

Essays on the Credit Cycle

by

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Abstract

Essays on the Credit Cycle

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The global experience of the last three decades illustrated the influence that credit markets impart on economic outcomes, culminating in the shift of the macroeconomic consensus to a new perspective where credit markets are seen as one of the key drivers of business cycle dynamics. Theoretical frameworks that incorporate this insight lie at the heart of this new perspective. These studies revealed that borrower balance sheets are key to narratives that link the business and the credit cycle. This core intuition spawned the vast financial-accelerator literature that analyzes the interaction of the business and credit cycles through the use of general equilibrium models.

This thesis aims to contribute to this literature, and consists of three essays that investigate different aspects of the credit cycle. Each essay presents a macroeconomic framework where credit markets and borrower balance sheets form the core shock transmission channel, advancing the research agenda through the novel nature of these frameworks and the manner in which they are applied.

The first essay presents a closed economy real business cycle model with financial frictions and two credit markets to investigate the qualitative and quantitative relevance of credit market heterogeneity. The model is estimated on U.S. data using Bayesian methods and is able to replicate observed changes in the composition of U.S. balance sheets. The findings indicate that credit market heterogeneity attenuates the impact of a financial shock by presenting borrowers with an alternative to the shock affected credit market. Balance sheet linkages within the financial sector reduce this shock

attenuation property and the origin of financial shocks can influence both the size and persistence of their impact. When financial shocks are borne directly by savers, their impact is relatively muted as they do not impair the efficiency of the financial sector. On the other hand, shocks borne directly by financial intermediaries have a large impact as they disrupt efficient intermediation between savers and borrowers.

In the second essay, an asymmetric two-country model is used to assess the impact of flow specific capital controls in an emerging market context. The inflow capital control is manifest as a restriction on borrower balance sheets that limits their exposure to foreign borrowing. The outflow capital control is manifest as a balance sheet restriction on the financial sector that limits their exposure to foreign assets. This analysis shows that both flow specific capital controls are effective in managing capital flows, and that their deployment could have reduced the build up in emerging market foreign debt following the financial crisis. Comparing across flow specific capital controls, the outflow capital control is preferred by society as it exhibits shock attenuation properties as opposed to the shock amplification properties associated with the inflow capital control. The shock attenuation benefits of the outflow capital control become enhanced as capital control regulation becomes easier, whilst stricter regulation serves to diminish this property of the outflow capital control. In contrast, the shock amplification property of the inflow capital control is diminished under stricter regulation, and enhanced under easier regulation.

The final essay concerns an analysis into the use of macroprudential instruments as a means to mitigate the negative consequences of positive foreign interest rate shocks. A small open economy real business cycle model with banking and foreign borrowing is presented, where loan-to-value regulation, minimum capital requirements, and reserve requirements co-exist. The findings indicate that these macroprudential instruments can attenuate the impact of foreign interest rate shocks, and that this attenuation is increasing in the strictness of the regulatory regime. In spite of exhibiting diminishing returns to scale, LTV regulation and capital requirements deliver significant attenuation benefits and are shown to be close substitutes. Reserve requirements are shown to interact with capital requirements such that their attenuation benefits are short-lived, indicating that this instrument is most effective when used to supplement existing capital requirement or LTV measures. Finally, because financial and macroeconomic objectives become aligned under positive foreign interest rate shocks, a macroprudential response to these shocks can be to the benefit of both objectives.

Uittreksel

Opstelle oor die Kredietsiklus

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Die wêreldwye ervaring van die afgelope drie dekades het die invloed van kredietmarkte op ekonomiese uitkomst geïllustreer en tot die verskuiwing van die makro-ekonomiese consensus gelei. Hierdie nuwe perspektief beskou kredietmarkte as belangrik vir sakesiklusdinamika en toon aan dat lener balansstate die kern vorm van verbintnisse tussen die besigheidsiklus en die kredietsiklus. Hierdie intuïsie het die groot finansiële-versneller literatuur ontplooi wat die interaksie van die besigheids- en kredietsiklusse ontleed deur die gebruik van ewewigsmodelle. Hierdie proefskrif poog om by te dra tot hierdie literatuur en bestaan uit drie opstelle wat verskillende aspekte van die kredietsiklus ondersoek. Elke opstel bied ’n makro-ekonomiese raamwerk aan waar kredietmarkte en lenerbalansstate die skoktransmissiekanale vorm. Die navorsingsagenda word bevorder deur die nuwe aard van hierdie raamwerke en die wyse waarop dit toegepas word.

Die eerste opstel bied ’n reële sakesiklusmodel aan met finansiële wrywings en twee kredietmarkte om die kwalitatiewe en kwantitatiewe relevansie van kredietmark heterogeniteit te ondersoek. Die model word toegepas deur Bayesiaanse metodes op Amerikaanse data en is in staat om veranderinge in die samestelling van Amerikaanse balansstate te herhaal. Die bevindinge dui aan dat kredietmark heterogeniteit die impak van ’n finansiële skok verminder deur leners met ’n alternatief tot die geskokte kredietmark aan te bied. Balansstaatverbindings binne die finansiële sektor verminder hierdie skokdemp eiendom en die oorsprong van finansiële

skokke kan beide die grootte en tydperk van hul impak beïnvloed. Wanneer finansiële skokke direk deur spaarders gedra word, is hul impak relatief gedemp omdat dit nie die doeltreffendheid van die finansiële sektor benadeel nie. Aan die ander kant, skokke wat direk deur finansiële tussengangers gedra word, het 'n groot impak, aangesien dit die doeltreffendheid van bemiddeling tussen spaarders en leners ontwig.

In die tweede opstel word 'n asimmetriese tweelandmodel gebruik om die impak van vloeispesifieke kapitaalkontroles in 'n opkomende markkonteks te bepaal. Die invloed van kapitaalkontrole se voorkoms is as 'n beperking op lener balansstate en beperk hul blootstelling aan buitelandse lenings. Die uitvloeï kapitaalkontrole se voorkoms is as 'n balansstaat beperking op die finansiële sektor en beperk blootstelling aan buitelandse bates. Hierdie analise toon dat beide vloeispesifieke kapitaalkontrole effektief is in die bestuur van kapitaalvloei, en dat hul ontplooiing die opbou van buitelandse skuld in opkomende markte na die finansiële krisis kon verminder het. Die uitvloeï kapitaalkontrole word deur die samelewing verkies, aangesien dit skokdempende-eienskappe vertoon wat in teenstelling staan met die skokversterkings-eienskappe van die invloed van kapitaalkontrole. Die skokdempings-voordele van die uitvloeï kapitaalkontrole word verbeter namate kapitaalkontrole regulering makliker word, terwyl strengere regulering hierdie eiendom van die uitvloeï kapitaalkontrole verminder. In teenstelling hiermee word die skokversterkings-eiendom van die invloed van kapitaalkontrole verminder onder strengere regulering, en verbeter onder makliker regulering.

Die finale opstel het betrekking op die gebruik van macroprudential instrumente as 'n middel om die negatiewe gevolge van positiewe buitelandse rentekoersskokke te versag. 'N Klein oop ekonomie-reële sakesiklusmodel met bank- en buitelandse lenings word aangebied, waar lening-tot-waarde-regulering, minimumkapitaalvereistes en reserwe-vereistes bestaan. Die bevindings dui aan dat hierdie macroprudential instrumente die impak van buitelandse rentekoersskokke kan demp, en dat hierdie skokvermindering met die strengheid van die regulasie toeneem. Ten spyte van afnemende opbrengs op skaal, bied LTV-regulering en kapitaalvereistes sterk verswakingsvoordele en blyk dit asof beide instrumente nuwe plaasvervangers is. Reserwevereistes word beïnvloed deur kapitaalvereistes, sodat hul vermindering voordele kleiner is. Dit dui aan dat doeltreffende gebruik van hierdie instrumente beperk moet word tot die aanvulling van bestaande kapitaalvereistes of LTV-maatreëls. Laastens, aangesien finansiële en makro-ekonomiese doelwitte gebonde word met positiewe buitelandse rentekoersskokke, kan 'n makro-ekonomiese reaksie op hierdie skokke tot voordeel van beide doelwitte wees.

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Dedications

This thesis is dedicated to my parents.

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Chapter 1

Introduction

Since the 1980s, mainstream macroeconomics has become increasingly concerned with embedding the relevance of credit markets and financial intermediation into business cycle theory (Schularick and Taylor, 2012). This credit perspective is motivated with reference to empirical evidence on the simultaneity of business and credit cycles and reflects a paradigm shift in the macroeconomic school of thought (Eckstein and Sinai, 1986). Previously, the Modigliani and Miller (1958) inspired macroeconomic consensus implied that explicit modelling of the credit intermediation process would offer limited benefits. This consensus was based on Modigliani and Miller's theory of capital structure irrelevance which opines that real economic decisions are independent of financing choices, and so, the financial sector can be treated as a veil. In contrast, the credit perspective asserts that if debt capacity is a function of borrower wealth, credit cycle dynamics will carry macroeconomic implications (Kaufman, 1986; Gertler, 1988).

The adoption of the credit view spawned a new generation of general equilibrium models where balance sheets and credit markets act as structural transmission mechanisms. Early examples focus on the role of borrower balance sheets and built on ideas originally articulated by Fisher (1933) and Gurley and Shaw (1955) following their experience of the Great Depression. The key finding from these analyses relates to how dynamic interaction between the real and financial sector can result in shock amplification and persistence (Mishkin, 1978; Bernanke, 1983). Subsequently, the benchmark macroeconomic framework has deviated from the frictionless real business cycle model of Kydland and Prescott (1982), toward a credit-centered model where the interaction between real and financial markets is endogenous (Quadrini, 2011).

The introduction of non-trivial borrower balance sheets into general equilibrium models hinges on the presence of frictions in the credit creation pro-

cess. These so-called financial frictions can result from agency costs that arise due to information asymmetries between borrowers and lenders, or collateral liquidation costs that render credit markets incomplete. Information asymmetries between borrowers and lenders see that the optimal contract is characterized by an external finance premium, where this premium is positively related to borrower leverage. Under the incomplete markets approach, collateral liquidation costs create credit ceilings that are a function of the value of collateral. As a result, access to credit co-moves with asset prices. The seminal contribution of Bernanke and Gertler (1989) formalizes the agency cost approach whilst that of Kiyotaki and Moore (1997) describes a setup with incomplete credit markets. In both cases the financial friction facilitates dynamic feedback between credit markets, borrower wealth, and the real economy. This feedback generates a financial accelerator effect, where credit and real variable dynamics reinforce one another and culminate in shock amplification and persistence similar to that witnessed in the data (Bernanke, Gertler and Gilchrist, 1999; Kocherlakota, 2000).

Subsequent work extends these models to international settings, showing that credit markets play a key role in the observed co-movement of macroeconomic variables across countries (e.g. Faia, 2002; Kehoe and Perri, 2002; Iacoviello and Minetti, 2006). In these models, international credit markets allow for the spill-over of foreign economy dynamics such that foreign shocks bear implications for domestic macroeconomic conditions. When this international credit market channel is absent, the models are unable to reproduce the international cycles witnessed in the data (Backus *et al.*, 1992). These findings point to the vulnerability of domestic outcomes to foreign conditions, generating support for the use of regulatory measures to mitigate this exposure. Research into the viability of such measures comprises two inter-related, but conceptually different strands in the literature. The first strand consists of studies into the effectiveness of capital controls, whilst the second relates to the use of macroprudential instruments.

Building on the ideas of Tobin (1978), several papers show that capital controls proffer a means through which domestic authorities can attenuate the international spill-over of shocks (Jeanne and Korinek, 2010; Bianchi, 2011; Brunnermeier and Sannikov, 2015). These analyses are predicated on the existence of pecuniary externalities that result from overborrowing relative to a socially desirable level. Capital controls serve to limit this overborrowing, reducing the size of the pecuniary externality. This reduction of the externality stems from the fact that capital controls constrain the transmission of foreign shocks through international credit markets, and as a result, their introduction can offer social welfare benefits.

Macroprudential instruments provide another channel through which

authorities can limit domestic exposure to foreign shocks and improve social welfare (Rubio and Carrasco-Gallego, 2014). These instruments differ from capital controls in that they do not discriminate based on the nationality or origin of credit flows. That is, whilst capital controls seek to influence the behaviour of international capital flows specifically, macroprudential instruments focus on domestic credit market conditions and aim to foster financial stability in general. Macroprudential instruments are also able to distinguish between the demand and supply sides of domestic credit markets, whereas capital controls are usually studied from a net flow perspective (IMF, 2011, 2012; Galati and Moessner, 2013). The pivotal role played by financial sector balance sheets in the 2007–2008 financial crisis served to catalyze the macroprudential research agenda, generating significant interest into the use and effectiveness of these instruments. In this regard, the literature indicates that loan-to-value (LTV) regulation, minimum capital requirements, and reserve requirements can be used to foster financial stability and smooth adjustments in the real economy (Glocker and Towbin, 2012; Mendicino and Punzi, 2014; Brzoza-Brzezina, Kolasa and Makarski, 2015).

Although the body of work cited above has improved our understanding of the importance of the credit cycle to macroeconomic outcomes, several unanswered questions remain. This thesis seeks to contribute to this literature, where each chapter is devoted to addressing a shortcoming in our understanding of the credit cycle. To perform this task, I depart from the canonical real business cycle framework, by providing a pivotal role for the credit cycle through non-trivial financial intermediation and Kiyotaki and Moore (1997) financial frictions. Chapter 2 deploys a closed economy version of this framework to assess the quantitative and qualitative relevance of credit market heterogeneity. This chapter relaxes the single-representative credit market assumption nested in previous models and is motivated with reference to observed changes in the balance sheet composition of U.S. firms after the financial crisis. Chapter 3 extends this model to an asymmetric two-country setting, where the analysis comprises an investigation into the efficacy of flow specific capital controls in reducing the increase in emerging market foreign liabilities following the financial crisis. Chapter 4 takes the imminent tightening of advanced economy monetary policy as a backdrop, and studies the effectiveness of macroprudential instruments in attenuating the negative impact of tightening foreign credit market conditions. The small open economy framework deployed in this chapter differs from previous studies in that it is characterized by the co-existence of LTV regulation, minimum capital requirements, and reserve requirements, with a view to inform policymakers on the comparative effectiveness of each instrument. Finally, chapter 5 provides a brief summary of the thesis.

Chapter 2

Credit market heterogeneity, financial shocks, and balance sheet (in)dependence

This essay presents a real business cycle model with financial frictions and two credit markets to investigate the qualitative and quantitative relevance of credit market heterogeneity. To address this line of inquiry, I contrast the transmission of financial shocks in an economy where loans are the only form of credit to one in which both loans and bonds exist. The model is estimated using Bayesian methods over the sample period 1985Q1-2015Q1 for the U.S. economy. The results show that credit market heterogeneity plays an important role in attenuating the impact of financial shocks by allowing borrowers to substitute away from the affected credit market. The shock attenuation property of credit market heterogeneity works through asset prices and substitution toward alternative credit types. Bank balance sheet linkages reduce the shock attenuation effect associated with heterogeneous credit markets. The origination of financial shocks can influence both the size and persistence of their impact.

2.1 Introduction

This essay presents a real business cycle model with financial frictions and two credit markets to investigate the qualitative and quantitative relevance of credit market heterogeneity. To address this line of inquiry, I contrast the transmission of financial shocks in an economy where loans are the only form of credit to one in which both loans and bonds exist. I argue that the heterogeneous structure of credit markets can attenuate the impact of financial shocks. If credit markets behave differently to one another, increases in the supply of one form of credit could make up for reductions in the supply of another - a “spare tyre” as noted by Greenspan (1999). The existence of heterogeneous credit markets thus offer firms a means to substitute between different credit sources, and in doing so, reduce their exposure to credit market specific shocks. A similar narrative holds true for banks: operational diversification allows for the re-allocation of resources toward more profitable markets. In this way, losses to financial sector efficiency can be limited during times of distress.

The development of macroeconomic models with a role for credit has come a long way since Kiyotaki and Moore (1997), however these models still assume a single representative credit market.¹ As such, the literature is silent on the evolution of credit composition over the business cycle. Furthermore, the absence of credit market heterogeneity implies an incomplete understanding of the benefits associated with operational diversification in the financial sector. This essay aims to fill this gap in the literature by investigating how balance sheet linkages within the financial sector impacts on the stability benefits offered by operational diversification.

Credit market heterogeneity is introduced through an assumed risk difference between bonds and loans. This assumption is motivated with the theoretical literature on corporate debt structure, which views financial intermediaries (FIs) as a solution to problems of information asymmetry and relates the optimal choice of debt instrument to the riskiness of borrowers (Holmstrom and Tirole, 1997; Repullo and Suarez, 2000).² It is then possible to achieve non-trivial heterogeneity between bond and loan markets by assuming that the risk profile of these two markets differ. In the context of this analysis, I assume that loans are considered more risky than bonds and

¹See Gertler and Kiyotaki (2011), Quadrini (2011), Brunnermeier *et al.* (2012) and Bràzdik *et al.* (2012) for surveys of macroeconomic models characterized by financial intermediation.

²See also the models of Hoshi *et al.* (1993), Besanko and Kanatas (1993), Chemmanur and Fulghieri (1994), and Bolton and Freixas (2000) for examples where borrower types are revealed by their choice of debt instrument.

that the role of FIs differs in each market. FIs' role in loan extension follows the traditional narrative; however, in the bond market they perform the role of underwriter.

Introducing credit heterogeneity by way of a risk-adjusted capital constraint provides a channel for FI balance sheets to influence the behaviour of the model's credit markets. This heterogeneity is introduced into the credit market by assuming that FIs consist of a loan branch and a bond underwriting branch. Each branch is then subjected to a risk weighted capital requirement, which serves to drive a wedge between the returns of the FIs' assets. This channel is akin to the lending channel of monetary policy as described in Kishan and Opiela (2000). In line with credit market behaviour post-2008, the lending channel sees credit quantities change as a result of supply-side factors as opposed to being driven by changes in demand (Adrian *et al.*, 2012; Becker and Ivashina, 2014; Kaya and Wang, 2016). This characteristic differentiates my analysis from that of De Fiore and Uhlig (2015), who incorporate credit heterogeneity into a costly state verification framework à la Townsend (1979). De Fiore and Uhlig (2015) do a good job at replicating the behaviour of aggregate credit data, however, their model is missing the important amplification effect of shocks since it is characterized by intra-period borrowing. As argued by Quadrini (2011), macroeconomic models characterized by intra-period borrowing are unable to contemporaneously capture the impact of expected future market conditions, resulting in a dampened response to shocks. In addition, their framework does not provide a role for FI capital. Adrian *et al.* (2012) present a model of the financial sector with pro-cyclical leverage as well as the coexistence of bond and loan markets. Although providing a good representation of FIs, the partial equilibrium nature framework of Adrian *et al.*'s (2012) analysis implies their model is silent on the broader macroeconomic implications of credit heterogeneity.

De Jonghe (2010) and Fomby *et al.* (2012) provide evidence which indicates that the stability benefits offered by credit market heterogeneity could depend on balance sheet linkages between financial agents. If balance sheets are interdependent across the entire financial sector, negative shocks to one credit market spill-over to other credit markets, thus, limiting the shock attenuation property of credit market heterogeneity. When financial sector balance sheets are independent from one another, negative shocks in one credit market may not spill-over and, thus, shock attenuation can be facilitated via substitution between credit types.

The contribution of this paper is three-fold. To the best of my knowledge, this paper is the first attempt to introduce credit market heterogeneity into a Kiyotaki and Moore (1997) world. I build on the contribution of

De Fiore and Uhlig (2015), providing a role for both FI capital and inter-period borrowing. These features incorporate insights offered by the existing literature on the importance of expected future market conditions as well as the financial sector's ability to fund credit expansions. Additionally, this new framework is consistent with the notion that the operational role of FIs differs across credit markets. From this property stems the second contribution of this essay, in that it provides a theoretical framework from which to study the effects of operational diversification within the financial sector. As opposed to De Fiore and Uhlig (2015) where FIs specialize in specific credit markets, the framework incorporates both specialization and diversification.³ This feature affords a contrast of settings where commercial banks are prohibited from engaging in proprietary trading activities as per the Glass-Steagall Act, to the current regulatory environment which affords commercial bank participation in these activities (Richardson *et al.*, 2010; Thakor, 2012). Finally, this essay provides a framework in which the origination of financial shocks across agents can influence their impact on macroeconomic outcomes.

The model performs reasonably well in terms of replicating the behaviour of US credit markets. The results show that the impact of financial shocks in the presence of heterogeneous credit markets is attenuated as compared to a single credit market economy as found in Iacoviello (2015). This results from the ability of borrowers to substitute away from the shock affected credit market toward alternate sources of financing. Additionally, the findings show that inter-period borrowing amplifies the financial sector's resilience to financial shocks as compared to De Fiore and Uhlig (2015).

Financial sector resilience is partly as a result of the different operational roles required of FIs in the bond and loan credit markets of the model. This characteristic affords revenue diversification in the financial sector, and in the framework deployed for this analysis, the effects thereof concur with existing evidence that links revenue diversification to financial stability (see e.g., Elsas *et al.*, 2010; Shim, 2013; De Jonghe *et al.*, 2015; Köhler, 2015). In agreement with De Jonghe (2010) and Fomby *et al.* (2012), the analysis shows that the stability benefits of the revenue diversification afforded by heterogeneous credit markets decrease when the balance sheets of financial agents are interdependent. This results from the shock spill-over that occurs under balance sheet interdependence. In the context of financial regulation, these findings indicate that the resilience of the financial sector as a whole can

³ De Fiore and Uhlig (2015) allow for two types of FIs – commercial banks, offering loan finance, and capital mutual funds, offering bond financing. The framework deployed here nests both the De Fiore and Uhlig (2015) setup as well as one where commercial banks can offer both loan and bond finance.

be amplified when commercial banks are prohibited from engaging in proprietary trading activities. At the same time, I find that the resilience of an individual commercial bank is amplified when allowed to participate in proprietary trading activities.

Finally, the results show that when the balance sheets of FIs are independent of one another, the origination of financial shocks can influence both the size and the persistence of their impact. Specifically, when savers are directly hit by financial shocks, the size of their impact on the real economy is limited since shocks on savers do not influence the functioning of the financial system. However, the impact of these shocks can be persistent through limiting savings behaviour. In comparison, shocks borne entirely by the financial sector are amplified as a result of their influence on the ability of the financial sector to efficiently intermediate fund flows between savers and borrowers. This is in line with Sandri and Valencia (2013), who find that when shocks are borne entirely by the financial sector, their impact on the real economy is more severe and prolonged.

The rest of the paper is structured as follows. Section 2.2 presents the empirical evidence on the behaviour of corporate finance and section 2.3 describes the baseline model. I describe extensions to the baseline model in section 2.4. Section 2.5 discusses the estimation of the model whilst in section 2.6 I investigate the qualitative and quantitative relevance of heterogeneous credit markets. Finally, section 2.7 concludes.

2.2 Empirical evidence on credit markets

In this section I motivate the need for credit market distinction by presenting empirical evidence on the heterogeneous behaviour of loan and bond markets.⁴ Figure 2.1 plots the cyclical component of HP-filtered real GDP and credit instruments on the balance sheets of non-financial corporations (NFCs) in the U.S.⁵ Thus, figure 2.1 illustrates whether there are any similarities between the business cycle, and the credit cycle of bond and loan markets. The figure shows that the credit cycle of loans mimics the business cycle more closely than the credit cycle of bonds. Bonds seem either decoupled from the business cycle or to exhibit mild counter-cyclical

⁴To simplify the narrative, I refer to the second credit market as the “bond” market. In reality it represents the whole market for non-financial corporate debt securities, of which bonds are the largest constituent. Thus, I use the data of debt securities for bonds in the study. A description of all the data used is offered in appendix A.3.

⁵HP filter with $\lambda = 1600$.

behaviour.⁶ This characteristic of bond markets helped mitigate the impact of the financial crisis by providing borrowers access to an alternative form of credit.

Figure 2.2 plots the flows of credit to NFCs. This figure provides a different perspective on this shift in the prominence of bond and loan markets. It shows that although substitution from loans to bonds may have dampened the effect of the crisis, the shift was not pronounced enough to entirely counteract the reduction in credit stemming from negative loan growth. By plotting the spreads of bond and loan interest rates to the federal funds rate, figure 2.3 shows the symmetrical behaviour of the two spreads despite the significant substitution from loans to bonds as shown in figure 2.2.⁷ It is, however, worth noting that there is a significant decline in the bond spread during the 2007-2008 crisis, prior joining the hiking of the loan spread. Taken together with the figure 2.2, this evidence concurs with the analyses of Adrian *et al.* (2012) and Becker and Ivashina (2014), where supply side factors are seen as initiating the shift from loan to bond finance for U.S. firms. Reduced bank lending realized higher loan interest rates and the subsequent increase in demand for alternative sources of credit saw bond rates rise. Corroborating this perspective, Kaya and Wang (2016) find that FI balance sheet constraints and risk perceptions lead to increased bond issuance by EU firms.

This adjustment in firms' financing behaviour saw FIs shift away from loan syndication and toward the underwriting of securities (Kaya and Meyer, 2014). The underwriting role played by FIs thus aided in diversifying their revenue streams during a period of stress. In this way, the different structures of credit markets (and firms' ability to substitute between these markets) can bolster the resilience of the financial sector through the benefits that revenue diversification offers to financial stability (Elsas *et al.*, 2010; Shim, 2013; De Jonghe *et al.*, 2015; Köhler, 2015).

In summary, the aggregate credit data presented above reveals an increasing share for bonds in aggregate credit following the crisis whilst the share of loans declined. Empirical studies on this change in credit composition see it being initiated by developments within the financial sector, assigning a key role to FIs in changing the composition of aggregate debt. Several studies also find that this substitution between credit types can bolster financial stability, especially when the balance sheets of FIs are independent of one another. In the next section, I present a model that incorporates these insights into a closed economy where alternative sources of credit exist.

⁶Where counter-cyclical is with reference to the business cycle.

⁷See Appendix section A.3 for details on series used in figure 2.3.

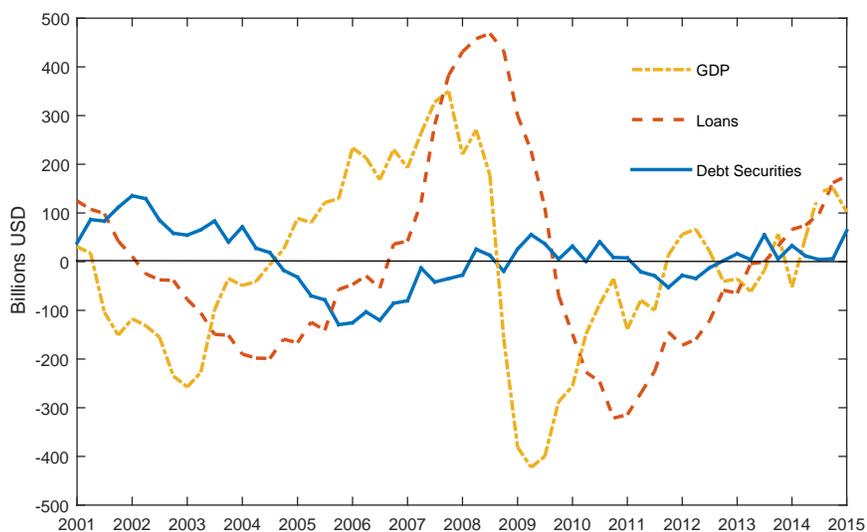


Figure 2.1: Non-financial corporate debt and real GDP in the U.S.

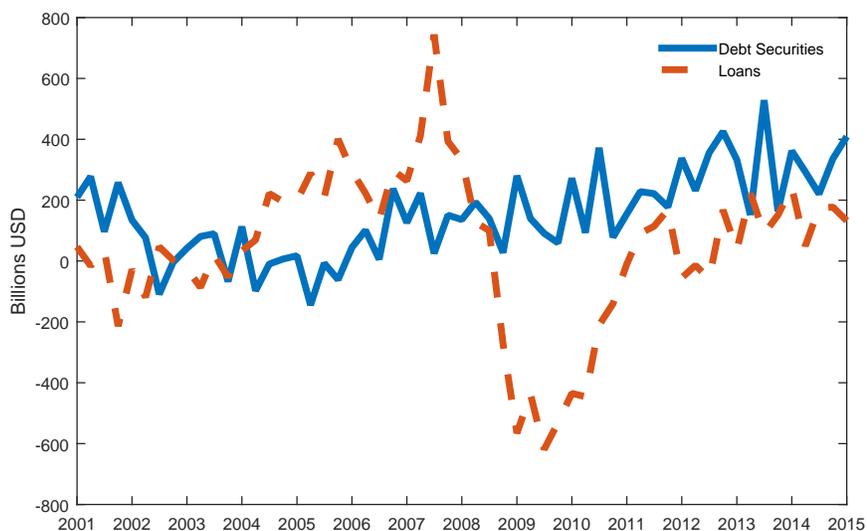


Figure 2.2: Credit flows for non-financial corporations in the U.S.

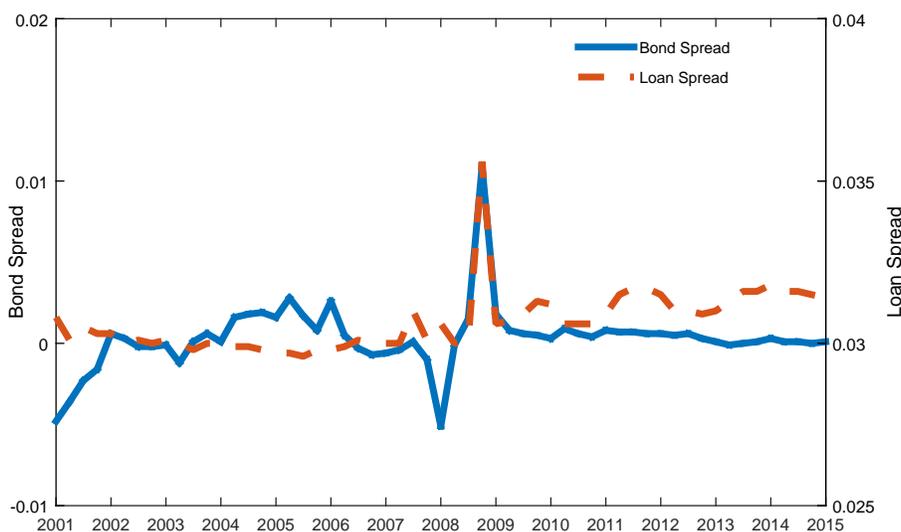


Figure 2.3: Bond spread vs. loan spread in the U.S.

2.3 The model

The model is populated by households, entrepreneurs, and FIs. Households consume, accumulate real estate and supply labour to entrepreneurs. Households are the savers in the model, providing funds in the forms of one period deposits and bond purchases to FIs. Entrepreneurs produce output, consume, and incur one period debts (both loans and bonds) in order to finance their production. Entrepreneurs are the borrowers in this model economy and their borrowing ceiling in each credit market is determined by a Kiyotaki and Moore (1997) collateral constraint. Financial intermediaries consist of a loan branch and a bond underwriting branch, where each branch's supply of credit to entrepreneurs is subject to their balance sheet identity and a risk-weighted capital adequacy constraint similar to that found in Iacoviello (2015).

Although households are the end holders of bonds, entrepreneurs have to interact with FIs in order to access this form of credit because they prefer to have their bond issues underwritten. The preference to underwrite arises because of information asymmetries that exist between entrepreneurs and households. Providing that entrepreneurs cannot gauge household demand, the supply of funds from bond issuances directly to households may be insufficient to meet their desire for credit. By underwriting their bond issuances, entrepreneurs can guarantee the amount of funds that they receive.

Specifically, the underwriting branch of the FI guarantees entrepreneurs an amount of bond finance that corresponds with the credit ceiling implied by their collateral constraint. The underwriting branch then distributes these bonds to households in accordance with household demand for bonds, where this demand is a function of household wealth based on the lending constraint of Minetti and Peng (2013).

Household demand for bonds need not coincide with the quantity guaranteed to entrepreneurs by FIs, motivating their desire to have their bond issuance underwritten. When this occurs, the underwriting branch is forced to hold the excess entrepreneur bonds on its balance sheet. Such instances reflect a misjudgement of household demand for bonds on the part of FIs, and since they value their reputation as underwriters, I assume that positive bond holdings by the FI underwriting branch (i.e. unsuccessful underwriting) carries utility costs such that FIs charge an underwriting premium on bond issuances.⁸

In keeping with the empirical evidence on the role of supply-side factors in the post-crisis shift from loan to bond finance (see section 2.2), branch-specific and risk-weighted capital adequacy constraints are used to introduce credit market heterogeneity into the model. These constraints afford a non-trivial role for FI balance sheets in determining the model's dynamics and are used to illustrate the role of FI balance sheets in the propagation of shocks. I assume that bonds carry a lower risk weight than loans, and combined with the utility costs associated with underwriting as described above, this difference in risk weights sees that the interest rate on loans is a premium over that charged on bonds. Thus, the heterogeneity between credit markets produced by the model is driven by supply-side factors in the form of branch-specific risk-weighted capital adequacy constraints and utility costs to unsuccessful underwriting.

Because this framework affords a non-trivial role for FIs in both bond and loan markets, it can offer insights on the benefits associated with operational diversification within the financial sector. I assess these benefits by contrasting the model's dynamics when I allow for operational diversification by FIs, to a scenario where FIs only operate in one of the two credit markets. The first of these scenarios reflects a Glass-Steagall setting, where deposit-taking FIs are prohibited from engaging in underwriting activities such that loan and bond branch balance sheets are regulated independently of one another (Richardson *et al.*, 2010; Thakor, 2012). In contrast, when regulation allows for operational diversification, bond and loan

⁸See Peng and Brucato (2004), Daniels and Vijayakumar (2007), and Andres *et al.* (2014) for evidence on the role of reputation in underwriting.

branch balance sheets are regulated on a consolidated basis as per Basel III (Drucker and Puri, 2005; BIS, 2010). These two scenarios are incorporated through adjustments to the capital adequacy constraints of FIs that allows for balance sheet linkages which bear real implications on financial sector resilience.

The model with heterogenous credit markets contrasts to the transmission of financial shocks in the single credit market economy of Iacoviello (2015); however because this model nest the framework of Iacoviello (2015), I can assess the influence of any additional features. In this regard, I assess the impact of introducing an additional credit market by comparing the transmission of a negative loan market financial shock – a negative shock to FI assets – in Iacoviello (2015) to that when two credit markets are active. This similarity between my framework and that of Iacoviello (2015) also affords introducing a shock to bonds purchased by households that contrasts to the loan market financial shock of Iacoviello (2015). This bond shock is in fact akin to a negative funding shock to FIs – a negative shock to FI liabilities – in their role as underwriter, and hence, serves as a new financial shock. As with the impact of credit market heterogeneity, the bond shock is assessed by comparing the model dynamics induced thereunder to those obtained under the loan shock of Iacoviello (2015). To focus on the role of FI balance sheets as endogenous shock propagation mechanisms these shocks are assumed to be credit market specific, implying that they are independent of one another. Because loan and bond shocks are independent of one another, the effects of loan shocks on the bond market (and bond shocks on the loan market) occurs endogenously and is not reliant on an ad-hoc relationship between loan and bond shocks.

2.3.1 Households

The representative household maximizes its expected lifetime utility function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log(\varepsilon_t^h C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right\}, \quad (2.1)$$

subject to the following budget constraint

$$C_t^h + D_t + B_t^h + \varepsilon_t^q q_t (H_t^h - H_{t-1}^h) = R_{t-1}^d D_{t-1} + R_t^h B_{t-1}^h + W_t N_t. \quad (2.2)$$

β_h gives the household discount factor. j and τ are coefficients. C_t represents household consumption whilst ε_t^h is a household preference shock. N_t

gives household labor that earns a real wage of W_t . D_t denotes bank deposits that earn a pre-determined gross return of R_t^d . B_t^h denotes household purchases of bonds. These purchases are intermediated by the FI and pay a state-contingent gross return of R_t^h .⁹ q_t gives the price of real estate (H_t^h) in units of consumption whilst ε_t^q is a real estate price shock that is common to both households and entrepreneurs. Both the household consumption shock and the common real estate price shock follow AR(1) processes:

$$\log(\varepsilon_t^h) = \rho_h \log(\varepsilon_{t-1}^h) + \iota_t^h, \quad (2.3)$$

$$\log(\varepsilon_t^q) = \rho_q \log(\varepsilon_{t-1}^q) + \iota_t^q, \quad (2.4)$$

where $\iota_t^i \sim N(0, \sigma_i)$ is a white noise process drawn from a normal distribution with a mean of zero and a standard deviation of σ_i for $i = h, q$.

As in Minetti and Peng (2013), I assume that households are subject to a lending constraint where their current period holdings of bonds cannot exceed a fraction ν_h of their net worth. Formally, this lending constraint is given by

$$B_t^h \leq \nu_h \left(R_t^h B_{t-1}^h + q_t H_{t-1}^h - \gamma_h \mathbb{E}_t \varepsilon_{t+1}^b \right). \quad (2.5)$$

Given the model's calibration, ν_h embeds the need for entrepreneurs to underwrite their bonds since it restricts household demand for bonds. In this regard, the calibration for ν_h sees that households' demand for bonds is inadequate to meet the supply thereof by entrepreneurs, implying that the underwriting of bond issuances reflects rational behaviour by entrepreneurs. Practically, one can think of ν_h as representing the fraction of net worth that households are willing to devote to acquiring risky assets.

I introduce a shock to bond holdings in the households' lending constraint, $\mathbb{E}_t \varepsilon_{t+1}^b$, capturing expected bond market losses that decrease the wealth of households, where $\gamma_h = \frac{B^h}{B}$ denotes the steady state household share of total bonds issued by entrepreneur.¹⁰ Given that bonds held by households appear on the liability side of FIs' balance sheet, this shock serves as a financial funding shock in the model. I assume that ε_t^b follows an AR(1) process:

⁹Section 2.3.3 discusses why R_t^h is state contingent.

¹⁰In this model, households hold approximately 98% of all bonds at the steady state, i.e. $\gamma_h = 0.98$. This assumption is motivated on the grounds that issues of underwritten bonds will mostly be fully subscribed, i.e. the FI is a successful underwriter.

$$\varepsilon_t^b = \rho \varepsilon_{t-1}^b + l_t^b. \quad (2.6)$$

In 2.6, $l_t^b \sim N(0, \sigma_b)$ is an independent white noise process with a normal distribution, zero mean, and standard deviation of σ_b .

