the economy and the shock common to all firms are correlated, i.e. $E[\epsilon_t\eta_t] \neq 0$. We therefore require an instrument z_t for the aggregate credit spread S_t in (3.5.1). This instrument can be constructed by taking the difference in the *share-weighted* sum of credit spreads and the *equally-weighted*, or unweighted, sum of credit spreads across the firm distribution. Let \bar{S}_t be the equally-weighted (weighted by $1/N$) sum of spreads in a given country. The GIV is then given by,

$$z_t = S_t - \bar{S}_t = \sum_j \left(w_j s_{j,t} - \frac{1}{N} s_{j,t} \right) \quad (3.5.3)$$

$$\begin{aligned} &= \sum_j \left((\lambda\eta_t + u_{j,t})w_j - (\lambda\eta_t + u_{j,t})\frac{1}{N} \right) \\ &= \sum_j u_{j,t} \left(w_j - \frac{1}{N} \right) \\ &= u_t - \bar{u}_t \end{aligned} \quad (3.5.4)$$

In other words, the GIV is the difference between the share-weighted and the equally-weighted sums of idiosyncratic shocks, $u_t - \bar{u}_t$. The GIV hence exploits the heterogeneity in shares of firm j 's credit spread in the aggregate credit spread. Intuitively, z_t picks up the variation in the share-weighted series of firm shocks relative to average shocks that is due to "granular" issuers. The definition of the instrument in (3.5.4) shows that the instrument would simply be zero and hence invalid if there was no heterogeneity in the size distribution of borrowers, i.e. $w_j = 1/N \quad \forall j$ where $\sum_j w_j = 1$.³³ It is therefore crucial that bond issuers within a given country in the cross-country panel are sufficiently heterogeneous in size.³⁴

Why is z_t a suitable instrument? Importantly, the GIV satisfies the exogeneity condition required for identification, $E[z_t \epsilon_t] = E[z_t \eta_t] = 0$ as long as the exclusion restriction $E[u_{j,t} \eta_t] = E[u_{j,t} \epsilon_t] = 0$ holds. That is, the instrument is valid if we can reasonably assume that firm-specific shocks are uncorrelated with common shocks. Moreover, idiosyncratic shocks to credit spreads must affect the macroeconomic variable of interest, F_t , only through changes in aggregate credit risk, S_t , such that they are hence orthogonal to unobserved aggregate shocks ϵ_t . I discuss these conditions in Section 3.7. Note also that the GIV is a relevant instrument $E[z_t F_t] = E[(S_t - \bar{S}_t) F_t] \neq 0$ by (3.5.1) and (3.5.3).³⁵ The strength of the GIV is that it is purged of the effect of the common shock η_t that affect credit spreads in (3.5.4). It can hence be used to identify a causal effect. To the extent that the common shock may also represent the impact of sovereign spreads on corporate spreads, the GIV also eliminates any confounding spillovers from sovereign bond markets into corporate bond markets.³⁶

Lastly, we may wonder why idiosyncratic risk $u_{j,t}$ should matter in the aggregate if a savvy investor could simply diversify this risk. Why should such seemingly diversifiable firm-specific risk influence how investors perceive economy-

³³Alfaro et al. (2019) provide important evidence that the idiosyncratic shocks of large firms in EMEs do have systemic impact such that $w_j \neq 1/N$.

³⁴By implication, several countries with one a handful of large firms borrowing in international debt markets need to be dropped from the sample.

³⁵The moment condition $E[(F_t - \alpha S_t) z_t] = 0$ implied by the exogeneity assumption $E[u_{j,t} \epsilon_t] = 0$ then serves to identify the elasticity $\alpha = \frac{E[F_t z_t]}{E[S_t z_t]}$.

³⁶These spillovers are arguably common to all firms except for state-owned enterprises with explicit or implicit government guarantees. I control for this possibility in my estimation.

wide risk? Note that it is not obvious that firm-specific shocks are fully diversifiable by investors. Traditional asset pricing theory assumes that firms are atomistic, and hence the impact of their risk vanishes in the aggregate under the central limit theorem. This is not the case in a granular economy where the distribution of firm-size is fat-tailed. By the granular hypothesis (Gabaix, 2011), firm shocks represent non-diversifiable “grains” rather than atoms of economic and financial activity. These grains can drive aggregate fluctuations and transmit to all other agents. Empirical evidence gives ample reason to believe that firm-level risk matters in the aggregate. Galaasen et al. (2020) show that idiosyncratic credit risk of granular borrowers survives aggregation in banks’ loan portfolios. Carvalho and Gabaix (2013) demonstrate that fundamental volatility, made up of an aggregate of purely idiosyncratic firm-level shocks, accounts for macroeconomic volatility observed over the past half-century. Herskovic et al. (2020) show that the dispersion of the firm-size distribution constitutes a common factor in individual firm volatilities that is priced by investors. In light of the stark evidence of granularity, a more recent body of work studies asset pricing in granular economies for equities (Abolghasemi, Bhamra, Dorion, & Jeanneret, 2020) and corporate bonds (Abolghasemi, 2021).³⁷ These models account for the fact that firm-specific risk of large firms affects systematic risk through a common component (Herskovic, Kelly, Lustig, & Van Nieuwerburgh, 2016). It is thus likely that idiosyncratic risk of large corporate borrowers influences international investors’ perception of economy-wide, systematic risk.

3.5.2 Application of GIV to Capital Flows

Country-level regression model. Equipped with the simple intuition of GIVs, I apply the stylized example of a country-specific macroeconomic variable F_t in (3.5.1) to the context of capital flows across a panel of EM countries. I postulate that changes in international investors’ capital allocations, i.e. (net) capital flows $F_{c,t}$, in a given country c at time t are linearly related to a country’s aggregate credit spread $S_{c,t}$ as well as a set of country-specific and global controls $X_{c,t}$,

³⁷In these extensions of the conditional CAPM, a firm’s market beta depends on the firm’s weight in the economy.

$$F_{c,t} = \alpha S_{c,t} + \beta \mathbf{X}_{c,t} + \epsilon_{c,t} \quad (3.5.5)$$

where $\epsilon_{c,t}$ denotes the aggregate shock to country c . Let $S_{c,t} = \sum_j w_{j,c,t-1} s_{j,c,t}$ where weights on firm j 's credit spread are lagged by one period.³⁸

As before, the challenge is to identify and estimate α , i.e. the elasticity of capital flows with respect to a change in the price of risk. I hypothesize that in normal times $\alpha = \alpha^{in} > 0$. That is, when the domestic economy goes through tranquil episodes, a widening of credit spreads attracts foreign capital. However, I expect that $\alpha = \alpha^{out} < 0$ when currency mismatch on corporate balance sheets and default risk endogenously interact to induce international investors to retract capital.³⁹ To estimate α , I instrument the credit spread $S_{c,t}$ with the GIV, i.e. a summary statistic of exogenous firm-specific shocks. How do we obtain these idiosyncratic shocks from the information content of corporate bonds?

Decomposing credit spreads to extract idiosyncratic shocks. The term credit risk subsumes various forms of risk that generate a wedge between the return on the risky security and the risk-free return on a safe asset of equivalent maturity, i.e. the credit spread. To understand which features intrinsic to the debt instrument and borrower as well as systematic market characteristics drive credit risk, Gilchrist and Zakrajšek (2012) decompose US corporate bond spreads into a fundamental counter-cyclical component of expected default and a cyclical expectations-driven residual component. They denote the latter as the “excess bond premium”. International evidence by Akinci (2013) suggests that credit spreads are driven by risk aversion of global investors as much as they are driven by domestic factors affecting corporate financial vulnerability.

Combining these insights, I decompose credit spreads into several risk factors to extract idiosyncratic bond-level shocks. Specifically, an individual firm j 's credit

³⁸Weights may be endogenous themselves. Although not a remedy, lagging the weights is a way to address this issue.

³⁹I remain agnostic about the precise definition of states of the economy as these states are themselves endogenously determined by the interplay of domestic credit risk and capital flows. For example, the notion of *risk-on* and *risk-off* episodes relates to episodes of capital flows that are driven by global factors. It would be misleading to search for causal effects of credit risk precisely during times when global factors prevail.

spread $s_{j,c,t}[k]$ in country c paid on bond k is assumed to be linearly related to a measure of the firm's default risk $D_{j,c,t}$, a vector of bond characteristics capturing the bond's liquidity risk $\mathbf{X}_{j,c,t}[k]$, a vector of country risk characteristics $\mathbf{Z}_{c,t}$, and a vector of global risk measures \mathbf{G}_t ,

$$s_{j,c,t}[k] = a_c + \Lambda^j D_{j,c,t} + \Lambda^k \mathbf{X}_{j,c,t}[k] + \Lambda^c \mathbf{Z}_{c,t} + \Lambda^g \mathbf{G}_t + u_{j,c,t}[k] \quad (3.5.6)$$

where $u_{j,c,t}[k]$ is the "pricing error" of bond k . $(\Lambda^j, \Lambda^k, \Lambda^c, \Lambda^g)$ represent the "factor loadings" on the firm (j), bond (k), country (c), and global (g) risk premia, respectively. a_c denotes country fixed effects. I explicitly account for the default risk premium at the firm-level by using a measure of a firm's probability of default (Gilchrist, Yankov, & Zakrajšek, 2009; Gilchrist & Zakrajšek, 2012). This premium captures *expected* default risk based on firm fundamentals. The model in (3.5.6) is the analogue to the model in (3.5.2) with $\lambda\eta_t$ representing the vector of common risk factors η_t and their loadings Λ . However, the model in (3.5.6) is defined at the individual bond level. To obtain a measure of the credit spread and idiosyncratic shock at the firm level, I take the share-weighted average of credit spreads and idiosyncratic shocks of firm j from the estimation of (3.5.6) across outstanding bonds,

$$s_{j,c,t} = \sum_k w_{j,c,t}[k] s_{j,c,t}[k] \quad \text{and} \quad \hat{u}_{j,c,t} = \sum_k w_{j,c,t}[k] \hat{u}_{j,c,t}[k] \quad (3.5.7)$$

where the weight $w_{j,c,t}[k]$ on each individual bond k is defined by its face value $V_{j,c,t}[k]$ relative to the total volume of bonds of firm j outstanding at time t , $w_{j,c,t}[k] = V_{j,c,t}[k] / \sum_k V_{j,c,t}[k]$.

The fact that the spread model in (3.5.6) omits a currency risk premium should not be a cause for concern. I only include hard-currency denominated bonds in the sample. Since international investors mainly finance their investments through USD debt, they do not face currency risk. One may argue that there is still implicit currency risk involved with lending to firms which face currency mismatch on their balance sheet. I argue that such a currency risk premium would be subsumed under the default risk component. The ultimate consequence for a firm facing currency mismatch is that it will not be able to liquidate sufficient

assets in local currency to repay foreign currency debt and hence default on its obligations.

How ought one interpret the persistent occurrence of idiosyncratic shocks, or in other words “pricing errors”, in the time series of corporate spreads? It is not too difficult to think of examples of firm-specific surprises that may not be priced by investors into the expected default component: sales receipts falling far short of a company’s forecast due to product faultiness; the unanticipated costs of a corporate lawsuit; damage to a local production facility due to a fire or natural disaster; the death of a CEO; an unexpectedly high exposure to a regulatory change.⁴⁰ What is important is that these shocks represent unexpected changes in a firm’s outlook that are not priced in yet.⁴¹ Or alternatively, as Gabaix and Koijen (2020) argue, idiosyncratic shocks may represent any unexpected changes in a firm’s *sensitivity* – its “loading” – to a common shock.

Constructing the optimal GIV. Having obtained the idiosyncratic shocks $\hat{u}_{j,c,t}$ at the firm-level, I next construct the GIV analogous to (3.5.4),

$$z_{c,t} = \sum_j w_{j,c,t-1} \hat{u}_{j,c,t} - \frac{1}{N_{c,t}} \sum_j \hat{u}_{j,c,t} \quad (3.5.8)$$

where $w_{j,c,t}$ is the share of firm j in the country aggregate (or the size of the firm relative to its peers) and $N_{c,t}$ is the total number of issuing firms in a given country. Both may vary over time. The baseline specification considers a firm’s “external debt at risk” relative to a country’s aggregate external debt issued by non-financial corporations.⁴² Thus, the weight captures the expected dollar loss on the face value of debt for a risk-neutral investor. Then, $z_{c,t}$ is a valid instrument constructed by

⁴⁰Engljäähringer and Stracca (2020) combine an econometric and narrative approach to compile a database of idiosyncratic shocks (events) of car manufacturers and global banks. They find that these shocks significantly affect firm’s equity valuations, also within the respective sector, in the short-term.

⁴¹From a *behavioral* perspective, these pricing errors may capture deviations from full information rational expectations (FIRE) of international investors.

⁴²The idea follows from the model of sovereign spillovers proposed by Gabaix and Koijen (2020) where “shares” of sovereign debt are computed based on a country’s “debt at risk”. Camanho et al. (2022) use as a weight an investment fund’s market capitalization relative to their respective country aggregate.

idiosyncratic shocks. Specifically, the instrument is valid if the exclusion restriction holds, $E[u_{j,c,t}[k]\epsilon_{c,t}] = 0$.

How can we be sure that the shocks $\hat{u}_{j,c,t}[k]$ are truly idiosyncratic? There may be factors not captured by the spread model in (3.5.6) after all. Ideally, one would use Principal Component Analysis (PCA) as a non-parametric approach to separating common shocks from idiosyncratic shocks (see for example Gabaix and Koijen (2020) and Aldasoro, Beltrán, et al. (2020)). This approach would have the advantage of not imposing assumptions on the structure of endogenous relationships while allowing for reverse causality. However, the unbalanced nature of the bond-firm-country panel does not allow for PCA without sacrificing sample size and thus statistical power. Alternatively, one may think of saturating the spread model with a host of bond, firm, sector, and country fixed effects. Depending on the interaction with time fixed effects, one would quickly run into the curse of dimensionality, given that spreads are recorded at weekly frequency. By contrast, using the specification in (3.5.6) allows us to give economic meaning to the various components of credit risk. It thus appeals to risk premia that the literature has found to be important.

