Essays in International Finance and Macroeconomics

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Abstract

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This dissertation consists of essays in the intersection of international finance, macroeconomics, and monetary economics.

The first essay studies the role of the financial sector in affecting domestic resource allocation and cross-border capital flows. I develop a quantitative, two-country, macroeconomic model in which banks face endogenous and occasionally binding leverage constraints. Banks lend funds to be invested in tradable or non-tradable sector capital and there is international financial integration in the market for bank liabilities. I focus on news about economic fundamentals as the key source of fluctuations. Specifically, in the case of positive news on the valuation of non-traded sector capital that turn out to be incorrect at a later date, the model generates an asymmetric, belief-driven boom-bust cycle that reproduces key features of the recent Eurozone crisis. Bank balance sheets amplify and propagate fluctuations through three channels when leverage constraints bind: First, amplified wealth effects induce jumps in import-demand (demand channel). Second, changes in the value of non-tradable sector assets alter bank lending to tradable sector firms (intra-national spillover channel). Third, domestic and foreign households re-adjust their savings in domestic banks, and capital flows further amplify fluctuations (international spillover channel). A common central bank's unconventional policies of private asset purchases and liquidity facilities in response to unfulfilled expectations are successful at ameliorating the economic downturn.

In the second essay, co-authored with Professor Ghironi, we study the implications of using the volatility of domestic interest rate as a policy instrument in a small open economy. We develop an international macroeconomic model of the interaction between an emerging market economy (EME) and global investors. EME central banker uses time-varying domestic interest rate volatility as a policy tool, and global investors have the opportunity to sell productive capital to the EME producers (FDI), in addition to having the opportunity to invest in one-period international and EME securities. We assess the effectiveness of using domestic interest rate volatility as a policy tool in distinguishing short-term security flows from long-term FDI flows, and identify the trade-offs that are faced in navigating financial strength and price stability. We find that an increase in interest rate volatility can attract FDI inflows while discouraging short-term security inflows, if the economy is subject to low-degree of pricing frictions. However, if prices are highly sticky, there is a co-movement of long-run FDI and short-run security outflows. Moreover, an increase in policy uncertainty induces higher price volatility.

TABLE OF CONTENTS

Page

List of Figures ii

List of Tables iv

Chapter 1: Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence 1
- 1.1 Introduction 1
- 1.2 The Model 7
- 1.3 Model Calibration and Simulations 22
- 1.4 Unconventional Central Bank Policies 32
- 1.5 Conclusions 40
- 1.6 References 42
- 1.7 Tables 50
- 1.8 Figures 54
- 1.9 Appendices 70
- 1.10 Additional Figures 85

Chapter 2: Interest Rate Uncertainty as a Policy Tool 91
- 2.1 Introduction 91
- 2.2 The Model 95
- 2.3 Model Calibration and Simulations 105
- 2.4 Conclusions 109
- 2.5 References 110
- 2.6 Figures 115
- 2.7 Appendices 121

LIST OF FIGURES

Figure Number — Page

1.1 Change in Bank Lending (Levels) 54
1.2 Shares of Sectors in Total Gross Value Added 55
1.3 Changes in Sectoral Unit Labor Costs 56
1.4 Eurozone exports and imports (in percent of GDP) 57
1.5 Sensitivity of Bank Leverage 58
1.6 Model and Data (1) 59
1.7 Model and Data (2) 60
1.8 Belief-driven business cycles: International Financial Autarky (with and without banks) 61
1.9 Belief-driven business cycles: Domestic banking vs. international financial integration 62
1.10 Propagation of fluctuations across sectors 63
1.11 Composition of Eurosystem Liabilities (in billions of euros) 64
1.12 Model and Data under Unconventional Policy (1) 65
1.13 Model and Data under Unconventional Policy (2) 66
1.14 Central Bank Asset Purchases 67
1.15 Asset Purchases vs. Liquidity Facilities 68
1.16 Model Structure 69
1.17 Impulse Response Functions:(Gertler-Karadi type NT Sector Capital Quality shock, Financial Autarky) 85
1.18 Impulse Response Functions:(Gertler-Karadi type NT Sector Capital Quality shock, International Financial Integration) 86
1.19 Asymmetric Responses Under Fundamental Shocks 87
1.20 Model and Data (Conservative calibration, 1) 88
1.21 Model and Data (Conservative calibration, 2) 90

2.1 Portfolio Flows to Emerging Markets (13-week moving average, bn USD) . . 115
2.2 Interest rate corridor and average funding cost, Turkey 116

2.3 Financing the current account, Turkey (12-month cumulative, bn USD) . . . 117
2.4 Illustration of first moment and second moment shocks 118
2.5 Model Outcome, phi = 0.25 119
2.6 Model Outcome, phi = 0.75 120

LIST OF TABLES

Table Number Page

1.1 Domestic credit outstanding at the end of the period - ratios to GDP 50
1.2 Quantitative Model Summary 51
1.3 Parameter Values 53

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Chapter 1

Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence

1.1 Introduction

This paper studies the role of the financial sector in affecting domestic resource allocation and cross-border capital flows, and in shaping dynamics such as the boom-bust cycle experienced by several Eurozone countries between the introduction of the euro and the recent crisis.

Following the creation of Europe's Economic and Monetary Union (EMU), large capital flows from Eurozone core to periphery were channeled through the banking sector. Financial institutions in Southern countries experienced an unprecedented growth in their loan portfolios (see Table 1) which was largely backed by foreign deposits.[1] A big portion of these loans was directed toward domestic non-traded sectors—construction and services. This contributed to an asset price boom, especially in the non-traded sectors, and led to an increase in wages and costs in a way that harmed export competitiveness, further worsening current account positions.[2] While the observed boom in non-traded sectors was out of line with historical data, the public's perception was that "something fundamental was different this time," because of the presence of the euro.[3]

[1]For instance, in Spain, only about 45 percent of total deposits in Spanish financial institutions were from the residents in 2007:QIV.

[2]The increase in the valuations of non-financials is well documented, and studies indicate that it started after the European Council's decision in 1998 in which countries were allowed to enter the final phase of EMU (Bris, Koskinen, and Nilsson, 2009, 2012). The results are stronger for firms in construction and service industries than for those in manufacturing. As Giavazzi and Spaventa (2010) note, the disproportionate allocation of foreign borrowing toward non-traded sectors made the sustainability of external accounts more stringent by making it harder to match current foreign liabilities with future surpluses.

[3]Economists and policymakers often conjecture that the surge in borrowing and expansion of output in these economies resulted from the expectation of a future favorable state of the economy due to entry in the Eurozone (Blanchard, 2006, Blanchard and Giavazzi, 2002, and Constâncio, 2005).

The "rose garden" feeling disappeared with the revelation of the Greek deficit deceit. It alerted authorities and public opinions in the Eurozone to the possibility of large violations of rules also by other countries, and cross-border capital flows stopped quickly. This sudden reversals in financing made Southern Eurozone bank balance sheets weak and raised suspicions about their solvency. Bank lending, investment, and output collapsed; the spreads between lending and risk-free rates rose steeply.[4] The rapid loss of investor trust in deficit nations was amplified through bank balance sheets. Loss in bank assets led to downward pressure on bank net worth, which further weakened bank lending.

Taking Spain as the bellwether country among those that experienced the imbalances discussed above, the amount of bank credit extended by Spanish financial institutions to non-traded sectors more than doubled in the first decade of the euro, whereas credit to tradable sectors increased by only approximately 20 percent (Figure 1). The rapid surge and subsequent decline of credit to each sector is also associated with an expansion of production costs in the respective sectors. Figures 2 and 3 illustrate the stronger fluctuations in non-traded sector variables in the boom-bust cycle. Regarding the divergence between sectors during the boom period, Santos (2014) highlights political motivations, arguing that the non-traded sectors were targets for politically influenced financial institutions, as it would be possible for politicians to be reelected by riding the short-run prosperity delivered by those sectors.[5]

To shed light on the link between bank lending, sectoral resource allocation, and external

[4]International borrowing did not receive any attention in the early years of the euro. To the best of my knowledge, Ingram (1973) was first to argue that a nation's balance of payments would be irrelevant under a monetary union. External balances found no place in the Maastricht criteria or in early European Commission reports. The crisis showed that external balances matter even in a monetary union.

[5]There are three types of credit institutions in Spain: cajas, commercial banks, and credit unions. The latter are very tiny in size, so can be ignored. Among the other two, lending by cajas accounts for approximately 50 percent of the total loans and deposits, and these institutions are under heavy political influence. Cajas played a key role in the massive funding of the non-traded sector from 1997 until the eve of the crisis. In 2007:QIV, loans from cajas to the real-estate sector constituted 61 percent of total commercial loans. See Santos (2014) for more in-depth details.

imbalances, I develop a quantitative two-country macroeconomic model with a financial sector in which banks lend funds to be invested in tradable or non-tradable sector capital and borrow from households in both countries. News about future valuation of assets are the key source of fluctuations I focus on: Specifically, optimistic valuation of non-traded sector capital triggers the boom part of the cycle, and later failure of this optimism to materialize triggers the bust. The goal is to have a model that not only explains non-traded sector boom periods when bank balance sheets are large but also can capture an economic downturn when expectations are unfulfilled and bank balance sheets play a crucial role in shock transmission and propagation within and across countries.

The model merges work on incomplete market models of international business cycles, such as Benigno and Thoenissen (2008) and Corsetti, Dedola, and Leduc (2008), and work on closed economy models with financial intermediation, as Gertler and Karadi (2011) and Gertler and Kiyotaki (2010).[6] The model extends the agency problem in the latter literature and allows intermediaries to hold a portfolio of assets from different sectors and borrow from both domestic and foreign savers. Bank constraints are allowed to be occasionally binding to capture the differences in bank incentives during boom and bust periods. The joint analysis of news shocks and the balance sheet structure of financial intermediaries yields new insights on the transmission and propagation of belief-driven fluctuations between sectors and across countries, extending results in studies by Beaudry and Portier (2004) and others referenced below.

I use aggregate macroeconomic and banking data to calibrate the model, and I investigate the ability of the model to match the dynamics of the Spanish economy for the 1999:QIV-

[6]The former literature has it roots in the influential articles of Backus, Kehoe, and Kydland (1992, 1994), Backus and Smith (1993), Mendoza (1991), and Stockman and Tesar (1995), while the latter is a rapidly growing literature with more recently circulated papers by Bocola (2015), Brunnermeier and Sannikov (2014), Gertler and Karadi (2013), Gertler and Kiyotaki (2015), Gertler, Kiyotaki, and Queralto (2012), and Mimir (2015).

2010:QI period that includes the Spanish boom-bust cycle. Model parameters are set to match the cumulative banking exposure to traded and non-traded sectors until 2008:QI. Simulations indicate that the model can generate persistent current account deficits with increasing banking exposure to the non-traded sector following positive news on the valuation of non-traded sector capital, and a sudden reversal of capital flows and an overall collapse in aggregate output through elevated borrowing costs of non-financials when optimistic expectations are not met.[7] The model thus provides a rigorous framework for the emerging consensus on the Eurozone crisis as the outcome of financial intermediation, resource allocation, and a reversal of capital flows (Baldwin and Giavazzi, 2015).