Optimal behaviour by households generates first-order conditions for deposits (2.7), real estate demand (2.8), bonds (2.9), and labour supply (2.10):

$$1 = m_t^h R_t^d, \quad (2.7)$$

$$\varepsilon_t^q q_t = \frac{j \varepsilon_t^h C_t^h}{H_t^h} + m_t^h \mathbb{E}_t \varepsilon_{t+1}^q q_{t+1} (1 + v_h \mathbb{E}_t \lambda_{t+1}^h), \quad (2.8)$$

$$1 + \lambda_t^h = m_t^h \mathbb{E}_t R_{t+1}^h (1 + v_h \mathbb{E}_t \lambda_{t+1}^h), \quad (2.9)$$

$$W_t = \frac{\tau \varepsilon_t^h C_t^h}{1 - N_t}, \quad (2.10)$$

where $m_t^h \equiv \frac{\beta_h \varepsilon_t^h C_t^h}{\mathbb{E}_t \varepsilon_{t+1}^h C_{t+1}^h}$ gives the household's stochastic discount factor, whilst

$\Lambda_t^h \equiv \frac{\lambda_t^h}{\varepsilon_t^h C_t^h}$ gives the multiplier on constraint 2.5 normalized by the marginal utility of consumption.¹¹ Equation 2.7 provides the behavioral rule for the benchmark interest rate in the economy. The asset pricing equation (2.8) equates the value of real estate to its direct utility benefits in units of consumption plus the discounted utility benefit it offers in the next period through its influence on household wealth. Equation 2.9 implies the period t utility cost of bond acquisition should equal to its discounted benefits in period $t + 1$. Current period costs consist of reduced consumption as well as a tightening of the lending constraint. Next period benefits accrue from increased consumption offered by the interest income households receive on bond holdings (R_{t+1}^h). Lastly, equation 2.10 gives the optimal wage rate.

To generate a non-trivial steady state role for the lending constraint, I assume that bonds are less liquid than deposits. As a result of this difference in liquidity, households require that their return on bond holdings be a premium on that offered for deposits held at the bank. Combining equations 2.7 and 2.9 gives this premium as

$$\mathbb{E}_t R_{t+1}^h - R_t^d = \frac{1 + \lambda_t^h}{m_t^h (1 + v_h \mathbb{E}_t \lambda_{t+1}^h)} - \frac{1}{m_t^h}, \quad (2.11)$$

¹¹Normalizing the multiplier on constraint (2.5) by the marginal utility of consumption simplifies the expression of the the first order conditions.

where variables without a t subscript denoting steady state values. At the steady state, a positive spread between R^h and R^d exists so long as $\lambda^h > 0$ and $0 < \nu_h < 1$. It can be shown that λ^h will be greater than zero when¹²

$$j < \frac{(1 - \beta_h)qH^h}{C^h}. \quad (2.12)$$

2.3.2 Entrepreneurs

Entrepreneurs maximize their lifetime utility function given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{ \log(C_t^e) \}, \quad (2.13)$$

subject to the following budget constraint:

$$C_t^e + \varepsilon_t^q q_t (H_t^e - H_{t-1}^e) + R_{t-1}^b B_{t-1} + R_t^l L_{t-1} + W_t N_t = Y_t + B_t + L_t. \quad (2.14)$$

β_e is the entrepreneurial discount factor and C_t^e gives entrepreneurial consumption. H_t^e gives the real estate holdings of entrepreneurs, whilst B_t gives the size of bond borrowed on which pre-determined gross interest of R_{t-1}^b is paid in period t . L_t and R_t^l denote loans and the state-contingent gross return to loans, respectively. The intuition behind the difference in timing between R_t^l and R_{t-1}^b is provided in section 2.3.3.

The borrowing constraints for entrepreneurs are given by conditions 2.15 and 2.16:

$$B_t \leq \frac{\omega \varepsilon_t^e \nu_e \mathbb{E}_t q_{t+1} H_t^e}{R_t^b}, \quad (2.15)$$

$$L_t \leq \frac{(1 - \omega) \varepsilon_t^e \nu_e \mathbb{E}_t q_{t+1} H_t^e}{\mathbb{E}_t R_{t+1}^l}. \quad (2.16)$$

In keeping with a desire to focus on the role of supply-side factors in the observed shift toward bond finance, entrepreneur preference for each type of

¹²To derive this result, take the steady state of equation (2.8), and impose the requirement that $\lambda^h > 0$.

credit is governed by the scalar ω .¹³ The loan-to-value ratio of entrepreneurs, ν_e , is subject to a shock as denoted by ε_t^e , where this shock is assumed to follow an AR(1) process

$$\log(\varepsilon_t^e) = \rho_e \log(\varepsilon_{t-1}^e) + \iota_t^e, \quad (2.17)$$

where $\iota_t^e \sim N(0, \sigma_e)$ is a white noise process drawn from a normal distribution with a mean of zero and a standard deviation of σ_e .

Entrepreneurs' production technology follows a Cobb-Douglas functional form with input shares of α for real estate and $(1 - \alpha)$ for labour. Formally,

$$Y_t = \varepsilon_t^a (H_{t-1}^e)^\alpha (N_t)^{1-\alpha}. \quad (2.18)$$

Where ε_t^a is a technology shock following an AR(1) process as given by

$$\log(\varepsilon_t^a) = \rho_a \log(\varepsilon_{t-1}^a) + \iota_t^a, \quad (2.19)$$

where $\iota_t^a \sim N(0, \sigma_a)$ is a white noise process drawn from a normal distribution with a mean of zero and a standard deviation of σ_a .

As was done for households, let $\Lambda_t^i \equiv \frac{\lambda_t^i}{C_t^i}$ for $i = b, l$ give the multipliers on constraints 2.15 and 2.16. Furthermore, denoting $m_t^e \equiv \frac{\beta_e C_t^e}{\mathbb{E}_t C_{t+1}^e}$ as entrepreneurs' stochastic discount factor, the entrepreneurs' optimal conditions for real estate, bonds, loans, and labour are as follows:

$$\varepsilon_t^q q_t = \varepsilon_t^e \nu_e \left[\frac{\omega \lambda_t^b}{R_t^b} + \frac{(1 - \omega) \lambda_t^l}{\mathbb{E}_t R_{t+1}^l} \right] \mathbb{E}_t \varepsilon_{t+1}^q q_{t+1} + m_t^e \left(\alpha \frac{\mathbb{E}_t Y_{t+1}}{H_t^e} + \mathbb{E}_t q_{t+1} \right), \quad (2.20)$$

$$1 - \lambda_t^b = m_t^e R_t^b, \quad (2.21)$$

$$1 - \lambda_t^l = m_t^e \mathbb{E}_t R_{t+1}^l, \quad (2.22)$$

$$W_t = \frac{(1 - \alpha) Y_t}{N_t}. \quad (2.23)$$

¹³Treating ω as a scalar is consistent with an implicit assumption that the theoretical findings on optimal corporate debt structure hold. This literature indicates that safe borrowers will make use of bond financing whilst risky borrowers make use of bank loans (see e.g., Besanko and Kanatas, 1993; Hoshi *et al.*, 1993; Chemmanur and Fulghieri, 1994; Bolton and Freixas, 2000)

Equation 2.20 shows that the cost to an additional unit of real estate in units of consumption is equal to the benefit arising from a relaxation of the borrowing constraint plus the benefits that result from its influence on entrepreneurial wealth as well as its use in production. Equations 2.21 and 2.22 are the asset pricing equations for bonds and loans, respectively. Equation 2.23 gives the optimal wage rate.

Since borrowers take interest rates on loans and bonds as given, the steady state of equations 2.21 and 2.22 can be used to derive the equilibrium condition for the coexistence of two debt instruments on entrepreneurs' balance sheets:

$$\lambda^b = \lambda^l + \beta_e(R^l - R^b). \quad (2.24)$$

Given that $R^l > R^b$, equation 2.24 states that for entrepreneurs to be indifferent between bonds and loans as sources of credit, the shadow value of their bond borrowing constraint needs to be larger than that on loans. This equilibrium condition implies that entrepreneurs are more constrained in accessing credit in the form of bonds than loans. It is intuitive to require a differential in the tightness of the two borrowing constraints such that both credit types exist in equilibrium. Since entrepreneurs can tap credit from the bond market at a cheaper rate than that charged on loans, they would make use of bond finance only if given the choice. However, by ensuring that $\lambda^b > \lambda^l$, their ability to do so is constrained.

In order to ensure entrepreneurs are credit constrained in equilibrium, restrictions are required on the feasible values for their discount factor β_e :

$$\frac{1}{\beta_e} > \frac{\vartheta\varphi_l}{\beta_f} + \frac{1 - \vartheta\varphi_l}{\beta_h}. \quad (2.25)$$

Entrepreneurs will be borrowing constrained in both bond and loan markets so long as condition 2.25 holds, given $\beta_e R^l < 1$, $\beta_e R^b < 1$, and $R^l > R^b$.¹⁴

Thus, provided that the steady state interest rate on loans is higher than that on bonds, entrepreneurs will be credit constrained in equilibrium so long as the inverse of the discount rate is larger than a weighted average of household and FI discount rates.

2.3.3 Financial intermediaries

FIs maximize their utility from consumption (C_t^f). Here, I introduce a utility cost ($v_f B_t^f$) due to the risks inherent in underwriting. Underwriting risk is

¹⁴I make use of the steady state of equations 2.7 and 2.40 in deriving this condition.

captured by insufficient household demand for bonds, requiring FIs to hold the remainder of it on their own balance sheet. Given that their holdings of bonds is defined as per equation 2.28, the FI's objective function is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left\{ \log(C_t^f) - \nu_f B_t^f \right\}. \quad (2.26)$$

In equation 2.26, β_f gives the FI's discount factor, whilst ν_f parametrizes the utility cost from underwriting risk.¹⁵

I assume that credit extension occurs via two separate branches within the FI, namely the loan branch and the bond underwriting branch. Each branch intermediates the flows associated with a specific credit type. This setup produces a budget constraint for the loan branch that is standard in the literature:

$$C_{l,t}^f + L_t + R_{t-1}^d D_{t-1} = D_t + R_t^l L_{t-1}. \quad (2.27)$$

$C_{l,t}^f$ refers to the consumption of the loan branch, which is equivalent to the profit made from the intermediation of loans between households and entrepreneurs. Here, the pre-determinate nature of R_{t-1}^d is consistent with its status as the benchmark interest rate in the model, whilst the state-dependency of R_t^l embeds the notion that FIs will adapt the interest rate on loans in accordance with changing economic conditions. The same timing assumption is deployed by Iacoviello (2015).

In the case of the bond underwriting branch, bond credit is extended using funds received from household bond purchases. Here, I assume that household demand for bonds is inadequate to meet the credit needs of entrepreneurs. In equilibrium FIs are prepared to hold the remaining underwritten bonds (B_t^f) on the asset side of their balance sheets. Equation 2.28 gives the aggregation of household (B_t^h) and bank holdings (B_t^b) of entrepreneurial bonds:

¹⁵These utility costs are included to embed the underwriting narrative. This narrative sees that the operational objective for FIs in the bond market is not to hold bonds, but rather to make a profit on the sales of bonds to households. These utility costs can be likened to a reputation cost associated with inefficient intermediation and is in keeping with existing literature on the role of reputation in underwriting (Peng and Brucato, 2004; Daniels and Vijayakumar, 2007; Andres *et al.*, 2014). The inclusion of these costs do not materially affect the results.

$$B_t = B_t^h + B_t^f. \quad (2.28)$$

The budget constraint for the bond underwriting branch is given by equation 2.29:

$$C_{b,t}^f + B_t + R_t^h B_{t-1}^h = B_t^h + R_{t-1}^b B_{t-1}. \quad (2.29)$$

Here, $C_{b,t}^f$ refers to the underwriting branch's consumption. The difference in timing between R_{t-1}^b and R_t^h stems from the fact that bond issues are underwritten. By underwriting their bond issuances, entrepreneurs can guarantee the cost of said issuances. In this case, the pre-determinate nature of R_{t-1}^b reflects this cost guarantee for entrepreneurs when their bonds are underwritten. Similarly, the state-dependent nature of R_t^h reflects the fact that the yield at which the underwriting branch sells the bonds to households will be dependent on prevailing market conditions (Melnik and Nissim, 2003).

Using the definition for bonds as per equation 2.28, one can substitute out for B_t , in which case equation 2.29 becomes:

$$C_{b,t}^f + B_t^f = R_{t-1}^b B_{t-1}^f + (R_{t-1}^b - R_t^h) B_{t-1}^h. \quad (2.30)$$

Equation 2.30 shows that the underwriting branch derives an income from performing its role as underwriter in intermediating the purchase of entrepreneurial bonds by households $((R_{t-1}^b - R_t^h) B_{t-1}^h)$ and own bond holdings $(R_{t-1}^b B_{t-1}^f)$. Combining equations 2.27 and 2.30, the aggregate FI budget constraint becomes:

$$C_t^f + B_t^f + L_t + R_{t-1}^d D_{t-1} = D_t + R_{t-1}^b B_{t-1}^f + (R_{t-1}^b - R_t^h) B_{t-1}^h + R_t^l L_{t-1}. \quad (2.31)$$

I assume that each branch of the FI has to finance a portion of their assets with branch capital. Letting E_t^i for $i = l, b$ denote FI branch i 's capital, this condition is formally stated as follows¹⁶:

¹⁶Here E_t^b refers to the bond underwriting branch's capital whilst E_t^l refers to the loan branch's capital.

$$E_t^l \geq \vartheta[\varphi_l(L_t - \mathbb{E}_t \varepsilon_{t+1}^l)], \quad (2.32)$$

$$E_t^b \geq \vartheta[\varphi_b(B_t) - \gamma_f \mathbb{E}_t \varepsilon_{t+1}^b]. \quad (2.33)$$

Where requiring the underwriting branch to hold capital against the aggregate level of entrepreneur bonds is consistent with the notion that the underwriting branch guarantees B_t before having sold any of these bonds onto households (B_t^h). Note that, as with the household, the impact of the bond shock on the underwriting branch is weighted by its steady state share of aggregate bond holdings: $\gamma_f = \frac{B^f}{B}$.¹⁷

Having a separate capital constraint for each FI branch is akin to assuming balance sheet independence between the two branches. This assumption is likened to operational diversification in the financial sector as a whole and is coherent with a Glass-Steagall setting where proprietary trading restrictions see that deposit-taking banks are prohibited from engaging in certain credit markets. As a result of balance sheet independence, the gains or losses made by one branch do not materially affect those of the other. In this way, balance sheet independence can help stabilize the financial sector when a credit market specific shock hits. This assumption is relaxed in section 2.4.1, where I allow for balance sheet linkages between FI branches.

Conditions 2.32 and 2.33 state that in each period FI branch capital must be greater than a fraction ϑ of its assets, taking into account expected losses. To generate a wedge between the cost of external finance for loans as compared to bonds, I assume that the imposed risk coefficient on loans (φ_l) is greater than that of on bonds (φ_b). This captures that, ceteris paribus, FIs need to hold more capital for loan extension than holding underwriting bonds according to the capital regulation authority.

As per Iacoviello (2015), FI loan branch capital at the beginning of the period (before credit market shocks have been realized) is defined as $E_t^l = L_t - D_t - \mathbb{E}_t \varepsilon_{t+1}^l$. Analogously, bond underwriting branch capital is given by $E_t^b = B_t - B_t^h - \gamma_f \mathbb{E}_t \varepsilon_{t+1}^b$. Letting $\kappa_i = 1 - \vartheta \varphi_i$ for $i = b, l$, I can rewrite (2.32) and (2.33) as

$$D_t \leq \kappa_l(L_t - \mathbb{E}_t \varepsilon_{t+1}^l), \quad (2.34)$$

$$B_t^h \leq \kappa_b(B_t - \gamma_f \mathbb{E}_t \varepsilon_{t+1}^b). \quad (2.35)$$

¹⁷Households hold approximately 98% of all bonds issued at the steady state and so $\gamma_f = 0.02$.

Where this re-phrasing of each branch's capital requirement negates the need to explicitly model branch capital.

Similar to the bond shock as defined by (2.6), ε_t^l gives losses arising from a shock to loan markets. The representation of this shocks sees that these losses serve to reduce the level of the loan branch's capital. As before, I assume that ε_t^l follows an AR(1) process:

$$\varepsilon_t^l = \rho\varepsilon_{t-1}^l + \iota_t^l. \quad (2.36)$$

In (2.36), $\iota_t^l \sim N(0, \sigma_l)$ is an independent white noise process with a normal distribution with zero mean and standard deviation of σ_l . This independence between loan and bond shocks – as per (2.6), bond shocks are also independent white noise processes – places focus on FI balance sheets in the propagation of shocks and reflects a desire to study credit market specific shocks as well as the difference between shocks that affect FI capital, and those that affect FI liabilities.¹⁸

The FI takes R_t^d and R_t^h as given and chooses D_t , B_t^h , B_t^f , and L_t to maximize (2.26) subject to (2.31), (2.34), and (2.35). Let $\Lambda_{i,t}^f \equiv \frac{\lambda_{i,t}^f}{C_t^f}$ for $i = l, b$ be the multipliers on constraints 2.34 and 2.35, whilst $m_t^f \equiv \frac{\beta_f C_t^f}{\mathbb{E}_t C_{t+1}^f}$ gives the FI's stochastic discount factor. The first order conditions for D_t , B_t^h , B_t^f , and L_t are given by

$$m_t^f R_t^d = 1 - \lambda_{l,t}^f, \quad (2.37)$$

$$m_t^f \mathbb{E}_t R_{t+1}^h = 1 + \nu_f C_t^f - \lambda_{b,t}^f, \quad (2.38)$$

$$m_t^f R_t^b = 1 + \nu_f C_t^f - \kappa_b \lambda_{b,t}^f, \quad (2.39)$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_l \lambda_{l,t}^f. \quad (2.40)$$

Equation 2.37 equates the utility benefit of lending from households in the current period to the discounted utility cost it generates in the next period. The next period utility cost is given by the interest rate on deposits multiplied by the stochastic discount factor. $1 - \lambda_{l,t}^f$ gives the utility gain

¹⁸The bond shock also affects FI capital; however, because $\gamma_f = 0.02$ and $\gamma_h = 0.98$ bond shocks predominantly affect B_t^h , and as such, serve as a shock to the liabilities of the underwriting branch's balance sheet.

offered by new deposits less the utility cost from a tightening of the capital constraint.

The first order condition for B_t^h shows that in order to intermediate the purchase of bonds by households, FIs require that the net benefit obtained from bond market intermediation equates to the discounted interest rate on bonds demanded by households. Benefits from intermediation in the bond market consist of the additional consumption that bankers can enjoy as a result of the funds received from households plus the utility gain (in consumption units) from lower underwriting risk. At the same time, household purchases of bonds infer a cost to bankers via a tightening of their capital constraint as per (2.35).

Equation 2.39 states that in underwriting bonds, FIs set the interest rate payable by bond issuers such that it equates to the utility cost of underwriting less the utility gained by the increase in bank capital necessitated by an extension of credit. In the case of loans, equation 2.40 equates the net cost of loan issuance today to the discounted benefits that accrue to the FIs in the next period. Period t utility costs consist of a one unit reduction in FI consumption less the utility value of higher capital as required by constraint 2.34. The benefits arising from loan extension equate to the interest rate on loans multiplied by the FI's stochastic discount factor.

Using equations 2.37 to 2.40, I derive the spreads between the different interest rates from the FI's perspective:

$$\mathbb{E}_t R_{t+1}^l - R_t^d = \frac{\lambda_{l,t}^f}{m_t^f} (1 - \kappa_l), \quad (2.41)$$

$$R_t^b - \mathbb{E}_t R_{t+1}^h = \frac{\lambda_{b,t}^f}{m_t^f} (1 - \kappa_b). \quad (2.42)$$

Equation 2.41 shows that the FI loan branch requires a premium over the deposit rate on their holdings of entrepreneurial loans whilst equation 2.42 governs the underwriting premium required by the FI bond underwriting branch. One can see from equations 2.41 and 2.42 that the loan-deposit spread and the underwriting premium are increasing in the multipliers on each FI branch's capital constraint. This results from the liquidity differential that capital constraints generate between the asset and liability sides of each branch's balance sheet.

The spreads between the interest rates on deposits and household bonds as well as that between the interest rates on entrepreneurial bonds and loans are given by equations 2.43 and 2.44 below:

$$\mathbb{E}_t R_{t+1}^h - R_t^d = \frac{1}{m_t^f} (v_f C_t^f + \lambda_{l,t}^f - \lambda_{b,t}^f), \quad (2.43)$$

$$\mathbb{E}_t R_{t+1}^l - R_t^b = \frac{1}{m_t^f} (\kappa_b \lambda_{b,t}^f - \kappa_l \lambda_{l,t}^f - v_f C_t^f). \quad (2.44)$$

Conditions (2.41) to (2.44) reveal that financial frictions in the form of capital requirements reduce the efficiency of the financial sector by generating a spread between the interest rate earned by savers (households) and that paid by borrowers (entrepreneurs).¹⁹

The household problem requires a positive spread between R^h and R^d . From equation 2.43 one can see that, from the FIs perspective, a positive spread between R^h and R^d requires $v_f C_t^f + \lambda_{l,t}^f - \lambda_{b,t}^f > 0$. Using steady state conditions of equations 2.37 and 2.38, this will be the case so long as $\frac{1}{\beta_h} < R^h$. Looking at equation 2.44, one can see that the spread between entrepreneurial loan and bond rates is declining in FIs' disutility to underwriting and increasing in the tautness of each branch's capital constraint. As a result, an assumption regarding the magnitude of v_f is necessary in order to preserve a positive spread between R_t^l and R_t^b in equilibrium, that is, $v_f < \kappa_b \frac{\lambda_b^f}{C^f} - \kappa_l \frac{\lambda_l^f}{C^f}$.

Non-trivial financial intermediation requires FIs to be credit constrained in equilibrium. Given that $\beta_f < \beta_h$, i.e., FIs are more impatient than households, the steady state of equation 2.37 shows that FIs will be credit constrained in equilibrium as long as the following condition holds²⁰:

$$\lambda^f = 1 - \beta_f R^d = 1 - \frac{\beta_f}{\beta_h} > 0. \quad (2.45)$$

2.3.4 Market clearing

Market clearing requires the aggregate of bonds (2.28) and the following conditions to hold:

¹⁹Indeed, absent these frictions and ignoring utility costs to underwriting (i.e. $v_f = 0$), one could abstract from explicit modelling of the financial sector since $R_t^d = R_t^b = R_{t+1}^l = R_{t+1}^h$.

²⁰I make use of the steady state of equation 2.7 in deriving this result.

$$H_t^h + H_t^e = 1, \quad (2.46)$$

$$Y_t = C_t^h + C_t^e + C_t^f. \quad (2.47)$$

Equation 2.46 is a simple normalization whilst equation 2.47 gives the aggregate resource constraint of the model economy.

2.4 Model extensions

Here, I discuss two extensions to the framework described in section 2.3. In the first extension, I impose balance sheet dependence between the loan and bond underwriting branches by subjecting FIs to an aggregate capital constraint. This extension serves to investigate how balance sheet linkages influence benefits to operational diversification within a bank, and compared to the framework in section 2.3, mimics a situation where a bank is allowed to participate in both traditional loan extension as well as proprietary trading activities. In the second extension, I restrict the baseline model to be characterized by a single credit market as in Iacoviello (2015), and make use of this extension to gauge the importance of credit market heterogeneity to the transmission of financial shocks.

I refer to the baseline model (that presented in section 2.3) as model 1, the extension to balance sheet dependence as model 2, and the single credit market economy as model 3. For brevity, I do not discuss the frameworks of these extensions in depth. In the case of model 2, I illustrate how balance sheet dependence is introduced and how it affects FIs' optimal behaviour. For model 3, I highlight the equations that are surplus to requirements for a single credit market economy and provide the complete set of equations for each model in appendix A.

2.4.1 A heterogeneous credit market economy with balance sheet dependence

In the baseline model (model 1), I assumed that the balance sheets of the FI loan and bond underwriting branches are independent of one another. As a result, bond and loan credit extension are not subject to the same financial constraints. In model 2, I reverse this assumption and introduce balance sheet dependence between branches by subjecting them to a common capital adequacy constraint. To be explicit, bar this change, the remainder of the model 2 setup is identical to that of model 1.

Defining aggregate FI capital as $E_t^f = E_t^l + E_t^b$, I impose balance sheet dependence by merging the capital constraints for model 1 as given by equations 2.32 and 2.33:

$$E_t^f \geq \vartheta \left[\varphi_l (L_t - \mathbb{E}_t \varepsilon_{t+1}^l) + \varphi_b (B_t - \gamma_f \mathbb{E}_t \varepsilon_{t+1}^b) \right]. \quad (2.48)$$

The balance sheet dependence between branches as suggested by equation 2.48 is akin to operational diversification within a bank. This constraint embodies a regulatory environment where agents are allowed to participate in multiple credit markets so that capital requirements need to be applied at a consolidated balance sheet level á la Basel III. In contrast, the balance sheet independence of model 1 embodies a regulatory environment where the prohibition of participation in proprietary trading activities sees that capital regulation can be applied at the branch level (BIS, 2010).

The first order conditions for D_t , B_t^h , B_t^f , and L_t are as follows:

$$m_t^f R_t^d = 1 - \lambda_t^f, \quad (2.49)$$

$$m_t^f \mathbb{E}_t R_{t+1}^h = 1 + \nu_f C_t^f - \lambda_t^f, \quad (2.50)$$

$$m_t^f R_t^b = 1 + \nu_f C_t^f - \kappa_b \lambda_t^f, \quad (2.51)$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_l \lambda_t^f. \quad (2.52)$$

$\Lambda_t^f \equiv \frac{\lambda_t^f}{C_t^f}$ gives the multiplier on constraint 2.48. Compared to the FI problem of model 1, the single capital constraint of model 2 produces a similar narrative for interest rate movements; however, the common multiplier (λ_t^f) that results from balance sheet dependence implies that interest rates will mimic each other much more closely in model 2 than in model 1. To ensure non-trivial financial intermediation in model 2, requires $\beta_f < \beta_h$ as this sees $\lambda^f > 0$. Similarly, a positive spread between R^l and R^b is ensured so long as $\nu_f < (\kappa_b - \kappa_l) \frac{\lambda^f}{C^f}$.²¹

2.4.2 A single credit market economy

To generate the framework for model 3, I reduce model 1 to an economy in which loans are the only form of credit. This change in model structure

²¹Note that a positive spread between R^h and R^d is already ensured from the household's side so long as $j < \frac{(1-\beta_h)qH^h}{C^h}$.

implies a removal of the underwriting role for FIs and assuming that households no longer invest in the bond market. Model 3's setup is thus a carbon copy of model 1's, except that it has no role for equations 2.5, 2.15, and 2.28. The complete set of equations for model 3 can be found in appendix A.2.

2.5 Estimation

The model is estimated using Bayesian methods over the sample period 1985Q1-2015Q1 for the U.S. economy. Following usual practice, I match the number of shocks to the number of observable variables and select observable variables that have a direct link to the shocks contained in the model. There are six shocks when both bond and loan markets are present, and five shocks in the single credit market economy (no bond shock). For the shock to household preferences (equation 2.3), I make use of household consumption data. Similarly, real estate price and entrepreneur real estate wealth data are used to identify the real estate and loan to value ratio shocks (equations 2.4 and 2.17). The technology shock (equation 2.19) is identified using real GDP data, whilst the financial shocks in loan and bond markets (equations 2.36 and 2.6) are identified with non-financial corporate bond and loan data. Each variable is log first differenced and de-meanned. Figure 2.4 provides a plot of the transformed data.²²

2.5.1 Calibration

Table 2.1 lists the parameters that are calibrated prior to estimation. The discount rates for households, entrepreneurs, and FIs are set as $\beta_h = 0.9925$, $\beta_e = 0.94$, and $\beta_f = 0.945$, respectively. These calibrated discount rates are coherent with binding constraints in equilibrium as given by conditions 2.12, 2.25, and 2.45. I set the weight on leisure in households' utility function as $\tau = 2$. This calibration sees households devote roughly a third of their available time to labour. Setting the household real estate preference as $j = 0.075$ and the share of real estate in production as $\alpha = 0.05$ implies an annualized ratio of real estate wealth to output of 3.67, similar to that found in Iacoviello (2015).

The minimum capital requirement is calibrated as $\vartheta = 0.1$ which is in line with Van den Heuvel (2008) and implies that each FI branch is required to hold at least 10% of the value of their assets in capital. A key novelty of the model lies in the risk weighted capital constraint applied to each FI branch. In this regard, I use the corporate risk weights provided in Basel

²²Appendix A.3 contains the source of the observed variables used for estimation.

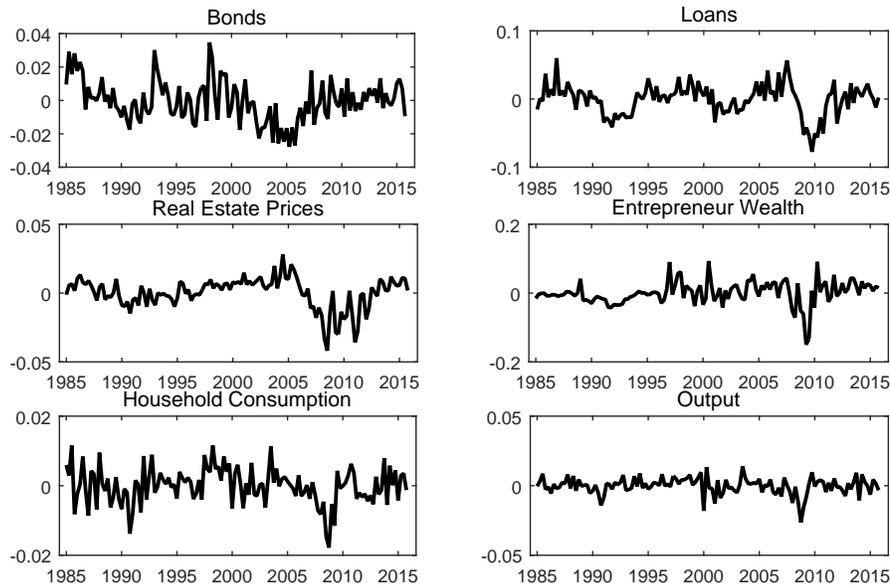


Figure 2.4: Data used in estimation. See appendix A.3 for data sources.

2 to calibrate the risk weight parameter for bonds and loans. Specifically, I make use of the AAA-rated corporate bond weight for $\varphi_b = 0.2$, and the unrated corporate debt weight for $\varphi_l = 1$ (BIS, 2006). Finally, I calibrate $\gamma_h = 0.98$ and $\gamma_f = 0.02$ as per the household and FI's steady state share of total entrepreneur bonds, ensuring that the bond shock is in fact a shock to the FI's liabilities. Given the utility costs that the FI faces from the risks of underwriting (see equation 2.26), this calibration for γ_h and γ_f nests the assumption that the FI is mostly successful as an underwriter in gauging household demand for bonds.

2.5.2 Prior distributions and posterior estimates

Table 2.2 contains the prior distributions and posterior estimates of the parameters. The prior distributions of the estimated parameters are reported in columns 3-5. I assume that all parameters are independent a priori and allow for their prior domains to cover a wide range of values. Here, I follow Iacoviello (2015) in being conservative with regards to the importance of shocks. Specifically, the prior means for the shock processes assumes that each shock accounts for 3% of the total variance in output and consumption.

The last three columns of table 2.2 contains the means as well as the 10% and 90% critical values for the estimated parameters. As evidenced by the difference between the prior and posterior distributions, the data appears

Table 2.1: Calibration of model parameters.

<i>Parameter</i>	<i>Symbol</i>	<i>Value</i>
Household discount factor	β_h	0.9925
Entrepreneur discount factor	β_e	0.94
Financial Intermediary discount factor	β_f	0.945
Financial intermediary disutility to underwriting	ν_f	0.1
Real estate share in production	α	0.05
Household real estate preference	j	0.075
Household labour supply parameter	τ	2
Capital to assets ratio	ϑ	0.1
Risk weight on loans	φ_l	1
Risk weight on bonds	φ_b	0.2
Household share of total bonds	γ_h	0.98
FI share of total bonds	γ_f	0.02

to be informative with regards to both the structural parameters as well as the stochastic processes. The estimated posterior mean for ν_h implies that households devote approximately 24% of their wealth to purchases of entrepreneurial bonds each period. The estimates for ν_e give a LTV ratio of 45% for entrepreneurs whilst a posterior mean of 0.35 for ω sees their financing mix tilted in favour of loans. The estimated autocorrelation parameters on the shock processes indicate quite a high degree of persistence in all shocks.

2.6 Credit market heterogeneity and financial shocks

In this section I assess the qualitative and quantitative relevance of credit market heterogeneity by contrasting the transmission of financial shocks across models 1, 2, and 3. Firstly, I contrast the transmission mechanism of loan shocks in models 1 and 3 to illustrate the attenuation benefits that arise when heterogeneous credit markets exist. Next, I investigate how balance sheet linkages influences this attenuation property by contrasting the transmission of loan shocks in models 1 and 2. Lastly, I compare the transmission mechanism of both loan and bond shocks in model 1 to illustrate the importance of an efficiently functioning financial sector to economic outcomes. As in Iacoviello (2015), both the bond and loan shock are designed to reflect balance sheet write-downs similar to that experienced by the banks during the financial crisis.

Table 2.2: Parameter estimates for model 1.

Parameter	Prior Distribution			Posterior Distribution			
		Mean	Density	Std. Dev.	10%	Mean	90%
Households bonds in total portfolio	v_h	0.06	gamma	0.05	0.1805	0.2345	0.2923
Loan-to-value ratio for entrepreneurs	v_e	0.7	beta	0.05	0.3535	0.4507	0.5416
Collateral share between bonds and loans	ω	0.5	beta	0.05	0.3028	0.3459	0.3871
Autocorr. tech shock	ρ_a	0.5	beta	0.1	0.9195	0.9415	0.9613
Autocorr. bond shock	ρ_b	0.5	beta	0.1	0.9428	0.9580	0.972
Autocorr. loan shock	ρ_l	0.5	beta	0.1	0.9943	0.9960	0.9977
Autocorr. HH pref shock	ρ_h	0.5	beta	0.1	0.9224	0.9435	0.9624
Autocorr. LTV shock	ρ_e	0.5	beta	0.1	0.9097	0.9292	0.949
Autocorr. house price shock	ρ_q	0.5	beta	0.1	0.8446	0.8717	0.8993
Std. dev. tech shock	t^a	0.003	invg	1	0.0137	0.0155	0.0172
Std. dev. bond shock	t^b	0.003	invg	1	0.0478	0.0610	0.0744
Std. dev. loan shock	t^l	0.003	invg	1	0.1311	0.1472	0.1632
Std. dev. HH pref shock	t^h	0.003	invg	1	0.1222	0.1674	0.2193
Std. dev. LTV shock	t^e	0.003	invg	1	0.0605	0.0895	0.1214
Std. dev. house price shock	t^q	0.003	invg	1	0.0814	0.0969	0.1114

The posterior density is constructed by simulation using the Random-Walk Metropolis algorithm (two chains with 30,000 draws each) as described in An and Schorfheide (2007).

The transmission mechanisms through which financial shocks in the loan market (loan shocks) affect the real economy are as follow. Loan shocks serve to reduce the level of the loan branch's capital, E_t^l . As a result, the loan branch has to reduce the quantity of loan credit extended to entrepreneurs in order to meet its capital requirement given by (2.32). This reduction in loan credit lowers entrepreneur demand for real estate through constraint 2.16, where the dynamic feedback that this constraint affords culminates in a downward spiral in real estate prices and credit quantities. Together, these effects see that loan shocks impart a persistent negative effect on asset prices and credit markets, and by extension, output. The introduction of a secondary credit market as per model 1 provides an alternative to the downward spiral in real estate prices and credit quantities as described above. Since entrepreneurs are able to access both bond and loan credit markets in model 1, reductions in the supply of one credit type as a result of a credit market specific shock can be attenuated by increases in the supply of credit from the unaffected market. In model 2, a common capital constraint as per (2.48) sees that loan and bond branch balance sheets are inter-dependent. As a result of this balance sheet dependence, loan shocks can spill over into the bond market limiting the attenuation impact as compared to model 1. In contrast, model 3 entrepreneurs are unable to substitute between credit types and, as a result, the impact of a loan shock can have a much more detrimental and persistent impact on aggregate output as compared to both models 1 and 2.

2.6.1 Financial shock in loan markets

To illustrate the shock attenuation property of credit market heterogeneity, I contrast the transmission of an innovation in $\iota_t^l \sim N(0, \sigma_l)$ in model 1 to that in model 3. Figures 2.5 to 2.6 below plot the impulse response functions (IRFs) of the main variables in models 1 and 3 to a negative loan shock.

Comparing the response of the variables that are common across both models, figure 2.5 clearly indicates that the presence of an additional credit market attenuates the impact of a negative loan market shock. Not only is the impact of the loan shock smaller in model 1 than in model 3, but the variables of model 1 return to equilibrium at a quicker rate than those of model 3. A similar narrative applies to the other variables in figure 2.5 in that they take much longer to return to equilibrium in the single credit market economy of model 3 than in its multiple credit markets counterpart.

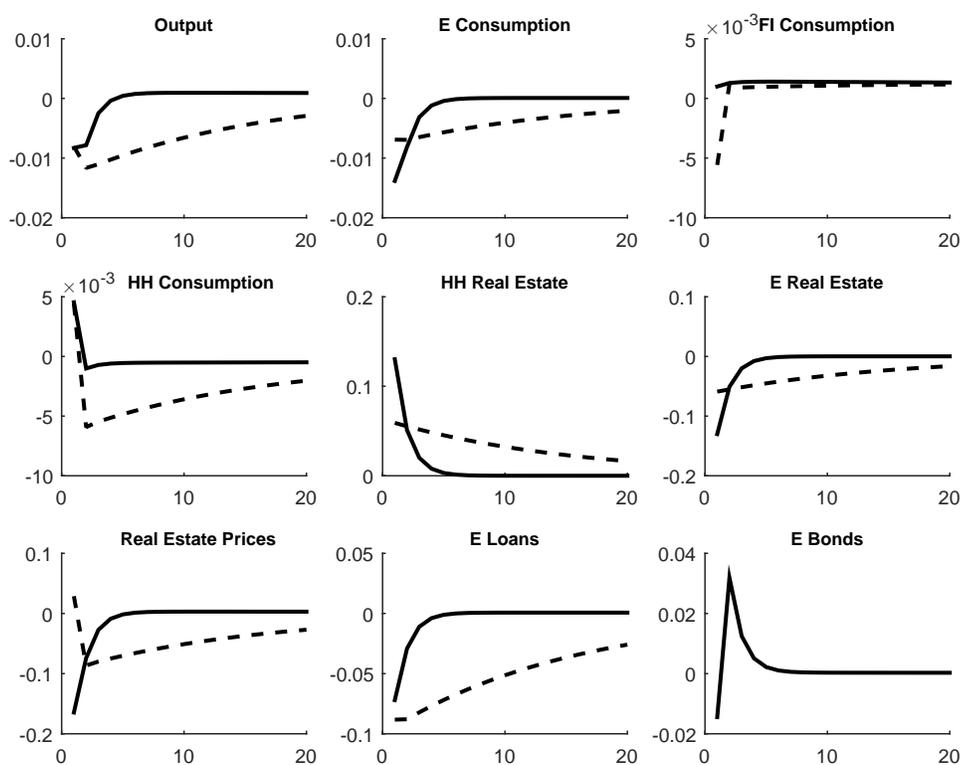


Figure 2.5: The impact of credit market heterogeneity (solid line: model 1; dash line: model 3).