Estimation through instrumentation. Once the GIV is obtained, the estimation proceeds with two-stage least squares. First, I run a regression of the aggregate credit spread onto the GIV and a set of controls $\mathbf{X}_{c,t}$ at the country-level c ,

$$S_{c,t} = \gamma^z z_{c,t} + \beta^s \mathbf{X}_{c,t} + \nu_{c,t} \quad (3.5.9)$$

where $\nu_{c,t}$ is an unobserved error. $\nu_{c,t}$ is most likely correlated with the aggregate shock $\epsilon_{c,t}$ in (3.5.5). This is remedied through the instrument z_t which is uncorrelated with the aggregate shock by construction. The predicted $\hat{S}_{c,t}$ from the first stage are then used as an independent variable in the second stage to estimate the regression model in (3.5.5) with OLS,

$$F_{c,t} = \alpha \hat{S}_{c,t} + \beta^f \mathbf{X}_{c,t} + \epsilon_{c,t} \quad (3.5.10)$$

where $\mathbf{X}_{c,t}$ also includes country fixed effects. The coefficient α is just identified

as long as the exclusion restriction $E[u_{j,c,t}\epsilon_{c,t}] = 0$ holds such that the instrument is valid $E[z_{c,t}\epsilon_{c,t}] = 0$

Summary of estimation procedure. The step-wise estimation procedure can be summarized as follows:

- (1) Decompose credit spreads $s_{j,c,t}[k]$ into risk components using (3.5.6) to purge the idiosyncratic shocks off common factors.
- (2) Aggregate idiosyncratic shocks at the firm level $\hat{u}_{j,c,t}$ using (3.5.7).
- (3) Construct optimal GIVs at the country level using (3.5.8).
- (4) Estimate 1st stage: regress $S_{c,t}$ onto $z_{c,t}$ using (3.5.9).
- (5) Estimate 2nd stage: regress $F_{c,t}$ on the instrumented changes in credit spread $\hat{S}_{c,t}$ using (3.5.10).

3.6 Results

3.6.1 Extraction of Idiosyncratic Shocks

As a first step in my identification strategy, I estimate the corporate spread model in (3.5.6) to decompose credit spreads into its risk components and idiosyncratic shocks. Following Gilchrist and Zakrajšek (2012), I regress bond k 's credit spread $s_{j,c,t}[k]$ on a set of bond-specific characteristics that include the bond's modified option-adjusted duration, the amount issued (in USD), the fixed coupon rate, the age of the issue, as well as an indicator variable for bonds with underlying call options, $CALL_j[k]$.⁴³ In addition, the firm-specific probability of default $EDF_{j,c,t}$ captures market-based changes in investors' expectations about firm fundamentals. The spread model is further augmented by the CBOE volatility index, VIX_t , and the 10-year US Treasury yield, $UST10Y_t$, to account for spillovers of US monetary policy and changes in global risk aversion following work by Miranda-Agrippino and Rey (2020).

I also include country as well as industry fixed effects to control for any factors specific to a country or industry. In line with Cameron, Gelbach, and Miller (2011),

⁴³I refrain from using a log-transformation as used by Gilchrist and Zakrajšek (2012) since it reduces the sample size as negative OAS values are excluded. Moreover, estimating the spread model in levels lends itself to a natural interpretation of the relevant factor loadings.

Table 3.3. Credit spread decomposition: extracting idiosyncratic shocks to credit spreads

	(1)		(2)	
	Est.	SE	Est.	SE
$EDF_{j,t}$	72.014***	9.817	48.810***	9.795
$Duration_{j,t}[k]$	-3.139	3.147	0.161	3.107
$Coupon_j[k]$	62.099***	14.138	50.867***	15.257
$Age_{j,t}[k]$	-0.190***	0.063	-0.198***	0.068
$Volume_j[k]$	-28.698*	15.930	11.295	19.669
$CALL_j[k]$	134.326***	28.429	256.717***	83.603
VIX_t	6.882***	1.476	6.842***	1.658
$UST10Y_t$	-87.075***	16.939	-55.421***	16.565
Government-Related _{<i>j</i>}	-101.081	73.469	-108.121*	58.591
$EDF_{j,t} \times CALL_j[k]$			49.123**	19.705
$Duration_{j,t}[k] \times CALL_j[k]$			-14.559**	5.341
$Coupon_j[k] \times CALL_j[k]$			7.193	16.705
$Age_{j,t}[k] \times CALL_j[k]$			0.299	0.310
$Volume_j[k] \times CALL_j[k]$			-186.343***	36.660
$VIX_t \times CALL_j[k]$			1.948	1.690
$UST10Y_t \times CALL_j[k]$			-68.304***	18.307
Country & Industry FE	YES		YES	
Observations	550,394		550,394	
Adjusted R ²	0.375		0.407	

Note: This table reports the baseline results of the corporate spread decomposition in (3.5.6). The sample period covers 2000/01/07 – 2020/11/27. The dependent variable is the option-adjusted spread (OAS). Standard errors are clustered in the country, industry, firm, and time dimension following Cameron, Gelbach, and Miller (2011). Daily expected default frequencies (EDFs) at the 1-year horizon are converted into weekly averages. The indicator variable $CALL_j[k]$ is one for bonds with any type of underlying call option. The VIX_t is the CBOE volatility index. The $USD10Y_t$ is the 10-year US Treasury yield. Industry fixed effects are based on the BICS industry level 1 classification system. The country subscript c is suppressed to preserve space.

standard errors are clustered along countries (c), industries, firms (j), and time (t). The BICS Level 1 industry classification summarizes government-related entities in one single industry. Including industry fixed effects based on this classification system therefore controls for spillover effects from the sovereign to the corporate bond market via state-owned enterprises.⁴⁴

The baseline results presented in column (1) of Table 3.3 indicate that both

⁴⁴This provides an additional backstop to the GIV which removes common sovereign exposure that is captured by η_t .

bond- and firm-specific factors as well as global risk affect spreads both in terms of magnitude and significance of the estimated coefficients. Consider an increase in the probability of default of an average firm by one percentage point, e.g. an increase in the EDF credit measure from 10 to 11.⁴⁵ The estimated coefficient translates into an increase in the OAS by 72 basis points at the margin. As expected, higher expected default risk commands a higher risk premium to compensate for potential default losses. Moreover, corporate spreads significantly increase when global risk rises, i.e. when the VIX increases, and when US Treasury yields fall.⁴⁶ However, they notably do so to a much lesser degree than in response to firm-specific default risk.

In a separate robustness check (not reported), I also account for the possible impact of oil price shocks on oil-exporting EMEs in the sample.⁴⁷ I therefore control for the spot oil price and the expected oil prices as measured by the 12-month Brent Crude Oil futures price, respectively. Neither of them comes out as economically and statistically significant, nor do they change the baseline results. Note also that government-related firms appear to pay a significantly lower credit spread by virtue of e.g. ringfencing or implicit or explicit guarantees by the state. While this finding is not statistically significant, it does not alleviate our initial concern about confounding effects and potential endogeneity due to the corporate-sovereign nexus. It still commands greater rigor with respect to the robustness of the GIV as outlined in Section 3.7.

What is the role of optionality in the underlying bond? The OAS, by definition, controls for the impact of the option to redeem the bond early on the riskiness of the bond to the bondholder. As such, OAS should correctly adjust for the cost of callable bonds being more sensitive to interest rate changes and the ben-

⁴⁵Moody's computes the EDF measure as a daily series which I aggregate to a weekly frequency. While the main inputs of the EDF model are quarterly balance sheet metrics – notably leverage – the key high-frequency component entering the EDF calculation is asset volatility. In a separate robustness check (not reported), I therefore include firms' equity volatility $EVOL_{j,t}$ as a regressor. The results remain unchanged, suggesting that the EDF carries information about the probability of default of a firm beyond the volatility in its equity returns. This corroborates the idea that the EDF serves as a sufficient statistic for a firm's solvency.

⁴⁶The latter effect is robust to using both the 10-year and the 2-year US Treasury yield.

⁴⁷Recent evidence by Miranda-Agrippino and Rey (2022) suggests that two global factors drive about a third of the variation in gross capital flows and that the second of these global factors in capital flows is highly correlated with oil prices.

efits of being less sensitive to default risk. Nevertheless, optionality may carry certain latent attributes that affect the desirability of holding callable bonds (Duffee, 1998; Gilchrist & Zakrajšek, 2012). To ensure that such features do not drive the results, I interact the regressors with the $CALL_j[k]$ variable. Augmenting the baseline model by these interaction terms changes the magnitude of coefficients but does not significantly affect the direction and significance of the coefficients of interest in column (2) of Table 3.3. Callable bonds do demand a significantly higher credit spread at the margin, yet they do not significantly weaken the power of expected default risk of a firm in explaining observed credit risk. In addition, callable bonds are significantly more sensitive to interest rate changes as suggested by the interaction with the bond's duration and the US yield curve.

Given the richness of risk factors that the spread model in (3.5.6) controls for, it is important to ensure that the remaining variation, i.e. the idiosyncratic shocks $\hat{u}_{j,c,t}[k]$, account for sufficient variation in credit spreads. If the bond-, firm- and country-level risk factors already absorbed most of the variation in spreads, the shocks $\hat{u}_{j,c,t}[k]$ would likely suffer from lack of relevance in explaining spreads, thus invalidating the GIV. Table 3.4 presents the variance decomposition of credit spreads based on the baseline specification in column (1) of Table 3.3. While default risk as captured by the $EDF_{j,c,t}$ takes up the largest share of almost 20% of the variance, the bulk of variation in spreads of around 70% is still left unexplained. This unexplained variation is arguably idiosyncratic firm risk captured by $\hat{u}_{j,c,t}[k]$. Interestingly, global risk as captured by the VIX_t and $UST10Y_t$ account for only a small fraction of 2.7% of variation in spreads. This finding stands in stark contrast to evidence in the literature that attributes a strong role to global factors in affecting asset prices around the world (Miranda-Agrippino & Rey, 2020).⁴⁸

For comparison, the variance decomposition for the sample of EMEs is juxtaposed with the variance decomposition of an equivalent spread model applied to US corporate bonds by Chitu, Grothe, and Schulze (2022) that follows the established methodology of Gilchrist and Zakrajšek (2012). The statistics are broadly

⁴⁸One may wonder whether the small variance share of global risk in credit spreads in the baseline specification in Table 3.3 may be attributable to collinearity between the $EDF_{j,c,t}$ and the VIX_t and $UST10Y_t$, respectively. However, the pairwise correlations of default risk with global risk factors at the firm level are only 0.04 and -0.02, respectively. Even at the aggregate country level, the pairwise correlations are only very small at 0.13 and -0.02, respectively.

Table 3.4. Variance decomposition of corporate spreads

	Variance in %	
	EMEs	US
EDF _{<i>j,t</i>}	19.81	22.69
Duration _{<i>j,t</i>} [<i>k</i>]	0.03	1.55
Coupon _{<i>j</i>} [<i>k</i>]	5.23	8.62
Age _{<i>j,t</i>} [<i>k</i>]	0.30	0.12
Volume _{<i>j</i>} [<i>k</i>]	0.04	0.05
VIX _{<i>t</i>}	0.81	
UST10Y _{<i>t</i>}	1.88	
Country FE	2.13	
Industry FE	0.55	1.27

Note: The first column shows the variance decomposition of the estimated model in (3.5.6) for the sample of EM bonds. The second column shows the variance decomposition for an equivalent estimation for a sample of US bonds taken from Chitu, Grothe, and Schulze (2022). The US estimates are based on a panel of bonds issued by S&P 500 firms spanning 01/2000–05/2021 following the methodology by Gilchrist and Zakrajšek (2012).

in line with those for the US. This provides reassurance that the spread model in (3.5.6) is an adequate representation of systematic risk factors that explain credit spreads.

3.6.2 Aggregation

Having obtained the idiosyncratic shocks $\hat{u}_{j,c,t}[k] = s_{j,c,t}[k] - \hat{s}_{j,c,t}[k]$ from estimating the second specification in Table 3.3, I aggregate the shocks at the firm-level as in (3.5.7) to construct the GIV for each country. I compute the GIV, $z_{c,t}$, for country c using the weights defined as $w_{j,c,t} = D_{j,c,t} / \sum_j D_{j,c,t}$. The total nominal bond debt volume, $D_{j,c,t}$, of firm j in country c is set in relation to the total bond debt volume of a given country. The weights are therefore time-varying.⁴⁹ The GIV is computed as in (3.5.8).

While there exists considerable heterogeneity in credit spreads, and hence firm-level shocks, across countries, it is nevertheless instructive to examine how these shocks behave at the aggregate level. The simple arithmetic average of idiosyn-

⁴⁹Gabaix and Koijen (2020) argue that the conditions for the validity of the GIV still hold under the assumption of time-varying, rather than fixed, weights.

cratic shocks of all firms across all countries in the sample is computed as,

$$\hat{U}_t^{EM} = \frac{1}{N_t} \sum_c \sum_j \sum_k \hat{u}_{j,c,t}[k] \quad (3.6.1)$$

where N_t is the number of bond-firm-country observations in week t . Figure 3.5 plots the resulting indicator, \hat{U}_t^{EM} , along with the excess bond premium (EBP) found by Gilchrist and Zakrajšek (2012) for the US.⁵⁰

The EBP in EMEs strongly comoves with the EBP estimated by Gilchrist and Zakrajšek (2012) around major crises episodes. However, the correlation vanishes after the GFC up until the Covid-19 crisis. While the pairwise correlation over the sample period from 01/2000 to 12/2009 is a striking 0.60, it drops to only 0.22 over the period from 01/2010 to 12/2019. This is further underpinned when computing the pairwise correlation over a rolling 10-year window (see Figure 3.D.1 in Appendix 3.D). This observation suggests that a common factor, e.g. a global factor, may have driven both the EBP in the US and in EMEs up until the GFC. However, in recent years there seems to have been a disconnect, giving room to other determinants. This finding provides confidence that the firm-specific shocks obtained from the granular spread decomposition are not simply an artefact of the sentiment of global investors that affects both corporate bond markets in advanced and emerging economies.

Gilchrist and Zakrajšek (2012) provide an alternative explanation for the driving force behind variation in the EBP in the US: the effective risk-bearing capacity of financial intermediaries. They find evidence that financial intermediaries' ability to provide funding liquidity may constrain the supply of credit (Brunnermeier & Pedersen, 2009). Both primary dealers, security broker-dealers, and large banks on the sell-side as well as institutional investors such as large banks, insurance

⁵⁰To ensure comparability with the baseline model by Gilchrist and Zakrajšek (2012), I run a separate estimation of the spread model in (3.5.6) with all variables except the EDF in logs. Then, the idiosyncratic shocks at the firm-level are computed by first obtaining the level prediction,

$$\hat{s}_{j,c,t}[k] = \exp \left[\hat{\alpha}_c + \hat{\Lambda}^j EDF_{j,c,t} + \hat{\Lambda}^k \mathbf{X}_{j,c,t}[k] + \hat{\Lambda}^g \mathbf{G}_t + \hat{\epsilon}_{j,c,t}[k] + \frac{\hat{\sigma}^2}{2} \right]$$

where $\hat{\epsilon}_{j,c,t}[k]$ is the unexplained variation in the *log*-credit spread, $(\hat{\alpha}, \hat{\Lambda}^j, \hat{\Lambda}^k, \hat{\Lambda}^g)$ denote pooled OLS estimates and $\hat{\sigma}^2$ is the estimated error variance. Given the level prediction, we can then compute the level-error term as $\hat{u}_{j,c,t}[k] = s_{j,c,t}[k] - \hat{s}_{j,c,t}[k]$, and aggregate across all bonds.