The model's success is the result of its nonlinear solution that captures the state dependent fluctuations based on whether bank net worth is high or low. Three key channels of shock amplification and transmission operates when the leverage constraints bind. First, a *demand channel* arises, as a stronger financial accelerator mechanism than in one-sector models amplifies simultaneous fluctuations across sectors. This contributes to a stronger wealth effect in the demand for imports. Second, bank behavior results in an *intra-national spillover channel* across sectors of the economy: When perceptions about asset valuation are skewed in favor of non-traded sector assets, banks expand their portfolios by attributing more weight to the non-traded sector; however, when perceptions are not materialized, the decline in traded sector assets contributes more to bank balance sheet shrinkage. This is because beliefs in higher non-traded valuation shift investment dynamics toward non-tradable non-financials even though the returns from them are relatively smaller. When individuals realize that their beliefs were wrong, credit spreads rise by more in the traded sector due to banking frictions, and traded sector lending becomes more expensive. Finally, a *cross-border*

[7] The results are not solely dependent on this specific case of calibration. Similar results emerge when the model is calibrated to match the cumulative increase in price-to-book ratios of the firms listed in the IBEX35 index. Robustness checks are available in appendices.

spillover channel arises from international financial integration through bank deposits. This further contributes to the size of bank balance sheets, and it amplifies effects on the domestic real economy through capital flows. Moreover, financial integration transmits the changes in the valuation of bank assets to the foreign economy through the international integration of bank liabilities. These mechanisms both increased the correction in the non-traded part of the economy and spread the effects of the crisis to traded sectors.

I also use the model to study unconventional monetary policy conducted by a common central bank for the two countries in the model, and I show that policies reminiscent of those implemented by the European Central Bank (ECB) help mitigate the adverse effects of unmaterialized optimism on the domestic economy. Three new ingredients characterize the study of unconventional policy in this paper relative to previous literature. First, the use of unconventional policy is triggered by unrealized expectations rather than rising borrowing costs, but policy ultimately affects the credit spreads that arise in response to unfulfilled news. Second, the policy design enables a response to sector-specific variables, as in the case of ECB interventions.[8] Third, the central bank intervention in the model is funded by issuing interest bearing reserves to domestic and foreign banks, which decreases the efficacy of the policy due to frictions in banking. This way of modeling unconventional policy is realistic for the Eurozone, as there is no central government that can issue bonds to households in both regions. With these new ingredients, the model suggests that liquidity facilities directed toward the financial sector are better at mitigating adverse conditions than direct asset purchases from non-financials.

In addition to the literature on international business cycles and closed economy macro models with financial intermediation, this paper contributes to three other literatures. First, since the non-traded sector in my model includes housing, the paper contributes to the liter-

[8]ECB interventions were mostly in response to situations in the non-traded sector.

ature that investigates the relationship between house prices and current account dynamics.[9] This paper differentiates itself by modeling a financial sector that optimizes over an infinite horizon and an endogenous balance sheet constraint in bank optimization. Furthermore, this paper uses news shocks to generate fluctuations rather than introducing housing-biased preference shocks. Finally, the literature on house prices and external imbalances does not study the unconventional policies analyzed in this paper.

Second, the paper contributes to a recently growing literature that investigates the role of financial intermediation in open economies.[10] This paper mainly distinguishes itself from previous models for three characteristics. First, the model distinguishes between differentiated goods produced in each country and assumes the existence of internationally incomplete financial markets through the banking sector. Second, the model features a non-traded sector that is dependent on bank funding. Third, the constraint on bank leverage binds only when bank net worth is low. The first feature implies a role for international relative prices, which interact with accumulation of foreign assets in internationally incomplete markets (bank deposits) in shaping the transmission of shocks between countries through banking. The second feature allows for asset heterogeneity within each economy. Banks hold a portfolio of assets from both sectors, and their optimization problem leads to an additional channel for shock transmission across sectors. The third feature captures the regime-dependent role of the funding constraints on the capital account. To my knowledge, this paper is also the first to study central bank asset purchases and liquidity facilities during news-led bust periods.

[9] This literature includes Coimbra (2010), Ferrero (2014), Gete (2010), and Punzi (2008). Related with this literature, Midrigan and Philippon (2010) also study a cash-in-advance economy in which home equity borrowing is used to conduct transactions. Independent of housing dynamics, Eggertsson and Krugman (2010) and Guerrieri and Lorenzoni (2010) highlight the importance of tightening borrowing constraints for overall demand.

[10] Among others, see Akinci and Queralto (2014), Cacciatore, Ghironi, and Stebunovs (2014), Dedola, Karadi, and Lombardo (2013), Kollmann, Enders, and Müller (2010), Krugman (2008), Lama and Rabanal (2015), Mendoza and Quadrini (2010), and Nuguer (2015).

Third, the paper contributes to the literature on belief-driven business cycles.[11] This literature faced major challenges in generating empirically plausible co-movement of aggregate variables within the economy. In my model, the problem is overcome through the inclusion of balance-sheet constrained banks and news about future capital quality (or valuation), instead of future productivity. Finally, the focus on non-fundamental driven fluctuations in asset values connects this paper to the literature on bubble-generated fluctuations and the consequences of bubbles bursting.[12]

The rest of the paper is organized as follows. Section 1.2 presents the model. Section 1.3 discusses the calibration and model simulation without policy. Section 1.4 describes the central bank's unconventional policy and discusses its results. Section 1.5 concludes.

1.2 The Model

I start with presenting the physical setup—a no-distortion two-country model, which allows non-tradable inputs in the production process—, and then, I add financial frictions within and across countries. The setup of the model assumes that the law of one price holds, and sources of PPP deviations are home bias in preferences and the presence of non-traded goods in the economy.[13] Banks are channelling funds from households (savers) to non-financial firms (borrowers), and their ability of intermediation is limited due to a moral hazard problem which is explained in the following sections. Banks are able to raise deposits from households in both countries, and provide funding to domestic two non-financial sectors.

[11] See Arezki, Ramey, and Sheng (2015), Beaudry and Portier (2004), Christiano, Ilut, Motto, and Rostagno (2008), Jaimovich and Rebelo (2009), Kanik and Xiao (2014), Lambertini, Mendicino, and Punzi (2013). See also Beaudry and Portier (2014) and references therein.

[12] The literature on rational bubbles dates back to papers of Samuelson (1958), Diamond (1965), Tirole (1985), and Weil (1987). Recent papers include Caballero and Krishnamurthy (2006), Martin and Ventura (2012, 2014), and Bengui and Phan (2015).

[13] Corsetti, Dedola, and Leduc (2008) uses all three of distribution costs, home bias in preferences and presence of non-traded goods as sources of PPP deviations.

I focus on a real model, because this setting is sufficient to generate the importance of financial market frictions on real activity. It is straightforward to extend the model to allow standard frictions in the literature, such as wage rigidity, price and wage indexation, etc.

Finally, I should make clear that I do not attempt to develop a model that provides a comprehensive explanation of the recent events in the eurozone. My goal is not to demonstrate the changes in public debt, nor the sovereign risk. Rather, my goal is to develop a simple international macroeconomic model to help understand the roles of financial frictions and beliefs on asset valuation in credit intensive boom-bust cycles.

In what follows, I focus on Home economy and, otherwise indicated, Foreign is symmetric.

1.2.1 Physical Setup

The world is composed of two countries, Home and Foreign. Foreign variables are denoted with an asterisk. Each country is populated by a unit mass of atomistic households with some fraction supplying labor to tradable and non-tradable intermediate good production. All trade happens in the first category of goods as there is technological constraints on moving the goods produced in second category.[14]

Non-financial firms in tradable and non-tradable sectors produce output using a Cobb-Douglas production function which combines capital and labor:

$$Y_{i,t} = F(K_{i,t}, L_{i,t}) = e^{a_{i,t}}(e^{\psi_{i,t}}K_{i,t})^{\alpha}{L_{i,t}}^{1-\alpha} \quad i \in \{T, NT\}, \tag{1}$$

where subscript T denotes the tradable sector variables, and NT denotes non-tradable sector counterparts. $e^{a_{i,t}}$ is the productivity shock to the production in sector i, and $e^{\psi_{i,t}}$ denotes a capital quality shock in sector i, that both follow log-normal processes. This shock can be

[14] To keep a parsimonious framework, I follow the strand of the literature that assumes exogenous existence of a non-traded sector. For a model, in which the non-traded sector arises endogenously, see Ghironi and Melitz (2005).

thought of as capturing some form of increase in valuation or obsolescence, in good and bad times, respectively.[15]

There are two types of capital producers, each of them producing capital for a respective sector. The law of motion of capital for each capital producer is subject to convex adjustment costs, and in the aggregate it follows the process:

$$K_{i,t+1} = (1-\delta)e^{\psi_{i,t}}K_{i,t} + I_{i,t} - f(\frac{I_{i,t}}{e^{\psi_{i,t}}K_{i,t}})e^{\psi_{i,t}}K_{i,t} \quad i \in \{T, NT\}, \tag{2}$$

where $f(\bullet)$ denotes the convex adjustment costs.

Non-financial goods producers obtain capital for the use in next period by issuing claims $S_{i,t}$, at the price of the capital, $Q_{i,t}$. By the assumption of no-arbitrage, value of claims issued should be equal to the value of capital bought by non-financials:

$$Q_{i,t}K_{i,t+1} = Q_{i,t}S_{i,t} \quad i \in \{T, NT\}. \tag{3}$$

The representative household consists of a family, in which workers in the family are divided into two, each group supplying labor to firms for tradable or non-tradable goods production. The whole family jointly maximize an inter-temporal utility function that derives utility from household's consumption of basket of goods, C_t, and disutility from supplying labor to tradable and non-tradable good production, $L_{T,t}$ and $L_{NT,t}$, respectively:

[15] Appendices of Gertler, Kiyotaki and Queralto (2012) provide micro foundations for the capital quality shock. As in Merton (1973), the capital quality shock provides fluctuations in the value of capital and therefore, endogenous fluctuations in relative prices.

$$U(C_t, L_{T,t}, L_{NT,t}) = \frac{C_t^{1-\rho}}{1-\rho} - \varpi \left(\frac{L_{T,t}^{1+\varphi_1}}{1+\varphi_1} + \frac{L_{NT,t}^{1+\varphi_2}}{1+\varphi_2} \right). \tag{4}$$

Within this setting, relative hours spent respond less to sectoral wage differentials due to sector specificity.

Households enjoy consumption of an Armington aggregate of composite tradable and non-traded goods. The final consumption aggregate is given by,

$$C_t = \left[a_T^{1/\kappa} C_{T,t}^{(\kappa-1)/\kappa} + (1-a_T)^{1/\kappa} C_{NT,t}^{(\kappa-1)/\kappa} \right]^{\kappa/(\kappa-1)}, \tag{5}$$

where $C_{T,t}$ is the consumption of the composite traded good, and $C_{NT,t}$ is the consumption of non-traded good. The parameter a_T denotes the share of tradables in final consumption, and κ is the inverse intratemporal elasticity of substitution between tradable and non-tradable goods.

The composite tradable good is also an Armington aggregate of Home and Foreign produced traded goods:

$$C_{T,t} = \left[a_H^{1/\omega} C_{H,t}^{(\omega-1)/\omega} + (1-a_H)^{1/\omega} C_{F,t}^{(\omega-1)/\omega} \right]^{\omega/(\omega-1)}, \tag{6}$$

where $C_{H,t}$ is the consumption of the traded good produced in Home, and $C_{F,t}$ is the consumption of the traded good produced in Foreign. The parameter ω is the inverse intratemporal elasticity of substitution between Home and Foreign goods, and there is home-bias in consumption if $a_H > \frac{1}{2}$.[16]

[16] A well known result in the literature from the work of Cole and Obstfeld (1991) is that when households have Cobb-Douglas preferences over Home and Foreign good consumption, and have log-utility, then international markets are complete even under financial autarky. In addition to introducing a non-traded production sector, here I deviate from this case by the assumption of non-logarithmic preferences, and setting a non-unitary elasticity of substitution between Home and Foreign good consumption.