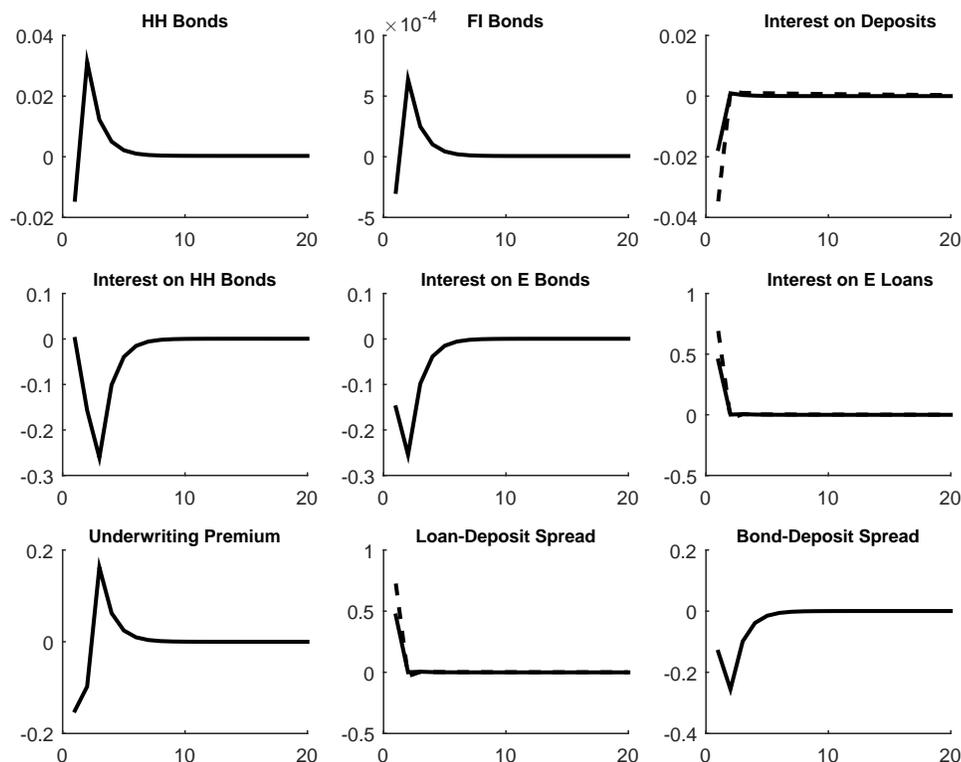


Figure 2.6: The impact of credit market heterogeneity (solid line: model 1; dash line: model 3).

The shock attenuation property of credit market heterogeneity works through asset prices and substitution toward alternative credit types. First, in model 1 real estate prices recover much quicker compared to their sustained negative response in model 3. Second, as shown in figure 2.5, although loans decline in both models following the shock, bonds increase marginally in model 1. Thus, the inclusion of an additional credit market has improved the resilience of the model's financial sector as evidenced by the quicker recovery of credit (loan) extension after the shock in model 1. Both, in turn, help output to recover quicker in the model with heterogeneous credit markets (model 1).

The results show that model 1 is able to replicate the shift toward bond finance witnessed in the data. Figure 2.6 indicates that the increase in bonds following the loan shock results mostly from an increase in household bond holdings, but also from a marginal increase in FI bond holdings. This shift

toward bond finance is facilitated by a reduction in bond interest rates, whilst the marginal increase in FI consumption (as per figure 2.5) is aided by a rise in the underwriting premium and the loan-deposit spread.

This reveals how operational diversification bolsters the financial sector's resilience by offering alternate revenue streams. The rise in the underwriting premium in combination with increased household bond holdings provide profits to the financial sector that help to attenuate the impact of loan losses²³. Here, it is prudent to highlight that the balance sheet independence between the two FI branches of model 1 implies that the model insights on operational diversification relate to the financial sector as a whole. Thus, a financial sector composed of agents that operate in heterogeneous markets is more resilient to financial shocks than a financial sector where all agents operate in the same market.

It is worth noting that the magnitude of variable responses are smaller than those of De Fiore and Uhlig (2015). Although this could partly be due to differences in shock size and origination, the attenuation of financial shocks under credit market heterogeneity could become amplified in my model vis-à-vis De Fiore and Uhlig (2015) via the contemporaneous impact of expected future market conditions.²⁴ With heterogeneous credit markets, the impact of shocks on both current and future market conditions is attenuated, reducing negative contemporaneous feedback from expected future market conditions. In this way, inter-period borrowing can introduce a virtuous feedback loop in a multiple credit market economy leading to amplified shock attenuation effects. In contrast, an intra-period framework would provide no such virtuous feedback link, explaining the disparity in magnitudes between the results presented here and those of De Fiore and Uhlig (2015).

Regardless of magnitude effect, model 1 successfully replicates the empirical evidence of bond and loan spreads during the 2007-2008 financial crisis; however, compared to figure 2.3, figure 2.6 shows that the baseline model is unable to replicate the rise in the bond-deposit spread post-2008. That being said, the relatively muted positive response of bonds to the loan shock matches the evidence contained in figures 2.1 and 2.2 where bonds depict a-cyclical behaviour.

²³Although the loan-deposit spread also increases as a result of the shock, lower loan holdings erode financial sector profits gained through this channel.

²⁴Whereas I estimate the size of the shock on US data, De Fiore and Uhlig (2015) calibrate their shock so that its response is in line with the EU data. Furthermore, whereas my shock originates on FI balance sheets and is isolated to the loan market only, theirs is modelled as a shock to the productivity of entrepreneurs' collateral in loan markets that affects both bond and loan markets.

2.6.2 Balance sheet dependence and shock attenuation

In this section I investigate how balance sheet dependence influences the shock attenuation properties of model 1 as described in section 2.6.1. To do so, I contrast the transmission of an innovation in $l_t^l \sim N(0, \sigma_l)$ in model 1 to that in model 2.

Figures 2.7 and 2.8 show that balance sheet linkages between FI branches imparts a non-negligible influence on the shock attenuation properties offered by heterogeneous credit markets. The response of model 2's variables are both larger and more persistent than those of model 1. Balance sheet dependence between FI branches also produces a further disparity between the models: in model 2 entrepreneurs are unable to shift toward bond finance in response to the loan market shock. Thus, as illustrated by the decline in entrepreneurial bonds in figure 2.7, balance sheet linkages allow for the loan market shock to spill over into bond markets.

Figure 2.8 reveals the causal chain behind the disparity in bond market dynamics between models 1 and 2. Although household bonds (B_t^h) increase by more in model 2 than in model 1, the common balance sheet of model 2 requires a much larger reduction in FI holdings of entrepreneurial bonds (B_t^f) which serves to dominate the rise in B_t^h . In comparison, balance sheet independence in model 1 allows both B_t^h and B_t^f to increase (see figure 2.6 for a clear illustration). Additionally, figure 2.8 shows that although deposit and loan interest rates behave similarly across models 1 and 2, the response of household and entrepreneurial bond rates are much more muted in model 1. As a result, the contemporaneous rise in the underwriting premium is larger in model 1 than that in model 2. Thus, benefits to revenue diversification are greater in the financial sector of model 1 than that of model 2.

Comparing figures 2.7 and 2.5 reveals a very similar response between models 2 and 3 to the financial shock for all common variables bar FI consumption and entrepreneurial loans. The positive response of FI consumption in model 2 following the shock is indicative of a more robust financial sector as compared to model 3. Further evidence in favour of model 2's financial robustness vis-à-vis model 3 can be found by comparing the impact of the financial shock on entrepreneurial loans. Compared to model 3, the impact of the loan shock is both shorter and less severe in model 2. Taken together, these results show that shock attenuation is present both when financial agents specialize in a specific credit market as well as when they diversify their operations across multiple credit markets.

Although the shock attenuation properties of model 2 are smaller than model 1, a comparison of models 2 and 3 shows that shock spill-over as a

result of balance sheet linkages within the financial sector do not erase all of the benefits offered by credit market heterogeneity. This suggests that, from an individual financial entity's perspective, the ability to operate over multiple credit markets is preferable to a Glass-Steagall environment as it affords diversification away from shock affected markets. These results are therefore coherent with both the literature which finds that operational diversification within a financial entity promotes financial stability as well as the literature which indicates that balance sheet linkages limit the degree to which revenue diversification can attenuate the impact of shocks (De Jonghe, 2010; Elsas *et al.*, 2010; Fomby *et al.*, 2012; Köhler, 2015). Specifically, I find that shock attenuation is most pronounced when the balance sheets of financial sector agents are independent as this removes a channel through which financial shocks can spill-over to unaffected markets.

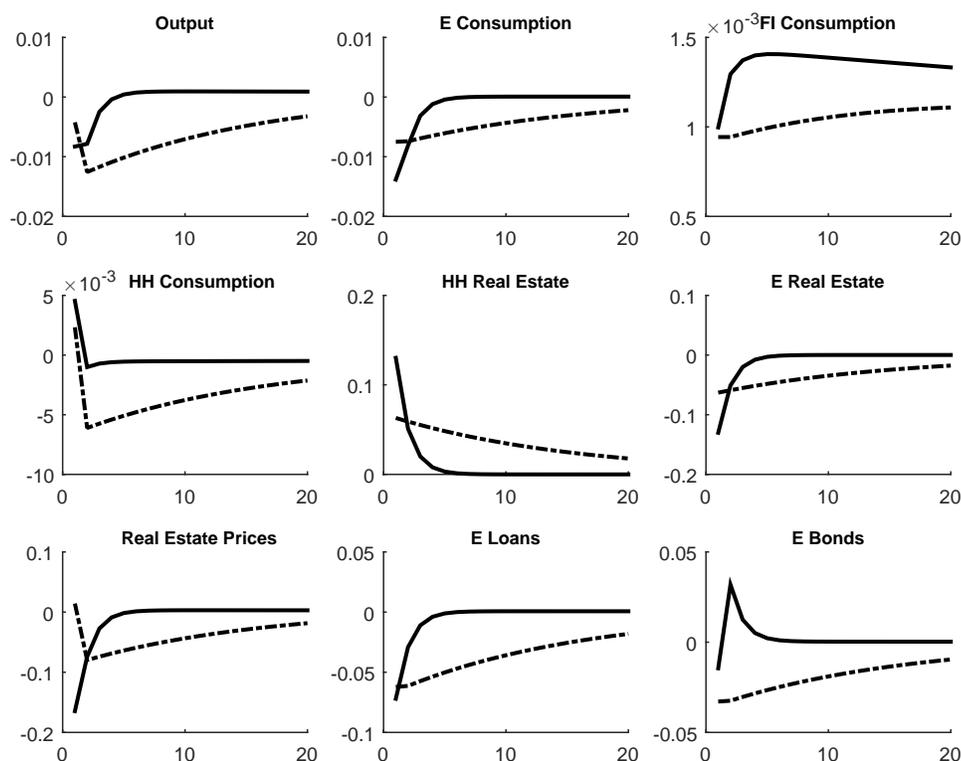


Figure 2.7: The impact of balance sheet independence (solid line: model 1; dash-dot line: model 2).

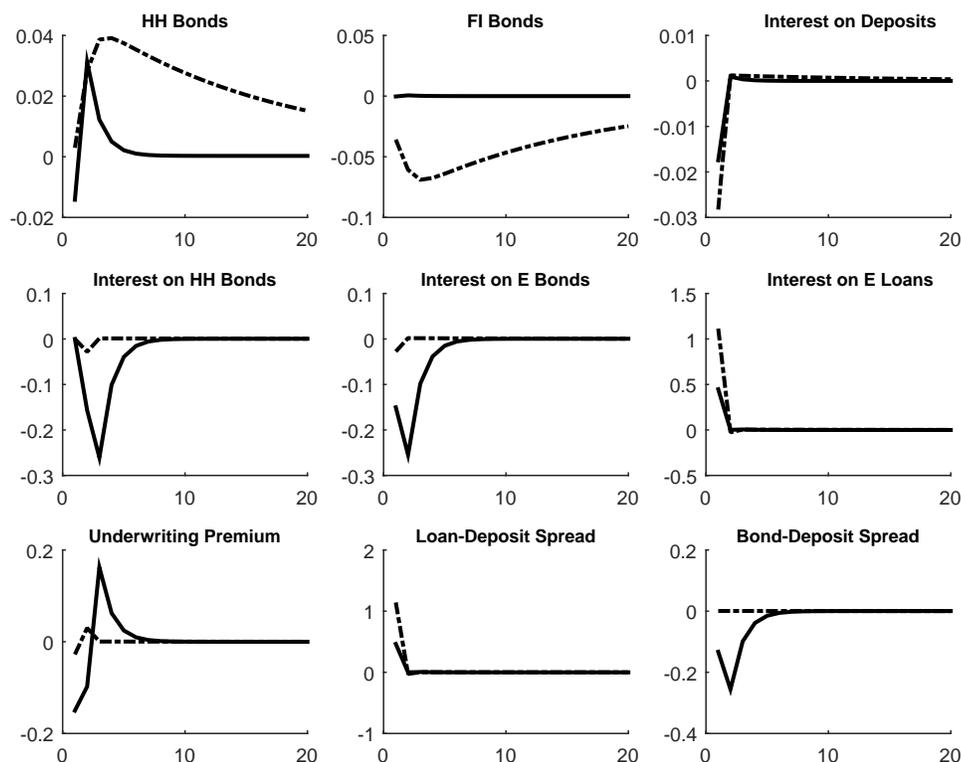


Figure 2.8: The impact of balance sheet independence (solid line: model 1; dash-dot line: model 2).

2.6.3 Financial shocks in bond and loan markets

In the final simulation exercise, I contrast the transmission of an innovation in $\iota_t^l \sim N(0, \sigma_l)$ to that of an innovation in $\iota_t^b \sim N(0, \sigma_b)$ in model 1. Figures 2.9 and 2.10 plot the IRFs of the main variables in response to a negative loan shock and bond shock in model 1.

As shown by figures 2.9 and 2.10, the impact of bond market financial shocks (bond shocks) differs from loan market financial shocks. In particular, bond shocks have a more muted impact than loan shocks, but last for longer. This disparity between the impact of a bond shock and a loan shock can be explained with reference to the household lending constraint (equation 2.5) and the FI's branch-specific capital constraints (equations 2.32 and 2.33). As these equations show, loan shocks are manifest on the balance sheet of the FI loan branch only, and thus realize a large reduction in loan

branch capital. In contrast, bond shocks are shared between households and the bond branch. Here, the fact that households hold 98% of the issued bonds in equilibrium, implies that bond shocks are mainly manifest as reductions in the bond branch's liabilities (B_t^h), with a small reduction required in bond branch capital. This difference between bond and loan shocks implies that loan shocks mostly affect the ability of the financial sector to efficiently intermediate funds, whilst bond shocks mostly affect the financial sector's access to said funds.

The more muted response of variables to the bond shock as compared to the loan shock can then be seen as illustrating how important a well functioning financial sector is in determining an economy's shock absorption capabilities. As per the discussion around equations 2.41 to 2.44, capital requirements reduce financial intermediation efficiency by introducing a spread between lending and borrowing interest rates. Because loan shocks require a large adjustment to the loan branch's capital, these shocks increase the friction associated with capital requirements. This prohibits the efficient flow of funds from savers to borrowers and results in a large decline in aggregate economic activity. Bond shocks serve mainly to reduce the bond branch's liabilities, requiring a smaller adjustment in bond branch capital than the reduction in loan branch capital following a loan shock. As a result, the friction associated with capital requirements is smaller under bond shocks compared to loan shocks. This implies that bond shocks bear less adverse consequences for the efficiency of financial intermediation, culminating in a more muted impact on the economy in comparison to a loan shock.

The disparity between the persistence of bond shocks and loan shocks can be explained with reference to their impact on household wealth. As per constraint (2.5), when bond shocks serve to decrease household wealth, and since households represent the savers of the economy, a shock to their wealth reduces their demand for both deposits and bonds. This prevents substitution between credit types as was seen (see figure 2.5) which leads to shock persistence. In contrast, because loan shocks are borne entirely by the financial sector, households are able to offer additional credit via their demand for entrepreneur bonds following a loan shock. Credit extension therefore recovers quicker under loan shocks than bond shocks, which explains why bond shocks are more persistent than loan shocks.

In summary, the simulations performed in section 2.6.1 above reveal that credit market heterogeneity plays an important role in attenuating the impact of financial shocks by allowing borrowers to substitute away from affected credit markets. Section 2.6.1 also illustrated how operational diversification within the financial sector can contribute to its resilience in response

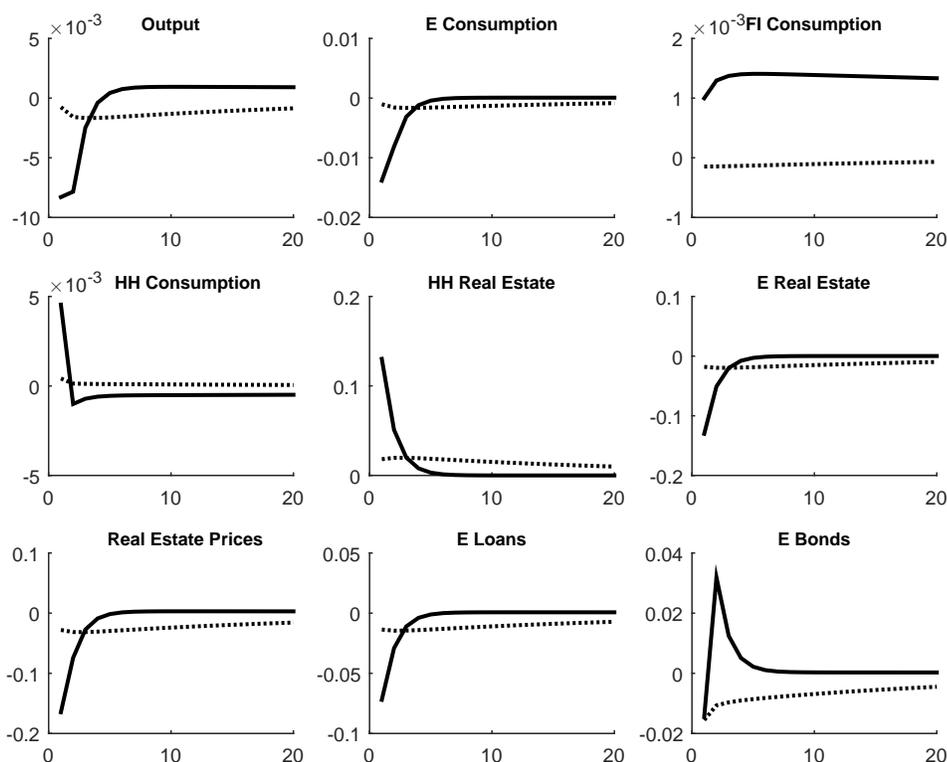


Figure 2.9: Bond shocks (dotted line) vs. loan shocks (solid line).

to market specific shocks by affording access to revenue streams from unaffected markets. Building on this result, section 2.6.2 indicates that balance sheet linkages between financial agents play an important role in determining the degree to which operational diversification can attenuate the impact of financial shocks. When the balance sheets of financial agents are interdependent, benefits to operational diversification are limited as a result of shock spill-over. These results indicate that, from a financial regulator's perspective, a Glass-Steagall environment may be preferable as this regulatory setup precludes balance sheet spill-over effects that can reduce the attenuation benefits associated with credit market heterogeneity. Nevertheless, a comparison between models 2 and 3 showed that this spill-over does not completely erode the attenuation benefits of credit market heterogeneity. Thus, from an individual financial entity's perspective, a Glass-Steagall regulatory environment may be sub-optimal. This sub-optimality stems from the fact that such a regulatory environment leaves balance sheets fully ex-

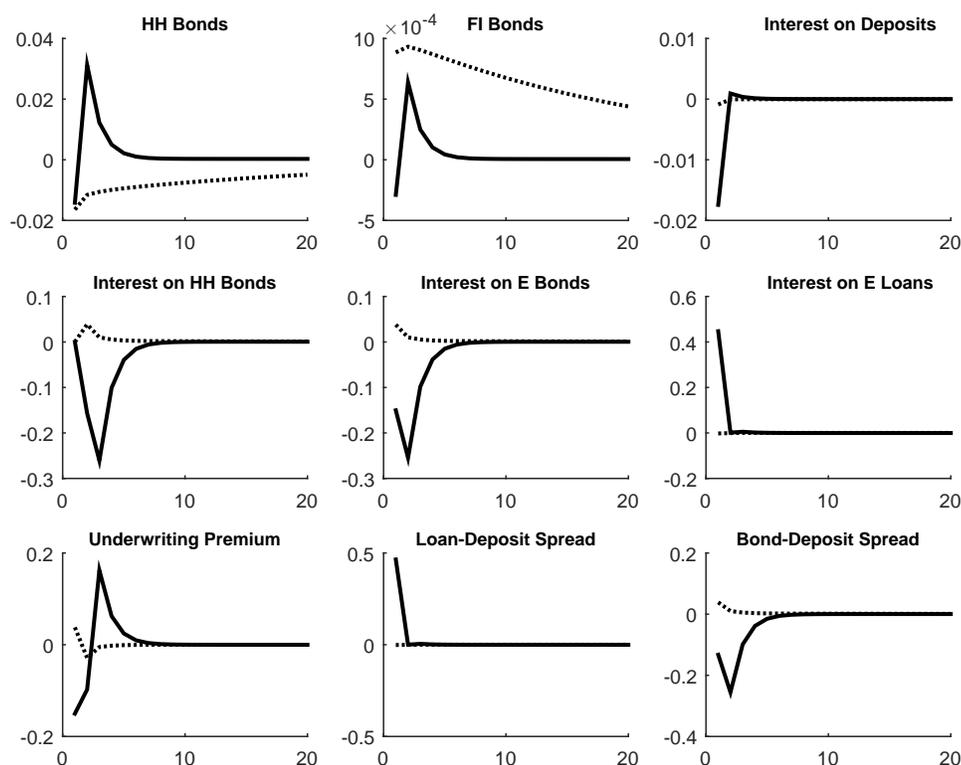


Figure 2.10: Bond shocks (dotted line) vs. loan shocks (solid line).

posed to shocks from the credit market to which financial entities are constrained. Instead, if financial entities were allowed to operate across multiple credit markets, their exposure to credit market specific shocks could be reduced. Finally, section 2.6.3 shows that the origination of financial shocks can influence both the size and persistence of their impact. When shocks are borne by savers (households) as opposed to FIs, the size of their impact on the real economy is limited since it does not reduce the efficient functioning of the the financial system. At the same time, when savers are directly hit by financial shocks, the impact thereof can be very persistent by way of limiting the aggregate amount of savings in the economy. Shocks that are borne by FIs have a more severe, but less persistent impact on the real economy. The severity of the impact results from reduced financial sector efficiency in intermediating fund flows from savers to borrowers, whilst reduced shock persistence stems from the limited impact that FI borne shocks have on aggregate savings.

2.7 Conclusion

This essay presents a model where two credit markets exist and studies the qualitative and quantitative relevance of credit market heterogeneity in a general equilibrium setting. The model framework allows the financial sector to perform both loan extension and bond underwriting activities which affords a comparison between the transmission of financial shocks where a single representative credit market is assumed to a scenario where multiple credit markets exist. Furthermore, the introduction of an additional credit market affords a contrast of the impact of credit market specific shocks. I estimate the model using US data and show that credit market heterogeneity can help mitigate the impact of financial shocks. Additionally, the findings indicate that the financial sector is more robust to balance sheet shocks in a framework that incorporates credit market heterogeneity as evidenced by a quicker recovery in credit extension. Lastly, I find that financial sector resilience to financial shocks is decreasing in the degree of balance sheet dependence between financial agents and that the origination of financial shocks bears implications for both the size and persistence of their impact.

To focus on the role played by financial sector balance sheets in the transmission of financial shocks, this essay opts for a simplistic real business cycle model structure without nominal rigidities or borrower risk. The introduction of nominal rigidities in the real sector are unlikely to alter the intuition behind financial sector balance sheets acting as mechanisms for the propagation of financial shocks. The results should also be insensitive to borrower risk; however this model feature could have a distributional impact. I leave an assessment into the role of these features for future research.

Chapter 3

Flow specific capital controls for emerging markets

This essay investigates the impact of capital controls on business cycle fluctuations and welfare. To perform this analysis, the essay deploys an asymmetric two country model that is subject to negative foreign interest rate shocks. The results show that both an inflow and outflow capital control are able to attenuate capital flow dynamics, but each control bears different implications for macroeconomic outcomes. Whilst the outflow capital control is associated with shock attenuation benefits, the inflow capital control is shown to amplify the impact of shocks. Easier capital control regimes enhance the attenuation and amplification properties associated with each capital control, whilst strict regimes do the opposite. Lastly, the welfare analysis shows that the welfare effects of capital controls are agent dependent, and that society prefers the outflow capital control to the inflow capital control. Taken together, these results are indicative of the comparative desirability of capital controls imposed on the financial sector (outflows) as compared to the real sector (inflows).

3.1 Introduction

The post financial crisis period has been characterized by a rise in emerging economies' use of foreign capital markets to meet their demand for credit. Following Al-Saffar *et al.* (2013) and Catão and Milesi-Ferretti (2014), this reliance on foreign credit markets leaves emerging markets vulnerable to output losses, with support growing for the use of capital controls to deal with

this external vulnerability (Fritz and Prates, 2014; Shin, 2014).¹ In this regard, the deployment of capital controls is usually motivated with reference to their effectiveness in curbing privately optimal behaviour that results in socially sub-optimal overborrowing (see e.g., Brunnermeier and Sannikov, 2015). Indeed, emerging markets have a history of capital control deployment to address concerns related to the dynamics of their foreign debt (see e.g., Eichengreen *et al.*, 2007; Forbes *et al.*). Through restricting participation in international credit markets, capital controls can increase emerging market reliance on domestic sources of credit, limiting their balance sheet vulnerability to foreign shocks (Burger and Warnock, 2006; Hale *et al.*, 2016).

The influence of monetary policy on lender risk appetite indicates that easy monetary conditions in advanced economies facilitated emerging market access to foreign sources of credit. Bruno and Shin (2015) find that reductions in the Fed policy rate serve to dampen global risk perceptions which serves to stimulate cross-border lending. Ahmed and Zlate (2014) show that reductions in risk perception are associated with net capital inflows into emerging markets. Similarly, Forbes and Warnock (2012) find that global risk factors are associated with extreme capital flow episodes. Rey (2015) proffers further evidence on the influence that advanced economy monetary policy bears on emerging market access to foreign credit, where this influence is predicated on a global financial cycle driven by the stance of U.S. monetary policy.

By plotting the total amount of outstanding international debt securities for non-financial corporations in Brazil and China, figure 3.1 illustrates the emerging market shift toward foreign credit markets. Since 2008, there has been a marked increase in the foreign liabilities of both countries. The outstanding amount of U.S. dollar (USD) denominated foreign liabilities of Chinese non-financial corporations was more than 5 times bigger in 2016Q3 than in 2010Q1. In Brazil, the USD liabilities of non-financial corporations almost tripled between 2010Q1 and 2016Q3. Although I only report the data for China and Brazil, the same narrative holds for other emerging markets such as India, Russia, and South Africa. Indeed, Shin (2014) finds that the post crisis period has seen a marked increase in emerging market debt issuance on advanced country credit markets. Consistent with the empirical evidence on the influence of monetary policy on lender risk appetite, figure

¹Al-Saffar *et al.* (2013) find that emerging market output is more adversely affected by increases in their gross external liabilities than advanced markets. Catão and Milesi-Ferretti (2014) find that the ratio of net foreign liabilities to GDP is a significant crisis predictor. For a discussion on the surge in global liquidity following the financial crisis, see Shin (2014). See Fritz and Prates (2014) for evidence on institutional support for active management of the capital account.

3.2 shows that this switch toward foreign credit markets occurred during a period where interest rates were comparatively lower in the U.S. than in emerging markets.

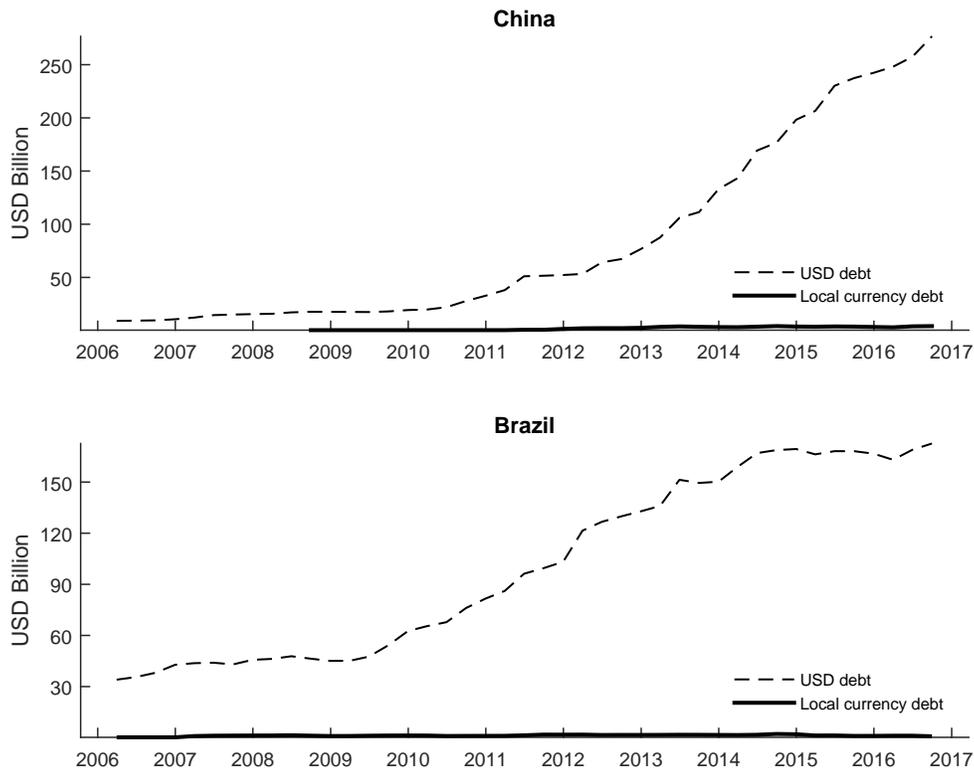


Figure 3.1: The outstanding international debt of non-financial corporations in USD (dotted line) and local currency (solid line). See appendix B.2 for source details.

This essay tests the efficacy of capital controls in curbing this shift toward foreign credit markets by comparing the dynamics and welfare implications of models where capital controls are present, to a baseline scenario where no such controls exist. To conduct this analysis, I design an asymmetric two-country framework with flow specific capital controls and credit market heterogeneity. This asymmetric model structure facilitates the adoption of an emerging market perspective whilst credit market heterogeneity affords the post 2008 emerging market switch toward foreign credit markets. In line with figures 3.1 and 3.2, this approach places focus on the

home economy (emerging markets) whilst still affording endogenously determined foreign economy (advanced countries) dynamics.

I embed the asymmetric model structure by assuming that the home economy is a net international creditor, and that it is characterized by comparatively less developed financial markets. The higher levels of financial market development in advanced economies is well established in the literature, whilst the net international creditor position of the home economy is in accordance with the savings-glut hypothesis put forth by Bernanke (2005)². Because foreign financial markets are more developed than their home counterparts, financial intermediation is only explicit in the home economy. This approach is coherent with Mendoza *et al.* (2009), where differences in financial market development are defined with reference to the enforceability of contracts. In line with Reinhart and Rogoff (2015), I further assume that financial repression is seen as unnecessary in advanced economies, and so, capital controls are only present in the home economy³.

I contrast an inflow capital control which is imposed on the real sector, to an outflow capital control which is imposed on the financial sector. Each flow specific capital control can be interpreted as a balance sheet restriction that can feasibly be implemented by emerging market authorities. The inflow capital control is introduced as a variant of the collateral constraints found in Iacoviello and Minetti (2006). This strategy sees the inflow capital control manifested as a restriction on the home entrepreneur's ability to allocate collateral to foreign credit markets. In this way, the inflow capital control exerts direct influence over capital inflows and can serve to increase the prominence of home credit markets on home entrepreneur balance sheets. The outflow capital control is in the spirit of Tobin (1978) and is manifested as a limit on the proportion of foreign assets on the home financial intermediary's (FI) balance sheet. Through this direct influence over capital outflows, the outflow capital control is able to increase the proportion of home credit on FI balance sheets.

This essay contributes to the literature on three fronts. Firstly, the capital controls that I study are flow specific. This implies that they are not modelled as taxes on foreign debt, but rather as quantitative limits on foreign

²See Edwards (2007), Reinhardt *et al.* (2013), Eichengreen and Rose (2014), and De Nicolò and Juvenal (2014) for evidence on the comparatively higher level of financial development in advanced economies vis-a-vis emerging markets.

³Eichengreen and Rose (2014) proffer further rationalization for this structural asymmetry by showing that advanced economies are significantly less likely to implement capital controls than developing countries. One can vindicate this belief with reference to the superior mobility of capital in advanced as compared to emerging economies and comparatively higher levels of financial development in advanced economies.

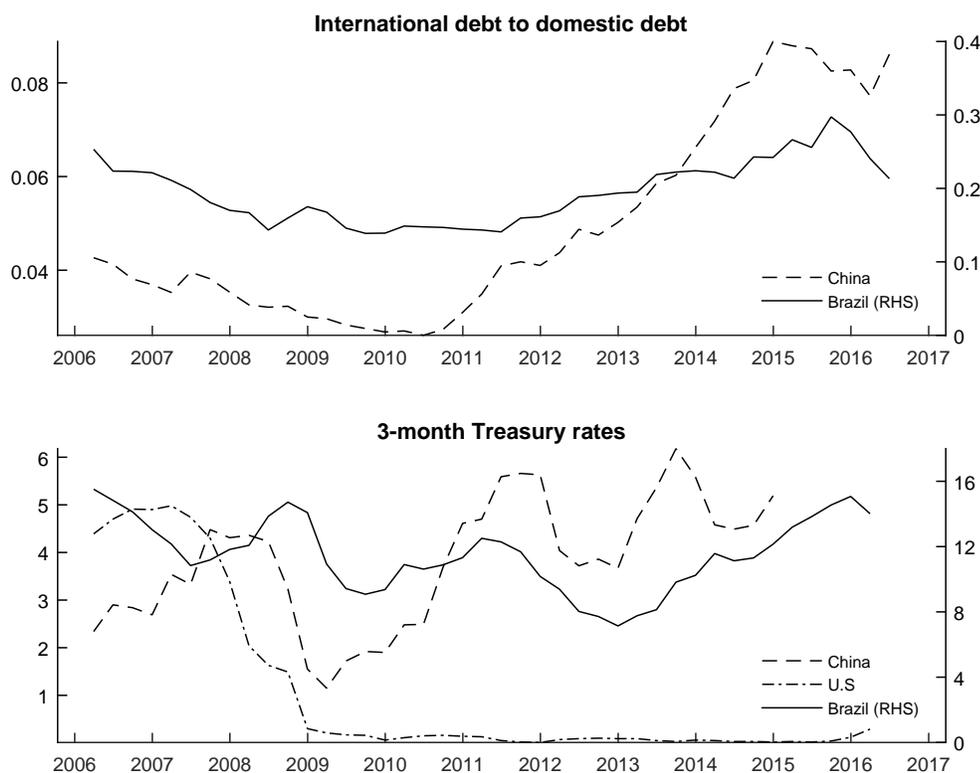


Figure 3.2: Emerging market international debt to domestic debt ratio and 3-month Treasury rates in advanced and emerging markets. See appendix B.2 for source details.

borrowing and lending. Previous studies deployed capital controls as a tax on net foreign borrowing, but because households are the only agents that borrow in these models, this approach cannot distinguish between tightening an inflow capital control and easing an outflow capital control. As a result, a tax on capital inflows is simultaneously a subsidy on capital outflows (and vice-versa, see e.g., Korinek, 2011; Bianchi and Mendoza, 2013; Farhi and Werning, 2014). The flow specific nature of the capital controls studied here implies that each one is imposed on a different agent, affording an analysis of the agent specific welfare effects of capital controls. This comprises the second contribution of this essay as the studies cited above focus on the social welfare implications of capital controls (see e.g., Jeanne and Korinek, 2010; Bianchi, 2011)). The final contribution of this paper stems from the fact that, in this analysis, financial frictions fall on both borrowers

and lenders. This contribution is synonymous with an investigation into flow specific capital controls and affords a contrast between capital controls imposed on the real sector to those imposed on the financial sector. In previous studies, the use of a single financial friction prevents such a comparison (Kitano *et al.*, 2016).

The results show that both the inflow and outflow capital control are effective tools for managing capital flows.⁴ However, the inflow capital control bears different implications for business cycle dynamics than the outflow capital control. In this regard, the inflow capital control amplifies the effect of foreign interest rate shocks on the business cycle, whilst the outflow capital control attenuates the effect of foreign interest rate shocks. The attenuation property of the outflow capital control and the amplification property of the inflow capital control result from their influence over the entrepreneur's ability to exploit the comparative cheapness of foreign credit markets following the shock. In the framework deployed for this analysis, optimal collateral allocation generates benefits by affording the entrepreneur freedom in exploiting differences in the cost of credit between home and foreign markets. The inflow capital control precludes such behaviour by directly constraining the entrepreneur's ability to allocate collateral to foreign credit markets. As a result, its presence effectively removes the shock absorption properties associated with optimal collateral allocation, resulting in amplified business cycle dynamics relative to the baseline. The outflow capital control does not impart such a direct influence over optimal collateral allocation. Instead, it provides a channel through which easier foreign credit market conditions can spill-over to home credit markets. This spill-over reduces the entrepreneur's incentive to shift toward foreign credit markets, resulting in attenuated business cycle dynamics relative to the baseline.

I test the sensitivity of these findings to changes in the capital control regime, and find that the implications of such changes are capital control dependent. In the case of the inflow capital control, easier regimes serve to increase the entrepreneur's exposure to foreign credit markets, resulting in heightened inflow sensitivity to foreign interest rate shocks. As a result, easier inflow capital control regimes serve to enhance the business cycle amplification property associated with this flow specific capital control. For the outflow capital control, easier regimes serve to increase the FI's exposure to

⁴The baseline model (no capital controls) replicates the emerging market shift toward foreign credit markets following a negative foreign interest rate shock, and generates business cycle moments that match the data quite well. Upon introduction of each flow specific capital control, the shift toward foreign credit markets is constrained, resulting in the attenuation of inflows and outflows relative to the baseline.

foreign assets, facilitating the spill-over of easier foreign credit market conditions to the home credit market. This implies that easier outflow capital control regimes serve to enhance the business cycle attenuation property of this flow specific capital control.