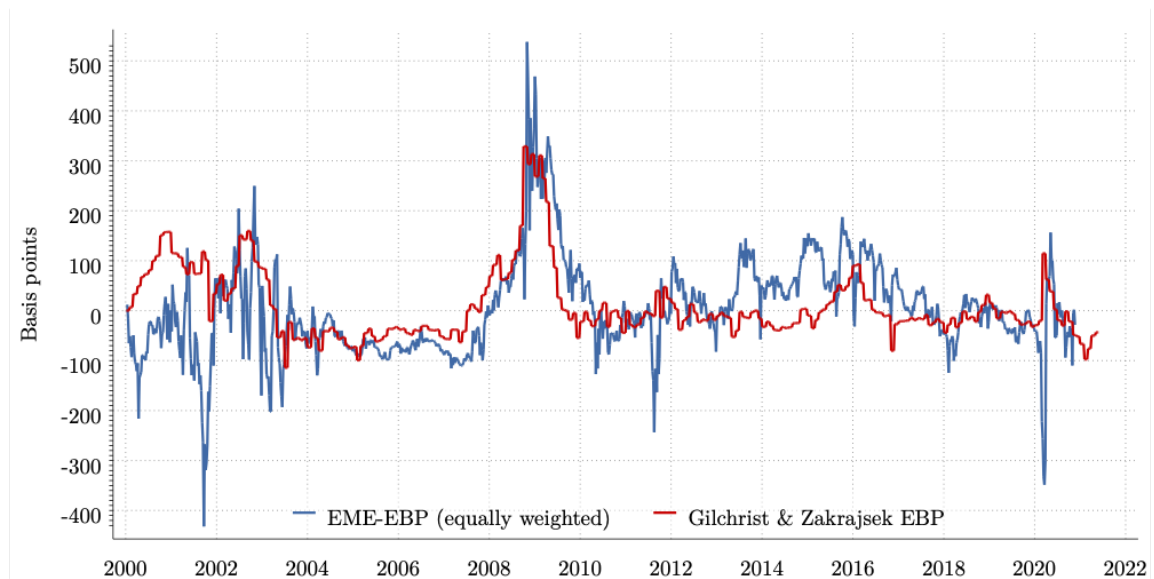


Figure 3.5. The Excess Bond Premium of Emerging Market Economies and the EBP of Gilchrist and Zakrajšek (2012).

Note: The excess bond premium (EBP) for emerging market economies is computed as the arithmetic average of residuals from the decomposition of the log of option-adjusted credit spreads (OAS) following closely the model in (3.5.6) and Gilchrist and Zakrajšek (2012). The EBP is based on an unbalanced panel of 27 EMEs. The EBP estimated by Gilchrist and Zakrajšek (2012) for the US is publicly available via the Federal Reserve. Countries include AE, AR, BR, CL, CN, CO, CZ, DO, HU, ID, IL, IN, KR, KZ, MX, MY, PE, PH, QA, RU, SA, SG, TH, TR, TW, VE, and ZA.

companies, and pension funds on the buy-side may be capital constrained. The high correlation of the US- and EME-EBPs up to and including the GFC suggests that liquidity frictions of financial intermediaries may account for variation in the EME-EBP. Yet, the lack of correlation between the two EBPs over the second half of the sample period sheds doubt on US-based financial intermediaries being the primary driver. Structural shifts in the global architecture of global banks and institutional investors (the “pipes” of global capital flows) could pose a further source of variation. Moreover, global commodity cycles and EM firms’ exposure to those cycles could play a role. I leave it to future research and data availability to tackle this important yet non-trivial empirical exercise.

3.6.3 Country-Level Estimation

Equipped with the GIV, I estimate the capital flow model in (3.5.10) with two-stage least squares, instrumenting the aggregate corporate spread by the GIV. The

Table 3.5. The effect of credit spreads instrumented by the GIV on bond portfolio flows

	(1) OLS		(2) IV	
	Est.	SE	Est.	SE
$S_{c,t}$	-0.003	0.003	0.039***	0.015
$MPR_{c,t}$	-0.005	0.007	-0.000	0.007
$GOV10Y_{c,t}$	-0.006	0.012	-0.030**	0.015
VIX_t	-0.224***	0.040	-0.246***	0.041
$UST10Y_t$	-0.070***	0.008	-0.026	0.016
Country FE	YES		YES	
Observations	9,569		9,569	
Adj. R^2	0.049		0.030	
F-Statistic			371.290	
χ^2 Statistic			372.185	

Note: The first column reports the results of a regression of the EPFR bond portfolio flow measure onto the option-adjusted spread $S_{c,t}$ of country c , the monetary policy rate $MPR_{c,t}$, the 10-year sovereign yield $GOV10Y_{c,t}$, the CBOE volatility index VIX_t , and the 10-Year US Treasury yield $UST10Y_t$, estimated with OLS. The second column reports the second-stage results of this specification whereby the credit spread $S_{c,t}$ is instrumented by the GIV, $z_{c,t}$. The unbalanced country panel model is estimated with country fixed effects and an indicator for the GFC and the Covid-19 crisis (not reported). Standard errors are robust with respect to serial correlation and cross-dependence. The table reports the F-statistic and χ^2 -statistic of the Sanderson and Windmeijer (2016) first-stage F-test for weak instruments and underidentification, respectively.

dependent variable is the EPFR bond portfolio flow measure (in millions) resulting from changes in funds' country allocations. The estimation period is restricted to January 2004 to November 2020 because the earliest available data for bond fund flows starts in 2004. Using EPFR flows further restricts the estimation sample to 16 countries. I include a set of controls that are assumed to affect the flow of capital into and out of an economy.⁵¹ The monetary policy rate $MPR_{c,t}$ and the 10-year government bond yield $GOV10Y_{c,t}$ of a given country form the block of higher-frequency domestic "pull factors" that, along with the corporate spread, affect the attractiveness of investing in the domestic economy in the short- and medium-term. The VIX_t and $UST10Y_t$ form the block of global "push factors" that act as a summary statistic for global risk. Finally, I also include country fixed effects.

⁵¹The chosen set of controls is limited by the availability of long high-frequency time series for the large sample of countries at hand.

Table 3.5 presents two sets of results. The first column contains the estimated coefficients of a fixed effects panel regression estimated with OLS. The second column contains the second-stage results of the model in (3.5.10) estimated with the credit spread, $\hat{S}_{c,t}$, as instrumented by the GIV, $z_{c,t}$. In the OLS regression, global factors clearly dominate. Rising global market volatility, i.e. risk aversion, and rising US yields result in net capital outflows. Domestic factors have virtually no significant impact, neither positive nor negative, on capital flows. This finding is in line with the literature on push factors that attribute a dominant role to global risk (Akinci, 2013; Bruno & Shin, 2015a; Forbes & Warnock, 2012; Fratzscher, 2012; Ghosh et al., 2014; Miranda-Agrippino & Rey, 2020).

However, once the corporate credit spread is instrumented using the GIV, there is a significant positive response of portfolio flows to a widening of credit spreads. The direction of the effect suggests that credit risk has an attracting effect on capital from abroad. Not only does the GIV enter the first stage regression with a highly statistically significant coefficient, but also the F-statistic and χ^2 -statistic of the Sanderson and Windmeijer (2016) first-stage F-tests for weak instruments and underidentification, respectively, are very high. They indicate that the GIV does not suffer from instrument weakness. Interestingly, US monetary policy seems to lose its clout on capital flows once the credit spread measure is instrumented. Since I control for the 10-year US yield in the previous step, this should not be driven by the correlation between credit spreads and US yields.⁵²

What may explain the downward bias in the OLS estimate? The coefficient on the credit spread $S_{c,t}$ switches from being insignificant and negative (but close to zero) in the OLS regression to being significant and positive in the instrumented regression. The downward bias in the OLS estimate likely results from the positive correlation between credit spreads and global risk factors during downturns. Specifically, global risk-off episodes are characterized by spikes in the VIX and in credit spreads as well as capital outflows. This dominating effect pushes the OLS estimate into negative territory when leaving the spread $S_{c,t}$ uninstrumented. The fact that the OLS coefficient on $S_{c,t}$ is close to zero is precisely an indication that

⁵²Caution is in place not to make any statements about which factors are the most powerful in affecting capital movements. Instead, the results indicate that domestic factors matter even *after* controlling for global push factors.

there may be asymmetric forces of the widening and tightening of spreads on inflows and outflows at play that, when not instrumented, net each other out. Absent a valid exogenous instrument, global factors therefore dominate.

One may argue that the GIV does not only affect capital flows through credit spreads but also through the stance of monetary policy or through sovereign yields. Such a relationship would violate the exclusion restriction and turn the instrument invalid. This could potentially also explain why the OLS estimates of $MPR_{c,t}$ and $GOV10Y_{c,t}$ are both insignificant. I argue that the effect of the GIV via the monetary policy stance of a country can be ruled out on the grounds of the high frequency nature of this analysis. Because monetary policy makers meet infrequently, monetary policy is sluggish to react to shocks emanating from the corporate sector or shocks affecting credit risk in capital markets within a one-week window. Moreover, to the extent that the spread decomposition in model (3.5.6) already controls for spillovers from sovereign bond markets onto state-owned enterprises, a possible effect of the GIV on sovereign yields should not be a cause for concern.

Notably, the direction of the effect of $\hat{S}_{c,t}$ on $F_{c,t}$ is positive. A widening of corporate spreads hence leads to net capital inflows, all else equal. This finding supports the idea that a higher level of credit risk (in good times) attracts capital from international investors in search for yield. Yet, taken symmetrically, it cannot be reconciled with the hypothesis that countries experience net capital outflows when credit risk rises to precariously high levels. Such a reversal could for example occur when firms face difficulties meeting financial obligations because the foreign currency value of their liabilities cannot be covered by the value of cash flows and liquidatable assets. Absent granular data on gross capital flows, it is not possible to disentangle the contribution of capital inflows vs. outflows to this effect.

To shed light on the possible *reversal* of capital flows in response to a widening of spreads, I augment the baseline model by interacting the spread with an indicator for large currency depreciations. The idea is that default risk, when exacerbated by rising currency mismatch, induces international investors to reprice risks in domestic bond markets and to retract. Because exchange rate movements are endogenous to capital flows, it is problematic to include the percentage change

in the exchange rate as a regressor. Instead, let $\mathbb{1}_{c,t}^{FX}$ be an indicator that takes the value of one if the bilateral real effective exchange rate is more than two standard deviations higher than the mean exchange rate at a given point in time. Both the standard deviation and mean are computed over a 2-year rolling window.

Reiterating (3.5.9)-(3.5.10), the augmented model takes the following first and second stage form,

$$\begin{aligned} S_{c,t} &= \gamma^s z_{c,t} + \beta^s X_{c,t} + \nu_{c,t}^s \\ S_{c,t} \times \mathbb{1}_{c,t}^{FX} &= \gamma^i z_{c,t} \times \mathbb{1}_{c,t}^{FX} + \beta^i X_{c,t} + \nu_{c,t}^i \end{aligned} \quad (3.6.2)$$

where the spread $S_{c,t}$ and the spread interaction term $S_{c,t} \times \mathbb{1}_{c,t}^{FX}$ are both instrumented in the first stage. The second stage is then given by,

$$F_{c,t} = \alpha^s \hat{S}_{c,t} + \alpha^i \hat{S}_{c,t} \times \mathbb{1}_{c,t}^{FX} + \alpha^f \mathbb{1}_{c,t}^{FX} + \beta X_{c,t} + \epsilon_{c,t} \quad (3.6.3)$$

Table 3.6 presents the results of this augmented specification for both the OLS and the instrumented estimation. The estimates on the instrumented interaction term suggest that a widening of credit spreads still attracts net capital inflows, potentially even during periods of high currency mismatch. However, during episodes of large real currency depreciations, net capital flows tend to fall. This contractionary effect on capital flows is similar in magnitude to the expansionary effect on the level of the spread, $S_{c,t}$. The indicator variable for real FX depreciations is only modestly significant and positive. A positive effect of real FX depreciations on net capital flows could point towards the trade channel of external adjustment. When a country's currency depreciates in real terms, the effect stimulates expected exports. Greater opportunities for growth may in turn attract capital. However, this evidence is rather tentative and the following exercises show that it partly lacks robustness.

The results of the model with asymmetric effects also shed light on the previous suspicion that the close to nil estimate in the baseline OLS specification in Table 3.5 may result from widening and tightening of spreads just cancelling each other out. This is corroborated through the interaction terms with the indicator variable for large currency depreciations. The coefficient on $S_{c,t}$ rises from 0.039 in column (2)

Table 3.6. Asymmetries in the effect of credit spreads on bond portfolio flows during large real exchange rate depreciations

	(1) OLS		(2) IV	
	Est.	SE	Est.	SE
$S_{c,t}$	-0.002	0.003	0.044**	0.017
$S_{c,t} \times \mathbb{1}_{c,t}^{FX}$	0.024**	0.012	-0.041**	0.020
$\mathbb{1}_{c,t}^{FX}$	-3.785	6.817	16.317*	9.027
$MPR_{c,t}$	0.001	0.007	0.001	0.007
$GOV10Y_{c,t}$	-0.024**	0.012	-0.036***	0.013
VIX_t	-0.231***	0.041	-0.251***	0.043
$US10Y_t$	-4.147***	0.680	-1.856*	1.013
Country FE	YES		YES	
Observations	9,569		9,569	
Adj. R^2	0.049		0.026	
F-Statistic			310.996	
χ^2 Statistic			311.811	

Note: The first column reports the results of a regression of the EPFR bond portfolio flow measure onto the option-adjusted spread $S_{c,t}$ of country c interacted with an indicator variable for large currency depreciations, $\mathbb{1}_{c,t}^{FX}$, as well as the monetary policy rate $MPR_{c,t}$, the 10-year sovereign yield $GOV10Y_{c,t}$, the CBOE volatility index VIX_t , and the 10-Year US Treasury yield $UST10Y_t$, estimated with OLS. The second column reports the second-stage results of this specification whereby the credit spread $S_{c,t}$ and its interaction term are instrumented by the GIV, $z_{c,t}$. The indicator variable for large currency depreciations is defined by the bilateral effective FX rate based on the consumer price index. The unbalanced country panel model is estimated with country fixed effects and an indicator for the GFC and the Covid-19 crisis (not reported). Standard errors are robust with respect to serial correlation and cross-dependence. The table reports the F-statistic and χ^2 -statistic of the Sanderson and Windmeijer (2016) first-stage F-test for weak instruments and underidentification, respectively.

of Table 3.5 to 0.044 in the GIV regression in column (2) of Table 3.6. This suggests that previously the effect was muted when not allowing for asymmetries.

Overall, the results make a strong case for domestic credit risk acting as a “pull factor” on international capital. They substantiate the claim that domestic credit risk can have a *causal* effect on capital flows above and beyond the driving forces of the Global Financial Cycle and global risks. The results also yield some suggestive evidence on the role of heightened credit risk as a repelling factor of international capital.