Market clearing in each sector requires that Home production equals Home and Foreign consumption, and investment:

$$Y_{T,t} = C_{H,t} + C^*_{H,t} + I_{T,t} \quad and \quad Y_{NT,t} = C_{NT,t} + I_{NT,t}. \tag{7}$$

If there were no financial frictions within and across countries, the competitive equilibrium would be the allocations of a social planner's solution that would be the result of choosing aggregate quantities ($C_{H,t}$, $C_{F,t}$, $C^*_{F,t}$, $C^*_{H,t}$, $C_{NT,t}$, $C^*_{NT,t}$, $L_{T,t}$, $L_{NT,t}$, $L^*_{T,t}$, $L^*_{NT,t}$, $I_{T,t}$, $I_{NT,t}$, $I^*_{T,t}$, $I^*_{NT,t}$, $S_{T,t}$, $S_{NT,t}$, $S^*_{T,t}$, $S^*_{NT,t}$) as a function of the aggregate state ($I_{T,t-1}$, $I_{NT,t-1}$, $I^*_{T,t-1}$, $I^*_{NT,t-1}$, $e^{\psi_{T,t}}$, $e^{\psi_{NT,t}}$, $e^{\psi^*_{T,t}}$, $e^{\psi^*_{NT,t}}$, $K_{T,t}$, $K_{NT,t}$, $K^*_{T,t}$, $K^*_{NT,t}$, $e^{a_{H,t}}$, $e^{a_{NT,t}}$, $e^{a^*_{F,t}}$, $e^{a^*_{NT,t}}$) to maximize the expected convex combination of Home and Foreign households' discounted utility subject to resource constraints and laws of motion of capital in each sector.

This frictionless economy is the bare-bone model. In what follows, I focus on the decentralized economy, and introduce financial frictions that will impede flow of funds within and across countries.

1.2.2 Households

When there is a financial sector, the representative household in each country consists of a fraction of g bankers, and $1 - g$ workers. Bankers manage financial intermediaries and transfer their earnings back to the household, and workers similarly return their income back to the household. Households do not provide funds to non-financial firms nor do they acquire capital. They deposit funds to financial intermediaries that they are not related with. This assumption generates perfect consumption insurance within the household. Banks raise funds from households only by offering non-contingent risk-less short term debt (deposits).

Households maximize expected inter-temporal utility from consumption, C_t, net of disutility from providing labor to traded and non-traded sectors, $L_{T,t}$ and $L_{NT,t}$, as given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_{T,t}, L_{NT,t}) \tag{8}$$

where $U(\bullet)$ is given by (4).

Households in each country hold one-period deposits supplied by domestic and foreign banks. I assume that deposits pay risk-free consumption-based real returns. Households enter period t with deposits of Home and Foreign banks, B_t and $\xi_t B_{*,t}$, in units of home consumption, where ξ_t represents the real exchange rate.[17] They receive gross income on deposits and labor income, and allocate these resources between consumption and purchases of deposits to be carried next period. The period budget constraint in units of consumption is

$$\begin{aligned} C_t + B_{t+1} + \xi_t B_{*,t+1} + \tfrac{\eta}{2}\xi_t (B_{*,t+1})^2 \\ = (1+r_t)B_t + \xi_t(1+r_t^*)B_{*,t} + w_{T,t}L_{T,t} + w_{NT,t}L_{NT,t} + \Pi_{T,t} + \Pi_{NT,t} + \Pi_{B,t} + T_t^{f*} + T_t, \end{aligned} \tag{9}$$

where $\frac{\eta}{2}\xi_t(B_{*,t+1})^2$ is the cost of adjusting holdings of Foreign deposits, T_t^{f*} is the fee rebate, taken as given by the household, and equal to $\frac{\eta}{2}\xi_t(B_{*,t+1})^2$ in the equilibrium, and T_t is the lump-sum transfers. For simplicity, I assume that the scale parameter η is identical across costs of adjusting Home and Foreign deposits. The representative Foreign household faces a similar constraint in units of foreign consumption. Introducing convex adjustment costs ensures that zero foreign deposit holding is the unique steady state, and hence economies go back to their initial position after temporary shocks. $\Pi_{T,t}$, $\Pi_{NT,t}$, and $\Pi_{B,t}$ represent the profits back to household by traded and non-traded sector workers, and bankers, respectively.

[17] Similarly, Foreign households hold deposits at Foreign and Home banks, which are denoted as $B^*_{*,t}$ and $\frac{B^*_t}{\xi_t}$, in terms of Foreign consumption units.

Home household maximizes (8) subject to (9). The Euler equations for deposit holdings at Foreign and Home banks are

$$C_t^{-\rho}\left[1+\eta B_{*,t+1}\right]=\beta(1+r_{t+1}^{*})\mathbb{E}_t\left[\frac{\xi_{t+1}}{\xi_t}C_{t+1}^{-\rho}\right], \tag{10}$$

$$C_t^{-\rho}=\beta(1+r_{t+1})\mathbb{E}_t\left[C_{t+1}^{-\rho}\right]. \tag{11}$$

I omit the transversality conditions for deposit holdings. With $\eta > 0$, no-arbitrage condition implies:

$$\frac{1+r_{t+1}}{1+r_{t+1}^{*}}=\frac{\mathbb{E}_t[\frac{\xi_{t+1}}{\xi_t}C_{t+1}^{-\rho}]}{(1+\eta B_{*,t+1})\mathbb{E}_t[C_{t+1}^{-\rho}]}.$$

Consumption-labor trade-offs are given by:

$$w_{T,t}=\frac{\varpi L_{T,t}^{\varphi_1}}{C_t^{-\rho}},\quad w_{NT,t}=\frac{\varpi L_{NT,t}^{\varphi_2}}{C_t^{-\rho}}. \tag{12}$$

These equations ensure that the marginal rate of substitution between consumption and leisure is equal to the respective wage rate in each sector.

Given (5) and (6), one can also derive the standard demand curves for traded Home good as follows:

$$C_{H,t}=a_H\left(\frac{RP_{H,t}}{RP_{T,t}}\right)^{-\omega}C_{T,t}\quad and\quad C_{H,t}^{*}=(1-a_H)\left(\frac{RP_{H,t}}{\xi_t RP_{T,t}^{*}}\right)^{-\omega}C_{T,t}^{*}, \tag{13}$$

where RP_H, RP_T and RP_T^* denote the relative prices of Home traded goods, composite traded goods, and Foreign composite traded goods. The conditions for the Foreign traded goods are analogous.

Similarly, the generic demand curve for Home non-traded and composite traded goods are given by:

$$C_{NT,t} = (1 - a_T)\left(RP_{NT,t}\right)^{-\kappa} C_t \quad and \quad C_{T,t} = a_T \left(RP_{T,t}\right)^{-\kappa} C_t. \tag{14}$$

1.2.3 Firms

There are two types of producers in each sector, namely goods producers and capital producers.

Goods Producers

Goods are produced under perfect competition in both sectors. The production technology at time t is given as a constant returns to scale function, $F(K_{T,t}, L_{T,t})$ for tradable good producers, and $F(K_{NT,t}, L_{NT,t})$ for non-tradable good producers as in (1).

Firms finance their capital expenditures in each period by issuing equities, and selling them to financial intermediaries. Firms issue $S_{i,t}$ amount of state-contingent claims to raise funding for buying capital that will be used in the next period, $K_{i,t+1}$. At the beginning of the period $t+1$, firms obtain revenues and make payments to shareholders. Using Euler's formula, the gross profits per unit of effective capital in each sector can be written as:

$$Z_{i,t} = \frac{RP_{ii,t} Y_{i,t} - w_{i,t} L_{i,t}}{K_{i,t}} = RP_{ii,t} F_{K_{i,t}}(K_{i,t}, L_{i,t}). \tag{15}$$

where $i \in \{T, NT\}$ and $ii \in \{H, NT\}$.

Banks can perfectly monitor and evaluate the non-financial firms, and hence, every financial contract between the non-financials and banks delivers its promises. Goods producing firms obtain zero profits state-by-state, and the return on capital is fully paid out to the financial intermediary. The period t payoff of capital in tradable and non-tradable sectors are:

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(1 + r_{i,k,t+1} \right) \right] = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{Z_{i,t+1} + (1-\delta) e^{\psi_{i,t+1}} Q_{i,t+1}}{Q_{i,t}} \right) \right]. \tag{16}$$

where $\Lambda_{t,t+1} = \frac{U_C(t+1)}{U_C(t)}$.

The interest paid out to the bank on the loan varies with the marginal product of capital and with the fluctuations in prices. In each sector, firms also choose labor demand as follows:

$$w_{i,t} = RP_{ii,t} F_{L_i}(K_{i,t}, L_{i,t}). \tag{17}$$

Labor demand conditions state that the marginal product of labor in each sector should be equal to the respective wage rate.

Capital Producers

Capital producers produce new capital that will be used by goods producers in the subsequent period. They decide for investment after buying the used capital from goods producers. The price of capital is equal to the marginal cost of investment goods production:

$$Q_{i,t} = \frac{1}{1 - f_I\left(\frac{I_{i,t}}{e^{\psi_{i,t}} K_{i,t}}\right) e^{\psi_{i,t}} K_{i,t}}. \tag{18}$$

Capital adjustment costs cause prices to deviate from unity and contribute to the financial accelerator mechanism that will be discussed below.

It is important to note that every period, there is a net profit transfer from capital producers and banks to the household that they are a member of. Profit transfers will affect the household's budget constraint at the equilibrium, and therefore they are important in determination of the law of motion of net foreign assets.[18]

[18]Namely, the equilibrium budget constraint of the home household will be $C_t + B_{t+1} + \xi_t B_{*,t+1} = (1+r_t)B_t + \xi_t(1+r_t^*)B_{*,t} + w_{T,t}L_{T,t} + w_{NT,t}L_{NT,t} + \Pi_{T,t} + \Pi_{NT,t} + \Pi_{B,t}$, and net profits from financial intermediaries and capital producers will be included in Π terms. Foreign household has a similar condition,

1.2.4 Financial intermediaries

Financial intermediaries obtain funds from both Home and Foreign households, and lend to domestic firms operating in traded and non-traded sectors. In doing so, they engage in maturity transformation as they hold long term risky assets of firms, and fund these assets by short term liabilities. Moreover, intermediaries can raise funds through their own net worth, which is accumulated through their earnings.