A comparison of social welfare dynamics under each capital control shows that, although both controls are effective at managing capital flows, society exhibits a strict preference for the outflow capital control over the inflow capital control. This preference results from the attenuation property associated with the outflow capital control, where its introduction improves on baseline social welfare dynamics. In contrast, shock amplification under the inflow capital control culminates in social welfare losses relative to the baseline. Lastly, this analysis indicates that capital controls have agent specific welfare consequences. An easing of foreign credit market conditions is welfare enhancing for entrepreneurs and welfare reducing for FIs. By removing their ability to exploit the cheaper cost of foreign credit, the inflow capital control sees the entrepreneur's welfare gain become a welfare loss. In contrast, the outflow capital control is able to mitigate the welfare loss that FIs associate with foreign interest rate shocks, leading to an improvement in FI welfare dynamics under the outflow capital control.

The rest of the paper is structured as follows. Before commencing with a description of the model setup, section 3.2 discusses the implications of the asymmetric modelling strategy, focussing on capital flows, capital controls, and negative foreign interest rate shocks. The model framework and calibration are presented in sections 3.3 and 3.4. Next, I assess the behaviour of the baseline model without capital controls in section 3.5. The impact of flow specific capital controls is analyzed in section 3.6, whilst the welfare effects associated therewith are investigated in section 3.7. Finally, section 3.8 concludes.

3.2 A primer on capital flows, capital controls, and foreign interest rate shocks

The asymmetric nature of the model takes the perspective of an emerging market economy, henceforth termed the home country. As a result of this perspective, capital inflows are reflected as changes to the foreign liabilities of the home country, whilst capital outflows affect its stock of foreign assets. In turn, the difference between the change in capital inflows and the change in capital outflows gives the change in net flows. Thus, net inflows imply that capital inflows were larger than capital outflows whilst the opposite

applies for net outflows.

In the model presented here, home country entrepreneurs incur foreign liabilities whilst home country FIs accumulate foreign assets. Thus, an increase in inflows is defined as an increase in the home entrepreneur's foreign liabilities, whilst an increase in outflows is defined as an increase in the home financial intermediary's foreign assets. Analogously, a decrease in inflows is defined as a decrease in the home entrepreneur's foreign liabilities whilst a decrease in outflows is defined as a decrease in the home financial intermediary's foreign assets.

The home economy's level of foreign liabilities is dependent on the credit ceiling of home borrowers in foreign credit markets as determined by their foreign credit market collateral constraint. In a similar fashion, the level of foreign assets owned by the home economy is determined by the collateral constraint of foreign economy borrowers. This demand-side approach to modelling credit access is standard in the literature as it affords dynamic feedback between credit markets and borrower wealth (see e.g., Kiyotaki and Moore, 1997; Bernanke *et al.*, 1999).⁵ As a result, capital inflows are driven by the home economy's demand for foreign credit whereas capital outflows are driven by the foreign economy's demand for credit.

Negative foreign interest rate shocks increase the present value of borrower collateral allocated to foreign credit markets, which leads to higher demand for foreign credit by both home and foreign borrowers. In turn, this increase in demand for foreign credit (by home and foreign borrowers) realizes a simultaneous increase in capital inflows and capital outflows. That is to say, both the foreign liabilities and foreign assets of the home economy increase following a negative foreign interest rate shock. The increase in foreign assets is counter-intuitive, as one would expect home economy accumulation of foreign assets to decline when the return that they offer decreases (see e.g., Cerutti *et al.*, 2017).

Figures 3.2 and 3.3 provide some empirical backing for the increase in home economy foreign assets, indicating that emerging market supply of foreign direct investment to advanced countries is relatively insensitive to declines in foreign interest rates. Data limitations on bilateral capital flows restrict my focus to outward foreign direct investment and the 2006-2012 period. Thus, the period covered by figure 3.3 is shorter than that of figure 3.2; however it does span implementation of the quantitative easing programs of the Federal Reserve (Eichengreen and Gupta, 2015; Feyen *et al.*, 2015). Similarly, although focusing on outward foreign direct investment

⁵Since collateral constraints are imposed on borrowers, they operate on the demand-side of the credit market.

precludes any insights on whether emerging markets increased their purchases of advanced economy debt securities or equities, it can still serve as a proxy of emerging market demand for advanced economy assets since such investments reflect a lasting interest and control in an enterprise resident in a foreign country (Buckley *et al.*, 2007). Nevertheless, this model characteristic cautions against the applicability of this analysis across all emerging markets. Indeed, the empirical evidence indicates that the impact of advanced economy monetary policy varies greatly across emerging markets (see e.g., Eichengreen and Mody, 1998; Arora and Cerisola, 2001; Ferrucci, 2003; Ahmed *et al.*, 2017).

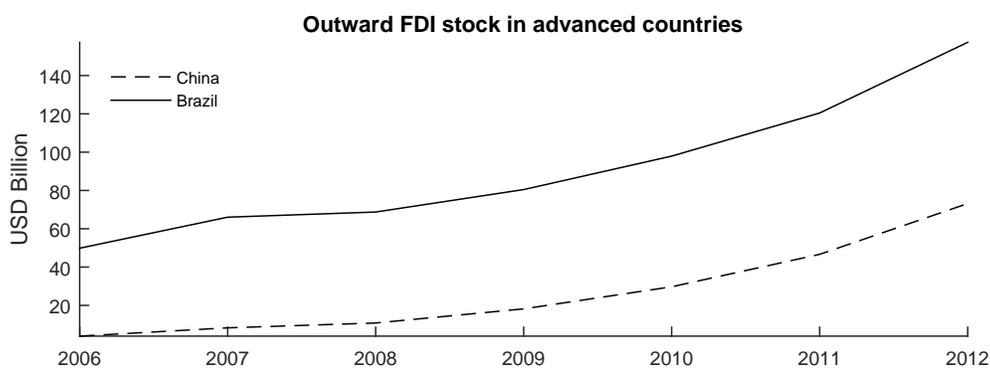


Figure 3.3: The stock of outward FDI held by emerging markets in developed economies. See appendix B.2 for source details.

The distinction between capital inflows and outflows in the model affords the introduction of flow specific capital controls by home authorities that can reduce the increase in net inflows to the home country. Since demand for foreign credit by home borrowers lies at the heart of capital inflow behaviour, the inflow capital control takes the form of a quantitative restriction on foreign borrowing by these agents (home entrepreneurs). Home regulators have no authority over foreign borrowers, and so cannot impose an outflow capital control on foreign borrowers. Instead, the outflow capital control takes the form of a quantitative restriction on home agent (FI) purchases of foreign assets.

The impact of these flow specific capital controls on inflows, outflows, and the business cycle are assessed by comparing the dynamics of a baseline model where these controls are absent, to one where either the inflow capital control or the outflow capital control are present. This approach is used to

indicate whether the capital controls attenuate or amplify the impact of a negative foreign interest rate shock on capital flows and the business cycle.

I test the sensitivity of these findings to changes in capital control regulation when either of the two capital controls are present. Here, I distinguish between baseline, strict, and easy flow specific capital control regimes. For both capital controls, strict regimes reduce the economy's exposure to foreign credit markets – foreign liabilities in the case of the inflow control, foreign assets in the case of the outflow control – relative to the baseline regime, whilst the opposite occurs under the easy regime. This exercise indicates how changes to each capital control influence its attenuation or amplification effects on capital flows and the business cycle.

3.3 The model

The world economy is populated by citizens of the home country (H) and citizens of the foreign country (F). The home country's citizens consist of households, entrepreneurs, and FIs. In the foreign country, a comparatively higher level of financial development precludes the need for explicit financial intermediation, and so their citizenship is composed of households and entrepreneurs only. Thus, I liken the home country to an emerging market economy, and the foreign country to an advanced economy.

As in Obstfeld and Rogoff (1995), trade between countries occurs exclusively through financial markets. I follow the standard approach, assigning the role of saver to households and that of borrower to entrepreneurs. Home entrepreneurs have access to the credit markets of both countries whilst foreign entrepreneurs make use of the foreign country's credit market only. Here, the model's asymmetrical structure sees that home households provide FIs with deposits which are used for credit extension. In comparison, foreign households can extend credit to home entrepreneurs directly. This asymmetrical model structure allows for an equilibrium spread between home and foreign interest rates and concurs with previous studies that identify country specific factors as important determinants of sovereign interest rate spreads (see e.g., Uribe and Yue, 2006; Bellas and Papaioannou, 2010; Kennedy and Palerm, 2014).⁶

Global risk sharing is imperfect in this asymmetric framework because financial markets are incomplete. Financial market incompleteness results from the presence of collateral constraints in both economies and a capi-

⁶The model's asymmetrical structure sees that foreign entrepreneurs can only access credit from the home FI; however the results are insensitive to allowing the foreign household to also extend credit to the foreign entrepreneur.

tal requirement for home FIs. As noted by Heaton and Lucas (1996) and Corsetti *et al.* (2008), when financial markets are incomplete, individuals are unable to adequately insure against country specific shocks. Thus, financial frictions in both the home and foreign economy retard the efficient transfer of resources between countries such that global risk-sharing is imperfect.

The model's transmission channel comprises the effect that changes in collateral values have on home entrepreneur credit ceilings. This channel works through dynamic feedback between credit ceilings and expected collateral values and is standard in models with collateral constraints à la Kiyotaki and Moore (1997). Here, home entrepreneur access to two credit markets requires two collateral constraints whereas restricting foreign entrepreneurs to foreign credit markets sees that they are only subject to one collateral constraint. The specification for the home entrepreneur's collateral constraints follows Iacoviello and Minetti (2006) and implies that home FIs face constant average liquidation costs whilst those of foreign households are increasing in the value of home entrepreneur collateral. This difference between the liquidation costs faced by home and foreign lenders implies that the dynamic feedback between home collateral values and inflows is less efficient than that between home collateral values and home loans. As a result, lower foreign interest rates are relatively inefficient in realizing virtuous feedback with home collateral values.

Departing from this baseline scenario, I assess the implications of flow specific capital controls that restrict home entrepreneur and FI participation in foreign credit markets. Here, the framework affords distinction between an inflow capital control that imparts direct influence over inflows, and an outflow capital control that directly influences outflows. The flow specific nature of these two instruments implies that introduction of the inflow capital control requires an adjustment to the baseline home entrepreneur optimization problem, whilst the outflow capital control requires an adjustment to the optimization problem of the home FI.

I subject this asymmetric framework to negative foreign interest rate shocks that serve to realize the shift toward foreign credit markets as depicted in figures 3.1 and 3.2. These shocks reduce the relative inefficiency of the home entrepreneur's foreign collateral constraint, facilitating the switch toward foreign credit markets.

This framework is presented in the next section, where I differentiate between countries by denoting country F 's variables with a star. I first consider a baseline version of the model where no capital controls are present (sections 3.3.1 – 3.3.4) and then describe the addition of flow specific capital controls in section 3.3.5. The full set of model equations can be found in appendix B.1.

3.3.1 Home households

The representative home household maximizes its lifetime utility function given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \{ \log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \}, \quad (3.1)$$

where β_h gives the home household's discount factor, whilst $\tau > 0$ and $j > 0$ are coefficients that govern the utility generated by leisure ($1 - N_t$) and real estate (H_t^h). Household consumption is denoted by C_t^h .

The maximization of household utility is restricted by their budget constraint as given by

$$C_t^h + q_t(H_t^h - H_{t-1}^h) + D_t = W_t N_t + R_{t-1}^d D_{t-1}. \quad (3.2)$$

The term $q_t(H_t^h - H_{t-1}^h)$ captures real estate purchases by the household where q_t denotes the domestic price of real estate. Households make use of interest income ($R_{t-1}^d D_{t-1}$) on their deposits (D_t) as well as labour income ($W_t N_t$) to finance their purchases of real estate.

This setup sees optimal behaviour in labour, real estate, and credit markets as given by:

$$q_t = \frac{j C_t^h}{H_t^h} + m_t^h \mathbb{E}_t q_{t+1}, \quad (3.3)$$

$$W_t = \frac{\tau C_t^h}{1 - N_t}, \quad (3.4)$$

$$1 = m_t^h R_t^d. \quad (3.5)$$

where $m_t^h \equiv \frac{\beta_h C_t}{\mathbb{E}_t C_{t+1}^h}$ gives the home household's stochastic discount factor.

The first order condition for labour supply (3.4) shows that the optimal household wage rate is given by the marginal rate of substitution between consumption and leisure. Equation 3.3 indicates that households require the present value of utility benefits associated with real estate accumulation to equate to the utility lost through postponed consumption. Lastly, the first order condition for deposits sees the interest rate on deposits to equate to the inverse of the household's stochastic discount factor.

3.3.2 Home entrepreneurs

Home entrepreneurs seek to maximize their lifetime utility as generated by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{\log(C_t^e)\}, \quad (3.6)$$

where β_e denotes entrepreneurs' discount factor and C_t^e gives entrepreneurial consumption.

The budget constraint of entrepreneurs is given by

$$C_t^e + q_t(H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + S_t R_t^H B_{t-1}^H + W_t N_t = Y_t + L_t + S_t B_t^H. \quad (3.7)$$

L_t gives loan finance obtained from home FIs that accrues state-dependent gross interest of R_t^l , whilst B_t^H denotes foreign capital inflows on which state-dependent gross interest of R_t^H is paid. The real exchange rate (home goods in terms of foreign goods) is given by S_t , and I assume that purchasing power parity holds (i.e. $S = 1$ at the steady state). H_t^e denotes entrepreneurs' stock of real estate whilst Y_t and $W_t N_t$ denote their real income and wage bill from production.

Domestic production takes a Cobb-Douglas form, where labour real estate serve as the factors of production:

$$Y_t = (H_{t-1}^e)^\alpha (N_t)^{1-\alpha}. \quad (3.8)$$

Here, α denotes the share of entrepreneur real estate in production and $1 - \alpha$ gives that of household labour.

Entrepreneurs make use of inflows and home loans to finance their use of the factors of production. If entrepreneurs "walk away" from their debt burdens, debt holders have to incur information and transaction costs before being able to sell the pledged collateral. The presence of these costs reduce debt holders' expected return should the issuer "walk away", and create quantitative credit limits that depend on the expected proceeds of collateral sales, net of information and transaction costs (Korinek, 2011).

I assume that information asymmetries exist in these markets such that the collateral liquidation ability of home and foreign lenders differ. Following Iacoviello and Minetti (2006), foreign lenders may have a poorer understanding of home country bankruptcy practices than home lenders, such that they need to hire costly legal expertise in order to obtain ownership of the collateral pledged by home entrepreneurs. Alternatively, Hermalin

and Rose (1999) argue that the information acquisition technology of foreign lenders exhibits decreasing returns to scale. Both cases indicate that the expected recovery value of foreign lenders will be lower than that of home lenders. These insights are embedded by making the home lender's transaction and liquidation costs a linear function of pledged collateral whilst that of foreign lenders is quadratic in nature.⁷ Formally, this setup sees the home entrepreneur's credit ceiling in each market as given by:

$$\mathbb{E}_t R_{t+1}^l L_t \leq \mu \Omega_t \mathbb{E}_t q_{t+1} H_t^e, \quad (3.9)$$

$$S_t \mathbb{E}_t R_{t+1}^H B_t^H \leq (1 - \Omega_t) \mathbb{E}_t q_{t+1} H_t^e \left(1 - \frac{1 - \mu}{q H^e} \mathbb{E}_t q_{t+1} (1 - \Omega_t) H_t^e \right), \quad (3.10)$$

where one can interpret $0 < \mu < 1$ as reflecting a loan to value regulatory parameter whilst $0 < \Omega_t < 1$ is a choice variable that allows the home entrepreneur to optimally allocate their collateral in each credit market.

With $m_t^e \equiv \frac{\beta_e C_t^e}{\mathbb{E}_t C_{t+1}^e}$ giving entrepreneurs' stochastic discount factor, $\Lambda_t^H \equiv \frac{\lambda_t^H}{C_t^H}$ denoting the multiplier on constraint 3.9, and $\Lambda_t^F \equiv \frac{\lambda_t^F}{C_t^F}$ denoting the multiplier on constraint 3.10, the first order conditions for labour, real estate, home loans, and foreign bonds are given by

$$W_t = (1 - \alpha) \frac{Y_t}{N_t}, \quad (3.11)$$

$$q_t = q_{t+1} (\mu \Omega_t \lambda_t^H + \mathbb{E}_t \tilde{\mu}_{t+1} (1 - \Omega_t) \lambda_t^F) + m_t^e \left(\mathbb{E}_t q_{t+1} + \frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e} \right), \quad (3.12)$$

$$1 = \mathbb{E}_t R_{t+1}^l (m_t^e + \lambda_t^H), \quad (3.13)$$

$$1 = \mathbb{E}_t R_{t+1}^H (m_t^e \frac{S_{t+1}}{S_t} + \lambda_t^F), \quad (3.14)$$

$$\mu \lambda_t^H = \mathbb{E}_t \tilde{\mu}_{t+1} \lambda_t^F. \quad (3.15)$$

Where $\mathbb{E}_t \tilde{\mu}_{t+1} \equiv 1 - \frac{2(1-\mu)}{q H^e} \mathbb{E}_t q_{t+1} (1 - \Omega_t) H_t^e$ gives the marginal productivity of collateral in foreign bond markets.

The first order condition for labour demand (3.11) shows that labour is paid its marginal product. Equation 3.12 indicates that entrepreneurs require the current price of real estate to reflect the discounted utility benefits

⁷The quadratic specification of the foreign lender's liquidation costs is similar to the financial asset transaction costs used by Heaton and Lucas (1996) and Aiyagari and Gertler (1999).

that its purchase proffers through relaxing constraints 3.9 and 3.10. Real estate accumulation also delivers utility benefits from the higher consumption that results from asset price growth and increased production. Entrepreneurs' first order conditions for home loans and foreign bonds shows that they require the interest on their debt to equate to the net utility gains associated with debt incursion. Utility benefits accrue through the higher consumption that debt affords whilst utility costs result from a tightening of entrepreneurs' collateral constraints 3.9 and 3.10. As per equation 3.15, optimal collateral allocation requires the multipliers on constraints 3.9 and 3.10 to equate the marginal productivity of collateral in each credit market.

The home entrepreneur's participation in foreign credit markets is motivated through an interest rate differential between home and foreign credit markets. In keeping with the empirical evidence contained in section 3.1, I desire an equilibrium where foreign interest rates are lower than home interest rates. Thus, I require $R^l > R^H$ at the steady state. Through equations 3.13 and 3.14 we have that

$$\mathbb{E}_t R_{t+1}^l = \frac{\mathbb{E}_t R_{t+1}^H (m_t^e \frac{\mathbb{E}_t S_{t+1}}{S_t} + \lambda_t^F)}{m_t^e + \lambda_t^H}. \quad (3.16)$$

Equation 3.16 is the uncovered interest parity (UIP) condition for home entrepreneurs. Absent the entrepreneur's collateral constraints (i.e. $\lambda_t^H = \lambda_t^F = 0$), (3.16) reduces to the standard UIP condition where the spread between interest rates is determined by expected exchange rate dynamics.

Re-arranging (3.16), one can show that $R^l > R^H$ in equilibrium will be optimal from the home entrepreneur's perspective when he is relatively more constrained in foreign credit markets:

$$\lambda^F > \lambda^H. \quad (3.17)$$

A pre-condition for (3.17) is that the home entrepreneur's collateral constraints are binding in equilibrium, i.e. $\lambda^H > 0$ and $\lambda^F > 0$, as ensured by conditions 3.18 and 3.19:

$$\frac{1}{\beta_e} > \frac{1 - \kappa_H}{\beta_f} + \frac{\kappa_H}{\beta_h}, \quad (3.18)$$

$$\beta_e < \beta_h. \quad (3.19)$$

Condition 3.18 is derived using equations 3.25 and 3.26, and requiring that $\beta_e R^H < 1$. In a similar fashion, condition 3.19 results from 3.41 with the

requirement that $\beta_e R^F < 1$. When (3.17), (3.18), and (3.19) hold, it will be the case that the home entrepreneur is both credit constrained in equilibrium and faces lower borrowing costs in foreign credit markets, i.e. $R^l > R^H$.

Taking (3.15) at the steady state, the equilibrium share of collateral devoted to home credit markets is given as

$$\Omega = \frac{1}{2(1-\mu)} \left(\frac{\mu\lambda^H}{\lambda^F} + 2(1-\mu) - 1 \right). \quad (3.20)$$

Re-arranging (3.20), it is possible to ensure that the home entrepreneur finds it optimal to be active in both home and foreign credit markets, i.e. $0 < \Omega < 1$, even though $R^l > R^H$:

$$2 - \frac{1}{\mu} < \frac{\lambda^H}{\lambda^F} < \frac{1}{\mu}. \quad (3.21)$$

When conditions 3.17, 3.18, 3.19, and 3.21 hold simultaneously, it will be the case that the model's equilibrium sees the home entrepreneur active in both home and foreign credit markets, $0 < \Omega < 1$, even though there is a positive spread between their home and foreign borrowing costs, $R^l > R^H$. These conditions ensure that the home entrepreneur is borrowing constrained in equilibrium and, even though the interest rate on foreign bonds is lower than that on home loans, is active in the credit markets of both countries.

3.3.3 Home financial intermediaries

The FI consumes all of its profits and uses a combination of capital and home household deposits to extend credit in the home and foreign economy. Home economy credit extension by the FI consists of issuing loans to the home entrepreneur, whilst foreign economy credit extension occurs through purchases of bonds issued by the foreign entrepreneur.

The FI seeks to maximize the present value of its expected lifetime utility function as per

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \{ \log(C_t^f) \}, \quad (3.22)$$

where β_f is the FI's discount factor and C_t^f gives FI consumption. The FI's budget constraint is given by

$$C_t^f + L_t + S_t B_t^F + R_{t-1}^d D_{t-1} = D_t + R_t^l L_{t-1} + S_t R_t^F B_{t-1}^F, \quad (3.23)$$

with B_t^F giving capital outflows that are remunerated at a state dependent gross interest rate of R_t^F . As before, D_t denotes deposits received from the home household on which the FI pays pre-determined gross interest of R_t^d whilst L_t gives loans issued to the home entrepreneur on which state-dependent gross interest of R_t^l is earned.

A non-trivial role for the FI is ensured by subjecting it to risk-weighted minimum capital requirements. With $BK_t = L_t + B_t^F - D_t$ giving FI capital, this requirement can be formally represented as

$$D_t \leq (1 - \vartheta\varphi_H)L_t + (1 - \vartheta\varphi_F)S_t B_t^F. \quad (3.24)$$

In (3.24), $0 < \vartheta < 1$ gives the minimum capital requirement whilst $0 < \varphi_H < 1$ and $0 < \varphi_F < 1$ give risk weights on home and foreign entrepreneur debt, respectively.

With $m_t^f \equiv \frac{\beta_f C_t^f}{\mathbb{E}_t C_{t+1}^f}$ giving the FI's stochastic discount factor and $\Lambda_t^K \equiv \frac{\lambda_t^K}{C_t^f}$ representing the multiplier on constraint 3.24, optimal behavior by the FI generates first order conditions for deposits, home loans, and foreign bonds as per:

$$m_t^F R_t^d = 1 - \lambda_t^K, \quad (3.25)$$

$$m_t^F \mathbb{E}_t R_{t+1}^l = 1 - \kappa_H \lambda_t^K, \quad (3.26)$$

$$m_t^F \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F = 1 - \kappa_F \lambda_t^K. \quad (3.27)$$

Where $\kappa_H = 1 - \vartheta\varphi_H$ whilst $\kappa_F = 1 - \vartheta\varphi_F$. The first order condition for deposits shows that the FI requires the present value of interest paid on deposits to equal the utility gains it proffers. In a similar fashion, FIs require the interest rate received on home and foreign entrepreneur debt to equal the utility lost through forgone consumption. Here, equations 3.25, 3.26, and 3.27 show that minimum capital requirements reduce the utility cost associated with purchases of entrepreneur debt, and increase the utility cost associated with deposits.

As per the empirical evidence, the interests rates in home credit markets should be higher than those in foreign credit markets, i.e. $R^l > R^F > R^d$.⁸

⁸A steady state where $R^l > R^F$ follows from figure 3.2. Although $R^F > R^d$ is not material to this analysis, it nests the idea that the FI will only be active on foreign credit markets if it is profitable to do so.

Using equations 3.25, 3.26, and 3.27 the relevant interest rate spreads are derived as:

$$m_t^f(R_{t+1}^l - R_t^d) = (1 - \kappa_H)\lambda_t^K, \quad (3.28)$$

$$m_t^f\left(\frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F - R_t^d\right) = (1 - \kappa_F)\lambda_t^K, \quad (3.29)$$

$$m_t^f\left(R_{t+1}^l - \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F\right) = (\kappa_F - \kappa_H)\lambda_t^K. \quad (3.30)$$

In the absence of the FI's capital requirement ($\lambda_t^K = 0$), (3.29) and (3.30) reduce to the standard UIP condition.

Equations 3.28, 3.29, and 3.30 show that a precondition to $R^l > R^F > R^d$ is that the FI's capital requirement is binding in equilibrium, i.e. $\lambda^K > 0$. Taking equation 3.25 at the steady state, a binding capital requirement in equilibrium is generated by assuming that the FI is less patient than the home household:

$$\beta_f < \beta_h. \quad (3.31)$$

Provided (3.31) holds, it will be the case that $R^l > R^d$ and $R^F > R^d$. Then, equation 3.30 shows that a positive spread between R^l and R^F requires a higher risk weight on home entrepreneur debt as compared to foreign entrepreneur debt:

$$\varphi_H > \varphi_F. \quad (3.32)$$

Thus, provided conditions 3.31 and 3.32 hold, the model's equilibrium will see that $R^l > R^F > R^d$.

3.3.4 The foreign economy

As stated in the model pre-ambule, the setup for the foreign economy is asymmetrical to that of the home economy. Since the focus of this analysis is on the home economy's (emerging market) dynamics, foreign agent participation in the model occurs within a simplified structure. I assume that the foreign household only purchases home entrepreneur debt issued in foreign credit markets. This assumption implies that all of the debt issued by the foreign entrepreneur is bought by the home FI.⁹

⁹For simplicity, I restrict the foreign entrepreneur's supply of credit to the home FI. This assumption is in keeping with a desire to focus on the home economy; however, the

I embed these assumptions by imposing fewer financial frictions on the foreign economy. Specifically, the absence of an FI in the foreign economy precludes the need for a minimum capital requirement as per (3.24), whilst sole reliance on foreign credit markets by the foreign entrepreneur is captured through a single collateral constraint. Given that these asymmetries are motivated as reflective of comparatively higher levels of financial development in advanced countries, the model nests an assumption that financial development is decreasing in the amount of financial frictions (see e.g., Mendoza *et al.*, 2009). Apart from these asymmetries, the setup for the foreign household and entrepreneur is identical to that of their home economy counterparts. I present the foreign economy problem (in foreign currency) below.

The utility function of the foreign household is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{h^*}^t \{ \log(C_t^{h^*}) + j \log(H_t^{h^*}) + \tau \log(1 - N_t^*) \}, \quad (3.33)$$

whilst their budget constraint is as per

$$C_t^{h^*} + q_t^* (H_t^{h^*} - H_{t-1}^{h^*}) + B_t^H = W_t^* N_t^* + R_t^H B_{t-1}^H. \quad (3.34)$$

$C_t^{h^*}$ and β_{h^*} gives the foreign household's consumption and discount factor, whilst $H_t^{h^*}$ and N_t^* gives their stock of real estate and supply of labour. In the foreign economy, labour fetches a real wage of W_t^* and the price of real estate is given by q_t^* . Equation 3.34 shows that the foreign household's only financial asset is given by B_t^H which earns state-dependent gross interest of R_t^H .

The foreign entrepreneur's utility function is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_{e^*}^t \{ \log(C_t^{e^*}) \}, \quad (3.35)$$

and their budget constraint is

$$C_t^{e^*} + q_t^* (H_t^{e^*} - H_{t-1}^{e^*}) + R_t^F B_{t-1}^F + W_t^* N_t^* = Y_t^* + B_t^F \quad (3.36)$$

qualitative implications of the results remain when foreign entrepreneurs can also access credit from the foreign household.

Where β_{e^*} gives the foreign entrepreneur's discount factor, $C_t^{e^*}$ gives their consumption, and $H_t^{e^*}$ is their real estate holdings.

In addition to their budget constraint, the foreign entrepreneur's maximization problem is subject to a Cobb-Douglas production function

$$Y_t^* = (H_{t-1}^{e^*})^\alpha (N_t^*)^{1-\alpha}, \quad (3.37)$$

and collateral constraint

$$\mathbb{E}_t R_{t+1}^F B_t^F \leq \mu_* \mathbb{E}_t q_{t+1}^* H_t^{e^*}, \quad (3.38)$$

with μ_* denoting the foreign economy's loan to value parameter.

Under this setup, the foreign household's first order conditions for labour, real estate, and credit are given by

$$W_t^* = \frac{\tau C_t^{h^*}}{1 - N_t^*}, \quad (3.39)$$

$$q_t^* = \frac{j C_t^{h^*}}{H_t^{h^*}} + m_t^{h^*} \mathbb{E}_t q_{t+1}^*, \quad (3.40)$$

$$1 = m_t^{h^*} \mathbb{E}_t R_{t+1}^H, \quad (3.41)$$

whilst those of the foreign entrepreneur are

$$W_t^* = (1 - \alpha) \frac{Y_t^*}{N_t^*}, \quad (3.42)$$

$$q_t^* = m_t^{e^*} (\mathbb{E}_t q_{t+1}^* (1 + \mu_* \lambda_t^* + \alpha \frac{\mathbb{E}_t Y_{t+1}^*}{H_t^{e^*}})) + \mu_* \mathbb{E}_t q_{t+1}^* \lambda_t^*, \quad (3.43)$$

$$1 = \mathbb{E}_t R_{t+1}^F (m_t^{e^*} + \lambda_t^*). \quad (3.44)$$

In equations 3.39 to 3.44, $m_t^{h^*} \equiv \frac{\beta_{h^*} C_t^{h^*}}{\mathbb{E}_t C_{t+1}^{h^*}}$ and $m_t^{e^*} \equiv \frac{\beta_{e^*} C_t^{e^*}}{\mathbb{E}_t C_{t+1}^{e^*}}$, give foreign agents' stochastic discount factors whilst $\Lambda_t^* \equiv \frac{\lambda_t^*}{C_t^{e^*}}$ gives the multiplier on constraint 3.38.

As with the home entrepreneur, a binding equilibrium collateral constraint in the foreign economy ($\lambda^* > 0$) is ensured by restricting the feasible values for their discount factor:

$$\frac{1}{\beta_{e^*}} > \frac{1 - \kappa_F}{\beta_f} + \frac{\kappa_F}{\beta_h}. \quad (3.45)$$

3.3.5 Flow specific capital controls

The focus of this essay lies in capital controls that can be implemented by home country authorities.¹⁰ To meet this requirement, I rely on capital controls that are manifest as quantitative limits on capital flows. This capital control structure constrains the ability of home agents to manage the composition of their balance sheets, with the objective being to minimize the home economy's exposure to foreign credit markets. In the case of the outflow control, the balance sheet restriction is imposed on the FI, whilst the inflow control sees this restriction imposed on the home entrepreneur. Thus, in the context of this analysis, the outflow capital control is imposed on the financial sector, whilst the inflow capital control is imposed on the real sector.

The manifestation of these capital controls as quantitative limits on capital flows differs from the capital inflow tax approach that is usually deployed in the literature. In this regard, the quantitative nature of the capital controls assessed here implies that their transmission effect will work through quantitative financial variables, not interest rates.¹¹

3.3.5.1 Outflow capital control

The outflow capital control (or outflow control) is inspired by Tobin (1978) and is manifest as a limit on the proportion of foreign entrepreneur debt on the FI's balance sheet¹²:

$$S_t B_t^F \leq \nu(L_t + S_t B_t^F). \quad (3.46)$$

Equation 3.46 shows that the outflow control restricts FI holdings of foreign entrepreneur bonds such that they cannot exceed a fraction, $0 < \nu < 1$, of total FI assets. (3.46) can be re-written to show that the outflow control imposes a linear relationship between the FI's assets, implying that L and B^F will exhibit similar dynamics when the outflow control binds:

¹⁰Sections 3.3.1 – 3.3.4 describe a model setup where no capital controls are present. Here, I extend this baseline setup such that home agents are subject to both inflow and outflow capital controls.

¹¹A tax-based approach to capital controls is feasible when authorities seek to curb foreign participation on domestic credit markets (see e.g., Jeanne and Korinek, 2010; Bianchi, 2011; Forbes *et al.*, 2016). In this analysis, capital flows are manifest in foreign credit markets, and so, the use of taxes imposed on foreign agents is not feasible for home authorities.

¹²Tobin (1978) argued for the use of capital controls that impair the efficient functioning of the financial sector.

$$S_t B_t^F \leq \frac{\nu}{1-\nu} L_t. \quad (3.47)$$

With this setup for the outflow control, $\nu \rightarrow 1$ implies easier outflow control regulatory regimes whilst $\nu \rightarrow 0$ implies stricter outflow control regulatory regimes.

When the outflow control is active, optimal behavior by the FI generates first order conditions for deposits, home loans, and foreign bonds as per:

$$m_t^F R_t^d = 1 - \lambda_t^K, \quad (3.48)$$

$$m_t^F \mathbb{E}_t R_{t+1}^l = 1 - \kappa_H \lambda_t^K - \nu \lambda_t^{\text{OC}}, \quad (3.49)$$

$$m_t^F \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F = 1 - \kappa_F \lambda_t^K + (1-\nu) \lambda_t^{\text{OC}}. \quad (3.50)$$

Where $\Lambda_t^{\text{OC}} \equiv \frac{\lambda_t^{\text{OC}}}{C_t^f}$ gives the multiplier on constraint 3.46.

Given that (3.31) holds (i.e. $\lambda^K > 0$), I make use of (3.13), (3.15), (3.41), (3.48), and (3.49) to solve for the equilibrium value of λ^{OC} as

$$\lambda^{\text{OC}} = \frac{1}{\nu} \left(1 - \kappa_H \left(1 - \frac{\beta_f}{\beta_h} \right) - \frac{\beta_f}{\beta_e + \frac{\tilde{\mu}}{\mu} (\beta_{h*} - \beta_e)} \right). \quad (3.51)$$

Using (3.51), the necessary condition for a binding outflow control in equilibrium is given by:

$$\frac{1}{(1 - \frac{\tilde{\mu}}{\mu}) \beta_e + \frac{\tilde{\mu}}{\mu} \beta_{h*}} < \frac{1 - \kappa_H}{\beta_f} + \frac{\kappa_H}{\beta_h}. \quad (3.52)$$

(3.52) and (3.18), the condition for a binding collateral constraint in the home economy ($\lambda^H > 0$), are quite similar. A comparison of these two conditions reveals that their co-existence requires $\tilde{\mu} > 0$ and $\beta_{h*} > \beta_e$, i.e. the marginal productivity of the home entrepreneur's collateral in foreign credit markets is positive, and the foreign household is more patient than the home entrepreneur.

The FI's first order conditions for loans and foreign bonds, (3.26) and (3.27), reveal that the outflow control reduces the utility cost of loan extension to home entrepreneurs and increases the utility cost associated with

foreign entrepreneur bond purchases. In this way, the outflow control can serve to subsidize credit extension from the FI to the home entrepreneur. That is, when $\lambda^{OC} > 0$, the cost of loan finance to the home entrepreneur is strictly lower than when there is no outflow control. In contrast, a binding outflow constraint implies that foreign entrepreneurs face borrowing costs that are strictly higher than when there is no outflow control in the home economy.

As a result of the outflow control's influence over home loan and foreign bond rates, generating $R^l > R^F$ in equilibrium requires a restriction on the outflow control parameter, ν . Taking (3.49), (3.50), and (3.51) at the steady state, this condition is derived as:

$$\nu > \frac{1}{(\kappa_F - \kappa_H) \left(1 - \frac{\beta_f}{\beta_h}\right)} \left(1 - \kappa_H \left(1 - \frac{\beta_f}{\beta_h}\right) - \frac{\beta_f}{\beta_e + \frac{\bar{\mu}}{\mu}(\beta_{h*} - \beta_e)}\right). \quad (3.53)$$

Thus, when conditions 3.52 and 3.53 hold, it will be the case that $R^l > R^F$ even though $\lambda^{OC} > 0$.

3.3.5.2 Inflow capital control

For the inflow capital control (or inflow control), I seek to restrict the home entrepreneur's ability to manage the composition of their debt. Thus, the inflow control is introduced by removing the home entrepreneur's ability to optimize the allocation of collateral between home and foreign credit markets. This implies that $\Omega_t \rightarrow \Omega$, such that the home entrepreneur's collateral constraints become

$$\mathbb{E}_t R_{t+1}^l L_t \leq \mu \Omega \mathbb{E}_t q_{t+1} H_t^e, \quad (3.54)$$

$$\mathbb{E}_t R_{t+1}^H S_t B_t^H \leq (1 - \Omega) \mathbb{E}_t q_{t+1} H_t^e \left(1 - \frac{1 - \mu}{q H^e} \mathbb{E}_t q_{t+1} (1 - \Omega) H_t^e\right), \quad (3.55)$$

where Ω gives the inflow control parameter. With this setup, $\Omega \rightarrow 1$ implies stricter inflow capital control regulatory regimes as the home entrepreneur is forced to allocate more collateral to the home credit market. Conversely, $\Omega \rightarrow 0$ implies easier inflow capital control regimes as the home entrepreneur is able to allocate more collateral to the foreign credit market.

The inability of the home entrepreneur to optimally allocate his collateral between credit markets sees that the inflow control imposes a linear relationship between his debt limit in home and foreign credit markets.

Thus, whilst the outflow control imposes a linear relationship between the FI's assets, the inflow control imposes this relationship between the home entrepreneur's liabilities. At the steady state, this relationship can be expressed as:

$$R^l L = \mu q H^e - \frac{\mu R^H B^H}{1 - (1 - \mu)(1 - \Omega)}. \quad (3.56)$$

And so, the entrepreneur's debt ceiling in the home credit market is decreasing in his preference for foreign debt.