3.6.4 Dynamic Responses to Credit Risk

Having established a causal link between credit risk and capital flows, it is instructive to examine how the system given by (3.5.9) and (3.5.10) behaves in response to shocks to aggregate credit risk.⁵³ Even more so, the wider implications for the real economy need to be examined. To that end, I formulate a dynamic model using Jordà (2005)'s local projection method with instrumental variables in a panel context (panel IV-LP) (Jordà et al., 2015).⁵⁴

Local projections have two advantages in the context of my analysis. First, they can accommodate potential non-linearities arising from the asymmetric effect of credit risk shocks on capital flows. For example, local projections can account for different time-varying states of *tightening versus widening* of credit spreads or capital *surges versus retrenchment* reminiscent of risk-on and risk-off episodes. Second and more generally, local projections are parametrically less intensive and less prone to model misspecification than standard VAR techniques. They impose little structure on the data generating process.

Mendoza (2010) and Bianchi (2011) suggest that the build-up of leverage during expansions is at the heart of capital flow reversals that occur in high-leverage states. I am therefore interested in the *cumulative* response of capital flows to the *build-up* of credit risk over a horizon from t to $t + h$. Let $\sum_{j=0}^h y_{c,t+j}$ denote the sum of the outcome variable of interest from t to $t + h$. The panel IV-LP method is a series of panel regressions for each horizon h ,

$$\sum_{j=0}^h y_{c,t+j} = \beta_h \sum_{j=0}^h \hat{S}_{c,t+j} + \phi_{c,h}(L) \mathbf{X}_{c,t-1} + \epsilon_{c,t+h} \quad \text{for } h = 0, \dots, H \quad (3.6.4)$$

where $\hat{S}_{c,t}$ denotes cumulative credit risk, $\mathbf{X}_{c,t}$ is a vector of control variables that includes country fixed effects, and $\phi_{c,h}(L)$ denotes its polynomial lag operator. The coefficient β_h carries the interpretation of a multiplier along the lines of Ramey and Zubairy (2018) and leaning on the financial accelerator literature (Bernanke et al., 1999; Mendoza, 2010). In addition to its intuitive interpretation, one advantage of

⁵³I leave it to future research to augment the existing system by an additional structural relationship between capital flows, credit risk, and exchange rates to capture the full feedback loop.

⁵⁴Alternatively, one can estimate a standard (panel) VAR model with a recursive ordering of financial and macroeconomic variables (Caballero et al., 2019; Gilchrist & Zakrajšek, 2012).

this specification is that it allows me to estimate the standard errors for the cumulative responses directly. This would not be possible if specified in levels (Ramey & Zubairy, 2018). The error term $\epsilon_{c,t+h}$ is known to suffer from serial correlation following successive leading of the dependent variable. Moreover, cross-panel correlation between countries cannot be ruled out. I therefore adjust standard errors such that they are robust to serial correlation and cross-panel heteroskedasticity (Driscoll & Kraay, 1998).

As before, the cumulative measure of credit risk is likely to suffer from endogeneity with respect to capital flows. By design, the local projections method is intended to provide a partial remedy to the problem of endogeneity. This is because the cumulative credit risk measures as well as the controls are pre-determined in the specification and should hence not be endogenous to future cumulative capital flows. This approach in itself however does not allow us to make *causal* statements. To identify the credit risk shock, I therefore instrument the cumulative credit spread $S_{c,t+j}$ by the GIV, $z_{c,t}$, through a first-stage panel regression,⁵⁵

$$\sum_{j=0}^h S_{c,t+j} = \gamma_{c,h} z_{c,t} + \phi_{c,h}(L) \mathbf{X}_{c,t} + \nu_{c,t+h} \quad (3.6.5)$$

which again includes a vector of control variables that also contains country fixed effects. The fitted spread $\hat{S}_{c,t}$ is then used in the second stage panel IV-LP in (3.6.4). I thus extract exogenous variation in credit spreads that can build up over time to act upon macroeconomic outcomes.

To exploit the full sample length, I use the monthly measure of net debt portfolio flows by the IIF rather than the weekly measure of net bond market portfolio flows by EPFR for this exercise. The IIF series starts as early as January 2000 for some countries while the EPFR measure starts only in 2004. Besides looking at the dynamic response of capital flows, I also estimate the panel IV-LP model in (3.6.4) for the terms of trade of a country, industrial production in the manufacturing sector, and the unemployment rate as measures of real economic activity. I limit my attention to these variables as they are available at monthly frequency for at least 14 (and up to 30) countries. The vector of controls $X_{c,t}$ comprises up to three lags

⁵⁵While the cumulative credit spread does not have a natural interpretation of an accumulating stock variable, I interpret it as the sum of risk premia, and hence the build-up of risk over time.

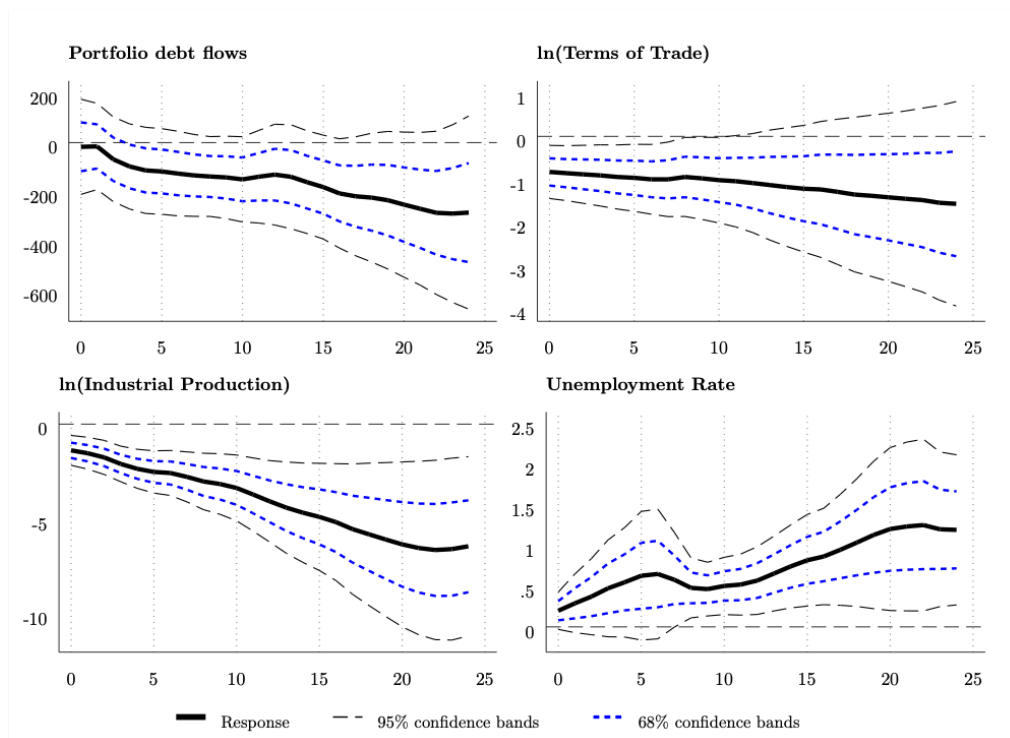


Figure 3.6. Impulse responses with respect to a credit risk shock

Note: The four panels show the impulse responses with respect to a 100 basis point increase in the average country-level option-adjusted credit spread in an unbalanced panel of countries. The impulse responses are estimated using a panel local projections framework whereby the credit spread is instrumented by the granular instrumental variable (GIV). Standard errors are robust with respect to serial correlation and cross-dependence. Portfolio debt flows are measured in millions and converted to reflect end-of-month changes. The monthly terms of trade and industrial production indices are measured in logs. The monthly unemployment rate is measured in percentage points. The x-axis indicates months after the shock.

of the domestic monetary policy rate, the domestic stock market index, the VIX, and the 2-year US Treasury yield.

Figure 3.6 presents the cumulative impulse responses of the key macroeconomic variables to a 100 basis point shock to the credit risk build-up in the average country-level OAS over a two-year horizon. Portfolio debt flows contract upon impact. The terms of trade – the ratio between the country’s export prices and import prices – deteriorate so that a unit of exported goods can purchase less units of imported goods. This likely makes the economy more competitive in terms of exports but impinges on households’ purchasing power with respect to imported goods, and hence overall consumption. Industrial production falls upon impact while the

unemployment rate rises by 0.75 percentage points over the first 6 months. The results suggest that the prolonged build-up of financial imbalances in the non-financial corporate sector can unleash powerful and adverse dynamics for the real economy as argued by Mendoza (2010) and Bianchi (2011).

There may be concern that while the GIV proved to be a valid instrument for credit risk in the static analysis of capital flows, it may not be a valid instrument to identify the impact of credit risk onto the terms of trade and economic activity. Two points alleviate these concerns. First, additional tests on the first stage of the panel IV-LP regressions suggest that the GIV does not suffer from instrument weakness and is a significant explanatory variable also of the *cumulative* credit risk premium. Second, credit spreads are an arguably faster-moving variable than real economic activity. Their higher-frequency nature is also exploited in the causal orderings of VAR frameworks. It is therefore unlikely that, for example, high unemployment would cause a prolonged build-up of leverage and credit risk in the economy. If anything, the results suggest that the reverse is happening.

Nevertheless, future work should address – through additional higher-frequency data of real activity – whether there are other channels that may play a role. In addition, future research should investigate how the results may depend on the interplay between the state of the domestic vs. the state of the global economy. This could for example be evaluated along the lines of domestic tightening vs. widening of (i) credit, (ii) capital controls, or (iii) exchange rate conditions, as well as global risk-on and risk-off episodes. The latter case may prove an instructive laboratory to evaluate whether domestic effects of credit risk dissipate once the Global Financial Cycle comes to dominate.

3.7 Robustness and Discussion

The validity of the GIV relies on a number of strong assumptions. In an emerging market setting with many confounding factors at play, it is important to carefully examine both *instrument relevance* and *instrument exogeneity*. This section outlines some of the robust features of the results and proposes possibilities to strengthen the results which are left to future research.

Instrument relevance. Ideally, the GIV should be able to explain a large share of variation in aggregate credit risk such that $E[z_{c,t}S_{c,t}] \neq 0$. That is, it needs to be *relevant* in the data generating process underlying credit spreads. As the previous section outlines, first-stage estimates of the effect of the GIV onto credit spreads are highly significant, even after controlling for other exogenous regressors.⁵⁶ Additional tests indicate that the GIV does not suffer from instrument weakness. Moreover, the exogenous regressors – the monetary policy rate, the VIX, and the 10-Year US Treasury yield – should be truly exogenous with respect to the dependent variable. This is likely to hold true. The only cause for concern pertains to the endogenous relationship between capital flows and domestic sovereign risk. Irrespective of this relationship, the GIV should be exogenous with respect to sovereign yields. Constructing the GIV as the difference between share-weighted and equally-weighted firm shocks removes common factors – such as sovereign risk – that affect all firms alike. Moreover, the spread decomposition controls for state-ownership, thereby capturing spillovers from sovereign into corporate bond markets.

Instrument exogeneity. It is pivotal that the idiosyncratic shocks extracted in the spread model in (3.5.6) truly represent unexplained firm-specific variation in credit risk. The idiosyncratic shocks $u_{j,c,t}[k]$ must be orthogonal to the common shock $\eta_{c,t}$ and the aggregate shock $\epsilon_{c,t}$ that affects country c . If there was a reason to believe that $E[u_{j,c,t}[k]\eta_{c,t}] \neq 0$ or $E[u_{j,c,t}[k]\epsilon_{c,t}] \neq 0$, then the resulting GIV would be invalid. That is, the exogeneity condition would be violated. Gabaix and Koijen (2020) propose PCA on credit spreads at the bond-level as a possible way to improve the soundness of the exogeneity assumption. PCA may be a superior method in that it ensures that results are not driven by the structure imposed on credit spreads in (3.5.6), but the unbalanced panel in this analysis does not lend itself to PCA.

In the absence of PCA as a viable option, explicitly decomposing spreads is the second best approach to accounting for *systematic* sources of risk. I argue that the unexplained variation $\hat{u}_{j,c,t}[k]$ obtained from estimating the spread model in (3.5.6) indeed represents idiosyncratic, firm-specific risk. First, the liquidity risk

⁵⁶Since the spread decomposition separates variation in global risk factors from idiosyncratic shocks, the GIV should be exogenous to the regressors included in (3.5.10).

premium arising from holding bonds is partly accounted for by using the option-adjusted spread in excess of US Treasury yields that are matched to each individual cash flow. Moreover, I only select bonds in my sample that are liquidly traded in international bond markets for the price to reveal sufficient information about the underlying risk of the security. Second, including the bond's duration as an explanatory variable controls for interest rate risk that arises when changes in interest rates change the value of the underlying coupon cash flows to investors. Third, I control for a firm's fundamental risk by including the EDF measure in the model. The EDF measure also picks up fundamental aggregate risk in the domestic economy as well as a country's growth prospects more generally. Fourth, I include industry and country fixed effects to account for any systematic sectoral and geographic variation. Fifth, the analysis is stripped of confounding effects of exchange rate risks since only USD-denominated bonds trading in international debt markets are selected. Arguably, this alleviates concerns about currency mismatch on international investors' balance sheets.⁵⁷ Finally, I control for global risk and global sentiment through leading indicators which the literature has found to adequately capture the Global Financial Cycle. Any remaining variation in corporate spreads must therefore capture risks that are non-systematic and specific to an individual firm.

Exclusion restriction. On a more subtle level, the validity of the exogeneity condition $E[z_{c,t} \epsilon_{c,t}] = 0$ relies on the question of whether the exclusion restriction $E[u_{j,c,t}[k] \epsilon_{c,t}] = 0$ holds. Is it reasonable to assume that idiosyncratic shocks to credit spreads affect capital flows, $F_{c,t}$ only through changes in aggregate credit risk, $S_{c,t}$ and are hence orthogonal to unobserved aggregate shocks $\epsilon_{c,t}$?⁵⁸ In other words, conditional on being exogenous with respect to both credit spreads and capital flows, does the effect of the GIV truly transmit via credit risk instead of affecting capital flows directly? For example, the GIV as a summary statistic of weighted shocks to large firms could attract or repel capital from abroad because

⁵⁷Due to a lack of granular data on the currency mismatch on corporate balance sheets, exchange rate risk premia arising from investors pricing in the currency mismatch of their investment cannot be captured.

⁵⁸That is, the only reason why the GIV $z_{c,t}$ is correlated with $F_{c,t}$ is through the correlation between $z_{c,t}$ and $S_{c,t}$, i.e. $z_{c,t}$ has no independent effect on $F_{c,t}$.

shocks to these firms may signal greater growth prospects to international investors. The question is whether this effect could materialize in the absence of any impact on observed credit spreads.