The value of loans extended to each sector is equal to the price, $Q_{i,t}$, times the amount of state-contingent claims of bank j, $S_{i,t}(j)$. The total value of loans supplied to both sectors should be equal to the bank net worth and total amount of deposits raised from Home and Foreign households. Hence, the intermediary balance sheet takes the following form:

$$\underbrace{Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j)}_{\text{Assets}} = \underbrace{B_{t+1}(j) + B^*_{t+1}(j)}_{\text{Liabilities}} + \underbrace{N_t(j)}_{\text{Bank Capital}} \tag{19}$$

The earnings of an individual Home bank j in period t is the payoff from total assets funded in the previous period net of cost of deposits raised from Home and Foreign:

$$N_t(j) = (1 + r_{k,T,t})Q_{T,t-1}S_{T,t-1}(j) + (1 + r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j) - (1 + r_t)\left(B_t(j) + B^*_t(j)\right) \tag{20}$$

To rule out the possibility of bankers' accumulating enough wealth to end their need to raise funding from households, bankers are assumed to be finitely lived. Each period, with probability $1 - \gamma$, bankers switch occupations. Thus, the average time that a household member being a banker is given by $\frac{1}{1-\gamma}$. Exiting bankers bring their end-of-period net worth back to their household, and entering bankers receive funding right before they start business. Thus, every period $(1 - \gamma)g$ bankers exit and enter, and the number of workers and bankers

and the difference between aggregate Home budget constraint and Foreign budget constraint will give the net foreign asset position of the economy. A detailed derivation is available in Appendix B.

is kept unchanged. Accordingly, the bankers' objective is to maximize their terminal net worth before they exit:

$$V_t = \mathbb{E}_t \left[\sum_{s=1}^{\infty} (1-\gamma)\gamma^{s-1} \beta \Lambda_{t,t+s} N_{t+s}(j) \right].$$

Following Gertler and Karadi (2011), Gertler and Kiyotaki (2010), and as earlier in Holmström and Tirole (1997), there exists an agency problem between banks and households. After collecting deposits, banks can divert funds to the household that they are a member of. In this case, households can force the bank into bankruptcy and recover a fraction of the assets that the intermediary is holding. The fraction that can be divertable by banks depends on the types of assets that they hold. In particular, I assume that it is harder to divert non-tradable sector assets than diverting tradable sector assets. By doing so, I attempt to capture that non-tradable sector assets are easier to monitor by households because most of these securities represent immobile resources.[19] Let $V_t(N_t(j))$ be the maximized value of V_t, given banks' period retained earnings.[20] The following incentive constraint will suffice to prevent bankers to run away with their assets:

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t} S_{T,t}(j) + \lambda_{NT} Q_{NT,t} S_{NT,t}(j), \tag{21}$$

with $\lambda_{NT} < \lambda_T$.

The above condition indicates that households finance bank j through holding its deposits, as long as the continuation value of the bank is at least equal to the total gain of the bank by diverting its assets.

[19] For instance, it would be harder to run away with houses than with automobiles.

[20] Under frictionless banking, the timing of the retained earnings would be irrelevant for a banker. In the existence of financial frictions, it is optimal for a banker to accumulate net worth until they exit and become workers.

At the end of period $t-1$, the intermediary's program becomes

$$V_{t-1}(N_{t-1}(j)) = \mathbb{E}_{t-1}\left[\beta \Lambda_{t-1,t}\left\{(1-\gamma)\, N_t(j) + \gamma \left(max_{S_{T,t},S_{NT,t}}\left(max_{B_{t+1},B^*_{t+1}} V_t(N_t(j))\right)\right)\right\}\right] \tag{22}$$

subject to (19), (20), and (21).

I guess and verify that the banks' value function is linear in their net worth, i.e. $V_t(N_t(j)) = \nu_t N_t(j)$. First order necessary conditions for the banker's problem yield

$$\beta \mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,T,t+1} - r_{t+1})\right] = \mu_t \lambda_T, \tag{23}$$

$$\beta \mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,NT,t+1} - r_{t+1})\right] = \mu_t \lambda_{NT}, \tag{24}$$

with

$$\mu_t = max\left\{1 - \left(\frac{\beta \mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})\right] N_t}{\lambda_T Q_{T,t} S_{T,t} + \lambda_{NT} Q_{NT,t} S_{NT,t}}\right), 0\right\}. \tag{25}$$

In the above conditions, μ_t is the Lagrangian multiplier associated with the banker's program; Ω_t is the shadow value of a unit of net worth to the banker at time t, which is given by $\Omega_t \equiv (1-\gamma+\gamma\nu_t)$, averaging the exiting and continuation states; and ν_t is the marginal value of net worth.[21]

When bankers' incentive constraint bind, their discount factor, $\beta\tilde{\Lambda}_{t,t+1} \equiv \beta\Lambda_{t,t+1}\Omega_{t+1}$, differentiates from household discount factor, $\beta\Lambda_{t,t+1}$. However, when $\mu_t = 0$, bankers' incentive constraint does not bind, and they acquire deposits until the discounted cost of deposits is equal to the gain from lending to non-financial firms. In that case, banks' value function is equal to their net worth (i.e. $\nu_t = 1$), indicating an equivalence of the stochastic discount factors of agents in the economy. If the incentive constraint does not bind, financial frictions within countries evaporate, and the difference between non-tradable sector and

[21] A detailed solution of the banker's problem can be found in Appendix A.

tradable sector firm financing vanishes.

When $\mu_t > 0$, the spreads between the gains from lending to non-financial firms and the cost of borrowing from households are non-zero in equilibrium, and they are scaled by the divertable proportion of assets in each sector. The magnitudes of spreads depend on both how tight the incentive constraint is binding for the banker and on the types of assets in the bank balance sheet. As it is harder to divert non-tradable producers' assets than tradable sector's assets, the impact of the moral hazard friction on the interest rate spread in non-traded sector is weaker. It is also useful to note that, heterogeneity in the divertable assets in bank balance sheet prevents the indeterminacy problem of bank portfolio allocation when balance sheet constraint binds.[22]

The linearity of the value function helps us to write the incentive constraint in the following form:

$$\frac{Q_{T,t}S_{T,t}(j) + \frac{\lambda_{NT}}{\lambda_T} Q_{NT,t}S_{NT,t}(j)}{N_t(j)} \leq \frac{\nu_t}{\lambda_T}. \tag{26}$$

When bank net worth is low, limits to arbitrage on bank portfolio leads to a maximum ratio of assets to net worth that satisfies the incentive constraint. In this case, the total amount of lending to non-financial firms is limited by the intermediary's net worth. The gain from running away with the assets is balanced with the cost of default of the intermediary. The ability to divert also depends on the asset class and captured by the $\frac{\lambda_{NT}}{\lambda_T}$ term in the above condition.

On the other hand, when bank net worth is high enough, incentive constraint does not bind, and banks are not constrained by their balance sheet when extending loans to non-financial sector.

Solution to the bankers' problem reads as marginal value of an additional bank net worth

[22]Devereux and Sutherland (2011) introduce a higher-order solution method for stochastic, general equilibrium models with portfolio choice that deals with this problem.

can be written in the following form:

$$\nu_t = \frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) \right]}{1 - \mu_t}. \tag{27}$$

It is important to note that the value from additional unit of net worth varies counter-cyclically. In the case of an economic downturn, banks' incentive constraint binds, sectoral spreads increase, and an additional unit of bank net worth becomes more valuable. Conversely, during the boom periods, banks' incentive constraint does not bind, and the continuation value is lower than the previous case.

Aggregation

The solution in Appendix A implies that leverage does not depend on bank specific factors, and the equation (25) can be aggregated to get a relationship between the aggregate bank demand on non-financial firm assets and aggregate bank net worth:

$$\frac{Q_{T,t} S_{T,t} + \frac{\lambda_{NT}}{\lambda_T} Q_{NT,t} S_{NT,t}}{N_t} \leq \frac{\nu_t}{\lambda_T}. \tag{28}$$

Total banking net worth is the sum of existing and entering bankers' net worth:

$$N_t = N_{x,t} + N_{n,t}, \tag{29}$$

where $N_{x,t}$ indicates existing banker net worth, and $N_{n,t}$ is entering banker net worth. Existing bankers carry out the earnings from the assets they held in previous period net of the cost of deposits, with a continuation probability of γ:

$$N_{x,t} = \gamma \left[\left(Z_{T,t} + (1 - \delta) \, Q_{T,t} \right) e^{\psi_{T,t}} S_{T,t-1} + \left(Z_{NT,t} + (1 - \delta) \, Q_{NT,t} \right) e^{\psi_{NT,t}} S_{NT,t-1} - (1 + r_t) \left(B_t + B_t^* \right) \right]. \tag{30}$$

Entering bankers receive start-up funds from the household that they are a member of. These start-up funds are a fraction of the assets that the exiting bankers bring back to the household. Without loss of generality, let $\frac{\varepsilon}{1-\gamma}$ of exiting bankers' assets are transferred to entering bankers within the same household, and then new banker net worth becomes:

$$N_{n,t} = \varepsilon \left[\left(Z_{T,t} + (1-\delta) Q_{T,t} \right) e^{\psi_{T,t}} S_{T,t-1} + \left(Z_{NT,t} + (1-\delta) Q_{NT,t} \right) e^{\psi_{NT,t}} S_{NT,t-1} \right]. \quad (31)$$

Now, equation (29) can be rewritten as:

$$\begin{aligned} N_t = \ & (\gamma + \varepsilon) \left[\left(Z_{T,t} + (1-\delta) Q_{T,t} \right) e^{\psi_{T,t}} S_{T,t-1} + \left(Z_{NT,t} + (1-\delta) Q_{NT,t} \right) e^{\psi_{NT,t}} S_{NT,t-1} \right] \\ & -\gamma \left(1 + r_t\right) \left(B_t + B_t^*\right). \end{aligned} \quad (32)$$

Equation (32) tells that the ex-post returns on non-financial firm assets are the main sources of fluctuations in net worth (see also equation (16)). Moreover, in any sector, a change in the valuation of capital affects both the bank net worth directly through itself, and indirectly through its impact on the other sector's returns. The latter is at work through equations (23) and (24), causing a stronger accelerator mechanism than in standard models. Furthermore, (23) and (24) also transmit the changes in valuations across sectors.

1.2.5 Equilibrium

Market clearing conditions in securities, deposits, goods and labor markets are required to close the model. The equilibrium in goods market in both sectors in Home is given by (7). A similar condition also holds in Foreign.

Market clearing for securities imply that the total supply of firm securities should be equal to the total amount of capital bought within respective sectors, as given in (3).

The equilibrium deposit market condition requires that total demand on deposits by Home and Foreign households should be equal to the aggregate bank assets net of bank net worth:

$$B_{t+1} + B^*_{t+1} = Q_{T,t}S_{T,t} + Q_{NT,t}S_{NT,t} - N_t. \tag{33}$$

And, labor demand equals sectoral labor supply, implying:

$$RP_{ii,t}(1-\alpha)e^{a_{i,t}}(e^{\psi_{i,t}}K_{i,t})^{\alpha}L_{i,t}{}^{-\alpha} = \varpi\frac{L^{\varphi}_{i,t}}{C_t^{-\rho}}. \tag{34}$$

Similar conditions hold also in Foreign.

Finally, under international incomplete markets, equilibrium allocation depends on the net foreign asset position at the beginning of each period. A detailed derivation of the net foreign asset position is given in Appendix B.