The use of Ω as an inflow control implies that the home entrepreneur's problem now consists of one fewer choice variable. As a result, optimal behaviour by the home entrepreneur is given by

$$W_t = (1 - \alpha) \frac{Y_t}{N_t}, \quad (3.57)$$

$$q_t = q_{t+1} (\mu \Omega \lambda_t^H + \mathbb{E}_t \tilde{\mu}_{t+1} (1 - \Omega) \lambda_t^F) + m_t^e \left(\mathbb{E}_t q_{t+1} + \frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e} \right), \quad (3.58)$$

$$1 = \mathbb{E}_t R_{t+1}^l (m_t^e + \lambda_t^H), \quad (3.59)$$

$$1 = \mathbb{E}_t R_{t+1}^H \left(\frac{\mathbb{E}_t S_{t+1}}{S_t} m_t^e + \lambda_t^F \right). \quad (3.60)$$

With $\mathbb{E}_t \tilde{\mu}_{t+1} \equiv 1 - \frac{2(1-\mu)}{q H^e} \mathbb{E}_t q_{t+1} (1 - \Omega) H_t^e$ giving the marginal productivity of collateral in foreign bond markets.¹³

3.3.6 Flow specific interest rate shocks

The bulk of the analysis relates to how the capital controls described above can influence the transmission of foreign interest rate shocks to the home economy. These shocks are designed to mimic the easy credit conditions that prevailed in advanced economies following the financial crisis. These shocks are defined below.

From the home country's perspective, R_t^F denotes the gross interest rate earned on capital outflows whilst R_t^H gives that paid on capital inflows. This association between interest rates and capital flows affords the introduction of flow specific interest rate shocks as per ε_t^F and ε_t^H below:

¹³Note that apart from the removal of condition 3.15, the introduction of an inflow control in the form of Ω does not require any other changes to the baseline model structure.

$$\log(R_t^F) = (1 - \rho) \log(R^F) + \rho \log(R_{t-1}^F) + \varepsilon_t^F, \quad (3.61)$$

$$\log(R_t^H) = (1 - \rho) \log(R^H) + \rho \log(R_{t-1}^H) + \varepsilon_t^H. \quad (3.62)$$

The specification of (3.61) and (3.62) assumes that each interest rate can be described as an AR(1) process where $\rho =$ governs the persistence of each process. $\varepsilon_t^F \sim N(0, \sigma^F)$ and $\varepsilon_t^H \sim N(0, \sigma^H)$ give flow specific white noise interest rate shocks. Letting Σ denote the variance-covariance matrix of the flow specific interest rate shocks, I incorporate correlated shocks through γ :

$$\Sigma = \begin{bmatrix} \sigma^F & \gamma \times \sigma^F \sigma^H \\ \gamma \times \sigma^H \sigma^F & \sigma^H \end{bmatrix}, \quad (3.63)$$

where $0 < \gamma < 1$ sees that the flow specific interest rate shocks are positively correlated.

With this setup, one can view a flow specific interest rate shock as reflecting a foreign monetary policy shock that lowers foreign interest rates such that both home and foreign entrepreneurs face lower borrowing costs. Here, positive correlation between ε_t^F and ε_t^H implies that each flow specific interest rate shocks affects both foreign credit markets (B_t^H and B_t^F); however, because $0 < \gamma < 1$ the impact of each shock is stronger on its respective interest rate. Thus, a shock to ε_t^F sees a response in both R^F and R^H , but the response is stronger in R^F than in R^H . Conversely, a shock to ε_t^H sees a stronger response in R^H than in R^F .

The asymmetric response of R^F and R^H under each shock implies that flow specific interest rate shocks are unevenly distributed between the FI and the home entrepreneur. Both shocks serve to reduce the return on outflows and inflows. For the home entrepreneur, this reduction affords higher levels of consumption, whilst the FI associates each shock with consumption losses. In this regard, $0 < \gamma < 1$ sees that an outflow interest rate shock is associated with larger consumption losses for the FI than gains for the home entrepreneur, and as a result, outflow interest rate shocks realize net consumption losses in the home economy. The opposite applies under inflow interest rate shocks, where the gain in home entrepreneur consumption dominates the loss suffered by the FI such that inflow interest rate shocks realize net consumption gains in the home economy.

3.3.7 Market clearing and the current account

The quantity of real estate in each economy is normalized to one so that real estate market clearing is given by

$$1 = H_t^h + H_t^e, \quad (3.64)$$

$$1 = H_t^{h*} + H_t^{e*}. \quad (3.65)$$

The home, foreign, and world economy aggregate resource constraints are given by

$$Y_t = C_t^h + C_t^e + C_t^f + S_t(B_t^F - R_t^F B_{t-1}^F + R_t^H B_{t-1}^H - B_t^H), \quad (3.66)$$

$$Y_t^* = C_t^{h*} + C_t^{e*} + B_t^H - R_t^H B_{t-1}^H + R_t^F B_{t-1}^F - B_t^F, \quad (3.67)$$

$$Y_t^W = C_t^h + C_t^e + C_t^f + S_t(C_t^{h*} + C_t^{e*}), \quad (3.68)$$

where $Y_t^W = Y_t + S_t Y_t^*$. As in Obstfeld and Rogoff (1995) (3.66) sees that, in the absence of goods trade, any income in excess of home consumption is transferred abroad through financial trade:

$$Y_t - C_t^h - C_t^e - C_t^f = S_t(B_t^F - R_t^F B_{t-1}^F + R_t^H B_{t-1}^H - B_t^H). \quad (3.69)$$

Each country's current account can be defined as the change in its net foreign assets within a period:

$$CA_t = S_t(\Delta B_t^F - \Delta B_t^H), \quad (3.70)$$

$$CA_t^* = \Delta B_t^H - \Delta B_t^F. \quad (3.71)$$

where $\Delta B_t^i = B_t^i - B_{t-1}^i$ for $i = F, H$. This definition for the current account produces the standard two-country model outcome in that $CA_t = -S_t CA_t^*$.

Defining the current account of each country as per (3.70) and (3.71) implies that net inflows ($\Delta B_t^H > \Delta B_t^F$) are associated with current account deficits, whilst net outflows ($\Delta B_t^H < \Delta B_t^F$) generate a current account surplus. Current account deficits therefore represent a decline in the net foreign asset position of the home country whilst the opposite occurs under current account surpluses.

Similar to Chang *et al.* (2015), (3.69) and (3.70) see that the home current account is defined as the sum of its financial trade surplus and net interest income received from foreign asset holdings, less the net interest paid on its foreign liabilities:

$$CA_t = Y_t - C_t^h - C_t^e - C_t^f + S_t(R_t^F - 1)B_{t-1}^F - S_t(R_t^H - 1)B_{t-1}^H. \quad (3.72)$$

Equation 3.72 shows that a balanced current account implies home consumption is matched perfectly by home production and the net income from financial trade.

3.4 Calibration

The model's calibration is presented in table 3.1, where the model is calibrated for a quarterly frequency. In line with conditions 3.18, 3.19, 3.31, and 3.45, the calibration is consistent with a steady state where minimum capital requirements and collateral constraints are binding. The parameter values are also in line with (3.52), such that when it is active, the outflow capital control binds in equilibrium.

Table 3.1: Calibration of model parameters.

<i>Parameter</i>	<i>Symbol</i>	<i>Value</i>
Foreign household discount factor	β_{h^*}	0.988
Home household discount factor	β_h	0.99
Foreign entrepreneur discount factor	β_{e^*}	0.94
Home entrepreneur discount factor	β_e	0.94
Home FI discount factor	β_f	0.945
Household utility to leisure	τ	2
Household utility to real estate	j	0.075
Real estate share in production	α	0.05
Home LTV ratio	μ	0.8
Foreign LTV ratio	μ_*	0.8
Home FI minimum capital requirement	ϑ	0.1
Risk weight on home loans	φ_H	1
Risk weight on foreign entrepreneur bonds (outflows)	φ_F	0.2
AR parameter for shocks	ρ	0.9
Correlation between shocks	γ	0.5

The parameters are calibrated so that in the baseline scenario, the steady state interest rate relationships are given by $R^l > R^H > R^F > R^d$. As per Iacoviello (2015), the calibration for $j = 0.075$ and $\alpha = 0.05$ implies a home real estate wealth to output ratio of approximately 3 at the steady state, whilst $\tau = 2$ sees households devote a third of their time to labour activities. The discount factor values are standard in the literature. I calibrate $\beta_{h^*} < \beta_h$ to generate a spread between entrepreneur borrowing rates in the foreign economy so that $R^H > R^F$. In this regard, setting $\beta_{h^*} = 0.988$

sees the foreign household require a return of $R^H = 4.84\%$ per annum on home entrepreneur bonds in equilibrium whereas the return on foreign entrepreneur bonds is given by $R^F = 4.44\%$. Therefore, in the foreign credit market, home entrepreneurs pay marginally more than foreign entrepreneurs. $\beta_h = 0.99$ sees home households require a deposit rate of $R^d = 4.04\%$ per annum. With the home entrepreneur's cost of loan finance given by $R^l = 5.96\%$, the baseline calibration sees a spread of $R^l - R^H = 1.12\%$ between home and foreign credit markets. The calibration for ϑ is taken from BIS (2010) whilst the values for φ_H and φ_F are as per the risk weights on AAA and BBB rated corporate debt given in BIS (2006). I assume symmetrical LTV regulation between the two countries, and in line with IMF (2011) and Iacoviello and Minetti (2006), set $\mu = \mu_* = 0.8$. Finally, the AR(1) parameter on the flow specific interest rate shocks is set at 0.9 and I assume that these shocks are positively correlated with $\gamma = 0.5$.

When the outflow capital control is active, I calibrate $\nu = 0.3$ such that 70% of the FI's balance sheet is devoted to home loans. Similarly, when the inflow capital control is active, I calibrate $\Omega = 0.6$ such that 60% of home entrepreneur collateral is allocated to the home credit market. The calibration for each of these controls is in line with the home bias observed on emerging market balance sheets (see e.g., Burger and Warnock, 2006; Hale *et al.*, 2016) and sees that in the absence of capital controls, foreign credit occupies a larger portion of both the FI and home entrepreneur's balance sheets.¹⁴

3.5 The baseline model performance

Before commencing with the analysis on the impact of flow specific capital controls, this section investigates the behaviour of the baseline model through two simulation exercises. The first exercise comprises an assessment of the business cycle performance of the baseline model whilst the second exercise comprises impulse response function analysis following negative flow specific foreign interest rate shocks.

3.5.1 Business cycle moments

To test the applicability of the framework, I compare the baseline model's moments to the data. The model moments are generated following a positive productivity shock in each country with technological spill-over as in

¹⁴That is, without capital controls, the steady state levels of inflows and outflows are higher.

Backus *et al.* (1992).¹⁵ Table 3.2 reports the correlation of home output with consumption, real estate prices, and credit flows. Following the international business cycle literature, I also consider the cross-country correlations of these variables. Here, I make use of emerging market data for the home economy and advanced market data for the foreign economy.

The data shows that emerging market output is positively correlated with all of the home variables considered. The positive correlation between emerging market output (Y) and inflows (B^H) concurs with the notion that the foreign debt dynamics of emerging markets are underpinned by economic fundamentals (Forbes and Warnock, 2012; Ahmed and Zlate, 2014). In terms of cross-country correlations, the data shows a positive correlation between emerging and advanced market output. This international cycle is also present in consumption and real estate prices, but not across all credit flows. In particular, emerging credit markets are negatively correlated with advanced credit markets. Nevertheless, capital inflows (B^H) and outflows (B^F) are positively correlated. Capital inflows and emerging market domestic debt are also positively correlated. Combined with the co-movement of emerging market output and outflows (B^F), and the positive relationship between capital flows, B^F and B^H , the data is indicative of an international credit cycle as described in Rey (2015).

Table 3.2: Business cycle moments of the baseline model.

	<i>Data</i>	<i>Baseline</i>
<i>Correlations with Y</i>		
Y	1	1
C	0.76	0.96
q	0.39	0.96
L	0.27	0.34
B^H	0.83	0.16
B^F	0.60	0.66
<i>Cross-country correlation</i>		
Y, Y^*	0.30	0.67
C, C^*	0.19	0.94
q, q^*	0.20	0.95
L, B^H	0.42	-0.84
L, B^F	-0.23	-0.10
B^F, B^H	0.49	0.61

¹⁵The formal setup for this shock is provided in appendix B.1.7 whilst the data sources and transformations used are described in appendix B.2.

The baseline model is generally able to replicate the direction of both the domestic and international correlations seen in the data; however, it mostly overestimates the magnitude of the relationships. This amplification stems from the relatively simplistic nature of the model setup and is in line with estimates produced by other papers that deploy the canonical real business cycle framework (Backus *et al.*, 1992; King and Rebelo, 2000; Kehoe and Perri, 2002). Similarly, the negative correlation between L and B^H is driven by model design. This outcome results from the collateral constraints of Iacoviello and Minetti (2006), where optimal collateral allocation allows the home entrepreneur to exploit differences in the liquidation technology of home and foreign lenders. Nevertheless, the baseline model's ability to match most of the correlations seen in the data implies that it provides a reasonably sound foundation from which to assess the implications of flow specific capital controls.

3.5.2 Foreign interest rate shocks in the baseline model

I subject the baseline model to negative foreign interest rate shocks designed to mimic easing conditions in advanced credit markets. Because these shocks reduce foreign interest rates (R_t^H and R_t^F), they serve to increase the present value of the home and foreign entrepreneur collateral in foreign credit markets, and by extension their foreign credit ceiling (see equations 3.10 and 3.38). This easing of foreign credit market conditions raises demand for foreign debt by both the home and foreign entrepreneur such that both inflows and outflows increase following the shock. However, the increase in outflows is insufficient to offset the increase in inflows, and so, the home economy experiences net inflows such that a home current account deficit results from the shock.¹⁶ The model's transmission channel comprises the effect that changes in collateral values have on home and foreign entrepreneur credit ceilings, where dynamic feedback between credit ceilings and expected collateral values culminates in shock amplification and persistence.

The asymmetrical two-country setup implies that the home economy is subject to two inter-related collateral value channels, whilst there is only one channel present in the foreign economy. Negative foreign interest rate shocks serve to reduce the relative inefficiency of the home economy's foreign collateral value channel, resulting in the home entrepreneur's switch to foreign debt. Although this behaviour allows the entrepreneur to exploit

¹⁶Apart from figure 3.3, this increase in the FI's holdings of foreign entrepreneur bonds is consistent with the increase in emerging market purchases of foreign assets as mentioned by Turner (2013).

the lower cost of foreign credit, it implies a net increase in foreign interest owed, and so, the shocks realize a redistribution of income between countries, such that negative foreign interest rate shocks realize contractionary effects in the home economy. These effects are coherent with a positive foreign money supply shock in Obstfeld and Rogoff (1995) and the positive foreign wealth shock deployed by Faia (2002). The contractionary effects on the home economy stem from the increased prominence of foreign credit markets following the shock. In this regard, the absence of goods trade in the model circumvents the expenditure switching channel present in Faia (2002). Instead, the focus on capital flows sees this channel manifested in the home entrepreneur's preference for foreign debt.¹⁷

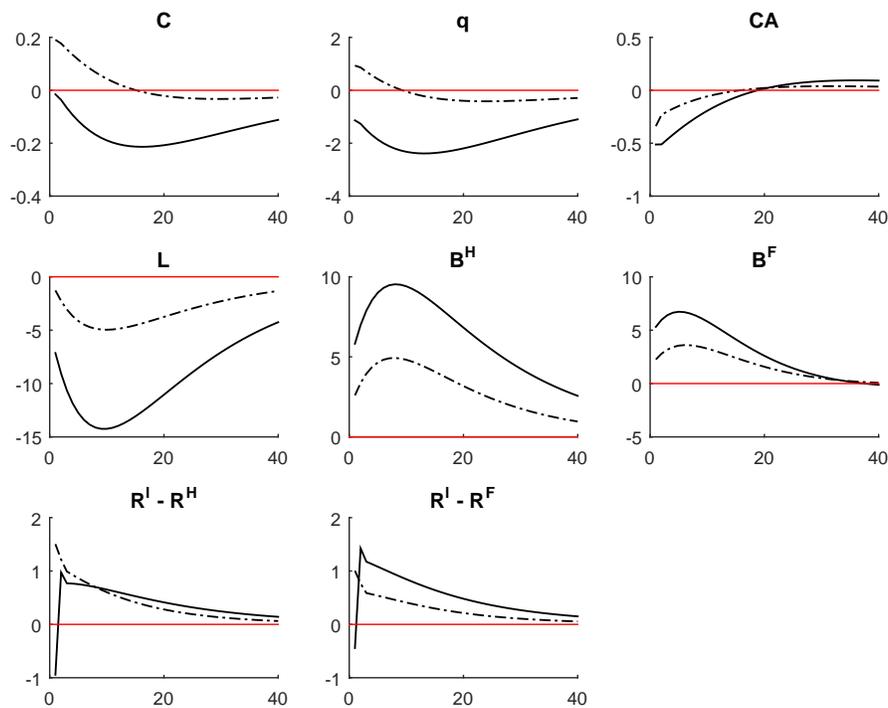


Figure 3.4: Negative foreign interest rate shocks in the baseline model (ε_t^F and ε_t^H). Outflow interest rate shock: solid line. Inflow interest rate shock: dash-dot line.

¹⁷The financial shock of Faia (2002) is manifest as an increase to foreign net wealth. Home output losses result from this shock as home agents exhibit a preference for foreign goods following the shock.

Figure 3.4 contains the impulse response functions for a selection of home variables in response to negative foreign interest rate shocks. Both shocks are associated with an increased spread between home and foreign credit markets ($R^I - R^H$ and $R^I - R^F$), a current account deficit in the home economy (CA), an increase in foreign credit extension (B^H and B^F), and an eventual contraction in consumption (C). In terms of credit flows, each shock increases the prominence of foreign capital flows (B^H and B^F) whilst the home credit market contracts (L).¹⁸ The balance sheet reduction associated with this contraction aggravates FI consumption losses, tightening home credit market conditions further. Together with the relative inefficiency of the home economy's foreign collateral value channel, this tightening of home credit market conditions reduces the entrepreneur's demand for real estate, culminating in lower real estate prices (q).

Both the qualitative and the quantitative differences between each shock's dynamics can be attributed to their distribution across the entrepreneur and the FI.¹⁹ The FI's consumption loss is greater under the outflow interest rate shock, which sees that the initial response of the spread between home and foreign interest rates differs between inflow and outflow interest rate shocks. Apart from this difference, the dynamics of an outflow interest rate shock are qualitatively similar to that of an inflow interest rate shock. Quantitatively, inflow interest rate shocks have a smaller impact than outflow interest rate shocks. In this case, the positive initial response of consumption and real estate prices reflect the net gain in home consumption associated with an inflow interest rate shock.

3.6 The impact of flow specific capital controls

The transmission of foreign interest rate shocks will differ when capital controls are introduced. For instance, the outflow control introduces linear dependence between the FI's assets that contrasts with the countercyclical relationship that they exhibit under the baseline model. This change in the relationship between FI assets bears implications for FI consumption, and by extension, the net consumption cost associated with outflow shocks. Similarly, the linear dependence introduced between entrepreneur debt types

¹⁸Aggregate home consumption is defined as the sum of home agent consumptions: $C = C^h + C^e + C^f$. The focus of this essay is on the home economy, and as such, I do not report the foreign economy dynamics here. Nevertheless, the shocks are expansionary in the foreign economy, where each shock is associated with an increase in C^* and q^* .

¹⁹See section 3.3.6 for a discussion on the distribution of flow specific interest rate shocks across the FI and home entrepreneur.

under the inflow control will influence the net consumption benefit associated with inflow shocks.²⁰ I subject the model to an outflow interest rate shock (ε_t^F) when looking at the impact of the outflow capital control, and to an inflow interest rate shock (ε_t^H) when looking at the inflow capital control. This approach focuses the effects of the shock on the agent most affected by the capital control.²¹

3.6.1 Outflow capital controls and outflow interest rate shocks

Figure 3.5 compares the impulse response functions obtained under the baseline and outflow control models following a negative outflow interest rate shock (ε_t^F). There are clear disparities between the dynamics of the baseline and those obtained when the outflow capital control is present. In terms of its influence on capital flows, the outflow control realizes a decline in both outflows (B^F) and inflows (B^H), culminating in a quicker return to equilibrium for the current account. Shock attenuation under the outflow control is reflected in the dynamics of home consumption, real estate prices, and credit quantities. That being said, the current account deficit is larger when the outflow capital control binds compared to the baseline. This outcome is to be expected, as the outflow control restricts the home FI's ability to lean against the current account deficit associated with the home entrepreneur's switch to foreign debt.

The outflow control's effectiveness in reducing the sensitivity of home variables results from the linear dependence that it imposes between L and B^F . This relationship implies that home entrepreneur loans and foreign entrepreneur bonds will exhibit the same dynamics. Because the control is imposed on the FI, linear dependence between L and B^F does not affect the home entrepreneur's tilt toward foreign sources of credit; however, it does provide a channel through which easier foreign credit market conditions can spill-over to the home credit market. Absent the outflow control, the collateral value channels of each country are independent of one another and move in opposite directions.²² When the outflow control is imposed, linear dependence between L and B^F pits these two forces against one an-

²⁰Equations 3.47 and 3.56 show how the capital controls impose this linear dependence between credit markets.

²¹Outflow shocks amplify the consumption losses of the FI whilst inflow shocks do the same for the home entrepreneur. As illustrated and discussed in section 3.7, the qualitative insights generated by this analysis are shock invariant.

²²This model characteristic is reflected in the decline of home entrepreneur loans and increase in foreign entrepreneur bonds following the shock.

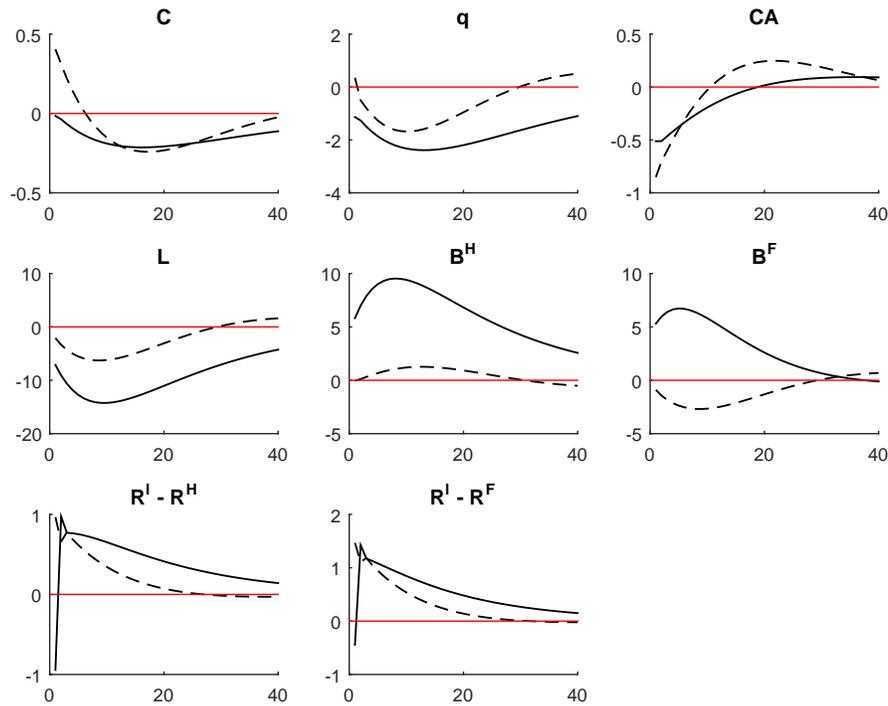


Figure 3.5: The impact of the outflow capital control following a negative foreign interest rate shock (ε_t^F). Baseline (no capital controls): solid line. Outflow capital control: dashed line.

other and home loan extension is less adversely affected than under the baseline. This reduction in the sensitivity of home loans implies that the entrepreneur's preference for foreign debt is attenuated such that inflows are less sensitive to the shock when the outflow capital control binds.

3.6.2 Model sensitivity to outflow capital control regimes

In aggregate, figure 3.5 illustrates that the outflow control is able to attenuate the sensitivity of inflows, outflows, and the business cycle (real economy variables) to negative foreign interest rate shocks. To check the sensitivity of these attenuation benefits of the outflow control, I compare the impulse response functions generated under three different outflow capital control regimes (outflow regimes for short). As per their calibrations in table 3.3, movement across regimes change the FI's exposure to outflows. Under the strict outflow regime, the share of outflows on FI balance sheets

is lower than that observed under the baseline regime. The opposite holds true for the easy outflow regime, where outflows occupy a larger share of FI balance sheets. Thus, relative to the baseline outflow regime, the strict regime reduces the home economy's exposure to foreign assets whilst the easy regime increases the home economy's exposure to foreign assets.

Table 3.3: Outflow capital control regimes.

Parameter	Symbol	Regulatory regime		
		Baseline	Strict	Easy
Outflow capital control	ν	0.3	0.15	0.45

Figure 3.6 plots the impulse response functions obtained under each outflow regime. In aggregate, figure 3.6 shows that the attenuation benefits associated with the outflow control increase as the outflow regime becomes easier. The easy regime attenuates the behaviour of all credit types relative to both the strict and baseline regimes. This does not hold for the contemporaneous response of outflows, where the shock's impact is largest under the easy outflow regime. Because home loans are less sensitive to the shock under the easy regime, the dynamics of home real estate prices are preferable to those obtained under the strict outflow regime. This outcome results from the higher marginal value of collateral with home lenders, where reduced sensitivity in home loans under the easy outflow regime feeds back into comparatively higher home real estate prices. In turn, higher real estate prices reduce the incentive for home entrepreneurs to borrow on foreign credit markets, implying a smaller increase in B^H under the easy regime. When the strict outflow regime is imposed, the narrative runs in the opposite direction, where the comparatively larger decline in home loans feeds back into lower home real estate prices and a more pronounced shift toward foreign credit markets.

The results show that the strict regulatory regime enhances the ability of the outflow control to attenuate home consumption dynamics. This finding contrasts with the superior real estate price dynamics under the easy outflow regime, and results from the consumption costs associated with negative outflow interest rate shocks. Recall that these shocks generate consumption gains for the home entrepreneur, but entail consumption losses for the FI. The easy outflow regime sees outflows occupy a larger share of FI balance sheets, amplifying this consumption loss. In contrast, the wealth effect of relatively higher real estate prices under the easy outflow regime increases both home household and home entrepreneur consumption. Figure 3.6 shows that this wealth effect is dominated by the consumption loss

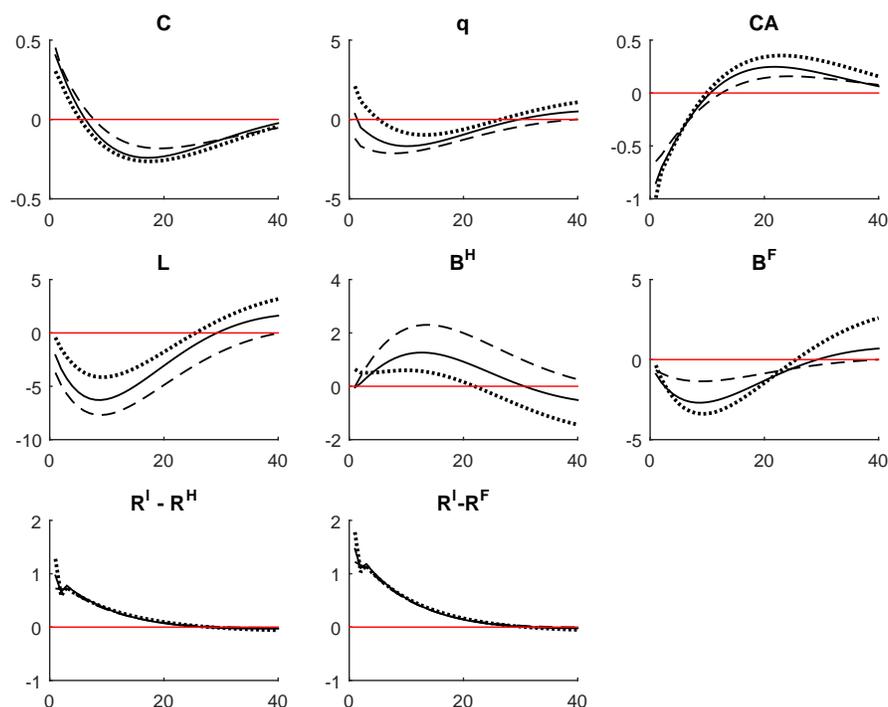


Figure 3.6: Model sensitivity to different outflow control regimes as per table 3.3 following a negative foreign interest rate shock (ε_t^F). Baseline outflow control regime: solid line. Strict outflow control regime: dashed line. Easy outflow control regime: dotted line.

of the FI, and as such, the strict outflow regime is associated with the best dynamics for home consumption.

The insensitivity of interest rate spreads to changes in the outflow control regime shows that the outflow capital control's attenuation properties are manifest through quantitative financial variables, not interest rates. Thus, shock attenuation under the outflow capital control is founded upon the benefits that it proffers for the FI's balance sheet. Indeed, the fundamental purpose of the outflow capital control is to reduce the home FI's balance sheet exposure to foreign interest rate shocks. This property of the outflow capital control implies that it reduces the foreign interest rate shock sensitivity of the FI's balance sheet relative to the baseline model. Since credit market conditions are pivotal to the model's dynamics, the comparatively smaller reduction in the FI's balance sheet under the outflow control explains its ability to improve upon baseline dynamics.

3.6.3 Inflow capital controls and inflow interest rate shocks

Whilst the outflow control identifies the FI's balance sheet as a means to dealing with foreign interest rate shocks, the inflow capital control places focus on the home entrepreneur's balance sheet. Relative to the baseline model, the inflow capital control is able to reduce the home entrepreneur's exposure to inflows, but in doing so, precludes optimal collateral allocation. This implies that the home entrepreneur is unable to exploit easier foreign credit market conditions, constraining virtuous feedback through the home economy's foreign collateral value channel.

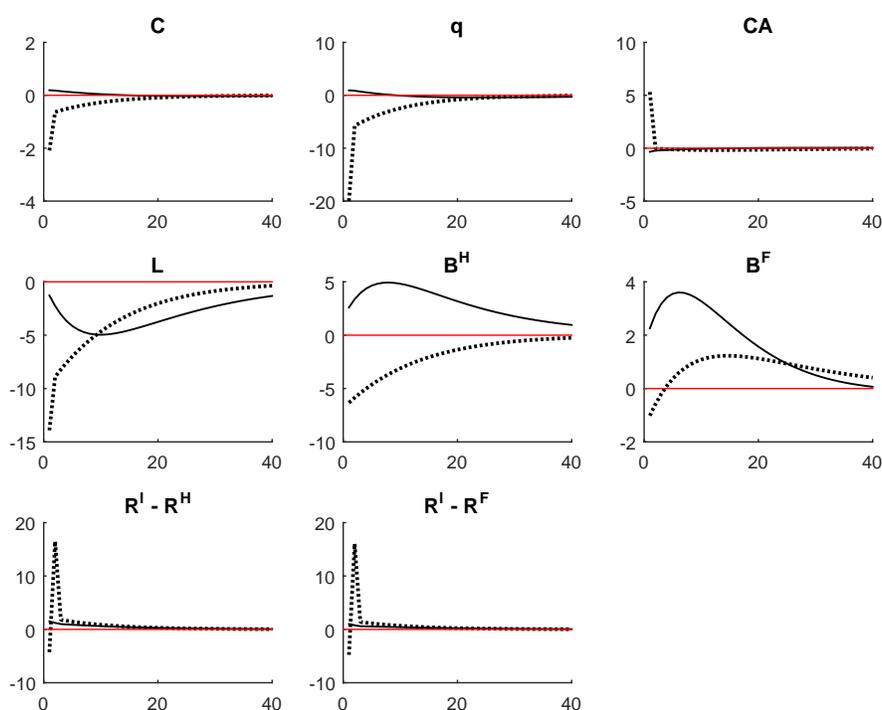


Figure 3.7: The impact of the inflow capital control following a negative foreign interest rate shock (ϵ_t^H). Baseline (no capital controls): solid line. Inflow control only: dotted line.

Figure 3.7 shows that the inflow capital control amplifies the effect of the shock relative to the baseline. Now, both types of entrepreneur debt decline and feed back into contemporaneously lower consumption and real estate prices. Dynamic feedback through the collateral value channel realizes a

contraction in home loans that is more severe under the inflow control, leading to a smaller FI balance sheet and fewer outflows. As before, this balance sheet reduction amplifies the consumption losses that the FI associates with the shock. The household and entrepreneur also experience consumption losses. Here, the wealth reduction associated with lower real estate prices bears consequences for their consumption streams. Thus, whilst the inflow interest rate shock is net consumption enhancing in the baseline model, it realizes a net consumption loss when the inflow control is present.

The dynamics of capital outflows in figure 3.7 show that when the inflow control is present, the comparatively larger reduction in the FI's balance sheet has an adverse effect on foreign entrepreneur access to credit. The FI consumption losses associated with this shrunken balance sheet enhances the sensitivity of interest rate spreads such that the qualitative characteristics of their dynamics become similar to that of an outflow interest rate shock in the baseline model.²³ Nevertheless, the reduction in outflows is insufficient to dominate the current account surplus emanating from the decline in inflows, and as a result, the inflow control sees a large contemporaneous current account surplus in the home economy. Thus, the inflow control is able to initially reverse the income redistribution associated with the home economy's position as net international creditor. As reflected by the increase in shock persistence under the inflow control, this effect is transitory and introduction of the inflow control merely delays the income redistribution associated with the shock.

3.6.4 Model sensitivity to inflow capital control regimes

Figure 3.7 illustrates that the inflow control is effective in curbing both the home entrepreneur's shift to foreign credit markets as well as the increase in the FI's foreign assets. However, this control over capital flows comes at the cost of an increase in the sensitivity of the business cycle to negative foreign interest rate shocks. Thus, whilst the outflow control exhibits shock attenuation properties, the inflow control exhibits shock amplification properties. I test the sensitivity of these amplification properties to changes in the inflow capital control regime (inflow regime for short) by comparing the impulse response functions obtained under baseline, strict, and easy inflow regimes as defined in table 3.4.

²³Recall that under the baseline model, outflow interest rate shocks initially bear net consumption losses whilst inflow interest rate shocks are initially net consumption enhancing. When the inflow control binds, inflow interest rate shocks bear net consumption losses and the interest rate dynamics are qualitatively similar to those of the baseline model following an outflow interest rate shock.

Table 3.4: Inflow capital control regimes.

Parameter	Symbol	Regulatory regime		
		Baseline	Strict	Easy
Inflow capital control	Ω	0.6	0.75	0.45

Figure 3.8 plots the impulse response functions generated under each inflow regime. The strict regime sees that the share of collateral devoted to home credit markets is larger than that under the baseline whilst the opposite holds true under the easy regime. Thus, the home entrepreneur's exposure to the consumption gain associated with inflow shocks is enhanced under the easy regime and impaired under the strict regime.

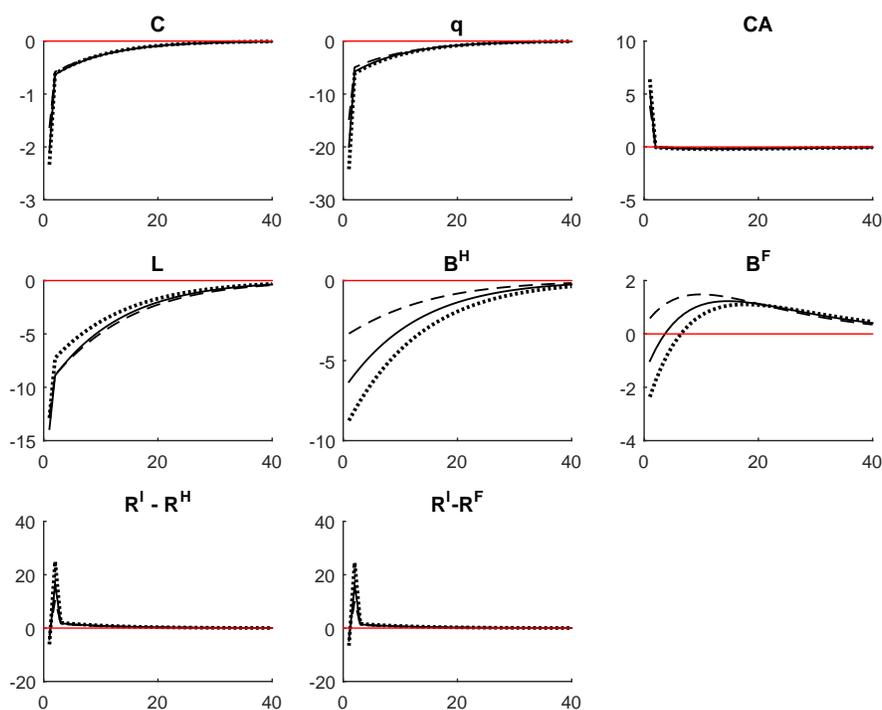


Figure 3.8: Model sensitivity to changes in the inflow capital control regime as per table 3.4 following a negative foreign interest rate shock (ε_t^H). Baseline inflow control regime: solid line. Strict inflow control regime: dashed line. Easy inflow control regime: dotted line.

Although only evident from the dynamics of B^H and B^F , the strict inflow regime reduces the impact of the shock across all of the variables plotted in figure 3.8, barring home loans. Thus, the amplification properties of the inflow control are reduced as the inflow regime becomes stricter.

The strict regime reduces the role of the foreign collateral constraint, limiting adverse feedback between inflows and real estate prices which attenuates the impact of the shock. The opposite holds true under the easy inflow regime, where an increased role for the foreign collateral constraint is associated with enhanced shock amplification relative to the baseline inflow regime. Here, the easy regime's relatively better dynamics for home loans is a product of the larger decline in foreign debt associated with the shock.²⁴ Regardless of the relative amplification of inflow interest rate shocks under the easy regime, figure 3.8 indicates that all three regimes return to equilibrium at a similar pace. Thus, changes to the inflow regime have a temporary impact. As with the outflow control, the insensitivity of interest rate spreads to changes in the inflow regime reflects the manifestation of the inflow capital control as a quantitative limit on inflows.

Taken together, the impulse response function analyses of the outflow and inflow capital controls are illustrative of the shock absorption properties of optimal collateral allocation. The model's dynamics under the inflow control indicate that when capital controls are manifest as quantitative limits that impair optimal collateral allocation, effective management of capital flows comes at the cost of shock amplification. In contrast, the outflow control analysis shows that quantitative limits which reduce the home economy's exposure to foreign credit markets without affecting optimal collateral allocation afford both effective capital flow management and shock attenuation. Thus, the outflow control's attenuation effects are driven by the fact that it does not directly influence the home entrepreneur's shift toward foreign credit markets. Instead, the co-existence of optimal collateral allocation and the outflow capital control affords virtuous feedback through the home economy's foreign collateral value channel, culminating in the outflow control's ability to improve upon the baseline model's dynamics.