I propose two arguments to rule out a direct effect of the GIV onto capital flows. First, even in a scenario in which only a handful of large firms experience shocks, it is unlikely that the average international investor would observe these shocks precisely and make an explicit change to their asset allocation. ETFs and passive funds that only track a corporate spread index (e.g. the CEMBI) make up an ever growing share of the global fund industry. These funds do not make discretionary decisions but rather passively react to movements in the observed aggregated credit spread. Second, if not prices in financial markets were to reveal a change in a borrower's credit risk, then international investors would need to receive this information from a different source. For this to be possible, firm-specific news shocks would need to accumulate as private information to induce investors to change their capital allocation. Provided that financial markets are efficient, this is unlikely to happen. If anything, the rapid information transmissions of such news shocks would occur via financial markets and hence be reflected in observable credit risk measures.

Firm-level heterogeneity. Identification via GIV assumes existence of substantial heterogeneity across the size distribution of firms. If the size distribution is not sufficiently fat-tailed within a given country, the instrument will be invalid. As discussed in Section 3.3, Figure 3.3 suggests that heterogeneity obtains in the *sample* of non-financial firms when firm size is measured by both market capitalization and total assets. To underline that this observation is robust, additional data that spans the *population* of firms in the panel of countries could be used. That is, international bond issuers should be sufficiently "granular" also with respect to large bond issuers in local-currency markets and financial firms. This could be verified with balance sheet data with more comprehensive coverage e.g. from ORBIS.

An additional milder requirement is placed on the heterogeneity in the distribution of idiosyncratic shocks to corporate borrowers. If these shocks do not exhibit sufficient variation within a given country, the instrument will be weak. Considering the large size of my sample and the heterogeneity of industries across

firms and countries, a sufficient level of heterogeneity in shocks is likely warranted. As verified in Figure 3.4, credit spreads are considerably heterogeneous across the size distribution of firms.

Time-varying weights in the GIV. The firm-specific weights $w_{j,c,t}$ used to compute the GIV are at the heart of the identification strategy. While the wrong set of weights does not invalidate the instrument, it does result in biased OLS estimates (Gabaix & Koijen, 2020). However, one threat to identification could stem from the weights being endogenous to the aggregate shock $\epsilon_{c,t}$. One way to mitigate, albeit not remedy, this issue is to lag the weights as in (3.5.8). Moreover, using weights based on different definitions of firm size could further strengthen the results. Thus, one could construct weights based on e.g. relative market capitalization, total book value of assets, or sales shares subject to comprehensive data availability.

The most promising, yet also hard to obtain, weights are index weights used in the construction of the CEMBI index commercialized by JP Morgan. The CEMBI index is a leading corporate bond index which serves as an important benchmark for mutual funds and other global investors. Using CEMBI index weights on bonds has two salient benefits. First, the spread between the country-specific CEMBI and the 10-year US Treasury yield is one of the most universally tracked high-frequency measures of *aggregate* corporate credit risk in EMEs. The weights on individual bonds included in the index therefore come closest to a measure of the relative share of a given issuer's credit risk in aggregate credit risk. Second, using CEMBI index weights would alleviate the concern in the GIV specification that company weights may be endogenous. Since the inclusion of bonds into the index is at the discretion of JP Morgan and since they generally lack transparency about index construction, their index weights are unlikely to correlate with unobserved idiosyncratic firm shocks that the spread model in (3.5.6) does not already account for. On the downside, using CEMBI weights would limit the sample to only a subset of bonds, firms, and hence countries as only bonds of a certain size (\geq USD 500 million) are eligible for inclusion in the index.

Robustness of the credit spread measure. What if the aggregate OAS does not capture the key observable to which investors react? While OAS is a suitable measure to homogenize corporate spreads across various bond characteristics, it is model-based and hence suffers from potential shortcomings in the underlying model. To ensure that the results are free from model-bias, I run the baseline specification with the Z-spread (zero-volatility spread) as the dependent variable. The Z-spread is computed by discounting each dated cashflow on a bond by the US Treasury spot yield curve at each point of maturity. This comes closest to Gilchrist and Zakrajšek (2012)'s spread measure which is purged of "duration mismatch", except that they use the estimated yield curve of Gürkaynak, Sack, and Wright (2007) rather than the spot yield curve. Table 3.E.1 in Appendix 3.E repeats the results of Table 3.3 with the Z-spread as the dependent variable, albeit with fewer observations due to limited data availability.

The baseline results remain robust with respect to the choice of dependent variable. The measure of a firm's likelihood of default, the $EDF_{j,t}$, remains a significant explanatory variable of the credit spread, with the magnitude of the coefficient increasing in size. The effect however disappears when interacting $EDF_{j,t}$ with an indicator for callable bonds, $CALL_j[k]$. Note that the Z-spread does not account for any options embedded in the bond and hence may be a flawed measure of the underlying riskiness of the bond, hence diluting the effect of the $EDF_{j,t}$. This finding strengthens the case for using the OAS as the baseline measure of credit spreads in my analysis. Moreover, since the Z-spread is only scantily available, the sample size drops from 550,394 to 85,973 bond-week observations. It is for these reasons that the Z-spread can be ruled out as a reliable alternative to the OAS.

Spillovers from sovereign risk. Approximately half of all bonds in the sample are issued by government-related firms. Of these bonds, about 80% are issued by firms of which the ultimate owner is the government but which do not enjoy any explicit government guarantees for debt (see Figure 3.C.6 in Appendix 3.A). This observation inevitably attributes greater relevance to the role of state-ownership as a potential confounder. State-ownership may lead to both spillovers from sovereign into corporate debt markets (Broner et al., 2021) and spillovers from corporate into sovereign debt markets (Kwak, 2021). The results of the baseline

spread decomposition in Table 3.3 do not confer a significant role of government-related firms in driving a wedge in borrowing costs. Yet, it may be the case that sovereign risk only latently transmits via time-varying spillovers from sovereign bond markets.

To control for sovereign risk spillovers, I repeat the spread decomposition in (3.5.6) by interacting the indicator variable with a country's JP Morgan Emerging Market Bond Index, $EMBI_{c,t} \times \text{Gov-Related}_j$ (see Table 3.E.2 in Appendix 3.E). Neither do the interaction term and the individual variables $EMBI_{c,t}$ and Gov-Related_j turn out significant, nor do they significantly affect the other estimates. Repeating the same test with the 10-year government yield $\text{Gov10Y}_{c,t}$ as a measure of sovereign risk – albeit with a smaller sample size due to limited data availability – yields similarly robust results.⁵⁹

The insignificance of sovereign risk indicators and government-related firms is somewhat surprising, considering that previous studies have found significant spillovers across the corporate-sovereign nexus. It is worth noting that the corporate spread used in this analysis is the spread over the US risk-free rate, not the spread over the local government yield. As an additional robustness check, one may construct local credit spreads relative to domestic sovereign risk. However, given the requirements on the data to construct maturity-matched option-adjusted spreads from the bottom up, I leave this endeavor to future research.

Even if confounding effects from sovereign risk still persisted in the supposedly idiosyncratic firm shocks $u_{j,c,t}$ after estimating the spread model in (3.5.6), the very step of constructing the GIV in (3.5.8) should strip off common exposure to sovereign risk. Sovereign risk would thus be captured by the common shock $\eta_{c,t}$ and differenced out through the GIV. Even if sovereign risk remained as a latent factor, the inclusion of local government yields in the country-level regression model in (3.5.9) should provide an additional backstop in accounting for that remaining variation. Hopefully this convinces the reader that the empirical strategy controls for the corporate-sovereign nexus at three separate stages, thus capturing plausibly exogenous variation in corporate credit risk.

⁵⁹The disadvantage of using the two proxies for sovereign risk is that both reduce the sample size and thus statistical power.

Robustness w.r.t sub-samples. To further strengthen the results and uncover potential latent channels at play, future checks should consider different sub-samples of bonds, firms, and countries, respectively. The obvious drawback of these sample splits is that they come at the expense of statistical power when the estimation is run on smaller samples that possibly exclude countries with less bond coverage. Notwithstanding, sub-samples could for example be split by (i) bonds issued onshore and offshore, (ii) bonds excluding those that were privately issued, and (iii) bonds issued by oil and gas-related companies to ensure that none of these issuer characteristics are driving the results. Similarly, different subsets of countries could be considered, in particular those with a fixed versus floating exchange rate. Evidence by Jordà et al. (2019) suggests that changes in global risk appetite induced by US monetary policy transmit more strongly to countries with a fixed exchange rate. The significant results for domestic pull factors obtained in this paper could thus be biased by the large presence of countries with a floating exchange rate in the sample. Additional checks could ensure that there are no distinct effects of domestic credit risk on capital flows for countries with a peg. By the same token, future robustness checks could control for the degree of capital account openness in a given country. The extent to which capital, more precisely portfolio flows, can enter and exit a country freely may be decisive in the asymmetric relationship between corporate credit risk and capital flows. The implicit assumption underlying this paper is that countries selected into the sample generally exhibit open capital accounts. To some extent, such effects should already be subsumed under the country fixed effects, unless they are strongly time-varying.

Gross capital flows. The importance of accounting for gross capital flows as opposed to net capital flows has been stressed by the literature in recent years (Avdjiev, Hardy, Kalemli-Özcan, & Servén, 2018; Caballero & Simsek, 2020; Forbes & Warnock, 2012). The portfolio flow measure of EPFR used in the benchmark exercises cannot be obtained on a gross basis. This is because EPFR only observes mutual funds' country allocations and changes in these allocations. These flows do not capture domestic capital retrenchment by domestic investors. To account for the potential dampening impact of repatriating funds domestically, it would be instructive to employ measures of gross capital flows obtained from the IMF's

Balance of Payments Statistics. Importantly, these flows do not only represent portfolio flows but also other items captured in the current account.⁶⁰ The main caveat of using IMF data is that it is compiled only at quarterly frequency. I argue that the high frequency nature of data on corporate credit risk and portfolio flows is crucial for identification, as the granular origins of the causal relationship will likely wash out once aggregated to quarterly frequency. Thus, benefits of the identification approach must be weighed against the costs of missing the effects of capital retrenchment. I leave it to future work to explore if there is sufficient information content in credit risk to explain capital flows at quarterly frequency.

Further limitations. In addition to those already mentioned above, there are several limitations of my analysis. For one, my empirical strategy does not explicitly control for shocks that could induce firms to substitute from bond financing to equity or bank credit, and vice-versa.⁶¹ The scope of my analysis is limited to credit risk emanating from international corporate bond markets only. This is partially addressed by including only non-financial firms in the sample of issuers in order to avoid potential cross-dependencies between banks issuing bonds at the same time as lending to other bond issuers. This also partially decouples the analysis from the financial cycle by shifting the focus to the real economy. Moreover, some of the issuers could be subject to implicit or explicit government guarantees (e.g. by virtue of state ownership). This may lead to spillovers between sovereign and corporate risks. Accounting for government-related entities in the spread decomposition partly controls for such guarantees but does not capture latent, implicit guarantees. In the absence of detailed information on such cross-dependencies, the only possible remedy is to explicitly control for sovereign risk in the IV regression. Future research should explore the role of state-ownership of large corporations and potential spillovers more explicitly.

⁶⁰As discussed by Coppola et al. (2021), it should not matter in theory whether foreign investments are booked as portfolio or FDI flows.

⁶¹Bond financing differs from financing through bank credit in several important ways. One such difference is that the former is preferably used by firms for longer-term investments while the latter is used to cover short-term financing needs (e.g. through revolving lines of credit as a type of loan).

3.8 Conclusion

In conclusion, I show that corporate credit risk, when stripped of any systematic variation in risk that is fundamental to a firm, a country, and the global economy, can explain capital flows above and beyond what sovereign risk and external factors can account for. Using the universe of corporate bonds issued by non-financial firms in 27 EMEs and 11 tax havens, I identify the causal effect of credit risk on capital flows using Granular Instrumental Variables (GIV). I exploit variation in the size distribution of firms as well as idiosyncratic shocks to firms' credit spreads to construct exogenous instruments that pick up, in simple terms, the degree to which large firms differ from the average firm in their idiosyncratic credit risk. In country panel regressions, I show that net capital inflows have granular origins in the credit risk of large borrowers. Impulse responses obtained from instrumented panel local projections indicate that the prolonged build-up of credit risk in the domestic economy can unleash capital outflows, deteriorate the terms of trade, decrease output, and raise unemployment. It will be instructive to discipline a model to better capture the precise mechanism underlying this state-dependent causal relationship. I relegate this to future research. My findings contribute to our understanding of the domestic origins of sudden stops and balance of payments crises in EMEs. They offer a complementary explanation to the vast literature on the Global Financial Cycle (Rey, 2015) as a driver of international capital flows.

Appendices of Chapter 3

Appendix 3.A Data Overview

Table 3.A.1. Classification of countries into emerging market economics (EMEs)

ISO	Country	MSCI EM index	JPM CEMBI index	IMF Fiscal Monitor	This sample
AR	Argentina		X	X	X
AZ	Azerbaijan		X	X	X
BH	Bahrain		X	X	X
BD	Bangladesh		X		X
BL	Belarus			X	X
BR	Brazil	X	X	X	X
BG	Bulgaria		X	X	X
BB	Barbados		X	X	X
CL	Chile	X	X	X	X
CN	China	X	X	X	X
CO	Colombia	X	X	X	X
CR	Costa Rica			X	X
HR	Croatia		X	X	X
CZ	Czech Republic	X	X		X
DO	Dominican Republic			X	X
EC	Ecuador			X	X
EG	Egypt	X	X	X	X
SV	El Salvador		X	X	X
GE	Georgia		X	X	X
GH	Ghana		X		X
GR	Greece	X		X	
GT	Guatemala		X	X	X
HK	Hong Kong		X		X
HU	Hungary	X	X	X	X
IN	India	X	X	X	X
ID	Indonesia	X	X	X	X
IQ	Iraq	X	X	X	X
IL	Israel		X		X
JM	Jamaica		X	X	X
JO	Jordan		X	X	X
KZ	Kazakhstan		X	X	X
KW	Kuwait	X	X	X	X
MO	Macao		X		X
MY	Malaysia	X	X	X	X
MX	Mexico	X	X	X	X
MA	Morocco		X	X	X
NG	Nigeria		X		
OM	Oman		X	X	
PA	Panama		X	X	
PY	Paraguay		X	X	X
PE	Peru	X	X	X	X
PH	Philippines	X	X	X	X
PL	Poland	X	X	X	X
QA	Qatar	X	X	X	X
RO	Romania			X	X
RU	Russian Federation		X	X	X
SA	Saudi Arabia	X	X	X	X
RS	Serbia			X	X
SG	Singapore		X		X
ZA	South Africa	X	X	X	X
KR	South Korea	X	X		X
TW	Taiwan	X	X		X
TH	Thailand	X	X	X	X
TT	Trinidad & Tobago		X	X	
TR	Turkey	X	X	X	X
UA	Ukraine		X	X	X
AE	United Arab Emirates	X	X	X	X
UY	Uruguay			X	X
VE	Venezuela			X	X
ZM	Zambia		X		

Note: The MSCI Emerging Markets Index is a composite indicator of equity market performance in global emerging markets based on market capitalization. Countries in this table reflect the index's 24 constituents as of March 2022. The JP Morgan Corporate Emerging Market Bond Index (CEMBI) is a suite of corporate bond indices for various segments of the corporate bond market. The index composition changes regularly. The above countries reflect those included in the CEMBI High-Yield + Index at any date since inception of the index in 2002. The IMF sample of countries includes 40 jurisdictions that are defined as "Emerging Market and Middle-Income Economies" in the Fiscal Monitor of the International Monetary Fund (2021). The last column refers to the initial set of countries for which bond data is obtained from Bloomberg.