The equations (1, 2, 3, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 23, 24, 25, 27, 32, 33) together with respective price equations, and their Foreign counterparts, in which (1, 2, 3, 15, 16 ,17, 18) have analogous components in traded and non-traded sectors, together with the net foreign asset condition determine the endogenous variables ($Y_{T,t}$, $Y_{NT,t}$, $K_{T,t+1}$, $K_{NT,t+1}$, $S_{T,t}$, $S_{NT,t}$, C_t, $C_{T,t}$, $C_{H,t}$, $C_{F,t}$, $C_{NT,t}$, $I_{T,t}$, $I_{NT,t}$, $L_{T,t}$, $L_{NT,t}$, $Z_{T,t}$, $Z_{NT,t}$, r_{t+1},$r_{k,T,t}$, $r_{k,NT,t}$, $Q_{T,t}$, $Q_{NT,t}$, $RP_{T,t}$, $RP_{NT,t}$, $RP_{H,t}$, $RP_{F,t}$, $w_{T,t}$, $w_{NT,t}$, ξ_t, ν_t, μ_t, N_t, B_{t+1}, $B_{*,t+1}$) and their Foreign counterparts as a function of the state variables ($I_{T,t-1}$, $I_{NT,t-1}$, $K_{T,t}$, $K_{NT,t}$, $(1+r_t)B_t$, $(1+r_t)B_{*,t}$, $e^{a_{H,t}}, e^{a_{NT,t}}$, $e^{\psi_{T,t}}, e^{\psi_{NT,t}}$) and their Foreign counterparts, together with the exogenous shock processes. Summary of the equilibrium conditions are available in Table 2.

1.3 Model Calibration and Simulations

In this section, I illustrate the model dynamics and highlight the role of financial frictions in explaining the imbalances.

1.3.1 Calibration

To begin with the conventional parameters, I set the depreciation rate, δ, the capital share, α, households' discount factor, β, to their standard values in the literature. I set them to 0.025, 0.333, and 0.995, respectively. As regards to the convex adjustment costs of foreign deposit holdings to the household, η, I use 0.025 as in Ghironi and Melitz (2005). This value implies that the cost of adjusting deposits has a very small impact on model dynamics, other than pinning down the deterministic steady state and ensuring mean reversion in the long run when shocks are transitory. Moreover, in line with the standard RBC literature, I set the inverse of the inter-temporal elasticity of substitution from consumption, ρ, to 2, and the inverse of the Frisch elasticities in traded and non-traded sectors, φ_1 to 0.276, and φ_2 to 0.276. These imply a Frisch elasticity of 10 in each sector, which is higher than in the conventional literature, which is typically between 1 and 3 for the whole economy. However, as stated by Gertler and Kiyotaki (2010), the calibration in the paper compensates for the absence of several features in quantitative macro models, including nominal price and wage rigidities. I also follow Gertler and Kiyotaki (2010) when setting the relative weight of labor in the utility, and set ϖ to 5.584. The functional form of the capital adjustment costs is given by $\frac{\varphi^K}{2}\left(\frac{I_{i,t}}{e^{\psi_{i,t}}K_{i,t}} - \delta\right)^2$ for every $i \in \{T, NT\}$. I use the value in Bernanke, Gertler, and Gilchrist (1999), and set φ^K to 5.

For the parameters that are of importance for the international dynamics, I again use the conventional values in the literature. I take the elasticity of substitution between home and foreign produced traded goods, ω, to 1.2, and I follow Drozd and Nosal (2010) to set the elasticity of substitution between traded and non-traded goods in the assembly of final consumption good, κ, to 1. As my scope of interest is to build a model that matches the eurozone dynamics, I set the share of home-produced intermediate inputs in the tradable intermediate input, a_H, to 0.55, and share of tradables in the final consumption, a_T to 0.55, which are both in line with the data.

Which is not standard in the literature is the calibration of this model's financial sector variables. The fractions of divertable capital in each sector, λ_T, λ_{NT}, λ_T^* , and λ_{NT}^*, are sector specific, and they capture the heterogeneity between the traded and non-traded sector assets of the financial intermediaries. Moreover, my choices of the proportional transfers to entering bankers, ε, and the survival probability of bankers, γ, are meant to be suggestive. I pick these parameters to hit the following targets: a home steady state interest rate spread in the tradable sector of 100 bps, a steady state interest rate spread in the non-tradable sector of 50 bps, and a steady state leverage ratios of 4 and 6 for Home and Foreign.[23] Leverage ratios are in the range of used values in the literature and I set a smaller steady state leverage ratio for Home because McKinsey Global Institute (2010) documents smaller leverage ratios for Spanish institutions vis-à-vis German credit institutions. Finally, I also set an average horizon of 10 years for bankers, fixing γ, to 0.975, and I set ε to 0.0001, to minimize the effects of bank entry from model dynamics.

Table 4 summarizes the parametrization of the model.

1.3.2 Sensitivity of Leverage Ratios

Before the discussion of belief-driven business cycles, it will be useful to see how the steady-state bank leverage behaves when bank net worth is sufficiently small (when balance sheet constraints bind). Figure 5A shows the results when holding the proportion of divertable assets constant at their calibrated values while varying credit spreads. Similarly, Figure 5B shows the results holding credit spreads constant at their calibrated values, but moral hazard parameters varying around their steady-state values. Figure 5A shows that

[23] I choose a smaller interest rate spread in the non-tradable sector, because those assets were seen as highly liquid in the pre-crisis period. The model dynamics are also not solely dependent on the choice of these parameters. The qualitative features of the results are the same even if one sets the gap between tradable and non-tradable sector spreads to a smaller or a larger value. Robustness checks are available upon request.

an increase in credit spreads will lead to an increase in bank leverage holding everything else constant. As staying in the financial sector becomes more profitable, banks will expand their asset portfolios and become more leveraged. Figure 5B shows that if the proportion of divertability of assets increases, banks shrink their asset portfolios. The reason is that under high divertability, households will be less willing to hold bank deposits, because of the high proportion of losses in the case of bank default. In this case banks cannot extend more credit even if they would like to do so, because they do not have sufficient funds.

1.3.3 Belief-Driven Dynamics

To identify the channels of shock propagation, I build up the final model through three layers. The first layer is a standard two-country model with non-tradable goods in the production process, in which there is no international financial asset trade. This layer is able to demonstrate some principles of belief-driven fluctuations when international financial markets are incomplete, such as low international consumption correlations, and the wealth effect driven changes in import demand.[24] Then, I introduce financial intermediaries in the second layer, but still keep the international financial markets under autarky. Having this second layer helps one to separate the domestic amplification and sectoral propagation mechanisms of balance sheet constrained banks from the international bank spillover channel. Finally, in the last layer, integration of deposit markets further affects banks' acquisition of funds for their activities, and the external account signals the elevated macroeconomic and financial stresses.

In what follows, I will first discuss the performance of the model with respect to its abilities of capturing Spanish data, and then I will identify the underlying channels at work

[24] In models with non-traded good production sector, even under a planner's solution, relative prices do not force equality between the marginal rates of substitution for non-tradable goods across countries, since the forward contracts for non-tradables are traded domestically. Hence, even under no restrictions of international asset trade, the existence of a non-traded sector implies lower international consumption correlations. For further discussion, see Obstfeld and Rogoff (1996, Chapter 5).

by comparing dynamics in each layer of the model.

Specification

The shock specification assumes an anticipated ($u^A_{i,t-n}$) and an unanticipated component ($u^U_{i,t}$) as follows:

$$\begin{aligned} \psi_{i,t} &= \rho_\psi \psi_{i,t-1} + \varepsilon_{i,t} \\ \varepsilon_{i,t} &= u^A_{i,t-n} + u^U_{i,t} \end{aligned}$$

where $\varepsilon_{i,t}$ represents a white noise error in forecasting $\psi_{i,t}$ that is based on its own past. $u^A_{i,t-n}$ constitutes a news shock about $\psi_{i,t}$ which is revealed n periods beforehand, and $u^U_{i,t}$ is the unanticipated component of the white noise, $\varepsilon_{i,t}$, which represents the last piece of information received by agents about $\varepsilon_{i,t}$. Sector specificity is again captured by the subscript $i \in \{T, NT\}$. $u^U_{i,t}$ and $u^A_{i,t}$ are mean-zero white noise terms that are not correlated over time and not correlated with each other. If $u^U_{i,t} = -u^A_{i,t-n}$ at $t = n$, then anticipations are not realized. In line with my motivation of the recent boom-bust period in Southern Eurozone, I set the number of anticipation periods to 33, indicating the number of quarters between 1999:QIV and 2008:QI. In period 33, $u^U_{i,t}$ hits as a counteracting shock that leads to a disappointment with unfulfillment of expected favorable conditions. Hence, the boom-bust period is pure belief-driven and not based on fundamentals.

Model Performance

I investigate the ability of the model to match the Spanish data. I adjust the expected valuation in assets to match the cumulative banking exposure to traded and non-traded sectors until 2008:QI. The adjustment implies 25 percent and 14.5 percent expected valuations in non-traded and traded sector assets, respectively.[25,26,27] Figures 6 and 7 compare model dynamics generated under these expectations with the data.

Figure 6A plots Spain's current account-to-GDP ratio over the period 1999:IV to 2010:I versus the value implied by the model experiment, while Figure 6B does the same for the financial sector credit extended to tradable and non-tradable sectors. In the former, I normalize the steady-state current account-to-GDP ratio to the 1995-2014 average. In the latter, dynamics show the increase in levels starting from the year 2000. The anticipation of an increase in the value of capital drives country borrowing and simultaneously generates an expansion in the credit extended to non-traded sectors. The model reasonably captures the pattern of the current account balance and the divergence in bank credit to the traded and non-traded sectors during the boom period. After 2008:QI, bank credit in the data declines slower than in the model, reflecting the interventions by the ECB and other policy issues going on in the Spanish economy.[28] Although the underlying factors for the boom and the bust are different in this model (i.e. optimism and disappointment), the model would again capture an asymmetry if the factors driving the boom and the bust were the same, due to the presence of occasionally binding constraints of banks. It is observed that fluctuations are more pronounced when bank constraints bind, highlighting the amplification role of banking

[25]Shock persistence is set to 0.999 since accession to the Eurozone was seen as an irreversible event.

[26]I also conduct experiments under which I match the cumulative changes in each sector's Tobin's Q. For a Tobin's Q proxy, I use price-to-book ratios of the construction and manufacturing firms listed in IBEX35 index. The model is again able to capture key feature of data, although the divergence in lending between sectors is less pronounced. Figures 21 and 22 in appendices exhibit this comparison. However, calibration with using data for firms listed in IBEX35 should be considered as a conservative one, because the effects of the crisis were more severe for small-to-medium enterprises (SMEs).

[27]The experiments with skewed expectations toward the valuation of non-traded-sector assets can be justified by several arguments. One possible motivation is by Santos (2014): The non-traded sector in Spain was a target for politicians due to its ability to deliver short-run prosperity that would help officials to get reelected. These incentives of politicians were known by the public, and this knowledge yielded a belief of higher valuation in non-traded sectors in the future, especially in the housing sector. Another motivation can be the power of manipulation and deception toward the non-traded sector assets (Akerlof and Shiller, 2015).

[28]When I introduce policy into the model in the next section, the model does a better a job in capturing the post-crisis period.

in bad times.

Figures 7A and 7B compare the shares of traded and non-traded sectors in overall gross value added versus the model counterparts.[29] The model is, again, doing well in capturing the relative growth in the non-traded sector although it exaggerates its expansion between 2007 and 2008. A collapse in non-traded sector funding after the unfullfilment of expectations shrinks the non-traded portion of the economy faster and overall distribution of sectors in the whole economy becomes balanced.