²⁴As shown by equation 3.56, the inflow control sees that declines in B^H raise L . Thus, the attenuation of home loan dynamics under the easy inflow regime are a product of the comparatively larger decline in B^H under this regime.

3.7 The welfare effects of flow specific capital controls

Both capital controls restrict the behaviour of home agents relative to the baseline model. In the case of the outflow capital control, the share of foreign assets on the FI's balance sheet is reduced and their ability to purchase these instruments is restricted. Alternatively, the inflow capital control precludes optimal collateral allocation and increases the home entrepreneur's dependence on home credit markets. The impulse response analysis conducted above showed that the introduction of these rigidities influence consumption dynamics, and as a result, flow specific capital controls carry consequences for welfare.

Following Rubio and Carrasco-Gallego (2014), I assess the welfare implications of these capital controls by numerically evaluating the welfare derived under each shock. This approach affords a distinction between the welfare of the home household (ω_t^h), entrepreneur (ω_t^e), and FI (ω_t^f) as defined by

$$\omega_t^h = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left[\log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right], \quad (3.73)$$

$$\omega_t^e = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \left[\log(C_t^e) \right], \quad (3.74)$$

$$\omega_t^f = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left[\log(C_t^f) \right], \quad (3.75)$$

with social welfare given by the weighted sum of individual welfares:

$$\omega_t = (1 - \beta_h)\omega_t^h + (1 - \beta_e)\omega_t^e + (1 - \beta_b)\omega_t^b. \quad (3.76)$$

Here, weighting each agent's welfare by their respective discount factor ensures that the household, entrepreneur, and FI all receive the same level of utility from a constant consumption stream. These specifications for the measurement of welfare implies that impulse response function analysis can be used to illustrate the welfare effects of the capital controls.

3.7.1 Flow specific capital controls and social welfare

The preceding analysis made use of outflow interest rate shocks to assess the impact of the outflow control and inflow interest rate shocks to assess that

of the inflow control. Notwithstanding the qualitative similarities between these shocks (see figure 3.4), it may be beneficial to determine whether the results are driven by this approach. To address these concerns, I compare the welfare implications of each control under both shocks, and plot the social welfare dynamics that result from this exercise in figure 3.9.

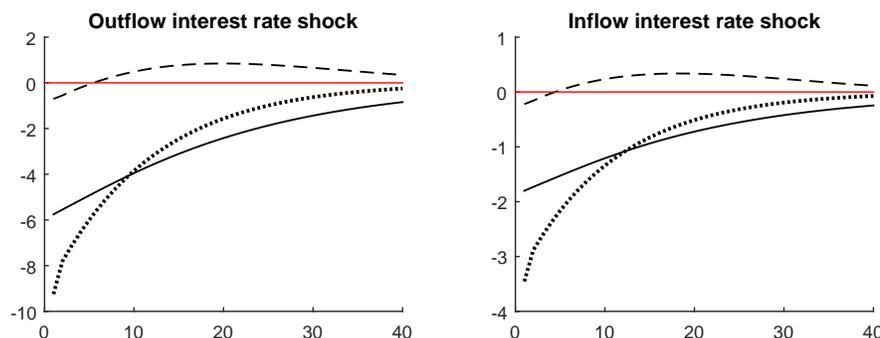


Figure 3.9: The implications of flow specific capital controls for social welfare following a negative foreign interest rate shock (ε_t^F and ε_t^H). Baseline (no capital controls): solid line. Outflow control only: dashed line. Inflow control only: dotted line.

Figure 3.9 shows that inflow and outflow interest rate shocks bear qualitatively similar consequences for the dynamics of social welfare, but differ quantitatively. Both shocks realize a reduction in social welfare under the baseline model. The outflow control unequivocally reduces this welfare loss whilst the inflow control is associated with a larger contemporaneous welfare loss. For both shocks, the attenuation of social welfare dynamics under the outflow control is coherent with the analysis in section 3.6.1. Similarly, the discussion in section 3.6.3 agrees with the amplified response of social welfare under the inflow control. Therefore, figure 3.9 indicates that the narratives presented in these sections are not shock dependent.

3.7.2 Flow specific capital controls and agent welfare

This similarity between inflow and outflow shocks is exploited in figure 3.10, where I compare the implications of each capital control for agent welfare following an outflow interest rate shock.²⁵ In the case of the entrepreneur and FI, welfare depends solely on consumption. For the house-

²⁵As in figure 3.9, making use of an inflow shock does not alter the qualitative implications of these results.

hold, welfare depends on a composite of consumption, real estate balances, and leisure time.

The welfare consequences of foreign interest rate shocks are agent dependent. Due to its effect on their wealth, the lower real estate prices that follow the shock negatively affects the household and entrepreneur's consumption streams. In the case of the household, the ensuing reduction in welfare is mitigated through increased leisure time and higher real estate balances.²⁶ For the entrepreneur, a concomitant increase in their foreign debt negates the consumption cost associated with this decline in their wealth. The FI's consumption depends solely on the size of their balance sheet and the spread between the interest rates on their assets and liabilities. Foreign interest rate shocks shrink their balance sheet and reduce the return on their foreign assets. Thus, whilst the household and entrepreneur are exposed to forces that mitigate their consumption losses, the FI is not. Together with the baseline dynamics of figure 3.10, this characteristic implies that the baseline social welfare losses depicted in figure 3.9 are driven by the FI.

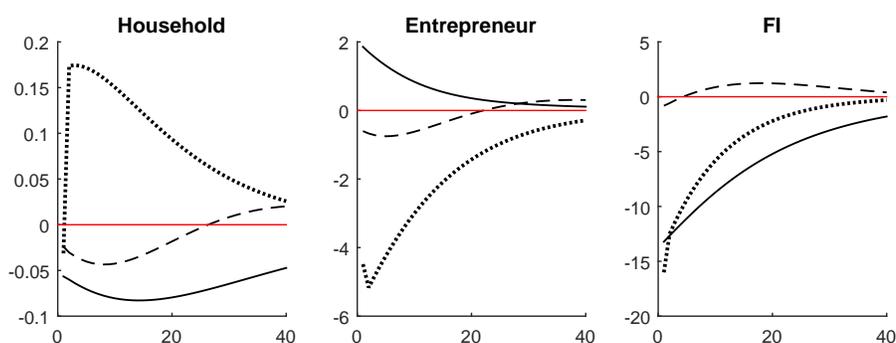


Figure 3.10: The implications of flow specific capital controls for agent welfare following a negative foreign interest rate shock (ε_t^F). Baseline (no capital controls): solid line. Outflow control: dashed line. Inflow control: dotted line.

The agent specific welfare dynamics of figure 3.10 illustrate that by preventing optimal collateral allocation, the inflow capital control generates social welfare losses that are driven by the entrepreneur. In this case, reduced access to inflows implies that the inflow control carries a consumption cost for the entrepreneur, and as such, the entrepreneur associates the inflow

²⁶Since the shock is contractionary for the home economy, the demand for labour services declines and real estate shifts from the entrepreneur to the household.

capital control with welfare losses.²⁷ In contrast, shock amplification under the inflow control implies that, from the household's perspective, the inflow capital control is associated with welfare gains. These welfare gains stem from amplification of household leisure and real estate dynamics under the inflow control. The FI's welfare dynamics are similar between the baseline model and when the inflow control is present. Here, the quicker recovery of FI balance sheets under the inflow control is negated by the larger initial balance sheet reduction that results from shock attenuation.

The outflow control bears no direct consequences for optimized collateral allocation by the entrepreneur, and affords virtuous spill-over of the foreign collateral value channel to the home economy. This property realizes an improvement on the baseline's dynamics as illustrated by the smaller welfare losses of the household and FI in figure 3.10. As with the inflow control, the home entrepreneur experiences a welfare loss when the outflow control binds. Therefore, the outflow control's attenuation of foreign debt dynamics sees that the wealth reduction associated with the shock dominates the entrepreneur's consumption dynamics. Because the outflow control bears no direct influence over collateral allocation, the entrepreneur's welfare loss is smaller than that associated with the inflow control, and so in terms of welfare, each agent strictly prefers the outflow control to the inflow control.

The preferability of the outflow control is consistent with the existing literature and, as per the analysis of section 3.6, this preference stems from the fact that the outflow control does not directly influence optimal collateral allocation. In previous studies, the welfare benefits of capital controls are predicated on these controls imparting an indirect influence over the borrowing behaviour that they seeks to address. Since this behaviour is optimal in the absence of such a control, capital controls that impart a direct effect on borrowing can reduce welfare by more than the gains stemming from a decrease in the external vulnerability of the economy (see e.g., Arnott *et al.*, 1994; Korinek, 2011). In contrast, capital controls that bear no direct consequences for this borrowing behaviour, but still reduce external vulnerabilities will be welfare enhancing.

Thus, because the outflow capital control is imposed on the financial sector, and not the real sector, it has an indirect effect on the borrowing behaviour exhibited by the real sector (home entrepreneur), and as such, is associated with improvements to the baseline's social welfare dynamics.²⁸

²⁷The baseline entrepreneur consumes the increase in foreign debt because of the negative effect that the shock has on home output.

²⁸Although the outflow control does reduce entrepreneur welfare, figure 3.9 shows that

In contrast, the inflow capital control's manifestation in the real sector implies that it directly affects the borrowing behaviour exhibited by the real sector, culminating in social welfare losses relative to the baseline.

3.8 Conclusion

This essay investigates the effectiveness of flow specific capital controls as a means to curb the increase in emerging market foreign debt that accompanied the post 2008 low interest rate environment. I contrast the impact of an outflow capital control imposed on the financial sector to an inflow capital control imposed on the real sector.

Both controls are shown to be effective at managing capital flows and can feasibly be implemented by emerging market authorities. The outflow control analysis shows that, in addition to its influence over capital flows, the outflow capital control is an effective insulator from negative foreign interest rate shocks. In contrast, the analysis of the inflow control suggests that its effectiveness at managing capital flows comes at the cost of shock amplification.

The findings indicate that the outflow capital control confers social welfare benefits whilst the inflow capital control is associated with social welfare losses. Social welfare gains under the outflow control stem from the ability of this control to co-exist with optimal collateral allocation. The welfare analysis also shows that each capital control bears different implications for agent welfare. Taken together, this essay points to the comparative desirability of capital controls imposed on the financial sector as opposed to the real sector.

Given the focus of this essay on the ability of capital controls to manage capital flows, the framework deployed in this analysis abstracted from nominal rigidities and the ability of monetary policy and foreign reserve accumulation to address such concerns. I leave the introduction of these features for future research.

the indirect nature of this influence implies a net welfare gain for the home economy.

Chapter 4

Macroprudential policy and foreign interest rate shocks in a small open economy

This essay presents a generic small open economy real business cycle model with banking and foreign borrowing. I incorporate capital requirements, reserve requirements, and loan-to-value (LTV) regulation into this framework, and subject the model to a positive foreign interest rate shock that raises the country risk premium and reduces the supply of foreign funds. The results show that these macroprudential instruments can attenuate the impact of such a shock, and that this attenuation property increases with the strictness of the regulatory regime. Capital requirements and LTV regulation deliver the largest attenuation benefits and are shown to be close substitutes. That being said, capital requirements are shown to be more effective at leaning against the financial cycle whereas LTV regulation is more effective at stimulating the financial cycle. The analysis indicates that capital and reserve requirements can interact such that reserve requirements are most effective when used to supplement existing capital requirement or LTV measures. I find that financial and macroeconomic stability objectives are aligned following a positive foreign interest rate shock such that a macroprudential response to such shocks can be to the benefit of both objectives. Lastly, the study shows that capital requirements and LTV regulation may exhibit decreasing returns to scale.

4.1 Introduction

This essay presents a generic small open economy framework with loan-to-value (LTV) regulation, capital requirements, and reserve requirements, and compares the ability of these instruments to insulate the economy from a positive shock to the foreign interest rate. My interest in studying a macroprudential response to foreign interest rate shocks stems from the tightening cycle currently underway in the United States and the reliance of emerging markets on foreign sources of credit.¹ Emerging markets' preference for foreign financing comes on the back of extensive quantitative easing and historically low interest rates in developed economies (Ahmed and Zlate, 2014; Shin, 2014). In this setting, the Federal Reserve's tightening efforts could increase the country risk premium of emerging markets, reducing their access to foreign funds (Bellas and Papaioannou, 2010; Dell'Erba *et al.*, 2013). In turn, restricted access to foreign funds can limit credit, asset price, and output growth in these economies, with accompanied negative consequences for their domestic macroeconomic environment (Forbes and Warnock, 2012; Bruno and Shin, 2015; Banerjee *et al.*, 2016).

I assess the impact of LTV, capital, and reserve requirements in isolation of other central bank tools, focusing on the transmission channels of each instrument and their comparative effectiveness in dealing with foreign interest rate shocks. In this chapter's model, the presence of a Kiyotaki and Moore (1997) collateral constraint amplifies the effects of positive foreign interest rate shocks, where macroprudential policy can offer shock attenuation benefits by limiting the feedback between the real and financial sector that results from this constraint. LTV regulation affects demand for real estate by limiting the degree to which real estate accumulation relaxes the model's collateral constraint, leading to reduced feedback between the real and financial sectors. Capital and reserve requirements affect the interest rate on entrepreneur loans, implying that these instruments proffer attenuation benefits by reducing demand for credit.

Macroprudential instruments have been shown as adept at addressing foreign shocks that are transmitted through the financial sector. For instance, Ozkan and Unsal (2014) find that the effectiveness of macroprudential policy is enhanced in the presence of financial shocks and foreign debt. In contrast, a monetary policy response to such shocks could be suboptimal. The cost-benefit framework of Svensson (2016) indicates that the costs associated with a monetary policy response to financial shocks outweigh

¹See Clarida (2015) for a discussion on the challenges faced by the Federal Reserve in the current tightening cycle.

the benefits. Glocker and Towbin (2012) and Bailliu *et al.* (2015) show that a coordinated monetary-macroprudential response offers few benefits over a setting where monetary policy and macroprudential policy operate independently. In Cesa-Bianchi and Rebucci (2017), monetary policy faces a trade-off between price and financial stability such that the introduction of a separate macroprudential instrument facilitates the simultaneous pursuit of both price and financial stability objectives. A capital control response to foreign interest rate shocks is also possible; however institutional support for such measures rests on the exhaustion of alternative policy tools (Fritz and Prates, 2014). Focusing on macroprudential instruments alone also facilitates the tractability of the analysis.

This essay contributes to the growing macroprudential literature through its comparison of LTV, capital, and reserve requirements in a small open economy model. In the existing literature, focus is placed on the interaction between monetary and macroprudential policy, or on the ability of macroprudential instruments to reduce the frequency with which economies find themselves in states where their financial frictions bind. These studies usually deploy a single rules-based macroprudential instrument in a closed economy environment, finding that macroprudential policy can be to the benefit of monetary policy, and that macroprudential regulation can limit the occurrence of states where financial frictions bind.² I take the desirability of macroprudential policy as indicated by this literature as given, and seek to enhance our understanding of the comparative effectiveness of different macroprudential instruments. By studying LTV, capital, and reserve requirements together, this analysis aims to provide insights into the difference between measures that operate on the supply (capital and reserve requirements) and demand (LTV regulation) sides of credit markets (Lim *et al.*, 2011; Galati and Moessner, 2013).

To compare the effectiveness of these different macroprudential instruments, I distinguish between strict, baseline, and easy regulatory regimes and analyze the model's volatility and impulse response functions for each instrument-regime pair. This ad-hoc approach to studying the effects of macroprudential policy differs from the optimized rules-based instruments deployed elsewhere (see e.g., Brzoza-Brzezina *et al.*, 2015). In this case, using an ad-hoc specification for different macroprudential instruments fa-

²See Glocker and Towbin (2012), Agénor and da Silva (2014), Mendicino and Punzi (2014), and Rubio and Carrasco-Gallego (2014) for studies on the interaction of macroprudential and monetary policy. Benigno *et al.* (2013), Bianchi and Mendoza (2013), and Cesa-Bianchi and Rebucci (2017) deploy frameworks with occasionally binding financial frictions to show that macroprudential policy limits the frequency with which these frictions bind.

facilitates instrument comparison since the movement between regulatory regimes entails a standardized change in the calibration of each instrument. As a result, I can comment on the relative effectiveness of each instrument in dealing with foreign interest rate shocks, as well as the returns to scale of each instrument. This approach also affords an assessment of the trade-offs between financial and macroeconomic stability when macroprudential regulation is changed.

Although this methodological approach affords a comparison across macroprudential instruments and regimes, one could argue that the absence of monetary policy or capital controls from the model negates the value of this analysis. Indeed, capital controls and the policy rate are macroprudential instruments as both proffer a means through which authorities can pursue financial stability objectives. In the case of the policy rate, theoretical evidence indicates that traditional macroprudential instruments are more effective when foreign liabilities are sizable, or when the economy is hit with financial shocks (Glocker and Towbin, 2012; Ozkan and Unsal, 2014).³ On the empirical front, the evidence indicates that a monetary policy reaction to financial stability concerns brings few benefits, if any at all (Bailliu *et al.*, 2015; Aiyar *et al.*, 2016; Svensson, 2016). In the case of capital controls, although support for their deployment has grown, these tools are still seen as a measure of last resort that should only be deployed once traditional macroprudential and policy rate measures have been exhausted.⁴

The results concur with existing evidence in that the deployment of macroprudential instruments can help to attenuate the negative consequences of foreign interest rate shocks. Capital requirements and LTV regulation offer large attenuation benefits that are of a similar magnitude. Reserve requirements also offer attenuation benefits, but these are small and diminish quickly. An assessment of the transmission channels of each instrument reveals that the smaller attenuation benefits of reserve requirements stem from their interaction with capital requirements. Thus, analyses that study reserve requirements in isolation of capital requirements may overstate the impact of this instrument as they do not account for this interaction (see e.g., Glocker and Towbin, 2012; Agénor and da Silva, 2014)

I also find that, following a positive foreign interest rate shock, macroeconomic and financial stability concerns become aligned such that macro-

³The model presented here bears both of these features – the banker has foreign loans and I subject the model to a foreign interest rate shock that increases the country risk premium.

⁴Fritz and Prates (2014) provide an excellent review of the institutional debate on the use of capital controls.

prudential policy is able to address both simultaneously.⁵ This result concurs with Angelini *et al.* (2014) where the authors find that, in the face of financial shocks, capital requirements proffer significant macroeconomic stabilization gains. Furthermore, my findings indicate that asymmetries exist between both macroprudential instruments and regimes. Specifically, strict macroprudential regulatory regimes reduce the impact of foreign interest rate shocks relative to easy regulatory regimes, and the impact of LTV and capital requirements diminishes as the regulatory regime becomes stricter. In contrast, the quantitative impact of reserve requirements does not change across regulatory regimes.

Taken together, the analysis indicates that LTV and capital requirements are effective in dealing with foreign interest rate shocks where the magnitude of their effects are quite similar. Thus, changes to LTV regulation can easily be substituted by changes to capital requirements. Nevertheless, the results indicate that choosing between macroprudential instruments depends on the objectives of the regulator. Specifically, capital requirements are shown to be more effective at leaning against the financial cycle whereas LTV regulation is more effective at stimulating the financial cycle. In the case of reserve requirements, the smaller attenuation benefits associated with this instrument points to its effectiveness as a supplement to existing capital requirement or LTV measures.

The remainder of the paper proceeds as follows. Section 4.2 presents the model framework, with its calibration provided in section 4.3. The analysis on the ability of macroprudential instruments to deal with foreign interest rate shocks is contained in section 4.4. Lastly, section 4.5 concludes.

4.2 The model

The generic small open economy is populated by households, entrepreneurs, bankers, and exogenous foreign lenders. Households consume, accumulate real estate, and supply labor to entrepreneurs. Households are the savers in this economy, providing bankers with one-period interest bearing deposits. Entrepreneurs take on the role of borrowers in this economy. They combine their real estate holdings with household labor to produce output, where the use of real estate in production affords use of the real estate

⁵The coincidence of macroeconomic and financial stability objectives in the face of foreign interest rate shocks concurs with the empirical evidence of Claessens *et al.* (2012), Antonakakis *et al.* (2015), and Dees (2016) in that stronger links between the financial and business cycle during times of distress provides scope for welfare improvements through macroprudential regulation.

price and credit as measures of financial stability (see e.g., Angelini *et al.*, 2014). To finance their demand for the factors of production, entrepreneurs incur one-period interest bearing loans with bankers, subject to a collateral constraint. Bankers intermediate the flow of credit between savers and borrowers. In addition to the funds provided by households, bankers finance entrepreneurial loan extension through funds provided by foreign lenders.

I subject this model economy to a positive world interest rate shock designed to mimic a change in the stance of foreign monetary policy. This shock increases the country risk premium and bankers' external financing costs, restricting credit extension to entrepreneurs. In turn, the entrepreneur's collateral constraint affords dynamic feedback between interest rates, credit quantities, and asset prices such that positive world interest rate shocks see a large and persistent decline in credit, asset prices, and output.

This framework incorporates LTV, capital, and reserve requirements to insulate the economy from such shocks. LTV regulation is imposed on the demand side of the credit market (entrepreneurs), whilst capital and reserve requirements are imposed on the supply side of the credit market (bankers). Each macroprudential instrument has a different transmission channel, where this analysis comprises a comparison of their effectiveness in dealing with the shock. In this regard, I study the effects of a standardized discretionary change in the calibration of each instrument on the impulse response functions and steady state standard deviations of the economy. I present the model economy that incorporates these three instruments below.

4.2.1 Households

The representative household maximizes its expected lifetime utility function

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right\}, \quad (4.1)$$

subject to the following budget constraint

$$C_t^h + D_t + q_t(H_t^h - H_{t-1}^h) + T_t = R_{t-1}^d D_{t-1} + W_t N_t. \quad (4.2)$$

In the household's utility function, the discount factor is given by β_h , whilst j and τ are utility parameters related real estate holdings (H_t^h) and

leisure $(1 - N_t)$. C_t^h and N_t give household consumption and labour supply, respectively. q_t denotes the price of real estate in units of consumption and W_t gives the wage rate. D_t denotes one-period bank deposits which earn a gross interest rate of R_t^d . Lastly, T_t gives lump-sum taxes imposed by the government.

Denoting $m_t^h \equiv \frac{\beta_h C_t^h}{\mathbb{E}_t C_{t+1}^h}$ the household's stochastic discount factor, the first order conditions for deposits (D_t), real estate (H_t^h), and labour (N_t) are as follows:

$$1 = m_t^h R_t^d, \quad (4.3)$$

$$q_t = \frac{j C_t^h}{H_t^h} + m_t^h \mathbb{E}_t q_{t+1}, \quad (4.4)$$

$$W_t = \frac{\tau C_t^h}{1 - N_t}. \quad (4.5)$$

Condition 4.3 provides the behavioural rule for the benchmark domestic interest rate in the economy. It requires R_t^d to be such that the current period utility cost of deposits equates to the returns in the following period. The asset pricing equation (4.4) equates the value of real estate to its direct utility benefits in units of consumption plus the discounted utility benefit it offers in the next period through its influence on household wealth. Lastly, equation 4.5 sees the optimal wage rate equalling the marginal rate of substitution between consumption and leisure.

4.2.2 Entrepreneurs

Entrepreneurs allocate their available resources between real estate, loans from domestic banks, and labour to maximize their lifetime utility function given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{\log(C_t^e)\}, \quad (4.6)$$

where β_e is the entrepreneurial discount factor and C_t^e gives entrepreneurial consumption. The budget constraint for entrepreneurs is given by

$$C_t^e + q_t(H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + W_t N_t = Y_t + L_t. \quad (4.7)$$

The left hand side of equation 4.7 represents entrepreneurs' total expenditure, which consists of consumption (C_t^e), purchases of real estate ($q_t(H_t^e - H_{t-1}^e)$), gross repayments on loans from the previous period ($R_t^l L_{t-1}$), and the wage bill ($W_t N_t$). As per the right hand side of (4.7), these expenditures are financed with total income (Y_t) and new loans incurred with domestic bankers (L_t).

Here I introduce the first macroprudential instrument – the LTV ratio. I assume that entrepreneurs' borrowing capacity is limited to a fraction v_e of the expected value of their real estate stock in the next period:

$$\mathbb{E}_t R_{t+1}^l L_t \leq v_e \mathbb{E}_t q_{t+1} H_t^e. \quad (4.8)$$

Following Iacoviello (2005), the entrepreneur's production technology has a Cobb-Douglas functional form with input shares of α for real estate and $(1 - \alpha)$ for labour:

$$Y_t = (H_{t-1}^e)^\alpha (N_t)^{1-\alpha}. \quad (4.9)$$

With this specification for the production function, the entrepreneur's real estate holdings can be thought of as a proxy for physical capital.

Letting $m_t^e \equiv \frac{\beta_e C_t^e}{\mathbb{E}_t C_{t+1}^e}$ and $\lambda_t^e \equiv \frac{\lambda_t^e}{C_t^e}$ denote entrepreneurs' stochastic discount factor and the multiplier on (4.8) respectively, optimal entrepreneurial behaviour generates the following first order conditions for H_t^e , L_t , and N_t :

$$q_t = m_t^e \left(\frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e} + \mathbb{E}_t q_{t+1} \right) + v_e \lambda_t^e \mathbb{E}_t q_{t+1}, \quad (4.10)$$

$$1 = (m_t^e + \lambda_t^e) \mathbb{E}_t R_{t+1}^l, \quad (4.11)$$

$$W_t = \frac{(1 - \alpha) Y_t}{N_t}. \quad (4.12)$$

Condition 4.10 relates the current period marginal cost of real estate accumulation to the sum of its discounted marginal product and the utility benefits that it proffers through a relaxation of the entrepreneur's collateral constraint (equation 4.8). Equation 4.11 is the asset pricing equation for domestic borrowing. Lastly, (4.12) sees that labor gets paid its marginal product.

To ensure that entrepreneurs are borrowing constrained in equilibrium (i.e. $\lambda^e > 0$), requires a restriction on the feasible value of their discount factor. Formally, so long as

$$\beta_e < \frac{\beta_b}{1 - (1 - \vartheta)\lambda^e}, \quad (4.13)$$

it will be the case that $\lambda^e > 0$.⁶ This implies that entrepreneurs are relatively more impatient than households and ensures that entrepreneur wealth is insufficient to finance production in equilibrium (see, Iacoviello, 2005).

4.2.3 Bankers

Bankers are consumption maximizers, making use of household deposits and foreign funds to extend loans to entrepreneurs. In their loan extension, bankers are subject to capital and reserve requirements. The representative banker's objective function is given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \left\{ \log(C_t^b) \right\}, \quad (4.14)$$

where C_t^b and β_b denote their consumption and discount factor, respectively. The banker's budget constraint is given by

$$C_t^b + L_t + R_{t-1}^d D_{t-1} + R_{t-1}^f B_{t-1}^f + \zeta_t = D_t + B_t^f + R_t^l L_{t-1} + \zeta_{t-1}. \quad (4.15)$$

In (4.15) above, L_t denotes current period loan extension to entrepreneurs which accrues gross interest of R_{t+1}^l , repayable in the next period. Similarly, bankers pay gross interest of R_t^d and R_t^f on household deposits (D_t) and foreign funds (B_t^f). Lastly, ζ_t denotes one-period interest free required reserves.

Bankers are subject to capital requirements on their net-assets excluding required reserves. Letting $BK_t = L_t + \zeta_t - D_t - B_t^f$ denote bank capital, the capital requirement is given by

$$D_t + B_t^f \leq (1 - \vartheta)L_t + \zeta_t, \quad (4.16)$$

where ϑ determines the proportion of bank assets that must be backed by bank capital.

⁶ To derive this result, substitute the steady state of (4.11) into the steady state of (4.20) for R^l , and require that $\lambda^e > 0$.

Following Agénor *et al.* (2014), bankers are required to hold a fraction of their domestic liabilities as reserves. Reserve requirements are governed by condition 4.17:

$$\zeta_t \geq \varphi D_t, \quad (4.17)$$

As with households and entrepreneurs, denoting $m_t^b \equiv \frac{\beta_b C_t^b}{\mathbb{E}_t C_{t+1}^b}$ as the banker's stochastic discount factor, the banker's problem produces the first order conditions for deposits (D_t), foreign borrowing (B_t^f), loan extension to entrepreneurs (L_t), and required reserves (ζ_t) as follows⁷:

$$m_t^b R_t^d = 1 - \varphi \lambda_t^r - \lambda_t^c, \quad (4.18)$$

$$m_t^b R_t^f = 1 - \lambda_t^c, \quad (4.19)$$

$$m_t^b \mathbb{E}_t R_{t+1}^l = 1 - (1 - \vartheta) \lambda_t^c, \quad (4.20)$$

$$\lambda_t^r = 1 - m_t^b - \lambda_t^c. \quad (4.21)$$

Equations 4.18 and 4.21 show that reserve requirements decrease both current period benefits and discounted future period costs associated with raising deposits from households. Bankers' behavioural rule for loan extension (4.20) shows that current period costs are reduced as a result of utility benefits that loan extension provides through relaxing the capital requirement constraint. In contrast, (4.18) and (4.19) show that the capital requirement constraint reduces utility benefits from deposits and foreign funds. The first order conditions also show that tight capital requirements increase current period benefits, whilst higher reserve requirements reduce current period benefits.

Through (4.18), (4.19), and (4.20) the evolution of the spreads between interest rates can be described by:

$$m_t^b (R_t^f - R_t^d) = \varphi \lambda_t^r, \quad (4.22)$$

$$m_t^b (\mathbb{E}_t R_{t+1}^l - R_t^d) = \varphi \lambda_t^r + \vartheta \lambda_t^c, \quad (4.23)$$

$$m_t^b (\mathbb{E}_t R_{t+1}^l - R_t^f) = \vartheta \lambda_t^c. \quad (4.24)$$

⁷The multipliers on constraint (4.16) is denoted as $\Lambda_t^c \equiv \frac{\lambda_t^c}{C_t^b}$ whilst that on (4.17) is given by $\Lambda_t^r \equiv \frac{\lambda_t^r}{C_t^b}$.

Equation 4.22 shows that the spread between the returns on foreign funds and deposits is increasing in the tightness of their proximity to the minimum level of required reserves, whilst (4.23) shows that bankers pass the cost of capital and reserve requirements on to entrepreneurs. Equation 4.24 indicates that the spread between lending and foreign fund rates is increasing in the tightness of the capital requirement constraint (4.16).

To ensure that bankers make profits on their loans regardless of the source of their funding requires a binding capital requirement in equilibrium (i.e. $\lambda^c > 0$). When $\lambda^c > 0$, loan extension requires that bankers forgo consumption such that the interest rate on entrepreneur loans is a premium over that of their funding sources⁸. Taking the steady state of (4.3), (4.18), and (4.21), one can solve for λ^c , with the result that $\lambda^c > 0$ so long as

$$\beta_b < \frac{(1 - \varphi)\beta_h}{1 - \varphi\beta_h}. \quad (4.25)$$

If condition 4.25 holds, it will be the case that $R^l > R^f$ and $R^l > R^d$.

Equation 4.22 shows how reserve requirements exert an asymmetrical influence on the funding markets of bankers – in equilibrium, $R^f > R^d$ so long as $\lambda^r > 0$ and $\varphi > 0$. Taking the steady state of (4.3), (4.21), and (4.22), we have $\lambda^r > 0$ so long as $\beta_h < 1$. Thus, an equilibrium where $R^f > R^d$ will result when reserve requirements are present ($\varphi > 0$) and binding ($\lambda^r > 0$). In equilibrium, household deposits are insufficient to meet bankers' demand for funding. Bankers, therefore, need to incur debts with foreign lenders (i.e., $B^f > 0$) at an interest rate that is higher than that on deposits (i.e., $R^f > R^d$). This implies that D_t and B_t^f are imperfect substitutes, creating a non-trivial role for foreign lenders in the banker's problem which facilitates a spread between the cost of domestic and foreign banker funding sources.

Together, these restrictions on household and banker discount factors and the presence of reserve requirements generate an equilibrium in which bankers generate profits from lending regardless of the source of their funding, and that the cost of domestic funds is lower than that of foreign funds. This equilibrium relationship between interest rates can be summarized as:

$$R^l > R^f > R^d. \quad (4.26)$$

⁸A binding capital requirement in equilibrium implies that, in equilibrium, banker capital is positive, and so, loan extension is partly financed out of forgone banker consumption.

4.2.4 Foreign lenders

Risk-neutral foreign lenders can allocate their funds between debt issued either by the rest of the world or by the small open economy's domestic bankers. Debt issued by the rest of the world pays interest of R_t^w , whilst that issued by domestic bankers pays R_t^f . I assume the existence of information asymmetries such that foreign lenders face additional monitoring costs in extending funds to domestic bankers as compared to the rest of the world. These monitoring costs result in a fraction δ_t of the repayment being lost where loans to domestic bankers are concerned. Thus, for foreign lenders to be indifferent between lending to domestic bankers or the rest of the world, a country risk premium is required over the interest paid on debt issued by the rest of the world.

Formally, foreign lenders will require that the interest rate they receive on domestic banker borrowing be such that, after paying monitoring costs, it equates to the world interest rate:

$$R_t^w = (1 - \delta_t)R_t^f. \quad (4.27)$$

Where the country risk premium is denoted as $\chi_t \equiv \frac{1}{1-\delta_t}$ such that this risk premium is increasing in the size of monitoring costs. Following Minetti and Peng (2013), the country risk premium is positively related to the external debt to output ratio and the world interest rate. Letting variables without a t subscript denote steady state values, the behavioural rule for χ_t is given by

$$\chi_t = \kappa \left(\frac{B_t^f}{Y_t} / \frac{B^f}{Y} \right)^{\gamma_f} (R_t^w)^{\gamma_w}. \quad (4.28)$$

Where $\kappa = \frac{R^f}{R^w}$. The parameters γ_f and γ_w capture the degree to which the country risk premium reacts to changes in the external debt to output ratio and the world interest rate.

The world interest rate is assumed to be exogenous and follows an AR(1) process:

$$R_t^w = \rho_w R_{t-1}^w + \varepsilon_t^w, \quad (4.29)$$

where ρ_w is the autocorrelation coefficient and ε_t^w is a white-noise shock to the world interest rate with a standard deviation of σ_w .

Substituting (4.28) into (4.27) and taking logs generates the rule governing the supply of foreign funds:

$$\gamma_f \log(B_t^f) = \log(R_t^f) + \gamma_f \log(Y_t) + \gamma_f \log\left(\frac{B^f}{Y}\right) - (1 + \gamma_w) \log(R_t^w) - \log \kappa. \quad (4.30)$$

(4.30) shows the supply of foreign funds is positively related to the interest rate received thereon (R_t^f) and domestic fundamentals (Y_t), and negatively related to the world interest rate. Thus, positive shocks to the world interest rate serve to reduce the supply of foreign funds.

4.2.5 Macprudential regimes and social welfare

To assess the welfare costs associated with each macroprudential instrument, I follow Rubio and Carrasco-Gallego (2014) and numerically evaluate social welfare derived in each case. With household (ω_t^h), entrepreneur (ω_t^e), and banker (ω_t^b) welfare given as

$$\omega_t^h = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left[\log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right], \quad (4.31)$$

$$\omega_t^e = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \left[\log(C_t^e) \right], \quad (4.32)$$

$$\omega_t^b = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \left[\log(C_t^b) \right], \quad (4.33)$$

social welfare can be defined as the weighted sum of individual welfares:

$$\omega_t = (1 - \beta_h) \omega_t^h + (1 - \beta_e) \omega_t^e + (1 - \beta_b) \omega_t^b. \quad (4.34)$$

Weighting each agent's welfare by their respective discount factors ensures that all groups receive the same level of utility from a constant consumption stream.

4.2.6 Market Clearing

Market clearing is given by the following conditions:

$$1 = H_t^e + H_t^h, \quad (4.35)$$

$$Y_t = C_t^h + C_t^e + C_t^b + R_{t-1}^f B_{t-1}^f - B_t^f, \quad (4.36)$$

$$T_t = \zeta_t - \zeta_{t-1}. \quad (4.37)$$

Equation 4.35 is a simple normalization for housing as in Angelini *et al.* (2014) whilst equation 4.36 is the aggregate resource constraint. To close the model, (4.37) shows I assume that changes in reserves are financed entirely out of lump-sum taxes (or subsidies). Since there is no trade in this model, the current account balance is given by equation (4.38):

$$CA_t = B_{t-1}^f - B_t^f. \quad (4.38)$$

4.3 Calibration

Table 4.1 contains the model parameters for the generic small open economy. The values for $\beta_h = 0.985$, $\beta_b = 0.945$, and $\beta_e = 0.94$ are standard and ensure that both the banker's capital requirement and the entrepreneur's collateral constraint are binding. As in the small open economy of Minetti and Peng (2013), $j = 0.3$ sees that households and entrepreneurs split the total stock of real estate equally in the steady state. Setting $\tau = 2$ as per Iacoviello (2015) sees households devote roughly a third of their time to labour. I follow Iacoviello (2005), Aguiar and Gopinath (2007), and Minetti and Peng (2013) in calibrating $\alpha = 0.4$, which corresponds to labour's share in output being 0.6.

The baseline calibrations for each macroprudential instrument are as follows. Minimum capital requirements for bankers are set at 10%, which is in line with the minimum total capital plus conservation buffer as per Basel III (BIS, 2010). The reserve requirements ratio $\varphi = 0.1$ is as per Agénor *et al.* (2014). For LTV regulation, we calibrate $\nu_e = 0.75$, in line with the cross country evidence presented in IMF (2011).

I calibrate the parameters relating to the country risk premium, (4.28), with reference to empirical evidence on the determinants of emerging market sovereign spreads. This literature indicates a high degree of heterogeneity between emerging markets in their experience of foreign interest rate shocks; however, in general the findings indicate that $\gamma_w > 0$ and

Table 4.1: Calibration of model parameters.

Parameter	Symbol	Value
Household discount factor	β_h	0.985
Entrepreneur discount factor	β_e	0.94
Banker discount factor	β_b	0.945
Household real estate preference	j	0.3
Household labour supply parameter	τ	2
Real estate share in production	α	0.4
Loan-to-value ratio for entrepreneurs	ν_e	0.75
Capital to assets ratio	ϑ	0.1
Reserve requirement	φ	0.1
Country risk premium sensitivity to R_t^w	γ_w	0.85
Country risk premium sensitivity to $\frac{B_t^f}{Y_t}$	γ_f	0.05
AR(1) coefficient on R_t^w	ρ_w	0.85
Standard deviation of ε_t^w	σ_w	0.01

$\gamma_f > 0$.⁹ I calibrate $\gamma_w = 0.85$ to match Minetti & Peng's 2013 estimates for a variant of (4.28). This value also concurs with the empirical analysis of Eichengreen and Mody (1998) as well as that of Arora and Cerisola (2001). In the case of the sensitivity of the country risk premium to external debt levels, I set $\gamma_f = 0.05$ to ensure that positive shocks to the world interest rate increases the country risk premium. This calibration is in line with the estimates of Bellas and Papaioannou (2010) and Dell'Erba *et al.* (2013) where these authors estimate that a 1 p.p. increase in the external debt-to-GDP ratio of emerging markets is associated with a 0.03–0.05 p.p. increase in their country spread. It is worth noting that although changes to the calibration of γ_w and γ_f affect the results quantitatively, they bear no influence qualitatively. In evidence, figure C.1 plots the impact of a foreign interest rate shock across alternative calibrations for γ_f and γ_w .¹⁰ Finally, I calibrate the AR(1) parameter on the world interest rate shock as $\rho_w = 0.85$ with a stan-

⁹See Eichengreen and Mody (1998), Arora and Cerisola (2001), Ferrucci (2003), and Ahmed *et al.* (2017) for evidence on the highly heterogeneous experience that emerging markets have with foreign interest rate shocks.