Table 3.A.2. Overview of number and volume of bonds by country

ISO	Country	Earliest Issue Date	No. of bonds		Volume (US\$ bn)	
			Onshore	Offshore	Onshore	Offshore
AR	Argentina	1991-07-11	412	4	76.29	1.68
AZ	Azerbaijan	2012-02-09	7		8.25	
BL	Belarus	2014-03-18	2		0.01	
BR	Brazil	1993-10-06	269	334	88.36	296.90
BG	Bulgaria	2005-11-18	34		3.56	
CL	Chile	1993-12-08	294	23	149.22	13.07
CN	China	1998-04-15	225	750	50.06	442.11
CO	Colombia	1994-12-16	46	27	31.45	14.19
CR	Costa Rica	2003-12-10	19		3.71	
HR	Croatia	2002-04-03	22		7.47	
CZ	Czech Republic	1997-05-28	94	6	30.65	3.13
DO	Dom Rep	1998-01-28	70	8	5.07	1.66
EC	Ecuador	2010-10-22	11		1.32	
EG	Egypt			5		3.05
SV	El Salvador			8		2.82
GE	Georgia	2010-07-22	12		2.97	
HU	Hungary	2005-10-05	11	7	3.95	3.11
ID	India	1995-09-27	133	51	61.08	24.18
IN	Indonesia	1993-11-04	148	17	88.08	13.08
IL	Israel			33		43.22
JM	Jamaica	2006-11-16	9	18	2.02	14.07
KZ	Kazakhstan	2001-07-06	51	16	46.38	10.21
MY	Malaysia	1993-07-01	106	2	73.67	6.00
MX	Mexico	1981-04-13	784	29	587.28	10.40
PY	Paraguay	2011-03-03	57		2.27	
PE	Peru	1998-12-16	181	11	35.43	7.21
PH	Philippines	1993-11-15	57	12	14.63	3.64
PL	Poland	2014-03-27	3	13	0.58	5.67
QA	Qatar	1996-12-15	22	19	17.09	14.75
RO	Romania	2001-04-06	9	5	2.41	2.64
RU	Russian Federation	1998-03-19	9	320	2.38	245.54
SA	Saudi Arabia	2019-04-16	18	23	33.50	24.30
SG	Singapore	1997-06-25	224	16	88.43	9.09
ZA	South Africa	1985-02-28	76	8	32.63	4.42
KR	South Korea	1992-08-06	451	7	92.13	2.40
TW	Taiwan	1999-02-23	9	12	2.38	7.18
TH	Thailand	1993-09-17	68		24.82	
TR	Turkey	2010-11-10	63	6	26.06	1.46
UA	Ukraine	2003-03-19	4	19	2.66	10.82
AE	United Arab Emirates	2006-10-27	95	33	83.39	22.61
UY	Uruguay	2007-04-30	14		0.18	
VE	Venezuela	1992-03-17	38	5	85.11	1.07
VN	Vietnam			2		1.36

Note: This table lists the cumulative number and volume of bonds outstanding for both onshore and offshore firms incorporated in the sample of EMEs, cumulated across the sample period from January 2000 to November 2020. The earliest issue date of bonds refers to those bonds included in the sample, i.e. those with reliable pricing data as of January 2000. Hence, some countries only exhibit bonds as early as 2019. The availability of bond data and bond issuance is very heterogeneous across countries, both in terms of the number of bonds issued and the notional volume. Large economies such as Argentina, Brazil, China, Mexico, and Russia exhibit large cumulative numbers of bonds traded by domestic firms in the sample. Firms in smaller EMEs with less developed capital markets such as Azerbaijan, Belarus, Jamaica, Poland, and Ukraine exhibit fewer bonds.

Appendix 3.B Bond-Firm Matching

To obtain the bond-firm-country panel, I match bonds retrieved from Bloomberg with information on default probabilities of firms from (i) Moody's CreditEdge and (ii) the Credit Research Initiative of the National University of Singapore (NUS-CRI). The NUS-CRI data is obtained for robustness.

A note on the NUS-CRI database The NUS-CRI provides monthly data on PDs and daily data on DTDs for all publicly listed companies across 66 countries, both EMEs and tax havens. The DTD measure of the NUS-CRI is calculated based on the Merton model just as the EDF measure of Moody's CreditEdge is calculated. However, the specific methodologies differ. Anecdotal evidence suggests a correlation of at least 80% among the two measures of expected default. The NUS-CRI database has several benefits over Moody's CreditEdge. It is free of charge, publicly accessible, and updated daily. One disadvantage of the NUS-CRI database is that it is only available with a one-year lag. Hence, the available time series cuts off on 27/12/2019, forgoing one additional year for the estimation. Just as Moody's CreditEdge, NUS-CRI links the companies in the dataset to unique company identifiers in Bloomberg. This aids bond-firm matching, albeit with caveats.⁶²

Bond-firm matching The matching exercise is complicated by a number of issues. First, the Moody's and NUS-CRI databases use slightly different alphanumeric identifiers for firms that make an exact matching with the alphanumeric identifiers retrieved from Bloomberg difficult. When exact matches cannot be found, firms are then matched by regular expressions within the alphanumeric identifiers or by different numeric or character identifiers.

Second, more than a third of all bonds are issued via subsidiaries in tax havens, most of which are privately owned by the parent company and hence do not have a default probability assigned to them. These bonds must be matched with the default data of their parent companies via the company ticker or company name. Company names are often recorded inaccurately or with slightly deviating words. This makes matching across the different databases less accurate and more difficult, as the standard algorithms ("fuzzymatch" in R) do not pick up these relations.

Third, assigning a unique company identifier to a bond in Bloomberg is complicated by the fact that Bloomberg provides different identifiers depending on whether an identifier "field" is queried via the CUSIP of the bond or via the ticker symbol of the bond's issuer.⁶³ In the following, I therefore distinguish between (a) tickers and (b) ISINs, that refer to (i) the subsidiary and (ii) the parent company.

To tackle the above problems, I iteratively match bonds with firms starting

⁶²Bloomberg currently does not support Moody's KMV identifiers to link bonds directly to firms in Moody's database

⁶³For example, the fields in Bloomberg entitled "DEBT_TO_EQUITY_FUNDAMENTALS_TKR" and "ISSUER_EQUITY_TICKER" may yield different ticker symbols depending on how they are queried via the Bloomberg Excel-API.

with the first identifier in the below lists. Any bonds that were not matched exactly through that identifier are then attempted to be matched by the following identifier in the following iteration. I first attempt to match any identifiers at the subsidiary level before moving to the parent level, if possible. The following steps outline the chosen identifiers by which I iteratively match bonds to firms.

Firms in Moody's CreditEdge:

- (i) Unique BB-ID (based on subsidiary-ticker) and subsidiary ISIN
- (ii) Unique BB-ID (based on parent ISIN)
- (iii) Subsidiary ISIN
- (iv) Subsidiary ticker
- (v) Parent ticker
- (vi) Parent ISIN

This matching procedure yields 3,129 bonds matched with 833 firms in 40 countries of incorporation. Some of these matches may arguably be imperfect and further cross-validation is needed.

Firms in the NUS-CRI:

- (i) Unique BB-ID (based on ticker-S) and subsidiary ISIN
- (ii) Unique BB-ID (based on ticker-S)
- (iii) Subsidiary ISIN
- (iv) Substring of unique BB-ID
- (v) Unique BB-ID (based on parent ISIN)
- (vi) Parent ISIN
- (vii) Subsidiary ticker and issuer name

This matching procedure yields 3,184 bonds matched with 863 firms in 36 countries. The bond matches with NUS-CRI firms may be more reliable than the bond matches with Moody's firms but are subject to the same uncertainty surrounding the uniqueness of company identifiers in Bloomberg.

Appendix 3.C Additional Descriptive Statistics

3.C.1 Time-Series Data

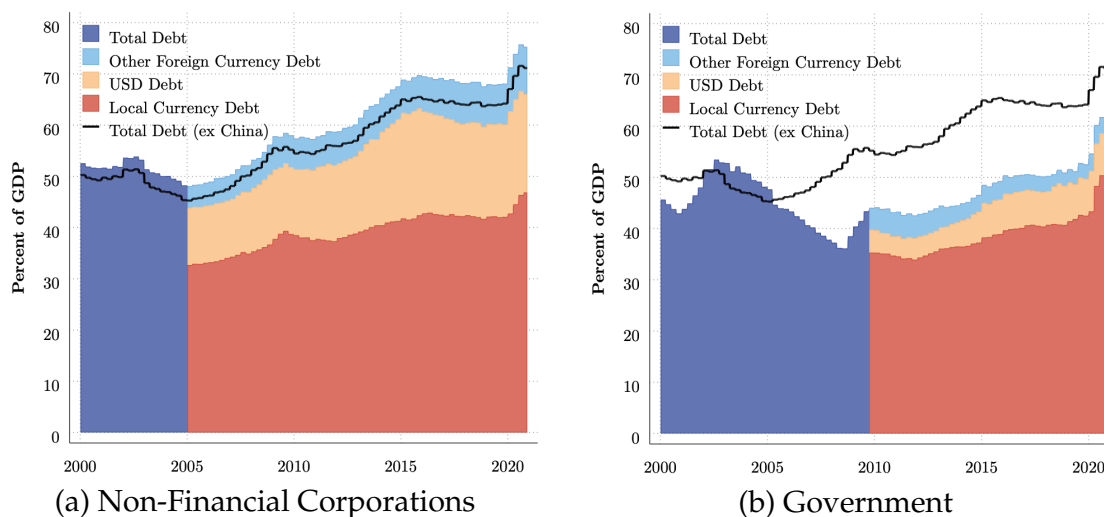


Figure 3.C.1. Decomposition of sectoral debt statistics into local and foreign currency debt

Note: This figure presents a decomposition of the average total stock of debt issued by non-financial corporations (NFCs, panel (a)) and the government (panel (b)) as a percentage of a country's GDP into its currency components. The aggregate debt levels are computed as a simple average across a sample of 22 EMEs. The black line presents the mean total debt level excluding China from this sample. The data is based on the quarterly global debt monitor of the Institute of International Finance (IIF). Details on the currency composition are available from Q1-2005 (NFC) and Q4-2009 (Government).

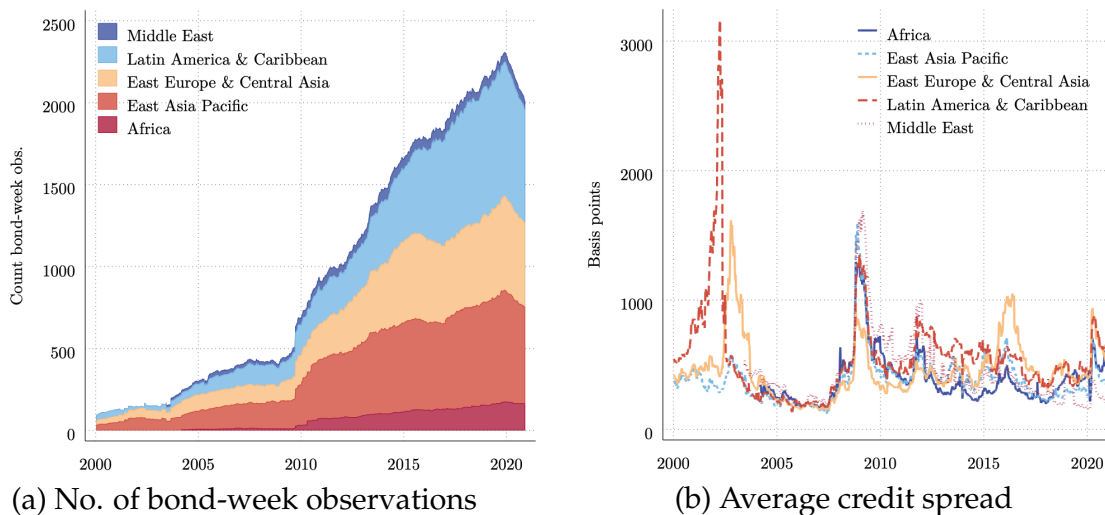


Figure 3.C.2. Regional differences in credit spreads and data coverage

Note: The graph in the left panel displays the count of bond-week observations of option-adjusted spreads (OAS) available for each region over the sample period. The the graph in right panel shows the simple arithmetic average of OAS for each region over the sample period. Both panels are based on the trimmed, unbalanced cross-country panel of bonds spanning 30 EMEs.

Table 3.C.1. Credit spreads along the firm-size distribution

	Obs.	Mean	Median	SD	5th Pct.	95th Pct.
0-20th pctile	35,962	853.62	423.39	1,486.14	75.04	3,451.95
21-40th pctile	36,853	685.17	402.50	1,043.74	101.66	2,260.01
41-60th pctile	36,596	516.96	274.87	1,000.26	88.49	1,741.57
61-80th pctile	37,164	391.62	245.41	1,006.19	83.62	780.86
81-100th pctile	37,205	276.45	205.19	398.47	95.20	634.12
Missing	192,264	522.58	298.44	964.02	96.47	1,512.48
Total	376,044	532.33	291.78	1,013.37	90.86	1,605.95

Note: This table presents statistics of option-adjusted spreads (OAS) computed at different percentiles of the firm-size distribution. Credit spreads at the firm level are first computed as a simple average of spreads across all bonds $K_{j,t}$ of a given firm j at time t . The number of observations in the table refers to firm-week observations. Firm size is measured by total assets. Due to limited data availability on total assets, the bottom row also reports statistics for the sample of firms with missing information on total assets.

3.C.2 Cross-Sectional Data

This section presents a descriptive overview of the cross-section of 6,006 bonds in the untrimmed, unmatched sample of bonds selected as described in Section 3.3. Figures 3.C.3 to 3.C.6 split the composition of the sample according to various bond characteristics. They also offer a split between bonds issued by onshore firms in 43 EMEs and by offshore subsidiaries in 11 tax havens.