Three Model Versions

As discussed in the previous subsection, the model captures the key features of bank lending, sectoral resource allocation, and external borrowing of the Spanish boom-bust cycle. To understand the contribution of key ingredients in the model in its success, I compare three model versions. First, I shut down the banking and international asset markets (Version I). Then, I add financial intermediaries but keep the international financial markets under autarky (Version II). Finally, I allow for international financial integration through liabilities, and compare model dynamics for each version (Baseline model).

Figure 8 compares Version I with Version II. The red line represents the dynamics from Version I, and the blue line indicates dynamics from Version II. It is observed that the difference between these two versions is small when the leverage constraints are not binding in the model with banking. Expectations of future favorable conditions lead to an increase in investment in both sectors (with an increase in banking lending under Version II). Higher investment turns into a higher production in each sector. Expansion of the economy puts downward pressure on domestic prices, and the balanced-trade together with an appreciation in real exchange rate imply higher exports. As there is no international asset trade in these versions, current account is always zero. There is no role for the interest rate spreads in

[29] Due to the discrepancies in the data, total gross value added do not add up to 200.

Version I due to absence of banking frictions. In Version II, although banking frictions are present, banks have sufficient net worth during the boom regime (such that their leverage constraints do not bind) which equals banks' borrowing costs with the yields obtained from the extension of credit. Finally, it is important to note that it would not be possible to observe an expansion in investment and output if the model dynamics were generated with an anticipation of higher future productivity, instead of an anticipation of higher asset values.

When optimistic expectations are not met under Version I, investment in the non-traded sector collapses, but traded sector investment first goes up and then declines gradually. There is a shift of resources toward the traded sector. The economic downturn implies an aggravated increase in the relative price of Home traded good, leading to a collapse in exports. Real exchange rate depreciates to compensate and exports gradually come back to its steady state value. However, the shift in resources toward traded sector is not enough to compensate for the overall fall of traded sector output. The outcome from the Version II under the bust regime is significantly different from the no banking case (Version I). First, there is an *amplification effect* that leads to a bigger collapse in investment and output in both sectors. The amplification effect is a result of the well known financial accelerator mechanism that arises when bank leverage constraints bind. Collapse in bank net worth implies a positive bank Lagrangian multiplier, leading to positive excess returns in each sector. Banks want to extend credit but their abilities are constrained by their net worth, making credit more expensive. Banks' asset portfolios imply a larger balance sheet than that of in one-sector models, implying a stronger accelerator effect. Furthermore, the fall in tradable sector investment and output is more pronounced in Version II. The reason is the spillover effect that arise when leverage constraints bind. Rewriting equation (28) in the bust regime is helpful in tracking the mechanism:

$$Q_{T,t}S_{T,t} + \frac{\lambda_{NT}}{\lambda_T}Q_{NT,t}S_{NT,t} = \frac{\nu_t}{\lambda_T}N_t.$$

When the disappointment is bigger in the non-traded sector, banks deleverage their non-traded sector assets in a greater fashion. Deleveraging leads to a fall in bank net worth, and then to a further deleveraging of traded sector assets. *Intra-national spillover effect* arises. The above equation also suggests that the spillover across sectors through bank balance sheets depends on the ratio of moral hazard parameters that apply to assets in each sector: $\frac{\lambda_{NT}}{\lambda_T}$. The greater the ratio of divertability of non-traded sector assets to divertability of traded sector assets, the stronger is the intra-national spillover effect. However, consumption of imports and exports still behaves at odds with the data because of the balanced trade condition.

Figure 9 exhibits the dynamics when there is international financial integration and compares those with the dynamics from Version II. Purple line indicates the outcome from the former. In the boom regime, when agents are hit by the news of higher future value of assets, Home banks expand their balance sheets and increase their borrowings from households in both countries. Expansion in the liabilities translates into an expansion of credit toward tradable and non-tradable non-financial sectors. The proportion of overall lending to non-traded sector is bigger because of the higher expected valuations vis-à-vis to those in traded sector. Expansion in Home economy decreases domestic price levels and a persistent appreciation in real exchange rate contributes to a long-lasting current account deficit. Wages in home economy arises more than their counterparts in Foreign, implying higher unit labor costs in Home. As seen in the data (Figure 3), model suggests that the overall increase in the unit labor costs is more pronounced in the non-traded sector until the crisis occurs. Higher income translates into a higher consumption demand for imports, and underlining the main cause of the persistent current account deficit (instead of a huge deterioration in exports).

The disappointment in expectations causes a sudden reversal of capital flows, depressing Home banks' balance sheets. Bank credit to traded and non-traded non-financials collapses in a more pronounced manner as the borrowing costs jump higher in this case. *International spillover channel* arises. The bust regime in the baseline model is associated with larger fluctuations in all variables than those in other model versions. Sudden reversals of capital flows imply a tighter leverage constraint and the amplification mechanism is stronger in this case. A stronger drop in non-traded sector bank assets contribute to a stronger intra-national spillover channel, indicating a bigger drop in traded sector bank assets. Investment in both sectors collapse and Home economy experiences a persistent recession. Collapse in relative wages lead to a stronger wealth effect, and is followed by a collapse in imports (*demand channel*). Real exchange rate depreciates severely, and the current account sharply corrects itself. Opening up the financial trade in international markets magnifies the contributions of intra-national spillover channel.

Propagation of Fluctuations Across Sectors

To understand the propagation from non-traded to traded sectors, I further compare the baseline model with the model dynamics that are driven by same amount of expected valuation in each sector (14.5% expected valuation of assets in each sector). Figure 10 compares these two versions. When agents are more optimistic about the valuation of non-traded sector assets, they shift resources from traded to non-traded sectors. Banks decrease lending to tradable sector even though the expected valuations of traded sector assets are the same in each case. However, when news become unfulfilled, sudden capital reversals shrink bank balance sheets and banks cut lending to both sectors. Stronger intra-national spillover channel in the baseline model contributes to a stronger fall in tradable sector output, and the overall economy gets into a deeper recession. The model suggests that if the proceedings of foreign borrowing is used toward lower return sectors, it becomes hard to match current liabilities with future surpluses when adverse conditions arise. Current account deficit becomes a problem. The model outcome is in line with the consensus narrative on the Eurozone crisis (see Baldwin and Giavazzi, 2015).

1.4 Unconventional Central Bank Policies

In the presence of financial frictions described above, inefficient spreads between the return to capital in each sector and the risk-free rate arise when expectations turn out to be incorrect. Fluctuations in these spreads affect the cost of capital, and in turn, overall output in the economy. A central bank, constrained by the zero-lower-bound, can intervene in markets by increasing demand on non-financial private sector assets, or by supplying further funding to the banking sector to overcome the restriction on the size of banks' portfolio of assets over their internal equity.

For central bank intervention to make a difference, it has to *ex-ante* justify its relative advantage in transferring resources with respect to no intervention case. If the central bank is subject to the same degree of frictions that the banking sector is subject to, then the unconventional policy will be neutral. However, if the central bank is privileged in raising funds for its policy applications, then substitution of central bank intermediation in lieu of private intermediation will have an impact on the inefficiencies present in the model. In the rest of this section, I assume that the central bank always honors its debt and can raise funds by issuing interest-bearing short-term claims. The relative efficiency of the central bank in intermediation makes the unconventional policy non-neutral.[30]

The policies that I am studying here are different than those in the recent literature by

[30] The irrelevance result is closely related with the Ricardian equivalence proposition in Barro (1974), and its extension to open market operations that is studied in Wallace (1981). Sargent and Wallace (1982) also provide an example that will make the credit policy special within real-bills regime.

its response to news-led bust cycles, by the choice of funding for intervention—resources for intervention are raised from banks instead of from households—, and by its response to sector specific variables. The assumption of the unconventional policy financed by interest-bearing reserves is in line with the evidence obtained from the Eurosystem balance sheet. Figure 11 exhibits the increase in deposit liabilities of the Eurosystem from Monetary and Financial Institutions (MFIs) after the start of the ECB unconventional policies in early 2008, indicative for the resources of the ECB firepower.

As the domestic economy is the one that is primarily affected by the adverse conditions, I further assume that there is limitation for domestic banks to raise funds from households to finance the global central bank's unconventional policy. This friction does not apply to banks abroad. In doing so, I would like to capture the risks borne by Home country's possibility of an exit from the eurozone, and domestic banks' ability to divert ECB assets in such occasion. It is a realistic case, as at the time of this writing, the potential exit of Greece from the Eurozone is occupying headlines. It is also important to note that the introduction of unconventional policies in this manner will contribute to the asymmetries in banking across two countries in the model.

In what follows, I examine the policy applications in greater detail.

1.4.1 Asset Purchases

On November 21, 2014, ECB started its private asset purchase program as a mean of using its powers as a lender of last resort. The relevant ECB announcement[31] indicated that these policies were mainly targeted toward acquiring non-traded sector assets.

Building motivation from this case, I assume that a global central bank has the option of intermediating a fraction $\varphi^{ump}_{T,t}$ of total domestic tradable, and a fraction $\varphi^{ump}_{NT,t}$ of non-tradable sector funding needs. In particular, now the central bank can purchase $S^{g}_{T,t} =$

[31] See Decision ECB/2014/45, November 19, 2014.

$\varphi_{T,t}^{ump} S_{T,t}$, or $S_{NT,t}^{g} = \varphi_{NT,t}^{ump} S_{NT,t}$, in fractions of total sectoral assets. The private assets intermediated by the financial intermediaries are denoted with $S_{T,t}^{p} = (1 - \varphi_{T,t}^{ump}) S_{T,t}$, and $S_{NT,t}^{p} = (1 - \varphi_{NT,t}^{ump}) S_{NT,t}$, respectively. Deviating from the previous literature, I specify the fractions of the assets intermediated by the central bank as an autoregressive processes with an innovation that occurs at the same time of the realization of incorrectness of the news on the value of capital, at $t = 33$. That is:

$$\hat{\varphi}_{i,t}^{ump} = \rho_{\varphi_i^{ump}} \hat{\varphi}_{i,t-1}^{ump} + u_{i,t}^{ump}, \tag{35}$$

where $u_{i,t}^{ump}$ has zero mean and standard deviation of $\sigma_{u_i^{ump}} = \kappa \sigma_{\varepsilon^U}$ with $i \in \{T, NT\}$. Capped variables indicate the deviations from their non-stochastic steady-state.

To finance these purchases, central bank issues debt to banks at rate $1 + r_{g,t+1}$, and banks fund this activity by issuing deposits to households at the risk-free rate. The rate $r_{g,t+1}$ is the interest that will be paid by central bank to the financial intermediary between periods t and $t+1$, and it is known in period t. Central bank's balance sheet takes the following form:

$$Q_{T,t} S_{T,t}^{g} + Q_{NT,t} S_{NT,t}^{g} = B_t^{g} + \xi_t B_{*,t}^{*g}.$$

In this setting, B_t^{g} and $B_{*,t}^{*g}$ can be thought of as interest bearing reserves of Home and Foreign banks at the central bank's account. The global central bank raises equal amount of resources from each country (*i.e.* $B_t^{g} = \xi_t B_{*,t}^{*g}$), as the sizes of the countries are equal to each other. Moreover, following the previous literature, I introduce inefficiency costs of τ_T and τ_{NT} per unit of private loans intermediated in each sector. For the asset purchase program to produce welfare gains, its disadvantage in making loans together with the additional frictions arisen in the financial sector due to the central bank policy should be offset by the central bank's advantage in obtaining funds.