¹⁰Uribe and Yue (2006) find that, in small open economy models, the optimal parameter values that govern external debt accumulation depend on the model structure. In simplified settings such as that presented here, the values needed to match the impulse response functions generated by a VAR can be quite large. For instance, in the absence of capital adjustment costs, Uribe and Yue (2006) find that $\gamma_f = 0.95$ is needed to minimize the distance

dard deviation of $\sigma_w = 0.01$.

4.3.1 Comparing the effectiveness of macroprudential instruments

To analyse and compare the effectiveness of the macroprudential instruments in our model, I deploy each instrument across a variety of regulatory calibrations as per table 4.2. I contrast the baseline macroprudential calibration to both strict and easy regulatory regimes. Strict macroprudential regimes are defined by higher capital or reserve requirements (relative to the baseline) or lower LTV requirements (relative to the baseline). The converse holds under an easy macroprudential regime, where capital and reserve requirements are lower, and LTV requirements are higher than the baseline calibration.

Table 4.2: Calibration of alternative macroprudential regimes.

Parameter	Symbol	Baseline	Strict	Easy
Loan-to-value ratio	ν_e	0.75	0.7	0.8
Capital to assets ratio	ϑ	0.1	0.15	0.05
Reserve requirement	φ	0.1	0.15	0.05

Table 4.2's ad-hoc specification of the different macroprudential regimes is consistent with a setup where the financial frictions always bind and a desire to conduct a comparison of different macroprudential instruments. Previous studies have made use of rules-based macroprudential instruments and optimized policy parameters to study the effectiveness of these instruments in limiting the frequency with which financial frictions bind, or to assess the merits of including a financial stability objective to monetary policy.¹¹ Since the entirety of this analysis occurs in a state where the financial frictions bind, modelling the macroprudential instruments as endogenous rules that reduce the frequency of such states is of little interest. Similarly, my interest in comparing different macroprudential instruments to one another negates the benefits of calculating optimal values for ν_e , ϑ , and φ . In this regard, calculating optimal policy parameters would only affect the

between their model and a VAR's impulse response functions.

¹¹Bianchi and Mendoza (2013), Akinci and Queralto (2014), and Cesa-Bianchi and Rebucci (2017) study the ability of macroprudential policy to limit the frequency with which financial frictions bind. Mendicino and Punzi (2014), Rubio and Carrasco-Gallego (2014), and Bailliu *et al.* (2015) study optimal macroprudential and monetary policy.

baseline level of the model's macroprudential calibration with no effect on the ad-hoc nature of the analysis. Nevertheless, the baseline calibration for each macroprudential instrument is in line with that advocated by international regulatory bodies (BIS, 2010; Lim *et al.*, 2011).

With the macroprudential calibration as per table 4.2, switching between regimes entails a standardized 5 percentage point (p.p.) increase or decrease relative to the baseline. I exploit the standardized nature of these changes in regulation to compare the effects of LTV, capital, and reserve requirements to one another. For instance, if \mathbf{X}_i^s is a vector containing the dynamics of variable X obtained under the strict regime of instrument i , instrument equality would imply that

$$\mathbf{X}_{LTV}^s = \mathbf{X}_{Capital}^s = \mathbf{X}_{Reserve}^s \quad (4.39)$$

$$\mathbf{X}_{LTV}^e = \mathbf{X}_{Capital}^e = \mathbf{X}_{Reserve}^e \quad (4.40)$$

Where vector \mathbf{X}_i^e contains variable X 's dynamics under the easy regime of instrument i . If both equations 4.39 and 4.40 hold, the analysis indicates that a 5 p.p. change in capital requirements has the same effect on X as a 5 p.p. change in LTV or reserve requirements.

The ad-hoc specification also afford an assessment of the returns to scale associated with each instrument. For an instrument to exhibit constant returns to scale, the quantitative impact of moving from the baseline to the strict regime must be the same as moving from the baseline to the easy regime, but of the opposite sign. For example, LTV regulation will exhibit constant returns to scale if

$$\frac{|\mathbf{X}_{LTV}^s|}{|\mathbf{X}_{Baseline}|} = \frac{|\mathbf{X}_{LTV}^e|}{|\mathbf{X}_{Baseline}|}, \quad (4.41)$$

where vector $\mathbf{X}_{Baseline}$ contains variable X 's dynamics under the baseline regime. Alternatively, decreasing returns to scale imply that the impact of macroprudential instruments decline as the regulatory regime moves from an easy to a strict calibration. In this case, the impact of moving from the easy to baseline regime would be greater than the impact of moving from the baseline to the strict regime.

4.4 A macroprudential response to foreign interest rate shocks

Positive foreign interest rate shocks increase the country risk premium as per equation 4.28, and reduce the supply of foreign financing. This increase in banker funding costs realizes higher domestic borrowing costs which impacts negatively on entrepreneur credit ceilings through their collateral constraint. In turn, lower credit extension to entrepreneurs tightens the banker's capital and reserve requirements, realizing additional increases in domestic borrowing costs and further declines in the banker's access to foreign funds. These dynamics culminate in a downward spiral in asset prices and credit extension, which see positive foreign interest rate shocks impart a persistent negative effect on both the financial sector and real economy.¹²

Macroprudential regulation can mitigate the negative effects of foreign interest rate shocks by limiting the vicious feedback that the shock induces between asset prices and credit extension. To illustrate this shock attenuation property, I discuss the different transmission channels of each of our macroprudential instruments and plot the impulse response functions obtained under each instrument and regime. Next, I assess whether there is a trade-off between financial stability and macroeconomic stability in the deployment of each instrument following a positive foreign interest rate shock and elaborate on these findings by comparing the effectiveness and returns to scale of each macroprudential instrument. Taken together, this analysis identifies which instrument(s) are best suited to respond to the negative effects of positive foreign interest rate shocks.

4.4.1 LTV regulation

The dynamic interaction between credit ceilings and asset prices afforded by constraint 4.8 underpins the magnitude and persistence of the negative effects associated with foreign interest rate shocks. This interaction between the real and financial sector is governed by the entrepreneur's first order condition for real estate holdings:

$$q_t = m_t^e \left(\frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e} + \mathbb{E}_t q_{t+1} \right) + v_e \lambda_t^e \mathbb{E}_t q_{t+1}. \quad (4.42)$$

In (4.42) the marginal value of credit to the entrepreneur, λ_t^e , provides the link between credit markets and the behaviour of asset prices. Thus, in or-

¹²The dynamics of the baseline model are in line with those in the small open economy literature (e.g., Neumeyer and Perri, 2005; Minetti and Peng, 2013).

der to mitigate the negative effects of foreign interest rate shocks, regulation should either reduce the interaction between credit and real estate markets, or reduce the marginal value of credit to the entrepreneur.

Changes to LTV regulation (v_e) can affect the downward spiral in loans and asset prices through the influence that this instrument has on the interaction between credit and real estate markets (λ_t^e and q_t). To illustrate, figure 4.1 compares the impulse response functions (IRFs) for select variables under the strict, baseline, and easy LTV regimes as per table 4.2. In the baseline regime, a positive foreign interest rate shock causes an increase in interest rate spreads, a reduction in entrepreneurial loans and foreign funds, as well as lower output, consumption, and asset (real estate) price growth.¹³

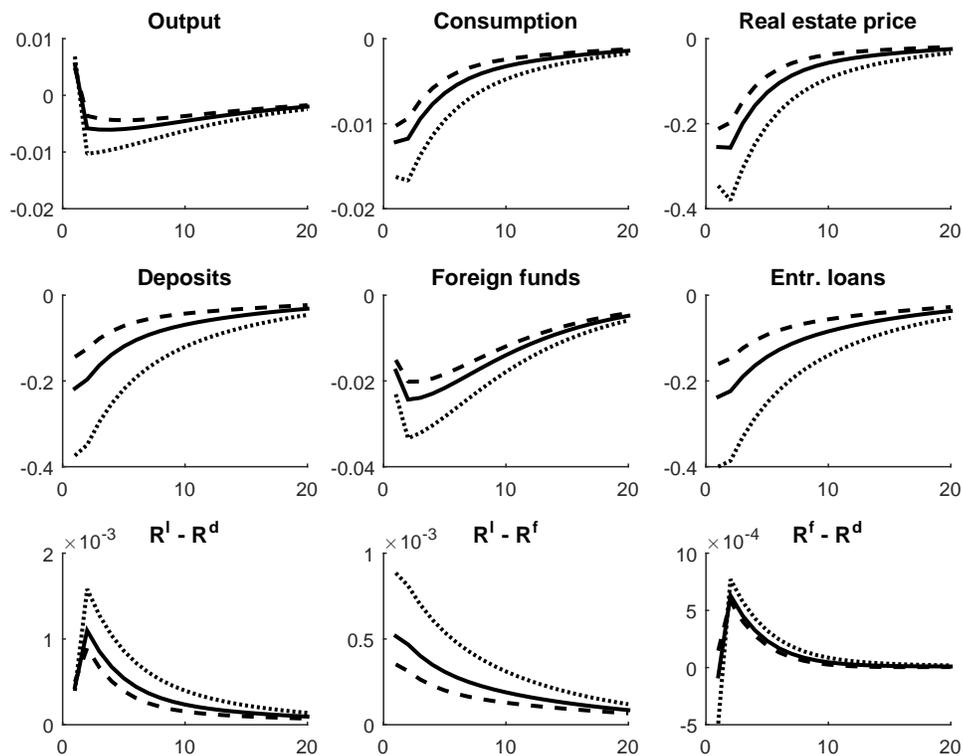


Figure 4.1: Impulse response functions following a positive shock to R_t^w for different LTV regimes as per table 4.2. Solid line: baseline calibration; Dashed line: strict LTV regime; Dotted line: easy LTV regime.

¹³ The figure plots aggregate consumption, defined as $C_t = C_t^h + C_t^e + C_t^b$.

As per (4.42), a strict LTV regime reduces the feedback between credit and asset markets such that the effects of foreign interest rate shocks are attenuated under a strict (as opposed to baseline) regime. Shock attenuation under the strict regime results from lower entrepreneur demand for real estate. When the strict LTV regime is imposed, an additional unit of real estate affords access to less loan credit, and since the entrepreneur's marginal value of credit (λ_t^e) is unaffected by LTV regulation, this translates into a demand for real estate that is both lower and less sensitive to foreign interest rate shocks than under the baseline. Under an easy regime, the opposite occurs, where (4.42) serves to enhance entrepreneur demand for real estate and the feedback between credit and asset markets relative to the baseline. This holds across all variables: the strict LTV regime attenuates the impact of foreign interest rate shocks relative to the baseline whilst the easy regime sees that their impact is amplified relative to the baseline.

4.4.2 Capital requirements

Whilst LTV regulation proffers attenuation benefits by reducing the entrepreneur's demand for real estate, capital requirements can influence (4.42) by targeting the entrepreneur's demand for credit. The banker's first order condition for loans shows that the capital requirement (ϑ) can affect the marginal value of credit to the entrepreneur, $\lambda_t^e = \frac{1}{R_{t+1}^l} - m_t^e$, through its influence over the interest rate on entrepreneur loans¹⁴:

$$m_t^b \mathbb{E}_t R_{t+1}^l = 1 - (1 - \vartheta) \lambda_t^c. \quad (4.43)$$

Where λ_t^c gives the marginal value of liquidity to bankers.

The stricter the capital requirement, the larger the fraction of loans that need to be financed with capital, and because raising capital entails a consumption cost for bankers, higher capital requirements increases the interest rate that bankers charge to entrepreneurs.¹⁵ Through (4.11), higher interest rates reduce the marginal value of credit to entrepreneurs. This lowers their demand for credit and reduces feedback between credit and asset markets as per (4.42). Figure 4.2 confirms this narrative and shows that the strict capital regime reduces the impact of foreign interest rate shocks on real and financial aggregates (top and middle rows). The opposite occurs when the

¹⁴ $\lambda_t^e = \frac{1}{R_{t+1}^l} - m_t^e$ is derived from the entrepreneur's first order condition for loans, (4.11).

¹⁵Bank capital is generated out of banker's consumption.

easy regime is imposed, and so the dynamics of these variables are amplified relative to the baseline.

A comparison across figures 4.1 and 4.2 shows that although strict LTV regulation and capital requirements exhibit similar shock attenuation properties for the quantitative macroeconomic variables of the model, these two instruments have different effects on interest rate spreads. This disparity illustrates the different transmission channels of LTV and capital requirements. Specifically, where changes in LTV regulation are initially transmitted through real estate markets, changes in capital requirements are initially transmitted through interest rates. This difference between the transmission channels of LTV and capital requirements is illustrated by the differential response of the interest rate spreads in figures 4.1 and 4.2.

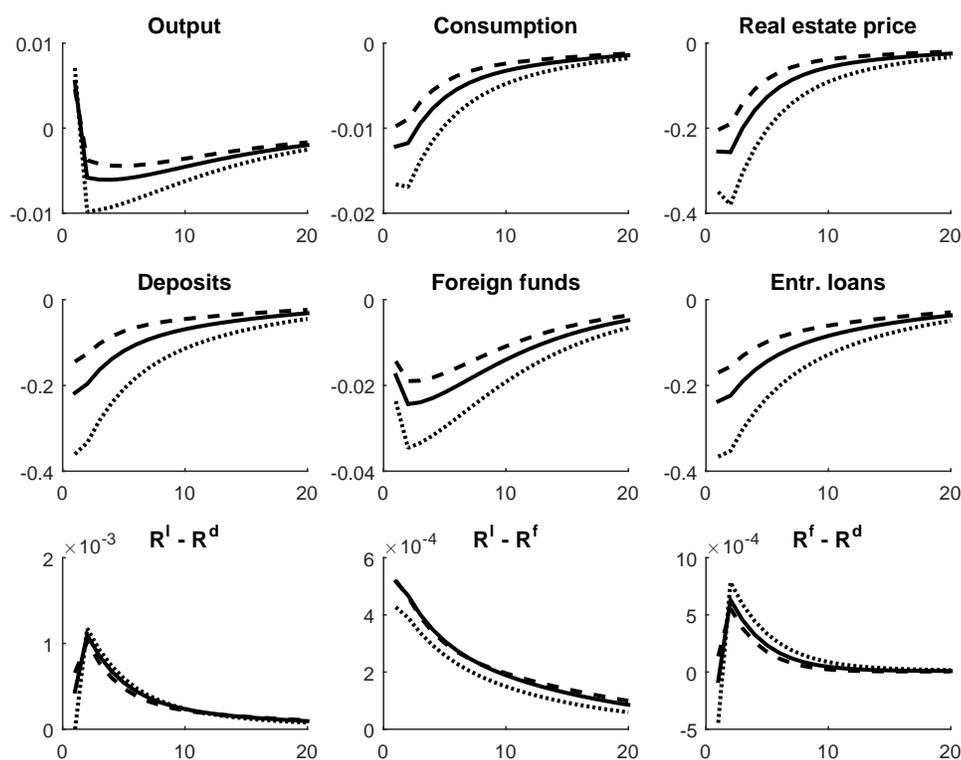


Figure 4.2: Impulse response functions following a positive shock to R_t^w for different capital requirement regimes as per table 4.2. Solid line: baseline calibration; Dashed line: strict capital requirement regime; Dotted line: easy capital requirement regime.

Using the relationship between interest rate spreads as given by equations 4.22 to 4.24, we can decompose the impact of capital requirements on interest rate spreads into two parts. The first part reflects the impact of capital requirements on the feedback between asset and credit markets in (4.42) through its influence over the marginal value of credit to the entrepreneur and is illustrated by $R^f - R^d$. The second part reflects the influence that capital requirements have on the sensitivity of the banker's consumption stream and is illustrated by $R^l - R^f$. In turn, the dynamics of $R^l - R^d$ can be seen as an amalgamation of these two forces.¹⁶ Thus, on the one hand, a strict capital regime attenuates the behaviour of domestic spreads ($R^l - R^d$) through its ability to limit the feedback between asset and credit markets in (4.42). On the other hand, a strict capital requirement regime amplifies the behaviour of domestic spreads by increasing the sensitivity of banker consumption to foreign interest rate shocks. As a result of these two opposing forces, changes in the capital requirement regime have a more muted effect on domestic interest rate spreads as compared to changes in LTV regulation. Nevertheless, the dynamics of $R^l - R^d$ shows a marginal attenuation of domestic spread dynamics under strict capital requirements.

4.4.3 Reserve requirements

The attenuation benefits of reserve requirements also result from their influence over the cost of loan finance to entrepreneurs; however this instrument imparts less influence over interest rates than capital requirements. The comparative inefficiency of reserve requirements stems from the fact that this instrument does not directly affect the interest rate on loans, rather it has direct bearing over the marginal value of liquidity to bankers, λ_t^c , which in turn affects R_{t+1}^l . Using equations 4.18 and 4.21, we can solve for λ_t^c as:

$$\lambda_t^c = 1 - (R_t^d - \varphi) \frac{m_t^b}{1 - \varphi}. \quad (4.44)$$

Equation 4.44 shows that the marginal value of liquidity to the banker is given by the extra consumption that borrowing affords, net of repayment obligations.

As per (4.43), reserve requirements (φ) can attenuate the impact of foreign interest rate shocks if they decrease the marginal value of liquidity to

¹⁶Equation 4.23 shows that the loan-deposit spread ($R^l - R^d$) depends on both capital and reserve requirements whilst (4.24) shows that the loan-foreign fund spread ($R^l - R^f$) depends solely on capital requirements. Lastly, equation 4.22 shows that the foreign fund-deposit spread ($R^f - R^d$) depends solely on reserve requirements.

bankers. Changes in reserve requirements exert two opposing effects on the marginal value of liquidity. On the one hand, stricter reserve requirements increase the marginal value of liquidity by reducing the interest rate on deposits (see equation 4.18). On the other hand, because the reserve requirement is financed with deposits, stricter regimes tighten the banker's capital requirement which serves to decrease their marginal value of liquidity.¹⁷ Because of these two opposing effects, changes in reserve requirements will have a more muted impact on R_{t+1}^l than capital requirements.¹⁸

The transmission of reserve requirements illustrates how different macroprudential instruments can influence one another. Previous analyses on the effects of reserve requirements focus on the liquidity benefits provided by this instrument and study it in isolation of capital requirements (see e.g., Glocker and Towbin, 2012; Agénor and da Silva, 2014). This analysis shows that capital and reserve requirements interact such that the influence of reserve requirements on loan interest rates is reduced relative to a scenario where reserve requirements are applied in isolation of capital requirements. Note that the impact of the capital requirement on the effectiveness of reserve requirements works in one direction: the presence of a reserve requirement does not affect the ability of capital requirements to influence interest rates. Furthermore, this interaction between capital and reserve requirements is predicated on the assumption that the capital requirement is binding. In this model, if the capital requirement does not bind, λ_i^c disappears from equation 4.43 and reserve requirements have no effect on loan interest rates or the feedback between asset and credit markets.

Figure 4.3 reveals that, as a result of the two opposing effects that reserve requirements have on the marginal value of liquidity to bankers, this instrument delivers smaller and less persistent attenuation benefits as compared to LTV and capital requirements. Strict reserve requirements reduce the contemporaneous impact of the shock on aggregate consumption, asset prices, and entrepreneur loans, whilst output and household deposits are almost invariant to changes in the reserve requirement regime.¹⁹

The analysis above provides the rationale for a macroprudential response to foreign interest rate shocks and is illustrative of the subtle differences

¹⁷The capital requirement tightens because higher reserve requirements increase the share of deposits on the banker's balance sheet with no effect on the level of banker capital.

¹⁸Specifically, a 1 p.p. increase/decrease in reserve requirements will increase/decrease the interest rate on loans by less than a 1 p.p. increase/decrease in capital requirements.

¹⁹Although graphically extremely similar, the policy and transition functions upon which the impulse responses for output and deposits basically show a very small attenuation benefit for the strict regime and a very small amplification of the shock for the easy regime.

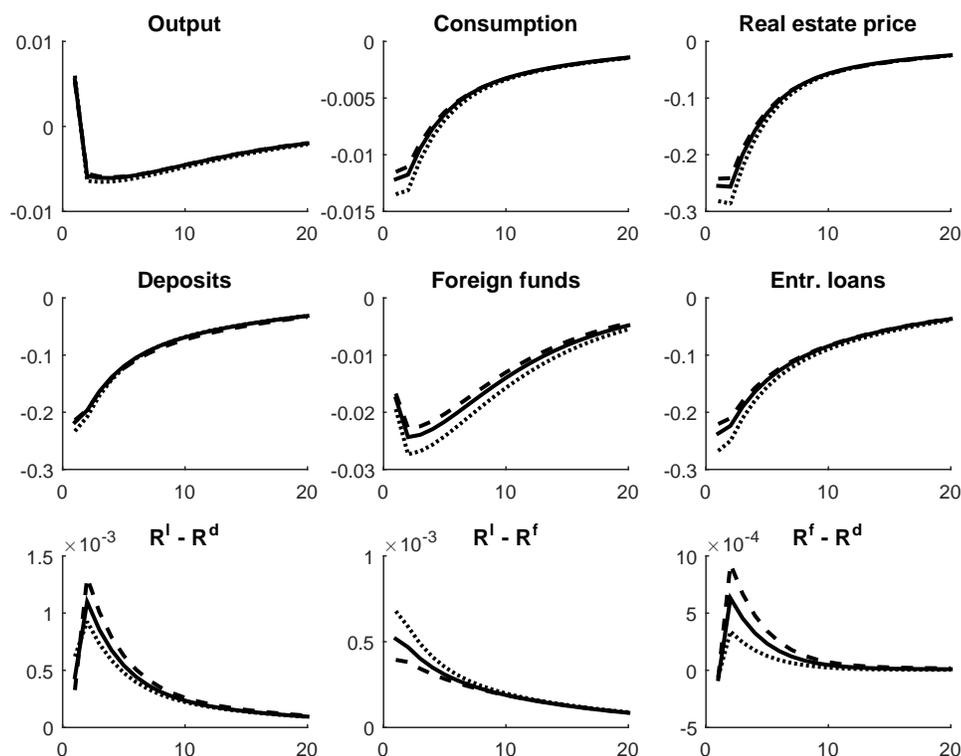


Figure 4.3: Impulse response functions following a positive shock to R_t^w for different reserve requirement regimes as per table 4.2. Solid line: baseline calibration; Dashed line: strict reserve requirement regime; Dotted line: easy reserve requirement regime.

and interactions between macroprudential instruments. For instance, even though changes to demand side regulation (LTV) are transmitted through real estate demand whilst changes supply side regulation (capital and reserve requirements) are transmitted through interest rates and credit demand, both can deliver similar shock benefits. Indeed, (4.8) implies that credit and real estate markets are in fact different sides of the same coin, and thus, measures aimed at the real estate market can be substituted for those aimed at the credit market. That being said, the analysis of reserve requirements shows that different supply side instruments can interact even though they have different transmission channels. As a result, the quantitative impact and comparative effectiveness of supply side macroprudential measures can vary across instruments.

4.4.4 Macroeconomic and financial stability across instruments and regimes

The simultaneity of business and financial cycles imply that macroprudential efforts can be complimentary to macroeconomic stability objectives (Borio, 2014; Smets, 2014). To assess whether macroprudential regulation can address both financial stability and macroeconomic stability concerns, I plot the change in the steady state standard deviation of output ($\Delta\sigma_Y$) and asset prices ($\Delta\sigma_q$) or loans ($\Delta\sigma_L$) for each instrument across the different regulatory regimes. In this case, $\Delta\sigma_Y$ serves as a measure of macroeconomic stability whilst the use of $\Delta\sigma_q$ and $\Delta\sigma_L$ as measures of financial stability is motivated with reference to their role in the financial cycle (see e.g., Galati and Moessner, 2013; Kuttner and Shim, 2016).

In line with Angelini *et al.* (2014), figure 4.4 illustrates that macroprudential regulation complements both financial and macroeconomic stability. This figure shows that, for each instrument, the standard deviation of output and asset prices (top panel) or output and loans (bottom panel) increases when we move from a strict to an easy regime. Therefore, stricter macroprudential regimes increase macroeconomic and financial stability, whilst easier regimes reduce macroeconomic and financial stability. Nevertheless, the size of the change in σ_Y , σ_q , and σ_L across regulatory regimes shows that although each instrument is able to foster both financial and macroeconomic stability, macroprudential regulation is more effective on the financial stability front. As per the IRF analysis, reserve requirements have a very small impact on the volatility of these three variables whilst LTV and capital requirements generate larger effects on variable volatility.²⁰

Although strict LTV and capital requirements deliver similar macroeconomic and financial stability benefits, the bottom panel of figure 4.4 indicates that moving from the baseline to the strict LTV regime realizes a marginally larger decrease in the volatility of loans than when moving from the baseline to the easy capital regime. Thus, in line with the different transmission mechanisms of LTV and capital requirements, these two instruments may impart different effects on different variables. Looking at the shape of the curves in figure 4.4, one can see that there may be decreasing returns to scale in LTV and capital requirements whereas reserve requirements exhibit constant returns to scale. Decreasing returns to scale in LTV and capital requirements is evidenced by the decline in the gradient of the LTV and capital requirement curves as we move from the easy to the strict

²⁰These findings are echoed by the steady state standard deviation of aggregate consumption, deposits, and foreign funds.

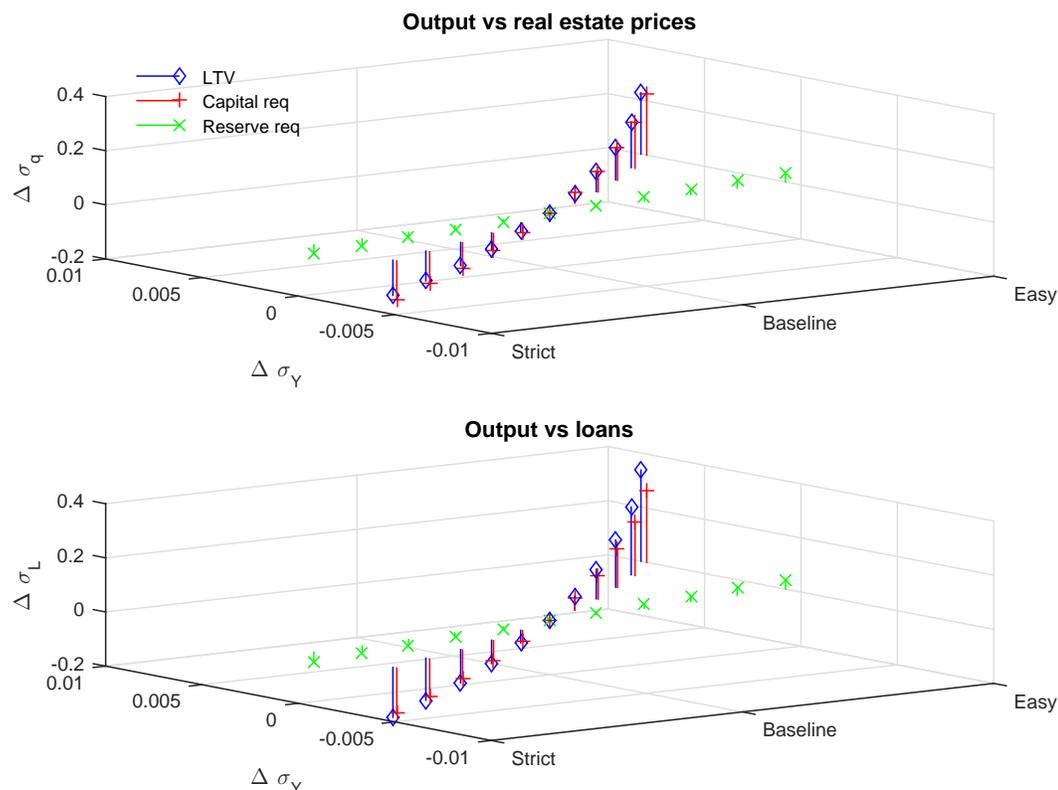


Figure 4.4: Trade-off between macroeconomic and financial stability across instruments and regimes. X-axis: macroprudential regimes, easy to strict. Y-axis: change in the standard deviation of output. Z-axis: change in the standard deviation of asset prices or loans. Top panel plots standard deviation of output vs. standard deviation of real estate prices. Bottom panel plots standard deviation of output vs. standard deviation of loans.

regime. Here, figure 4.4 shows that as authorities increase the strictness of LTV and capital requirements, the reductions in the standard deviations of output, asset price, and loans become smaller.

To get a better illustration of each instrument's influence over the financial and business cycle, figure 4.5 shows how the impact of the shock on output, asset prices, and loans varies across macroprudential instruments and regimes. I divide the absolute value of the contemporaneous response of each variable under each instrument-regime pair by the absolute value of its contemporaneous response under the baseline. Thus, in figure 4.5, values larger than one indicate cycle amplification relative to the baseline whilst values smaller than one are associated with cycle attenuation relative to the baseline.

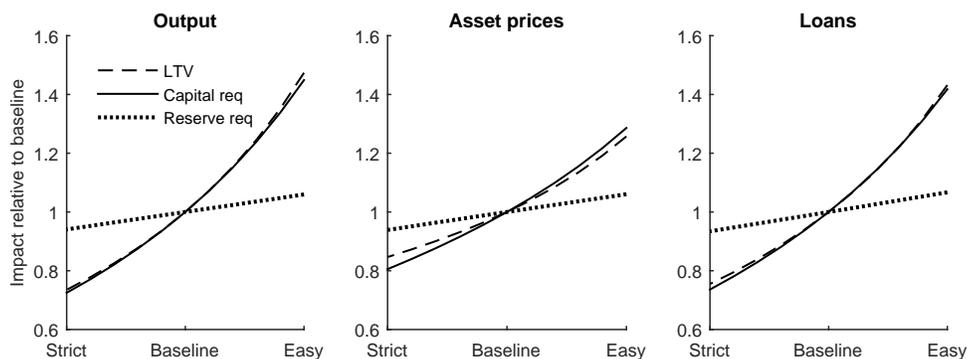


Figure 4.5: Macprudential instrument effectiveness. Values larger than 1 indicate shock amplification relative to the baseline. Values smaller than 1 indicate shock attenuation relative to the baseline.

This exercise reveals that LTV and capital requirements have very similar effects on output and loans, but differ in their impact on asset prices. Thus, the desirability of different macroprudential instruments depend on the objectives of the regulator. In this regard, figure 4.5 indicates that strict capital requirements may be more effective than strict LTV regulation when authorities seek to lean against the financial cycle. On the other hand, when authorities are interested in stimulating the financial cycle, easy LTV regulation is more productive than easy capital requirements. This insight is evidenced by the fact that strict LTV regulation has a smaller attenuation effect on asset prices than strict capital requirements, and easy LTV regulation has a smaller amplification effect on asset prices than easy capital requirements. In addition, the attenuating effect of strict LTV regulation on output and loans is marginally smaller than strict capital requirements, but the amplification effect of easy LTV regulation on output and loans is marginally larger than that of easy capital requirements. Within instruments, figure 4.5 reveals that both capital and LTV regulation exert the most influence over output, marginally less influence over loans, and the least influence over asset prices. In contrast, reserve requirements impart the same influence over output, asset prices, and loans.

Figure 4.5 is also indicative of decreasing returns to scale in LTV regulation and capital requirements. For instance in response to a 5 p.p. increase (strict) in capital requirements, the decline in asset prices following the foreign interest rate shock is approximately 20 p.p. smaller than under the baseline. In contrast, when capital requirements are decreased by 5 p.p. (easy), the decline in asset prices is approximately 30 p.p. larger than under

the baseline. As a result, authorities are able to realize larger macroeconomic and financial stability gains through LTV regulation and capital requirements when moving from the easy to the baseline regime, than when moving from the baseline to the strict regime. In contrast, the gradient of the reserve requirement curve in figure 4.5 remains constant regardless of the target variable, indicating that when changing reserve requirements, authorities can impart a small, but predictable influence over both the financial and business cycle.

Together, figures 4.4 and 4.5 indicate that following a positive foreign interest rate shock, macroeconomic and financial stability concerns are aligned: stricter policy can enhance both financial and macroeconomic stability. This result is in keeping with Claessens *et al.* (2012) and Antonakakis *et al.* (2015) where the findings of these studies indicate that the link between the financial and business cycle strengthens during times of distress. As per Dees (2016), the strengthening of this link during times of distress implies that the international transmission of financial shocks on the business cycle can be large, providing scope for welfare improvement through macroprudential regulation.²¹

This analysis shows that capital and LTV regulation proffer the most productive means with which to address the negative consequences of foreign interest rate shocks. As per the discussion of their different transmission channels, these two instruments work on different sides of the same coin: capital requirements reduce entrepreneur demand for credit whilst LTV regulation reduces the entrepreneur's demand for real estate (collateral assets). This difference in transmission mechanism sees that capital requirements are more effective in leaning against the financial and business cycle, whilst LTV regulation is more effective in stimulating said cycles. However the difference between these two instruments is marginal, indicating toward their substitutability.

The similarity of social welfare dynamics under the strict LTV and capital regimes as per figure 4.6 reiterates the substitutability of these instruments when dealing with foreign interest rate shocks.²² Although the contemporaneous shock attenuation benefits of the capital requirement are marginally larger than that of LTV regulation, the disparity diminishes quickly. Looking at the effect of the strict reserve requirement regime on social welfare, the small and temporary attenuation benefits associated with this instru-

²¹The shock is manifest in the foreign economy, where international transmission occurs through the country risk premium, equation 4.28.

²²Social welfare is defined by equation 4.34. I focus on the strict regime as it attenuates the impact of the foreign interest rate shock.

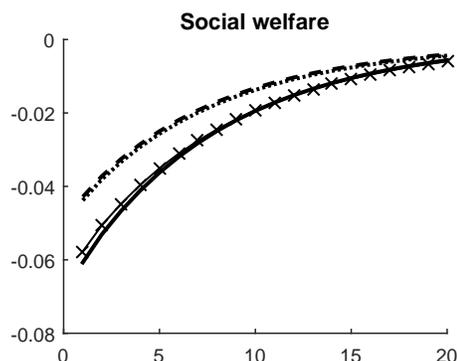


Figure 4.6: Impulse response functions of social welfare following a positive shock to R_t^w for different macroprudential instruments under the strict regime of table 4.2. Solid line: baseline calibration; Dashed line: strict LTV regime; Dotted line: strict capital requirement regime; Crossed line: strict reserve requirement regime.

ment points to its effectiveness as a supplement to existing LTV or capital requirement measures.

4.5 Conclusion

Although there is ample theoretical and empirical evidence on the benefits of macroprudential regulation to economic outcomes, not much is known about the comparative effectiveness of the various macroprudential instruments available to authorities. This essay contributes to our understanding of a subset of these instruments through the design a generic small open economy with banking and foreign borrowing where capital requirements, reserve requirements, and LTV regulation coexist. To compare these instruments, I subject the model to a positive foreign interest rate shock that increases the country risk premium with negative consequences for credit extension, asset prices, and output. I find that these macroprudential instruments can attenuate the impact of a positive foreign interest rate shock, and that a strict regulatory regime outperforms a baseline and an easy regime in this regard. I study the transmission channels of these three instruments and show that although capital and LTV regulation are imposed on different sides of the credit market, they are substitutable. This analysis of the transmission channels of reserve requirements indicate that capital requirements interacts with this instrument so as to negate the attenuation benefits of reserve requirements. As a result of this instrument interaction, the effects of reserve requirements diminish quite rapidly, indicating that this instrument

CHAPTER 4. MACROPRUDENTIAL POLICY AND FOREIGN INTEREST RATE SHOCKS IN A SMALL OPEN ECONOMY **115**

should be used to supplement existing LTV and capital requirements. The analysis also shows that financial stability concerns are complimentary to macroeconomic stability concerns following a positive foreign interest rate shock and that the desirability of different macroprudential instruments depend on the objectives of the regulator. In this regard, capital requirements seem most effective at leaning against the financial cycle whilst LTV regulation is most effective at stimulating the financial cycle. Lastly, the results indicate that that LTV and capital requirements may exhibit decreasing returns to scale.

Chapter 5

Summary

The seminal contributions of Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) greatly improved our understanding of the relationship between the credit cycle and macroeconomic outcomes. These authors endogenized the credit cycle into standard macroeconomic theory through the introduction of financial frictions that were predicated on information asymmetries or incomplete markets. Through these frictions, macroeconomic frameworks generate financial accelerator effects that replicate the amplitude and persistence of observed cyclical fluctuations. This result concurred with empirical evidence on the simultaneity of the business and credit cycle and pointed to credit markets as important structural transmission mechanisms that affect macroeconomic dynamics.

This thesis contributes to this literature in three respects. Firstly, in chapter 2 a closed economy model with heterogeneous credit markets is derived and estimated using Bayesian techniques. The model relaxes the single-representative credit market assumption inherent in most of the existing literature and affords an assessment of the effects of credit market heterogeneity. The model also provides a theoretical framework from which to study the benefits associated with revenue diversification within the banking sector. This feature affords a contrast of settings where commercial banks are prohibited from engaging in proprietary trading activities, to settings where no such prohibition exists. Chapter 3 extends this model to an asymmetric two-country setting, and investigates the efficacy of flow specific capital controls in attenuating the effects of foreign interest rate shocks. The use of an asymmetric setup is novel to the literature, and is used to replicate structural differences between developed and developing markets. Flow specific capital controls present another departure from the norm as these afford a regulatory focus on inflows and outflows separately. As an alternative to capital controls, the trade-offs between three different macropru-

dential instruments are investigated in chapter 4. The small open economy framework deployed for this analysis differs from existing work in that it is characterized by the co-existence of loan-to-value regulation, minimum capital requirements, and reserve requirements. This model is used to compare the effectiveness of each instrument in dealing with a tightening in foreign credit markets.