Unsurprisingly, BRICs countries such as Mexico, China, Brazil, and Russia experience the largest cumulative volume of bonds outstanding across the sample period (Figure 3.C.3). Offshore issuance of bonds takes up the lion's share of issuances by volume for the case of China, Brazil, and Russia. This is in line with evidence by Coppola, Maggiori, Neiman, and Schreger (2020) who find similar shares of debt issued offshore by these countries.⁶⁴ They highlight the risk and policy implications arising when portfolio flows into these offshore markets are masked as FDI flows. As becomes clear from Figure 3.C.3, ignoring offshore bonds would omit a significant share of portfolio flows into EM corporate balance sheets that could bias the analysis.

Figure 3.C.4 shows that roughly half of the cumulative volume of bonds is company guaranteed debt. About 40 % of bonds are senior unsecured debt. A larger fraction of senior unsecured debt is issued offshore than onshore. This once again points towards the riskiness of offshore issuance.

About two thirds of bonds in the sample are standard bonds that are held until maturity (Figure 3.C.4). The remaining third represents bonds with underlying option features.⁶⁵ This embedded optionality is accounted for in the option-adjusted spread (OAS) measure that I use in the estimation. Hence, the OAS allows for comparison between bonds with different cash flow characteristics and contingencies.

The bulk of bonds issued by non-financial firms in the sample have a maturity of 3, 5, 7, or 10 years (Figure 3.C.5). Only a handful of bonds have a 30 year tenure. The medium- to long-term nature of bond credit has implications for the severity of currency mismatch on firms' balance sheet. Currency mismatch and maturity mismatch may act to amplify each other if left unhedged. The sample also includes a number of perpetuities, which however will be excluded from the estimation because they exhibit different properties from standard bonds.

⁶⁴Note that their comprehensive sample of debt securities also covers bonds issued by financial firms.

⁶⁵A callable bond gives the issuer the right to redeem the bond before maturity, e.g. so as to benefit from favorable interest rate drops. A sinkable bond requires the issuer to adhere to a specified schedule when redeeming the bond early. Money is set aside in a sinking fund to avoid a large lump-sum payment at maturity.

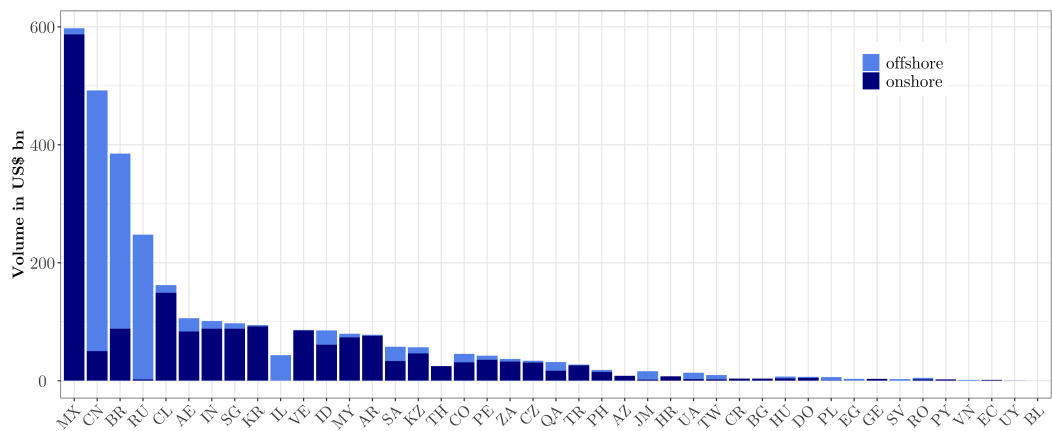


Figure 3.C.3. Volume of bonds outstanding split by country and onshore-offshore issuance

Note: This figure displays the cumulative notional volume of corporate bonds outstanding over the sample period 01/2000-11/2020, split by country and onshore-offshore issuance. Note that the volume at each point in time represents the cumulative face value of bonds but does not take into account early redemption or default. The bars are sorted according to the maximum notional volume from highest to lowest.

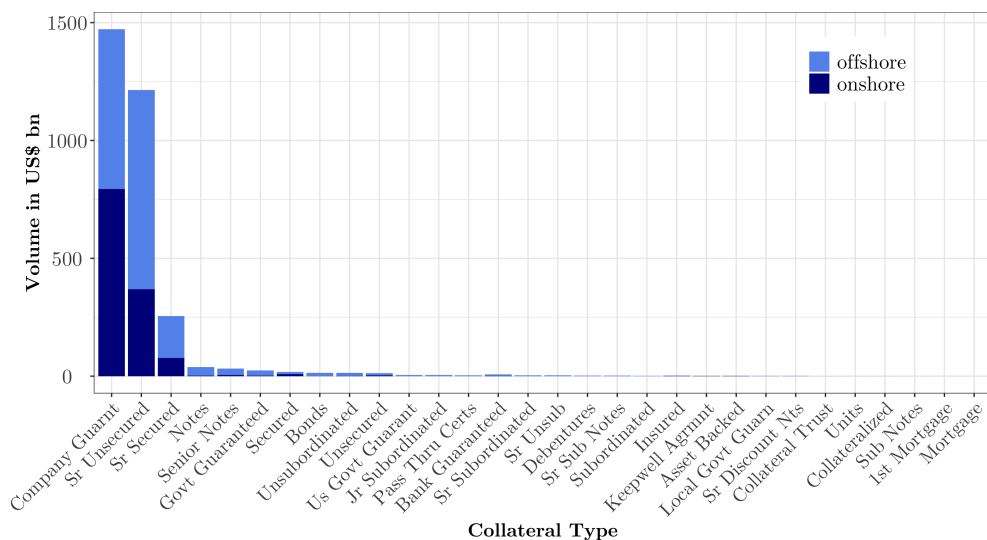


Figure 3.C.4. Volume of bonds of different collateral types split by onshore-offshore issuance

Note: This figure displays the cumulative notional volume of corporate bonds outstanding over the sample period 01/2000-11/2020, split by collateral type of bonds and onshore-offshore issuance. Note that the volume at each point in time represents the cumulative face value of bonds but does not take into account early redemption or default. The bars are sorted according to the maximum notional volume from highest to lowest.

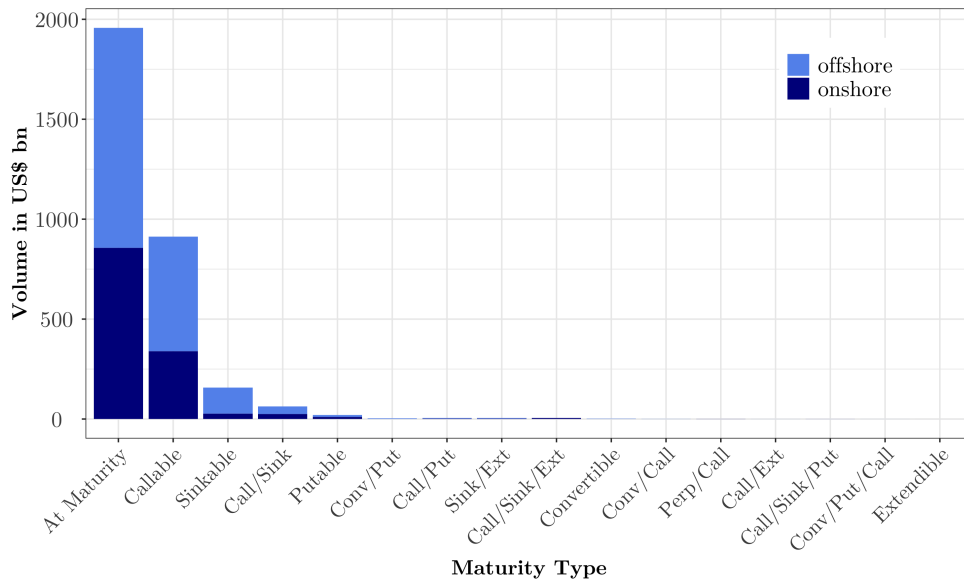


Figure 3.C.4. Volume of bonds of different maturity types split by onshore-offshore issuance.

Note: This figure displays the cumulative notional volume of corporate bonds outstanding over the sample period 01/2000-11/2020, split by maturity types of bonds and onshore-offshore issuance. Note that the volume at each point in time represents the cumulative face value of bonds but does not take into account early redemption or default. The bars are sorted according to the maximum notional volume from highest to lowest.

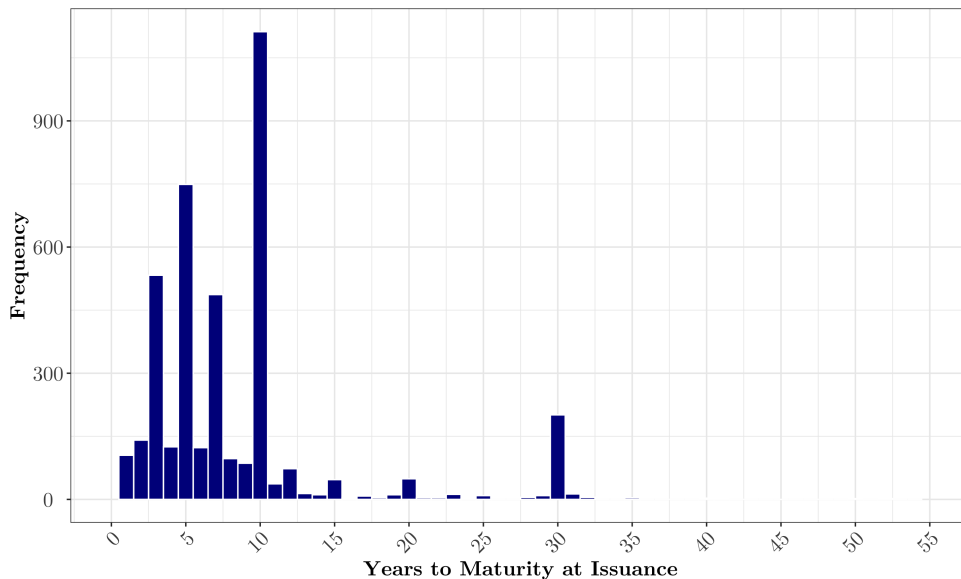


Figure 3.C.5. Maturities of corporate bonds

Note: This figure displays the number of corporate bonds in the sample according to the maturity length of the bond at issuance. The counts are based on the full, pre-trimmed sample.

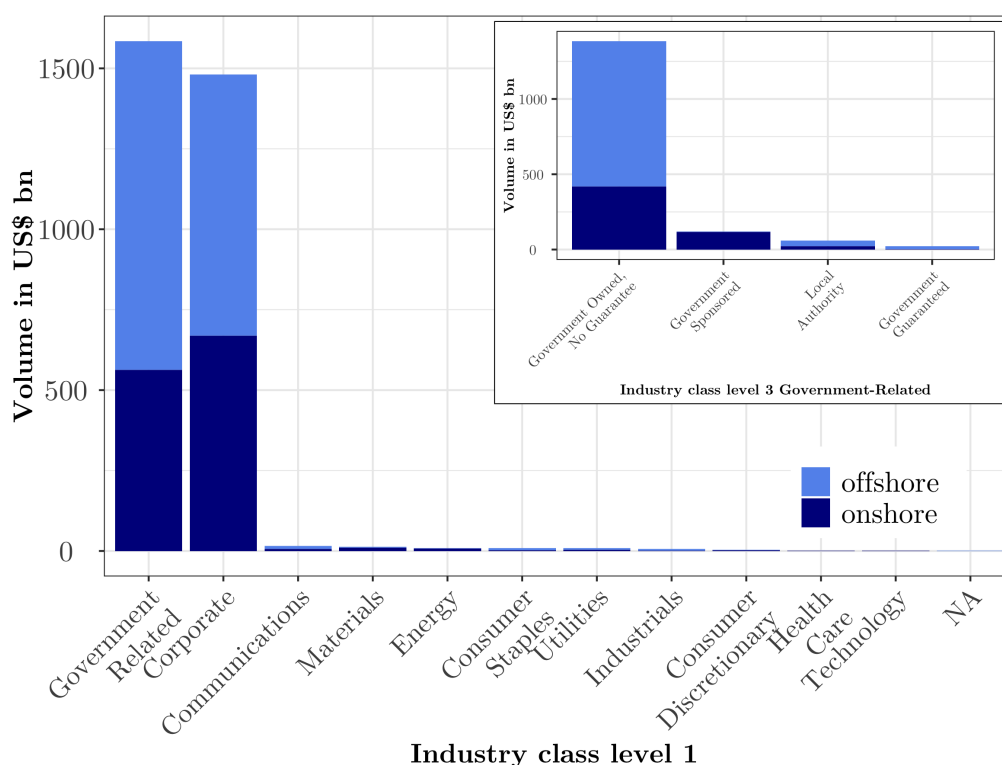


Figure 3.C.6. Volume of bonds of different industry classes split by onshore-offshore issuance.

Note: This figure displays the cumulative notional volume of corporate bonds outstanding over the sample period 01/2000-11/2020, split by industry class of the issuer and onshore-offshore issuance. Note that the volume at each point in time represents the cumulative face value of bonds but does not take into account early redemption or default. The bars are sorted according to the maximum notional volume from highest to lowest. The inset graph further breaks down government-related bonds into four sub-industry classes.

Figure 3.C.6 presents the breakdown of outstanding bond volume by Bloomberg’s industry classification.⁶⁶ Approximately half of all bonds in the sample are issued by government-related firms. Of these bonds, about 80% are issued by firms where the ultimate owner is the government but without any explicit government guarantees for debt. Interestingly, Figure 3.C.6 also shows that government-related firms predominantly issue bonds offshore rather than onshore. This poses the question whether government relations as defined by the Bloomberg classification system truly map into ultimate ownership and implicit or explicit corporate control by the government – or whether these firms act in a stand-alone manner. Further research is warranted.

⁶⁶The BCLASS classification system is the one most commonly used by users of Bloomberg commercial products. Alternative classification labels that are more prevalent in the academic literature include NAICs industry codes. These are available for firms in the Moody’s database but not in the NUS-CRI database.

Appendix 3.D Additional Results: Excess Bond Premium

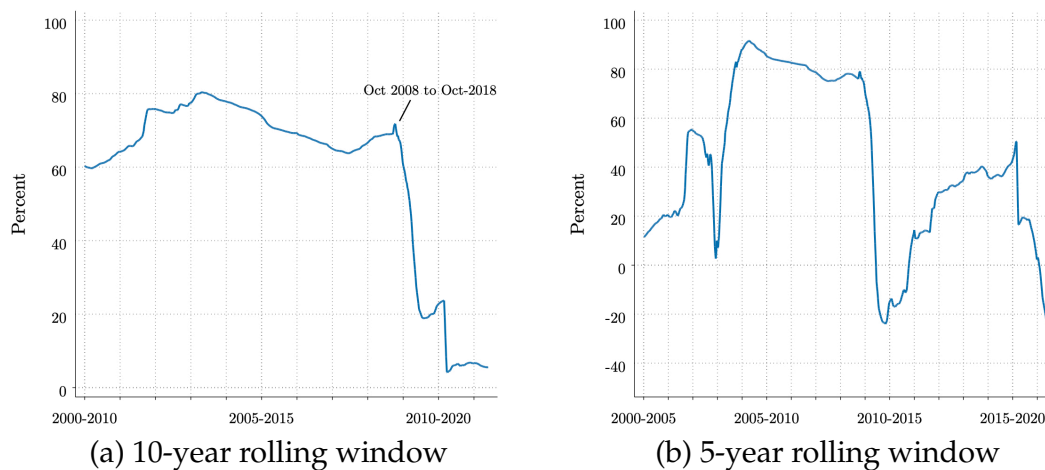


Figure 3.D.1. Time-varying correlation between the EME-EBP and the US-EBP of Gilchrist and Zakrajšek (2012).