Now, the financial intermediary balance sheets become

$$\underbrace{Q_{T,t}S^{p}_{T,t}(j) + Q_{NT,t}S^{p}_{NT,t}(j)}_{\text{Private Assets}} + \underbrace{B^{g}_{t}(j)}_{\text{Interest-Bearing Claims}} = \underbrace{B_{t+1}(j) + B^{*}_{t+1}(j)}_{\text{Liabilities}} + \underbrace{N_t(j)}_{\text{Bank Capital}}, \quad (36)$$

with the incentive constraint now also indicating the banks' ability to divert central bank debt in the case of default:

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t}S_{T,t}(j) + \lambda_{NT} Q_{NT,t}S_{NT,t}(j) + \lambda_{ECB} B^{g}_{t}(j), \quad (37)$$

where $\lambda_{ECB} < \lambda_{NT}$. Here, it is easier for depositors to monitor the performance of central bank debt than the performance of private asset portfolios, and hence, the former is subject to a lower degree of bank malfeasance. In particular, in the quantitative analysis of this section, *w.l.o.g.* I assume $\lambda_{ECB} = \frac{\lambda_{NT}}{2}$.

It is shown in the appendices that the rate $1 + r_{g,t+1}$ should also be set according to the following equation:[32]

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \Omega_{t+1}(r_{k,NT,t+1} - r_{t+1}) = \frac{\lambda_{NT}}{\lambda_{ECB}} \mathbb{E}_t \beta \Lambda_{t,t+1} \Omega_{t+1}(r_{g,t+1} - r_{t+1}). \quad (38)$$

As limits to arbitrage is weaker for central bank debt, the inefficient spread on central bank debt is a fraction, $\frac{\lambda_{ECB}}{\lambda_{NT}}$, of the inefficient spread on non-traded assets. After these modifications, the restriction on the bank portfolio also depends on the magnitude of the central bank intervention. Combination of the above identities leads to the following relationship between the total value of intermediated private securities and bank net worth:

$$(1 - \varphi^{ump}_{T,t}) Q_{T,t}S_{T,t} + \frac{\lambda_{NT}}{\lambda_T}(1 - \varphi^{ump}_{NT,t}) Q_{NT,t}S_{NT,t} + \frac{\lambda_{ECB}}{\lambda_T} B^{g}_{t} \leq \frac{\nu_t}{\lambda_T} N_t. \quad (39)$$

[32] A detailed solution of banks' problem when there is unconventional policy can be found in Appendix C.

If the above condition is not binding, there does not exist any inefficient spreads, and the unconventional monetary policy is neutral. With the inefficiency costs and the additional frictions in the banking sector present, the unconventional monetary policy will be welfare reducing in this case. However, if the above condition is binding, neutrality of the policy disappears and the central bank intervention leads to an overall increase in asset demand depending on the magnitude of the intervention. Equation (39) also states that the central bank intervention will have effects in different magnitudes depending on which asset it acquires. The acquisition of non-traded assets will free up bank capital by a factor of $\frac{\lambda_{NT}}{\lambda_T}$ vis-à-vis acquisition of traded sector assets.

The evolution of aggregate bank net worth also takes the following form:

$$\begin{aligned} N_t = \ & (\gamma + \varepsilon) \left[(Z_{T,t} + (1-\delta) Q_{T,t}) e^{\psi_{T,t}} S^p_{T,t-1} + (Z_{NT,t} + (1-\delta) Q_{NT,t}) e^{\psi_{NT,t}} S^p_{NT,t-1} + (1 + r_{g,t}) B^g_{t-1} \right] \\ & -\gamma \left[(1 + r_t) (B_t + B^*_t) \right]. \end{aligned} \tag{40}$$

Finally, it should be noted that the possible profits obtained by central bank intervention are distributed back to households in Home and Foreign, in equal amounts, implying $T_t = \xi_t T^*_t$. Balanced budget of the central bank implies:

$$(r_{k,T,t} - r_{g,t}) Q_{T,t-1} S_{T,t-1} \varphi^{ump}_{T,t-1} + (r_{k,NT,t} - r_{g,t}) Q_{NT,t-1} S_{NT,t-1} \varphi^{ump}_{NT,t-1} = \Upsilon_{t-1} + T_t + \xi_t T^*_t,$$

where $\Upsilon_{t-1} = \tau_T \varphi^{ump}_{T,t-1} Q_{T,t-1} S_{T,t-1} + \tau_{NT} \varphi^{ump}_{NT,t-1} Q_{NT,t-1} S_{NT,t-1}$, is the expression for total inefficiency costs per unit of intermediation (e.g. central bank monitoring costs). Transfers of central bank profits to domestic and abroad households do not have a direct effect on net foreign asset position, as they cancel out each other in the equilibrium. However, the unconventional monetary policy will affect the net foreign position through the deposit market clearing condition in Home.[33]

1.4.2 Liquidity Facilities

An alternative unconventional policy that is more reminiscent of the LTROs[34] of the ECB is liquidity facilities conducted by the common central bank in the model. Under this policy alternative, the central bank lends funds to financial intermediaries, which in turn will lend to non-financial private firms.

In this case, it is important for the central bank to distinguish illiquid banks from the insolvent ones, as otherwise can lead to excessive forbearance and debt hangover as highlighted in Bagehot (1873), and more recently in Gertler and Kiyotaki (2010). To overcome this issue, the central bank provides liquidity facilities at a penalty rate and against eligible collateral to discourage the inefficient use of central bank funding.

I assume that the central bank provides non-contingent loans, M_{t+1}, to banks, at a rate, $1 + r_{m,t+1}$, which is known in period t. Financial intermediary balance sheets take the following form:

$$Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j) + B^g_t(j) = B_{t+1}(j) + B^*_{t+1}(j) + \underbrace{M_{t+1}(j)}_{\text{Discount Window Lending}} + N_t(j). \quad (41)$$

The financial intermediary's non-tradable sector firm assets and interest bearing reserves are eligible collateral for the central bank liquidity facilities. Hence, for any unit of discount

[33] A detailed derivation is available in Appendix D.

[34] To address the illiquidity issues in the financial sector of the eurozone, the first supplementary longer-term refinancing operation (LTRO) of ECB with a six-month maturity was announced in March 2008. Between April 2008 and October 2011, the ECB conducted twenty LTROs with six-month maturity. Details of the ECB's announcements can be found in their website: https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html

window lending, a borrowing bank cannot divert any of those assets:

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t} S_{T,t}(j) + \lambda_{NT}(Q_{NT,t} S_{NT,t}(j) - M_{t+1}) + \lambda_{ECB}(B_t^g(j) - M_{t+1}(j)). \quad (42)$$

The details of the bankers' problem under these assumptions is available in Appendix D. The cost of central bank funding is related to the excess returns on non-traded sector firm assets as below:

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (r_{k,NT,t+1} - r_{t+1}) \right] = \frac{\lambda_{NT}}{\lambda_{ECB} + \lambda_{NT}} \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (r_{m,t+1} - r_{t+1}) \right]. \quad (43)$$

After the appropriate aggregation in the banking sector, it can be shown that banks' assets are now proportional to their net worth and the amount of central bank liquidity in the financial sector:

$$Q_{T,t} S_{T,t} + \frac{\lambda_{NT}}{\lambda_T} Q_{NT,t} S_{NT,t} + \frac{\lambda_{ECB}}{\lambda_T} B_t^g \leq \frac{\nu_t}{\lambda_{T\,t}} N_t + \frac{\lambda_{ECB} + \lambda_{NT}}{\lambda_T} M_{t+1}, \quad (44)$$

with the evolution of aggregate bank net worth:

$$\begin{aligned} N_t = \; & (\gamma + \varepsilon) \left[(Z_{T,t} + (1-\delta) Q_{T,t}) e^{\psi_{T,t}} S_{T,t-1} + (Z_{NT,t} + (1-\delta) Q_{NT,t}) e^{\psi_{NT,t}} S_{NT,t-1} + (1 + r_{g,t}) B_{t-1}^g \right] \\ & -\gamma \left[(1 + r_t)(B_t + B_t^*) + (1 + r_{m,t}) M_t \right]. \end{aligned} \quad (45)$$

Equation (44) indicates that liquidity facilities will free up bank capital by a factor of $\frac{\lambda_{ECB}+\lambda_{NT}}{\lambda_T}$, when leverage constraints bind.

Finally, the magnitude of liquidity facilities are determined by a similar rule as in the case of private asset purchases, yielding to the following relationship:

$$M_{t+1} = \varphi_{T,t}^{ump} Q_{T,t} S_{T,t} + \varphi_{NT,t}^{ump} Q_{NT,t} S_{NT,t}, \quad (46)$$

where $\varphi_{T,t}^{ump}$ and$\varphi_{NT,t}^{ump}$ are given by (35).

Under liquidity facilities, the central bank budget constraint is also modified as follows:

$$(r_{m,t} - r_{g,t}) Q_{T,t-1} S_{T,t-1} \varphi_{T,t-1}^{ump} + (r_{m,t} - r_{g,t}) Q_{NT,t-1} S_{NT,t-1} \varphi_{NT,t-1}^{ump} = \Upsilon_{t-1} + T_t + \xi_t T_t^*.$$

There is no modification in Foreign banking sector conditions as none of the policy related frictions are applicable to the banks abroad.

1.4.3 Experiments under Unconventional Central Bank Policies

When running simulations, I set $\varphi_{T,t}^{ump} = 0$ and $\kappa = 30$. Hence, I investigate the policy's contribution to model performance when it is conducted in response to non-traded sector variables.

Figures 12 and 13 exhibit the model's performance with respect to the Spanish data, when central bank asset purchase program is in place. As discussed in section 3.3.2, including policy in the model improves the model's post-crisis performance. The collapse in bank credit toward non-tradable sectors is less pronounced due to the central bank's asset purchasing program. The central program helps leverage constraints to relax, and banks start to allocate more capital to tradable toward tradable sector firms, as returns from there is higher. Global central bank is channeling funds from Foreign to Home when conducting policy, and private outflow of capital is replaced by public inflow of capital, yielding a softer correction in the current account. This is exactly the case observed in the Eurozone, and documented by Merler and Pisani-Ferry (2012). Figure 13 shows that the correction in the non-traded share of the economy is slower as the central bank is using its fire power to compensate for the loss in that sector.

Figure 14 compares the model dynamics under unconventional monetary policy (asset purchases) with the baseline model. Relaxation in the restriction on the size of bank portfolio over bank net worth is relaxed, and the financial accelerator effect is partially offset by the policy. Hence, the fall in investment and output in the non-traded sector is smaller when central bank action is in place. Through the spillover channel discussed in Section 3, traded sector asset deleveraging is less pronounced, causing the investment in the traded sector fall less than in the baseline model. The unconventional policy studied above is more successful at preventing the spillover of the crisis to the traded-sector than preventing the fall in output in the non-traded sector, where crisis is originated. The reason is that returns are higher in the traded sector, and banks allocate funds to the high return sectors after the realization of fundamentals. Figure 14 also shows that the proceedings of public flows that replaced private flows across countries contributes to expansion of imports.

Finally, Figure 15 compares the dynamics under central bank asset purchases with liquidity facilities. To keep the experiment more realistic, I set the policy magnitude, κ, to 10. The figure shows that liquidity facilities are better at ameliorating the economy when equal amount of central bank fire-power is in place under both options. Inefficients spreads in non-traded and traded sector decline 12bps and 24bps more under liquidity facilities, and it contributes to a further relaxation of leverage constraints. Financial intermediaries use the central bank funding to compensate for the losses in traded sector assets, and it contributes to a softer decline in traded sector variables. Hence, the unconventional policies laid out in this paper are successful at ameliorating the adverse conditions in Home economy.