The post financial crisis shift by U.S. non-financial corporations away from loans and toward bond finance provides the empirical motivation behind the focus of chapter 2. This behaviour indicated that, if credit markets behave differently to one another, increases in the supply of one type of credit could make up for reductions in the supply of another. To test this hypothesis, this chapter extends the framework of Iacoviello (2015) to include both a bond and a loan market. Heterogeneity between bonds and loans is introduced in two ways. Firstly, through an assumed risk differential in the minimum capital requirements of financial intermediaries, and secondly, by assuming financial intermediaries only act as underwriters in the bond market.

Chapter 2's model is able to replicate the behaviour of U.S. non-financial corporate debt following the crisis and shows that the heterogeneous structure of credit markets can attenuate the impact of financial shocks. This result stems from the ability of borrowers to substitute away from the shock affected credit market toward alternate sources of financing. The model dynamics also indicate that financial shocks borne by savers deliver a smaller impact than financial shocks borne by financial intermediaries. This disparity results from the fact that financial shocks borne by savers do not directly influence the functioning of the financial sector. In contrast, when a financial shock impacts financial intermediaries directly, the efficiency of credit markets becomes impaired such that the shock's impact becomes amplified.

The results from chapter 2 indicate that the shock attenuation property of credit market heterogeneity is declining in the degree of balance sheet linkages within the financial sector. This result stems from the fact that such linkages allow for the spill-over of credit market specific shocks and implies that borrowers are unable to substitute away from the shock affected credit market. In agreement with De Jonghe (2010) and Fomby *et al.* (2012), this finding indicates that the resilience of the financial sector as a whole is complimented by restrictions on proprietary trading. Nevertheless, the results also show that from an individual financial institution's perspective, proprietary trading affords revenue diversification that reduces its vulnerability to credit market specific shocks. This finding is in agreement with Elsas *et al.* (2010), De Jonghe *et al.* (2015), and Köhler (2015), where revenue diversification is shown to enhance financial stability.

Historically low interest rates in advanced economies and the concomitant increase in emerging market foreign borrowing serves as the backdrop for chapter 3. This increase in foreign borrowing leaves the emerging market macroeconomic dispensation vulnerable to changes in advanced economy conditions (see e.g. Catão and Milesi-Ferretti, 2014). Capital controls proffer a means for emerging market authorities to address such concerns by limiting their exposure to international credit markets. To ascertain whether such a policy response would have been effective in curbing the build up of emerging market foreign debt, this chapter deploys an asymmetric two-country model with flow specific capital controls, and studies the model's dynamics following a negative foreign interest rate shock.

The use of this asymmetric setup facilitates the adoption of an emerging market perspective and embeds the idea that advanced economy financial markets are comparatively more developed than their emerging market counterparts (see e.g. Reinhardt *et al.*, 2013; Eichengreen and Rose, 2014). This asymmetrical setup also concurs with the savings–glut hypothesis advanced by Bernanke (2005), where emerging markets are net international creditors. In this regard, the inflow capital control restricts firms' ability to issue debt in foreign markets, whilst the outflow capital control restricts financial intermediary purchases of foreign debt.

The findings from chapter 3 indicate that deployment of either the inflow capital control or the outflow capital control could have reduced the increase in emerging market foreign debt following the decline in advanced economy interest rates. That being said, each flow specific capital control is associated with different model dynamics. Specifically, the inflow capital control is shown to exhibit shock amplification properties, whilst the outflow capital control is associated with shock attenuation. In this two-country model, the exploitation of comparatively cheaper foreign credit markets acts as a natural foreign interest rate shock absorber. Thus, shock amplification under the inflow capital control occurs because it directly affects emerging market firms' ability to exploit cheaper foreign economy credit markets. This amplification property of the inflow capital control declines as capital control regulation becomes stricter, whilst the opposite occurs when regulation becomes easier.

When the outflow capital control is present, easy foreign credit market conditions can spill-over to home credit markets through financial intermediary balance sheets. This spill-over mitigates the impact of foreign interest rate shocks and culminates in lower emerging market demand for foreign debt. Thus, the outflow capital control only indirectly affects firms' ability to exploit comparatively cheaper foreign economy credit markets, and so, foreign interest rate shocks are attenuated when it is present. As capital con-

control regulation becomes stricter, the virtuous spill-over that occurs through financial intermediary balance sheets is reduced, mitigating the attenuation property of the outflow capital control. The opposite holds when capital control regulation becomes easier, where increased spill-over enhances its shock attenuation properties. In line with the existing literature, these attenuation properties generate social welfare dynamics such that society exhibits a preference for the outflow capital control (Bianchi, 2011; Korinek, 2011; Brunnermeier and Sannikov, 2015).

The emerging market reliance on foreign sources of credit leaves these economies vulnerable to a tightening of monetary conditions in advanced economies. Through the design of a small open economy model with banking and foreign borrowing, chapter 4 contrasts the ability of macroprudential instruments to reduce this vulnerability following a positive foreign interest rate shock. Three different macroprudential instruments co-exist in this framework, namely loan-to-value (LTV) regulation, minimum capital requirements, and reserve requirements. Whilst LTV regulation operates on the demand side of credit markets, the other two measures operate on the supply side of credit markets.

The co-existence of these instruments and the distinction between demand and supply side measures provide insights into the comparative effectiveness of each instrument in dealing with positive foreign interest rate shocks. The results from chapter 4 concur with the existing evidence in that the deployment of macroprudential instruments help to attenuate the negative consequences of a positive foreign interest rate shock (see e.g. Galati and Moessner, 2013; Brzoza-Brzezina *et al.*, 2015). For each macroprudential instrument, shock attenuation results from diminished feedback between credit markets and asset prices.

The analysis of chapter 4 reveals further that asymmetries exist between both macroprudential instruments and regimes. Strict macroprudential regimes reduce the impact of foreign interest rate shocks relative to easy regimes. Looking across instruments, capital requirements and LTV regulation deliver similar sized social welfare benefits, pointing to their substitutability. On the other hand, because reserve requirements interact with capital requirements, this instrument imparts a much more muted effect on social welfare. In light of the fact that capital requirements and LTV regulation exhibit diminishing returns, this finding illustrates that reserve requirements are best used to complement these two instruments. The results also indicate that financial and macroeconomic stability concerns become aligned in the wake of tighter foreign credit market conditions, indicating that a macroprudential response to foreign interest rate shocks can address both objectives.

Appendices

Appendix A

Credit market heterogeneity, financial shocks, and balance sheet (in)dependence

A.1 Model 1 and 2 equations

A.1.1 Households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log(\varepsilon_t^h C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right\} \quad (\text{A.1})$$

$$C_t^h + D_t + B_t^h + \varepsilon_t^q q_t (H_t^h - H_{t-1}^h) = R_{t-1}^d D_{t-1} + R_t^h B_{t-1}^h + W_t N_t \quad (\text{A.2})$$

$$B_t^h = \nu_h \left(R_t^h B_{t-1}^h + q_t H_{t-1}^h - \gamma_h \mathbb{E}_t \varepsilon_{t+1}^b \right) \quad (\text{A.3})$$

$$1 = m_t^h R_t^d \quad (\text{A.4})$$

$$\varepsilon_t^q q_t = \frac{j \varepsilon_t^h C_t^h}{H_t^h} + m_t^h \mathbb{E}_t \varepsilon_{t+1}^q q_{t+1} (1 + \nu_h \mathbb{E}_t \lambda_{t+1}^h) \quad (\text{A.5})$$

$$1 + \lambda_t^h = m_t^h \mathbb{E}_t R_{t+1}^h (1 + \nu_h \mathbb{E}_t \lambda_{t+1}^h) \quad (\text{A.6})$$

$$W_t = \frac{\tau \varepsilon_t^h C_t^h}{1 - N_t} \quad (\text{A.7})$$

A.1.2 Entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{\log(C_t^e)\} \quad (\text{A.8})$$

$$C_t^e + \varepsilon_t^q q_t (H_t^e - H_{t-1}^e) + R_{t-1}^b B_{t-1} + R_t^l L_{t-1} + W_t N_t = Y_t + B_t + L_t \quad (\text{A.9})$$

$$Y_t = \varepsilon_t^a (H_{t-1}^e)^\alpha (N_t^e)^{1-\alpha} \quad (\text{A.10})$$

$$B_t \leq \frac{\omega \varepsilon_t^e \nu_e \mathbb{E}_t q_{t+1} H_t^b}{R_t^b} \quad (\text{A.11})$$

$$L_t \leq \frac{(1-\omega) \varepsilon_t^e \nu_e \mathbb{E}_t q_{t+1} H_t^e}{\mathbb{E}_t R_{t+1}^l} \quad (\text{A.12})$$

$$\varepsilon_t^q q_t = \varepsilon_t^e \nu_e \left(\frac{\omega \lambda_t^b}{R_t^b} + \frac{(1-\omega) \lambda_t^l}{\mathbb{E}_t R_{t+1}^l} \right) \mathbb{E}_t \varepsilon_{t+1}^q q_{t+1} + m_t^e \left(\alpha \frac{\mathbb{E}_t Y_{t+1}}{H_t^e} + \mathbb{E}_t q_{t+1} \right) \quad (\text{A.13})$$

$$1 - \lambda_t^b = m_t^e R_t^b \quad (\text{A.14})$$

$$1 - \lambda_t^l = m_t^e \mathbb{E}_t R_{t+1}^l \quad (\text{A.15})$$

$$\frac{(1-\alpha) Y_t}{N_t} = W_t \quad (\text{A.16})$$

A.1.3 Financial intermediaries

A.1.3.1 Model 1

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left\{ \log(C_t^f) - \nu_f B_t^f \right\} \quad (\text{A.17})$$

$$C_t^f + B_t + L_t + R_{t-1}^d D_{t-1} + R_t^h B_{t-1}^h = D_t + B_t^h + R_t^l L_{t-1} + R_{t-1}^b B_{t-1} \quad (\text{A.18})$$

$$D_t \leq \kappa_l (L_t - \mathbb{E}_t \varepsilon_{t+1}^l) \quad (\text{A.19})$$

$$B_t^h \leq \kappa_b (B_t - \gamma_f \mathbb{E}_t \varepsilon_{t+1}^b) \quad (\text{A.20})$$

$$m_t^f R_t^d = 1 - \lambda_t^{f,l} \quad (\text{A.21})$$

$$m_t^f \mathbb{E}_t R_{t+1}^h = 1 + \nu_f C_t^f - \lambda_t^{f,b} \quad (\text{A.22})$$

$$m_t^f R_t^b = 1 + \nu_f C_t^f - \kappa_b \lambda_t^{f,b} \quad (\text{A.23})$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_l \lambda_t^{f,l} \quad (\text{A.24})$$

A.1.3.2 Model 2

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \left\{ \log(C_t^f) - \nu_f B_t^f \right\} \quad (\text{A.25})$$

$$C_t^f + B_t + L_t + R_{t-1}^d D_{t-1} + R_t^h B_{t-1}^h = D_t + B_t^h + R_t^l L_{t-1} + R_{t-1}^b B_{t-1}^b \quad (\text{A.26})$$

$$D_t + B_t^h \leq \kappa_l (L_t - \mathbb{E}_t \varepsilon_{t+1}^l) + \kappa_b (B_t - \gamma_f \mathbb{E}_t \varepsilon_{t+1}^b) \quad (\text{A.27})$$

$$m_t^f R_t^d = 1 - \lambda_t^f \quad (\text{A.28})$$

$$m_t^f \mathbb{E}_t R_{t+1}^h = 1 + \nu_f C_t^f - \lambda_t^f \quad (\text{A.29})$$

$$m_t^f R_t^b = 1 + \nu_f C_t^f - \kappa_b \lambda_t^f \quad (\text{A.30})$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_l \lambda_t^f \quad (\text{A.31})$$

A.1.4 Market clearing

$$1 = H_t^h + H_t^e \quad (\text{A.32})$$

$$Y_t = C_t^h + C_t^e + C_t^f \quad (\text{A.33})$$

$$B_t = B_t^h + B_t^f \quad (\text{A.34})$$

A.1.5 Shocks

The model allows for six shocks. First, there is a preference shock to household consumption as given by ε_t^h in equation A.1. Second, is a housing price shock that is common to both households and entrepreneurs as per ε_t^q in equations A.2 and A.9. Third, is a technology shock as given by ε_t^a in equation A.10. Fourth is a shock to entrepreneurs' loan to value ratio as given by ε_t^e in equations A.11 and A.12. Fifth is the financial shock to bond markets as per ε_{t+1}^b in equation A.3. Lastly, the sixth shock relates to a financial shock in loan markets as given by ε_{t+1}^l in equation A.19.

These shocks all follow AR(1) processes with the following specifications:

$$\log(\varepsilon_t^h) = \rho_h \log(\varepsilon_{t-1}^h) + l_t^h \quad (\text{A.35})$$

$$\log(\varepsilon_t^q) = \rho_q \log(\varepsilon_{t-1}^q) + l_t^q \quad (\text{A.36})$$

$$\log(\varepsilon_t^e) = \rho_e \log(\varepsilon_{t-1}^e) + l_t^e \quad (\text{A.37})$$

$$\log(\varepsilon_t^a) = \rho_a \log(\varepsilon_{t-1}^a) + l_t^a \quad (\text{A.38})$$

$$\varepsilon_t^b = \rho \varepsilon_{t-1}^b + l_t^b \quad (\text{A.39})$$

$$\varepsilon_t^l = \rho \varepsilon_{t-1}^l + l_t^l \quad (\text{A.40})$$

In equations A.35 to A.40 above, $l_t^i \sim N(0, \sigma_i)$ is an independent white noise process with a normal distribution with zero mean and standard deviation of σ_i for $i = a, b, e, h, l, q$.

A.2 Model 3 equations

A.2.1 Households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log(\varepsilon_t^h C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right\} \quad (\text{A.41})$$

$$C_t^h + D_t + \varepsilon_t^q q_t (H_t^h - H_{t-1}^h) = R_{t-1}^d D_{t-1} + W_t N_t \quad (\text{A.42})$$

$$1 = m_t^h R_t^d \quad (\text{A.43})$$

$$\varepsilon_t^q q_t = \frac{j \varepsilon_t^h C_t^h}{H_t^h} + m_t^h \mathbb{E}_t \varepsilon_{t+1}^q q_{t+1} \quad (\text{A.44})$$

$$W_t = \frac{\tau \varepsilon_t^h C_t^h}{1 - N_t} \quad (\text{A.45})$$

A.2.2 Entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{ \log(C_t^e) \} \quad (\text{A.46})$$

$$C_t^e + \varepsilon_t^q q_t (H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + W_t N_t = Y_t + L_t \quad (\text{A.47})$$

$$Y_t = \varepsilon_t^a (H_{t-1}^e)^\alpha (N_t^e)^{1-\alpha} \quad (\text{A.48})$$

$$L_t \leq \frac{v_e \varepsilon_t^e \mathbb{E}_t q_{t+1} H_t^e}{\mathbb{E}_t R_{t+1}^l}, \quad (\text{A.49})$$

$$\varepsilon_t^q q_t = \varepsilon_t^e v_e \left[\frac{\lambda_t^l}{\mathbb{E}_t R_{t+1}^l} \right] \mathbb{E}_t \varepsilon_{t+1}^q q_{t+1} + m_t^e \left(\alpha \frac{\mathbb{E}_t Y_{t+1}}{H_t^e} + \mathbb{E}_t q_{t+1} \right) \quad (\text{A.50})$$

$$1 - \lambda_t^l = m_t^e \mathbb{E}_t R_{t+1}^l \quad (\text{A.51})$$

$$\frac{(1 - \alpha) Y_t}{N_t} = W_t \quad (\text{A.52})$$

A.2.3 Financial intermediaries

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \{ \log(C_t^f) \} \quad (\text{A.53})$$

$$C_t^f + L_t + R_{t-1}^d D_{t-1} = D_t + R_t^l L_{t-1} \quad (\text{A.54})$$

$$D_t \leq \kappa_l (L_t - \mathbb{E}_t \varepsilon_{t+1}^l) \quad (\text{A.55})$$

$$m_t^f R_t^d = 1 - \lambda_t^{f,l} \quad (\text{A.56})$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_l \lambda_t^f \quad (\text{A.57})$$

A.2.4 Market clearing

$$1 = H_t^h + H_t^e \quad (\text{A.58})$$

$$Y_t = C_t^h + C_t^e + C_t^f \quad (\text{A.59})$$

A.2.5 Shocks

Model 3 allows for five shocks. First, there is a preference shock to household consumption as given by ε_t^h in equation A.41. Second, is a housing

price shock that is common to both households and entrepreneurs as per ε_t^q in equations A.42 and A.47. Third, is a technology shock as given by ε_t^a in equation A.48. Fourth is a shock to entrepreneurs' loan to value ratio as given by ε_t^e in equations A.49. Lastly, the fifth shock relates to a financial shock in loan markets as given by ε_{t+1}^l in equation A.55.

These shocks all follow AR(1) processes with the following specifications:

$$\log(\varepsilon_t^h) = \rho_h \log(\varepsilon_{t-1}^h) + l_t^h \quad (\text{A.60})$$

$$\log(\varepsilon_t^q) = \rho_q \log(\varepsilon_{t-1}^q) + l_t^q \quad (\text{A.61})$$

$$\log(\varepsilon_t^e) = \rho_e \log(\varepsilon_{t-1}^e) + l_t^e \quad (\text{A.62})$$

$$\log(\varepsilon_t^a) = \rho_a \log(\varepsilon_{t-1}^a) + l_t^a \quad (\text{A.63})$$

$$\varepsilon_t^l = \rho \varepsilon_{t-1}^l + l_t^l \quad (\text{A.64})$$

In equations A.60 to A.64 above, $l_t^i \sim N(0, \sigma_i)$ is an independent white noise process with a normal distribution with zero mean and standard deviation of σ_i for $i = a, e, h, l, q$.

A.3 Data

All of the data relates to the U.S. economy and was downloaded from the Federal Reserve Bank of St. Louis FRED database. The sample runs from 1985Q1 to 2015Q1 and is in a quarterly format. All figures are in real terms and where necessary, were deflated using the U.S. implicit GDP deflator. To produce figure 2.1 presented in section 2.2, I applied an HP-filter with $\lambda = 1600$ to each of the series to generate the cyclical variation plotted in the figure. For figure 2.3, we used the 3-month AA rated commercial paper rate as the interest rate for bonds whereas the bank prime lending rate was used for loans. The data are as follows:

- Output: Y_t . U.S. Real Gross Domestic Product. Source: U.S. Bureau of Economic Analysis.
- Household consumption: C_t^h . Real Personal Consumption Expenditures. Source: U.S. Bureau of Economic Analysis.
- Entrepreneur Consumption: C_t^e . Nonfinancial corporate business: Profits before tax (excluding IVA and CC Adj.). Source: U.S. Bureau of Economic Analysis.

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- Financial Intermediary Consumption: C_t^f . Financial business; corporate profits before tax (excluding IVA and CC Adj.). Source: Financial Accounts of the U.S. Table Z.1.
- Real Estate Prices: q_t . All-Transactions House Price Index for the United States, Index 2009=100. Source: U.S. Federal Housing Finance Agency.
- Household Real Estate Wealth: $q_t H_t^h$. Households and nonprofit organizations; real estate at market value. Source: Board of Governors of the Federal Reserve System.
- Entrepreneur Real Estate Wealth: $q_t H_t^e$. Nonfinancial corporate business; real estate at market value. Source: Board of Governors of the Federal Reserve System.
- Hours worked: N_t . Average Weekly Hours of Production and Non-supervisory Employees: Manufacturing. Source: U.S. Bureau of Labor Statistics.
- Entrepreneurial Loans: L_t . Nonfinancial corporate business; total loans; liability. Source: Board of Governors of the Federal Reserve System.
- Entrepreneurial Bonds: B_t . Nonfinancial corporate business; debt securities; liability. Source: Board of Governors of the Federal Reserve System.
- Interest Rate on Deposits: R_t^d . Effective Federal Funds Rate. Source: Board of Governors of the Federal Reserve System.
- Interest Rate on Household Bonds: R_t^h . 3-Month AA Nonfinancial Commercial Paper Rate. Source: Board of Governors of the Federal Reserve System.
- Interest Rate on Loans: R_t^l . Bank Prime Loan Rate. Source: Board of Governors of the Federal Reserve System.
- GDP deflator. Gross Domestic Product: Implicit Price Deflator. Source: U.S. Bureau of Economic Analysis.

Appendix B

Flow specific capital controls

B.1 Model equations

Below, we present the full set of model equations for the baseline scenario, i.e. when no capital controls are active. When capital controls are active, section 3.3.5 shows the changes to the model setup.

B.1.1 Home households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \{ \log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \} \quad (\text{B.1})$$

$$C_t^h + q_t(H_t^h - H_{t-1}^h) + D_t = W_t N_t + R_{t-1}^d D_{t-1} \quad (\text{B.2})$$

$$q_t = \frac{j C_t^h}{H_t^h} + m_t^h \mathbb{E}_t q_{t+1} \quad (\text{B.3})$$

$$W_t = \frac{\tau C_t^h}{1 - N_t} \quad (\text{B.4})$$

$$1 = m_t^h R_t^d \quad (\text{B.5})$$

B.1.2 Home entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{ \log(C_t^e) \} \quad (\text{B.6})$$

$$C_t^e + q_t(H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + S_t R_t^H B_{t-1}^H + W_t N_t = Y_t + L_t + S_t B_t^H \quad (\text{B.7})$$

$$Y_t = A_t (H_{t-1}^e)^\alpha (N_t)^{1-\alpha} \quad (\text{B.8})$$

$$\mathbb{E}_t R_{t+1}^l L_t \leq \mu \Omega_t \mathbb{E}_t q_{t+1} H_t^e \quad (\text{B.9})$$

$$S_t \mathbb{E}_t R_{t+1}^H B_t^H \leq (1 - \Omega_t) \mathbb{E}_t q_{t+1} H_t^e \left(1 - \frac{1 - \mu}{q H^e} \mathbb{E}_t q_{t+1} (1 - \Omega_t) H_t^e \right) \quad (\text{B.10})$$

$$W_t = (1 - \alpha) \frac{Y_t}{N_t} \quad (\text{B.11})$$

$$q_t = \mathbb{E}_t q_{t+1} (\mu \Omega_t \lambda_t^H + \mathbb{E}_t \tilde{\mu}_{t+1} (1 - \Omega_t) \lambda_t^F) + m_t^e \left(\mathbb{E}_t q_{t+1} + \frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e} \right) \quad (\text{B.12})$$

$$1 = \mathbb{E}_t R_{t+1}^l (m_t^e + \lambda_t^H) \quad (\text{B.13})$$

$$1 = \mathbb{E}_t R_{t+1}^H \left(\frac{\mathbb{E}_t S_{t+1}}{S_t} m_t^e + \lambda_t^F \right) \quad (\text{B.14})$$

$$\mu \lambda_t^H = \mathbb{E}_t \tilde{\mu}_{t+1} \lambda_t^F \quad (\text{B.15})$$

B.1.3 Home financial intermediaries

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_f^t \{ \log(C_t^f) \} \quad (\text{B.16})$$

$$C_t^f + L_t + S_t B_t^F + R_{t-1}^d D_{t-1} = D_t + R_t^l L_{t-1} + S_t R_t^F B_{t-1}^F \quad (\text{B.17})$$

$$D_t \leq (1 - \vartheta \varphi_H) L_t + (1 - \vartheta \varphi_F) S_t B_t^F \quad (\text{B.18})$$

$$m_t^f R_t^d = 1 - \lambda_t^K \quad (\text{B.19})$$

$$m_t^f \mathbb{E}_t R_{t+1}^l = 1 - \kappa_H \lambda_t^K \quad (\text{B.20})$$

$$m_t^f \frac{\mathbb{E}_t S_{t+1}}{S_t} \mathbb{E}_t R_{t+1}^F = 1 - \kappa_F \lambda_t^K \quad (\text{B.21})$$

B.1.4 Foreign households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_t^t \{ \log(C_t^{h*}) + j \log(H_t^{h*}) + \tau \log(1 - N_t^*) \} \quad (\text{B.22})$$

$$C_t^{h*} + q_t^* (H_t^{h*} - H_{t-1}^{h*}) + B_t^H = W_t^* N_t^* + R_t^H B_{t-1}^H \quad (\text{B.23})$$

$$W_t^* = \frac{\tau C_t^{h*}}{1 - N_t^*} \quad (\text{B.24})$$

$$q_t^* = \frac{j C_t^{h*}}{H_t^{h*}} + m_t^{h*} \mathbb{E}_t q_{t+1}^* \quad (\text{B.25})$$

$$1 = m_t^{h*} R_{t+1}^H \quad (\text{B.26})$$

B.1.5 Foreign entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_t^t \{ \log(C_t^{e*}) \} \quad (\text{B.27})$$

$$C_t^{e*} + q_t^* (H_t^{e*} - H_{t-1}^{e*}) + R_t^F B_{t-1}^F + W_t^* N_t^* = Y_t^* + B_t^F \quad (\text{B.28})$$

$$Y_t^* = A_t^* (H_{t-1}^{e*})^\alpha (N_t^*)^{1-\alpha} \quad (\text{B.29})$$

$$\mathbb{E}_t R_{t+1}^F B_t^F \leq \mu_* \mathbb{E}_t q_{t+1}^* H_t^{e*} \quad (\text{B.30})$$

$$W_t^* = (1 - \alpha) \frac{Y_t^*}{N_t^*} \quad (\text{B.31})$$

$$q_t^* = m_t^{e*} \left(\mathbb{E}_t q_{t+1}^* (1 + \mu_* \lambda_t^* + \alpha \frac{\mathbb{E}_t Y_{t+1}^*}{H_t^{e*}}) \right) + \mu_* q_{t+1}^* \lambda_t^* \quad (\text{B.32})$$

$$1 = \mathbb{E}_t R_{t+1}^F (m_t^{e*} + \lambda_t^*) \quad (\text{B.33})$$

B.1.6 Market clearing

$$1 = H_t^h + H_t^e \quad (\text{B.34})$$

$$1 = H_t^{h*} + H_t^{e*} \quad (\text{B.35})$$

$$Y_t = C_t^h + C_t^e + C_t^f + S_t(B_t^F - R_t^F B_{t-1}^F + R_t^H B_{t-1}^H - B_t^H) \quad (\text{B.36})$$

$$Y_t^* = C_t^{h*} + C_t^{e*} + B_t^H - R_t^H B_{t-1}^H + R_t^F B_{t-1}^F - B_t^F \quad (\text{B.37})$$

$$Y_t^W = Y_t + S_t Y_t^* \quad (\text{B.38})$$

$$CA_t = S_t(\Delta B_t^F - \Delta B_t^H) \quad (\text{B.39})$$

$$CA_t^* = \Delta B_t^H - \Delta B_t^F \quad (\text{B.40})$$

B.1.7 Technology shocks

The model moments in table 3.2 are generated following a positive productivity shock in the home country. Supposing that home and foreign technologies are given by A_t and A_t^* , the model setup assumes exogenous technological processes in each country as described by

$$\begin{bmatrix} \log(A_t) \\ \log(A_t^*) \end{bmatrix} = \begin{bmatrix} \rho & \eta \times \rho \\ \eta \times \rho & \rho \end{bmatrix} \begin{bmatrix} \log(A_{t-1}) \\ \log(A_{t-1}^*) \end{bmatrix} + \begin{bmatrix} \iota_t \\ \iota_t^* \end{bmatrix} \quad (\text{B.41})$$

Where $\iota_t \sim N(0, \sigma)$ gives the home technology shock whilst $\iota_t^* \sim N(0, \sigma^*)$ gives that of the foreign country. This specification allows for technological spill-over between countries through the scaling parameter $\eta < 1$. I incorporate this feature to realize positive cross-country output correlations as per the international business cycle literature. I follow Backus *et al.* (1992) and Iacoviello and Minetti (2006) and set the value for this parameter at $\eta = 0.1$ such that $\eta \times \rho = 0.09$.

B.2 Data

B.2.1 Empirical evidence

To generate figure 3.1, I sum the amount of USD international debt securities outstanding for Chinese and Brazilian non-financial corporations according to the resident definition with that according to the nationality definition. As noted by Shin (2014), this affords inclusion of debt issuances that occur

through the foreign branches of these corporations. The data used in figures 3.1, 3.2, and 3.3 were gathered from the following sources:

- Figure 3.1
 - Brazil USD: Total international debt securities issued by non-financial Brazilian residents + total international debt securities issued by non-financial Brazilian nationals in USD. Source: BIS table C3.
 - Brazil local currency: Total international debt securities issued by non-financial Brazilian residents in local currency. Source: BIS table C3.
 - China USD: Total international debt securities issued by non-financial Chinese residents + total international debt securities issued by non-financial Chinese nationals in USD. Source: BIS table C3.
 - China local currency: Total international debt securities issued by non-financial Chinese residents in local currency. Source: BIS table C3.
- Figure 3.2
 - Brazil international debt to domestic debt ratio: Total amount of non-financial international debt securities of Brazilian nationals and residents outstanding divided by total amount of non-financial domestic debt securities of residents outstanding. Source: BIS table C3.
 - China international debt to domestic debt ratio: Total amount of non-financial international debt securities of Chinese nationals and residents outstanding divided by total amount of non-financial domestic debt securities of residents outstanding. Source: BIS table C3.
 - Brazil treasury rate: 3-month treasury bill rate. Source: Federal Reserve Bank of St. Louis.
 - China treasury rate: 3-month treasury bill rate. Source: Federal Reserve Bank of St. Louis.
 - U.S. treasury rate: 3-month treasury bill rate. Source: Federal Reserve Bank of St. Louis.
- Figure 3.3
 - Brazil: Outward FDI stock in advanced countries. Source: UNCTAD Bilateral FDI Statistics 2014.

- China: Outward FDI stock in advanced countries. Source: UNCTAD Bilateral FDI Statistics 2014.

B.2.2 Business cycle moments

The data below are used to generate the cross country correlations in table 3.2. All of the data are denominated in constant 2010 U.S. dollars. I take the natural logarithm of each series and de-trend the data with a quadratic time trend. An emerging market sample is constructed for comparison to country H variables whilst country F moments are compared to a sample of advanced countries. To create the data series for each sample, I sum across countries. Thus, emerging market GDP is given by the sum of Chinese, Brazilian, Russian, South African, Mexican, Turkish, and South Korean GDP in constant 2010 USD. The relevant model variables and data sources are as follows:

- GDP implicit price deflator. Re-based so that 2010=100. Source: U.S. Bureau of Economic Analysis.
- Home country output: Y_t . Current price GDP in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2000Q1–2016Q3. Source: OECD, Board of Governors of the Federal Reserve System.
- Foreign country output: Y_t^* . Current price GDP in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: United States, Japan, United Kingdom, and the Eurozone. Time period: 2000Q1–2016Q3. Source: Eurostat, Japan Cabinet Office, Great Britain Office for National Statistics, Board of Governors of the Federal Reserve System.
- Home country aggregate consumption: C_t . Private final consumption expenditure in national currency converted into USD at spot rate and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2000Q1–2016Q3. Source: OECD, Board of Governors of the Federal Reserve System.
- Foreign country aggregate consumption: C_t^* . Private final consumption expenditure in national currency converted into USD at spot rate

and deflated into 2010 constant USD using the U.S. GDP implicit price deflator. Sample: United States, Japan, United Kingdom, Germany, France, Italy, Spain, Netherlands. Time period: 2000Q1–2016Q3. Source: OECD, Board of Governors of the Federal Reserve System.

- Home country real estate price: q_t . Residential price index (2010=100) in national currency converted into constant 2010 USD. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2001Q1–2016Q3. We aggregate these indices into a single emerging market index by assigning time-varying GDP weights to each country's residential price index.
- Foreign country real estate price: q_t^* . All transactions house price index for the United States, 2010=100. Sample: United States. Time period: 2000Q1–2016Q3. Source: U.S. Federal Housing Finance Agency.
- Home entrepreneur home loans: L_t . Non-financial corporations domestic market debt securities outstanding in constant 2010 USD. Sample: China, Brazil, Russia, South Africa, Mexico, Turkey, and South Korea. Time period: 2000Q1–2016Q3. Source: BIS.
- Home entrepreneur foreign bonds: B_t^H . Non-financial corporations international market debt securities outstanding by nationality and residence in constant 2010 USD. Sample: BIS developing countries. Time period: 2000Q1–2016Q3. Source: BIS.
- Foreign entrepreneur bonds: B_t^F . Total credit to non-financial corporations in constant 2010 USD. Sample: Japan, Euro Area, United Kingdom, United States. Time period: 2000Q1–2016Q3. Source: BIS and Federal Reserve Bank of St. Louis.

Appendix C

Macroprudential policy and foreign interest rate shocks in a small open economy

C.1 Model equations

C.1.1 Households

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left\{ \log(C_t^h) + j \log(H_t^h) + \tau \log(1 - N_t) \right\} \quad (\text{C.1})$$

$$C_t^h + D_t + q_t(H_t^h - H_{t-1}^h) + T_t = R_{t-1}^d D_{t-1} + W_t N_t \quad (\text{C.2})$$

$$1 = m_t^h R_t^d \quad (\text{C.3})$$

$$q_t = \frac{j C_t^h}{H_t^h} + m_t^h \mathbb{E}_t q_{t+1} \quad (\text{C.4})$$

$$W_t = \frac{\tau C_t^h}{1 - N_t} \quad (\text{C.5})$$

C.1.2 Entrepreneurs

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_e^t \{ \log(C_t^e) \} \quad (\text{C.6})$$

$$C_t^e + q_t(H_t^e - H_{t-1}^e) + R_t^l L_{t-1} + W_t N_t = Y_t + L_t \quad (\text{C.7})$$

$$\mathbb{E}_t R_{t+1}^l L_t \leq \nu_e \mathbb{E}_t q_{t+1} H_t^e \quad (\text{C.8})$$

$$Y_t = (H_{t-1}^e)^\alpha (N_t)^{1-\alpha} \quad (\text{C.9})$$

$$q_t = m_t^e \left(\frac{\alpha \mathbb{E}_t Y_{t+1}}{H_t^e} + \mathbb{E}_t q_{t+1} \right) + \nu_e \lambda_t^e \mathbb{E}_t q_{t+1} \quad (\text{C.10})$$

$$1 = (m_t^e + \lambda_t^e) \mathbb{E}_t R_{t+1}^l \quad (\text{C.11})$$

$$W_t = \frac{(1-\alpha)Y_t}{N_t} \quad (\text{C.12})$$

C.1.3 Bankers

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_b^t \{ \log(C_t^b) \} \quad (\text{C.13})$$

$$C_t^b + L_t + R_{t-1}^d D_{t-1} + R_{t-1}^f B_{t-1}^f + \zeta_t = D_t + B_t^f + R_t^l L_{t-1} + \zeta_{t-1} \quad (\text{C.14})$$

$$D_t + B_t^f \leq (1-\vartheta)L_t + \zeta_t \quad (\text{C.15})$$

$$\zeta_t \geq \varphi D_t \quad (\text{C.16})$$

$$m_t^b R_t^d = 1 - \varphi \lambda_t^r - \lambda_t^c \quad (\text{C.17})$$

$$m_t^b R_t^f = 1 - \lambda_t^c \quad (\text{C.18})$$

$$m_t^b \mathbb{E}_t R_{t+1}^l = 1 - (1-\vartheta)\lambda_t^c \quad (\text{C.19})$$

$$\lambda_t^r = 1 - m_t^b - \lambda_t^c \quad (\text{C.20})$$

C.1.4 Foreign lenders

$$R_t^w = (1-\delta_t)R_t^f \quad (\text{C.21})$$

$$\chi_t = \left(\frac{B_t^f}{Y_t} / \frac{B^f}{Y} \right)^{\gamma_f} (R_t^w)^{\gamma_w} \quad (\text{C.22})$$

$$R_t^w = \rho_w R_{t-1}^w + \varepsilon_t^w \quad (\text{C.23})$$

C.1.5 Market clearing

$$1 = H_t^h + H_t^e \quad (\text{C.24})$$

$$Y_t = C_t^h + C_t^e + C_t^b + R_{t-1}^f B_{t-1}^f - B_t^f \quad (\text{C.25})$$

$$CA_t = B_{t-1}^f - B_t^f \quad (\text{C.26})$$

$$T_t = \zeta_t - \zeta_{t-1} \quad (\text{C.27})$$

C.2 Model sensitivity to changes in country risk premium parameters

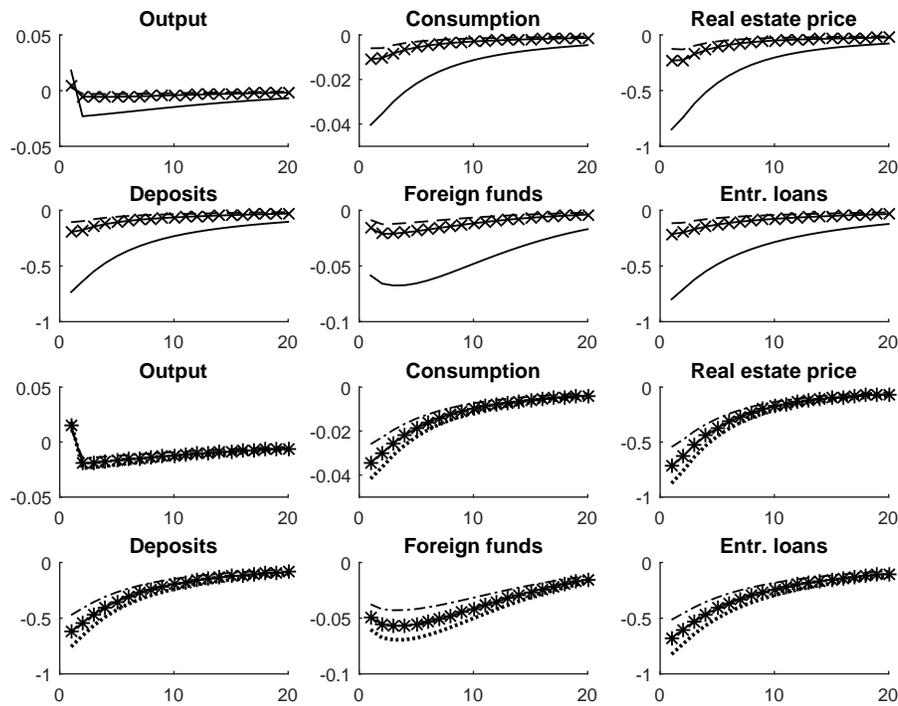


Figure C.1: Impulse response functions following a positive shock to R_t^w for different calibrations of γ_f and γ_w . Dashed line: $\gamma_f = 0.85$ and $\gamma_w = 0.85$. Crossed line: $\gamma_f = 0.45$ and $\gamma_w = 0.85$. Solid line: $\gamma_f = 0.05$ and $\gamma_w = 0.85$. Dotted line: $\gamma_f = 0.05$ and $\gamma_w = 0.85$. Star line: $\gamma_f = 0.05$ and $\gamma_w = 0.45$. Dash-dot line: $\gamma_f = 0.05$ and $\gamma_w = 0.05$.

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