Note: This figure presents the 10-year and 5-year backward rolling window correlations, respectively, between the Excess Bond Premium of Emerging Market Economies (EME-EBP) and the US-EBP of Gilchrist and Zakrajšek (2012) estimated for the United States at a monthly frequency. The x-axes indicate the 10-year and 5-year time windows, respectively, over which the correlation is computed. The US-EBP series is publicly available via the Federal Reserve (see Favara, Gilchrist, Lewis, and Zakrajšek (2016)).

Appendix 3.E Additional Results: Regressions

Table 3.E.1. Z-spread decomposition: extracting idiosyncratic shocks to credit spreads

	(1)		(2)	
	Est.	SE	Est.	SE
$EDF_{j,t}$	107.398***	20.083	59.212	37.585
$Duration_{j,t}[k]$	-13.506***	4.329	-5.771	4.359
$Coupon_j[k]$	73.639***	15.922	77.865***	16.004
$Age_{j,t}[k]$	-0.144	0.099	-0.274***	0.090
$Volume_j[k]$	-42.210	34.882	15.080	24.596
$CALL_j[k]$	225.505***	35.798	266.894*	140.742
VIX_t	4.151***	1.300	2.538**	1.053
$UST10Y_t$	-111.915***	21.981	-73.355***	19.891
$Gov-Related_j$	-242.197*	121.156	-198.262	131.516
$EDF_{j,t} \times CALL_j[k]$			55.322*	31.866
$Duration_{j,t}[k] \times CALL_j[k]$			-24.416**	10.461
$Coupon_j[k] \times CALL_j[k]$			-3.197	21.994
$Age_{j,t}[k] \times CALL_j[k]$			0.831**	0.363
$Volume_j[k] \times CALL_j[k]$			-176.186***	36.608
$VIX_t \times CALL_j[k]$			5.656*	2.862
$UST10Y_t \times CALL_j[k]$			-100.104*	49.772
Country & Industry FE	YES		YES	
Observations	85,973		85,973	
Adjusted R ²	0.400		0.419	

Note: This table reports the results of a version of the corporate spread decomposition in equation (3.5.6) where the dependent variable is the Z-spread. The sample period covers 2000/01/07 – 2020/11/27. Standard errors are clustered in the country, industry, firm, and time dimension following Cameron, Gelbach, and Miller (2011). Daily expected default frequencies (EDFs) at the 1-year horizon are converted into weekly averages. The indicator variable $CALL_j[k]$ is one for bonds with any type of underlying call option. The VIX_t is the CBOE volatility index. The $USD10Y_t$ is the 10-year US Treasury yield. Industry fixed effects are based on the BICS industry level 1 classification system. The country subscript c is suppressed to preserve space.

Table 3.E.2. Spread decomposition with sovereign risk indicators interacted with government-related firms

	(1)		(2)		(3)		(4)	
	Est.	SE	Est.	SE	Est.	SE	Est.	SE
EDF _{<i>j,t</i>}	78.094***	10.390	78.039***	10.391	74.216***	4.551	74.264***	4.475
Duration _{<i>j,t</i>} [<i>k</i>]	-4.206	3.285	-4.115	3.228	1.802	2.356	1.564	2.214
Coupon _{<i>j</i>} [<i>k</i>]	60.221***	19.437	59.973***	19.305	45.336***	6.848	45.393***	6.878
Age _{<i>j,t</i>} [<i>k</i>]	-0.169*	0.087	-0.171*	0.087	-0.150***	0.038	-0.154***	0.040
Volume _{<i>j</i>} [<i>k</i>]	-26.455	18.989	-29.972*	16.135	-60.716***	12.043	-60.979***	12.353
CALL _{<i>j</i>} [<i>k</i>]	132.253***	33.655	131.794***	33.250	76.846**	28.152	76.417**	28.317
VIX _{<i>t</i>}	6.862***	1.228	6.872***	1.237	5.039***	0.660	5.041***	0.660
UST10Y _{<i>t</i>}	-117.904***	17.892	-118.105***	17.814	-81.903***	19.636	-82.076***	19.678
Gov-Related _{<i>j</i>}	-110.247	94.057	-138.147	105.949	-94.213	97.537	-62.901	119.653
EMBI _{<i>c,t</i>}	-0.211	0.200	-0.224	0.209				
EMBI _{<i>c,t</i>} x Gov-Related _{<i>j</i>}			0.052	0.080				
Gov10Y _{<i>c,t</i>}					23.657*	11.350	24.455*	12.407
Gov10Y _{<i>c,t</i>} x Gov-Related _{<i>j</i>}							-5.830	10.547
Country & Industry FE	YES		YES		YES		YES	
Observations	445,546		445,546		269,375		269,375	
Adjusted R ²	0.375		0.375		0.432		0.432	

Note: This table reports the results of an augmented version of the corporate spread decomposition in equation (3.5.6). The baseline model is augmented by the country-level JP Morgan Emerging Market Bond Index EMBI_{*c,t*} (columns 1-2) and the country-level 10-year government yield Gov10Y_{*c,t*} (columns 3-4). These two indicators of sovereign risk are also interacted with an indicator variable, Gov-Related_{*j*}, that takes a value of one for government-related firms following the BICS industry classification system. The sample period covers 2000/01/07 – 2020/11/27. The dependent variable is the option-adjusted spread (OAS). Standard errors are clustered in the country, industry, firm, and time dimension following Cameron, Gelbach, and Miller (2011). Daily expected default frequencies (EDFs) at the 1-year horizon are converted into weekly averages. The indicator variable CALL_{*j*}[*k*] is one for bonds with any type of underlying call option. The VIX_{*t*} is the CBOE volatility index. The USD10Y_{*t*} is the 10-year US Treasury yield. Industry fixed effects are based on the BICS industry level 1 classification system. The country subscript *c* is suppressed for most variables to preserve space.

Conclusion

A decade of near zero interest rates in Advanced Economies (AEs) and capital influx in Emerging Market Economies (EMEs) has brought the importance of financial stability to the forefront of attention of both monetary policy makers and regulators. This thesis explores two important questions that have shaped the research agenda in the field of international macroeconomics and finance since the Global Financial Crisis (GFC). The first of these questions relates to whether central banks ought to take financial stability into account when determining their monetary policy stance. The debate about this fundamental institutional design is divisive. At the heart of it lies the question of whether monetary policy ought to internalize the negative externalities that it poses to the financial system – or whether it is the separate task of regulators to address financial imbalances through appropriate macroprudential instruments and controls on capital flows.

The research in this thesis presents several implications for policy-relevant research. Chapters 1 and 2 establish that there are benefits to incorporating financial stability objectives into monetary policy in both AEs and EMEs. The benefits stem from taking into account the effect of monetary policy onto the level of private default and its consequence for bank profitability in the economy. This is particularly relevant in the Euro Area where legacy debt and subdued bank profitability continue posing challenges to debt sustainability and financial stability (Goodhart et al., 2021) amidst the urgency to raise policy rates. The findings of Chapter 1 suggest that central bankers may achieve lower volatility in consumption, and thus in welfare, by internalizing how their monetary policy decision may exacerbate fire sale externalities in collateralized markets. This is equally relevant in EMEs, where fickle capital flows lead to over-borrowing in good times and sudden deleveraging in bad times. The results of Chapter 2 argue that central bankers may benefit from

taking into account how their interest rate decisions affect aggregate default and thus transmit to credit spreads via the financial sector.

In light of the importance of default as a channel of propagation, the second question of this thesis relates to whether default risk in the productive sector of the economy can pose empirically underexplored risks to financial stability. Such vulnerabilities may manifest in the form of short-term capital flow volatility in response to changes in domestic credit risk in EMEs. Chapter 3 provides causal evidence that one of these domestic sources of risk – corporate default risk – can explain international capital flowing into and out of EMEs. Importantly, credit risk emanating from the corporate sector drives capital flows even after accounting for global risk and US monetary policy, so-called global “push factors”. It is a source of instability to the macroeconomy beyond these push factors, which have been found by the literature to be powerful drivers of capital flows (Bruno & Shin, 2015a; Ghosh et al., 2014; Jordà et al., 2019; Miranda-Agrippino & Rey, 2020).

Chapter 3 likewise yields a number of implications for academic and policy research. My findings add a novel angle to what has become the predominant view of the global architecture of capital flows. This view suggests that the Global Financial Cycle (Rey, 2015) provides the main impetus to the magnitude and timing of international financial flows. I argue that corporate credit risk as a domestic “pull factor” of capital flows, while not necessarily dominating over global push factors, should nonetheless be monitored cautiously. Rising credit risk and leverage in the domestic corporate sector call on monetary and regulatory policy makers to preemptively act against the build-up of financial imbalances. They may do so by “leaning against the wind” (as proposed in Chapter 2) or employing preemptive capital flow management measures such as targeted taxes and macroprudential policies.⁶⁷

The first question of this thesis exposes a fundamental relationship. To paraphrase Goodhart and Tsomocos (2011), default – the possibility that not all debts are fully repaid – gives meaning to the study of financial stability. Liquidity gives meaning to the study of monetary policy. But without default there is no role for money. In a frictionless world, monetary policy cannot affect allocations. Money

⁶⁷The preemptive nature of such measures was proposed by the International Monetary Fund (2022) in its recent review of its institutional view.

remains neutral. The conduct of monetary policy can therefore not be separated from default, and hence from the study of financial stability. The empirical counterpart to this theoretical relationship is found in the second question addressed in this thesis. It shows in the data that default indeed affects the flow of credit. The risk that debt may not be repaid corrupts financial stability in vulnerable economies. One way to rein in this vulnerability is to let default matter for the conduct of monetary policy.

A number of interesting questions and research avenues could not be addressed within the scope of this thesis. Chapter 1 highlights the trade-offs faced by the central bank conditional on the decision to exit the low interest rate environment. Yet, it does not analyze the circumstances under which the lift-off ought to be decided upon. That is to say the decision to depart from the ZLB is exogenous to the model. While the model laid out in Chapter 1 provides a vital theoretical framework to analyze different channels at play in general equilibrium, it does not offer the quantitative rigor and flexibility to give precise policy advice. Future research should address this shortcoming by working out a set of criteria that determine the right timing and pace of an exit from low interest rates. This could be evaluated in a quantitative, dynamic model, calibrated to real world moments in the data. Disciplining a quantitative model on data using, e.g., Bayesian estimation techniques and accounting for the relevant trade-offs is a non-trivial task.⁶⁸ Greater policy relevance comes at the cost of greater model complexity. I leave it to future research to optimize on *this* trade-off.

Chapter 2 equally provides a framework along the lines of which the various transmission channels of financial shocks to EMEs can be traced. Notwithstanding the focus on providing intuition of these channels, it would be desirable to estimate the model on Mexican, or even better, cross-country data. This would enable to give quantitative advice on the magnitudes of non-performing loans (NPLs) and credit contraction to be expected when external shocks hit. Along similar lines, it would be desirable to explore the precise coefficients on the leaning against the wind (LAW) term in the interest rate rule using structural estimation methods.

⁶⁸See for example Andreev et al. (2020) and Martínez et al. (2020) for a model featuring both default and agent heterogeneity.

The study of financial vulnerabilities in EMEs also opens the door to feedback effects from the rest of the world to the small open economy. Another interesting question relates to how default risk in the corporate sector could spill over to foreign investors' balance sheet and affect their willingness to lend to the domestic private sector. To date, my model does not feature amplification from default risk to capital flight. Capital outflows are subject to an exogenous shock but do not move endogenously. However, the causal evidence in Chapter 3 suggests that credit risk in the non-financial private sector may indeed accelerate capital flow volatility. This feature could be accounted for by modelling the portfolio choice problem of both firms and foreign investors who choose between local and foreign currency debt and investment, respectively.⁶⁹ This could yield rich implications for the macroprudential role of monetary policy and regulatory instruments.

Extending the model in Chapter 2 with a more nuanced feedback channel of currency choice of debt could also further complement the analysis in Chapter 3. The identification strategy in Chapter 3 builds in reduced form on the assumption that credit risk has an asymmetric effect on capital inflows versus outflows. It implicitly assumes that there is a "pivoting point" of default risk in the corporate sector beyond which foreign investors reverse their risk assessment. That is, rising currency mismatch and leverage may initially attract investment, but may trigger sell-offs of securities beyond a threshold. It would be insightful to complement the reduced form analysis through a theoretical mechanism. Modelling demand and supply forces separately would enable to cleanly recover the elasticities in the asymmetric cases based on structural parameters. The empirical flipside to this undertaking, however, is that more granular data is needed to distinguish between demand and supply of corporate debt. To date, my analysis remains silent on the question whether the surge in corporate bond volume in EMEs results from a rise in demand for funding by firms or an increase in supply of funding by investors. Complementing the trading data from Bloomberg with primary issuance data on corporate bonds from Dealogic could help to tackle this problem.

Chapter 3 moreover builds on a breadth of data both in the cross-section and time series of bonds and firms that should not be left unexploited. It would be in-

⁶⁹For example, Gabaix and Maggiori (2015) build a model which features such a portfolio choice problem. They however focus on liquidity risk instead of default risk.

interesting to further explore whether capital flows to international tax havens that are masked by multinational corporations pose any particular risks to financial stability. Does the obscurity with which these transactions take place reveal anything about the risks associated with offshore debt issuance posed to policy makers and investors? Do investors price in these risks? A first tentative glance at this question in Chapter 3 indicates that they do not differentially price these securities. Yet, this picture could change with more detailed firm-level data on company interlinkages.

Equally interesting is the question whether spillovers exist between corporate and sovereign bond markets via government-related corporations. The analysis in Chapter 3 controls for spillovers from sovereign into corporate bond markets. Yet, there may exist feedback effects in the reverse direction. The data on corporate bonds could be complemented with data on sovereign and municipal bonds to test for this relationship.

Chapter 3 provides an insightful but limited glimpse into the risks associated with USD-denominated debt. However, it abstracts from substitution effects between different debt markets, especially local currency debt markets. Complementing the data with information on local currency bonds as well as syndicated loans could provide intriguing new insights. Such cross-country data endeavors are rare in the literature and oftentimes limited to one specific market. Expanding my dataset to greater data coverage and sources could therefore pave the way to a fruitful future research agenda in the empirical field of international macro-finance.

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