1.5 Conclusions

This paper presented a two-country model of macroeconomic interdependence with banking frictions in which positive news about future asset values that are eventually unmaterialized lead to a boom-bust cycle. The credit channel plays a key role in transmission and propagation of fluctuations within and across countries. Over-optimism on the future value of non-traded sector assets can generate excessive investment in that sector although returns are relatively smaller. When expectations turn to be wrong, a sudden reversal of capital flows makes bank balance sheets weaker, and it becomes hard to match current liabilities with future surpluses. The current account deficit becomes stringent. The results are relevant because the recent consensus narrative on the Eurozone crisis (see Baldwin and Giavazzi, 2015) suggests a similar view: "Capital flows tended to feed non-tradable sectors in the periphery of the Eurozone, and when the investors lost trust in deficit nations, the effects of a sudden-stop were amplified due to the predominance of bank financing." This paper contributes to this debate by providing a rigorous framework for this consensus view.

I also use the model to study the performance of several types of unconventional policies such as those implemented by the ECB. Existence of heterogeneous types of assets in the model makes it possible to design policy in response to sector-specific variables. Moreover, the funding of central bank intermediation is obtained through issuing interest bearing reserves to banks in both regions, in line with the evidence for the Eurozone. With these new ingredients, the model shows that liquidity facilities directed toward the financial sector perform better at mitigating the downturn than direct asset purchases from non-financials in the non-traded sector. These results contribute to the recently growing debate on assessing unconventional policies.

An extension of the model that will capture additional features of the Eurozone crisis will be to introduce government debt in bank balance sheets. In this case, suspicions about government solvency can induce suspicions about the solvency of banks, which in turn will further weaken the economy. This can be captured in the model by introducing an endogenous government default risk that varies with the expectations on the future state of the economy. I leave this extension for future work.

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1.7 Tables

Table 1.1: Domestic credit outstanding at the end of the period - ratios to GDP

	Germany	France	Italy	Ireland	Greece	Spain	Portugal
2000	106	72	71	100	42	87	110
2004	101	76	78	126	62	111	124
2008	95	95	95	202	85	171	151

Source: Giavazzi and Spaventa (2010).

Table 1.2: Quantitative Model Summary

Euler equation, domestic deposits	$C_t^{-\rho} = \beta(1+r_{t+1})\mathbb{E}_t\left[C_{t+1}^{-\rho}\right]$
Euler equation, deposits abroad	$C_t^{-\rho}\left[1+\eta B_{*,t+1}\right] = \beta(1+r_{t+1}^*)\mathbb{E}_t\left[\frac{RER_{t+1}}{RERt}C_{t+1}^{-\rho}\right]$
Consumption-labor trade-offs	$w_{T,t} = \frac{\varpi L_{T,t}^{\varphi_1}}{C_t^{-\rho}}$ $w_{NT,t} = \frac{\varpi L_{NT,t}^{\varphi_2}}{C_t^{-\rho}}$
Demand functions	$C_{H,t} = a_H\left(\frac{RP_{H,t}}{RP_{T,t}}\right)^{-\omega}C_{T,t}$ $C_{F,t} = (1-a_H)\left(\frac{RP_{F,t}}{RP_{T,t}}\right)^{-\omega}C_{T,t}$ $C_{T,t} = a_T\left(RP_{T,t}\right)^{-\kappa}C_t$ $C_{NT,t} = (1-a_T)\left(RP_{NT,t}\right)^{-\kappa}C_t$
Price indexes	$RP_{T,t}^{1-\omega} = a_H RP_{H,t}^{1-\omega} + (1-a_H)RP_{F,t}^{1-\omega}$ $1 = a_T RP_{T,t}^{1-\kappa} + (1-a_T)RP_{NT,t}^{1-\kappa}$
Labor Demand	$\frac{w_{T,t}}{RP_{H,t}} = (1-\alpha)e^{a_{T,t}}(e^{\psi_{T,t}}K_{T,t})^{\alpha}L_{T,t}{}^{-\alpha}$ $\frac{w_{NT,t}}{RP_{NT,t}} = (1-\alpha)e^{a_{NT,t}}(e^{\psi_{NT,t}}K_{NT,t})^{\alpha}L_{NT,t}{}^{-\alpha}$
Gross profits per unit of capital	$Z_{T,t} = \alpha RP_{H,t}e^{a_{T,t}}(e^{\psi_{T,t}}K_{T,t})^{\alpha-1}L_{T,t}{}^{1-\alpha}$ $Z_{NT,t} = \alpha RP_{NT,t}e^{a_{NT,t}}(e^{\psi_{NT,t}}K_{NT,t})^{\alpha-1}L_{NT,t}{}^{1-\alpha}$
Ex-post Return to Capital	$\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\left(1+r_{k,T,t+1}\right)\right] = \beta\mathbb{E}_t\left[\Lambda_{t,t+1}\frac{Z_{T,t}+Q_{T,t+1}e^{\psi_{T,t+1}}(1-\delta)}{Q_{T,t}}\right]$ $\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\left(1+r_{k,NT,t+1}\right)\right] = \beta\mathbb{E}_t\left[\Lambda_{t,t+1}\frac{Z_{NT,t}+Q_{NT,t+1}e^{\psi_{NT,t+1}}(1-\delta)}{Q_{NT,t}}\right]$
Tobin's Q	$Q_{T,t} = \frac{1}{1-f_I(\frac{I_{T,t}}{e^{\psi_{T,t}}K_{T,t}})e^{\psi_{T,t}}K_{T,t}}$ $Q_{NT,t} = \frac{1}{1-f_I(\frac{I_{NT,t}}{e^{\psi_{NT,t}}K_{NT,t}})e^{\psi_{NT,t}}K_{NT,t}}$
Resource constraints	$e^{a_{T,t}}(e^{\psi_{T,t}}K_{T,t})^{\alpha}L_{T,t}{}^{1-\alpha} = C_{H,t} + C_{H,t}^* + I_{T,t}$ $e^{a_{NT,t}}(e^{\psi_{NT,t}}K_{NT,t})^{\alpha}L_{NT,t}{}^{1-\alpha} = C_{NT,t} + I_{NT,t}$
Laws of motion of capital	$K_{T,t+1} = (1-\delta)e^{\psi_{T,t}}K_{T,t} + I_{T,t} - f(\frac{I_{T,t}}{e^{\psi_{T,t}}K_{T,t}})e^{\psi_{T,t}}K_{T,t}$ $K_{NT,t+1} = (1-\delta)e^{\psi_{NT,t}}K_{NT,t} + I_{NT,t} - f(\frac{I_{NT,t}}{e^{\psi_{NT,t}}K_{NT,t}})e^{\psi_{NT,t}}K_{NT,t}$
No-arbitrage condition	$Q_{T,t}K_{T,t+1} = Q_{T,t}S_{T,t}$ $Q_{NT,t}K_{NT,t+1} = Q_{NT,t}S_{NT,t}$
Excess returns on bank assets	$\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,T,t+1}-r_{t+1})\right] = \lambda_T\mu_t$

Table 1.2: Quantitative Model Summary (Continued)

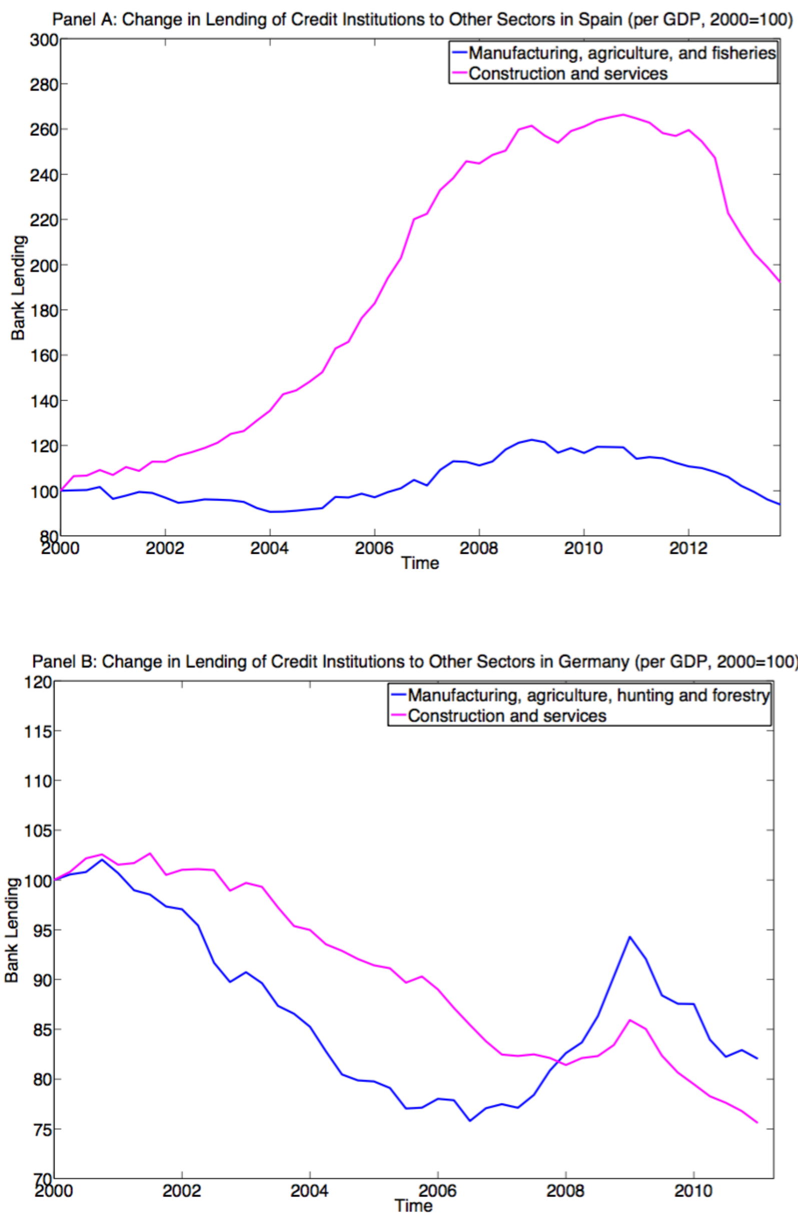
	$\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,NT,t+1}-r_{t+1})\right]=\lambda_{NT}\mu_t$
Shadow marginal value of net worth	$\Omega_t\equiv(1-\gamma+\gamma\nu_t)$
Marginal value of banks' net worth	$\nu_t=\frac{\beta\mathbb{E}_t[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})]}{1-\mu_t}$
Banks' Lagrange multiplier	$\mu_t=max\left\{1-\left(\frac{\beta\mathbb{E}_t[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t]}{\lambda_T Q_{T,t}S_{T,t}+\lambda_{NT}Q_{NT,t}S_{NT,t}}\right),0\right\}$
Aggregate net worth	$N_t=(\gamma+\varepsilon)\left[(Z_{T,t}+(1-\delta)\,Q_{T,t})\,e^{\psi_{T,t}}S_{T,t-1}\right.$ $\left.+\,(Z_{NT,t}+(1-\delta)\,Q_{NT,t})\,e^{\psi_{NT,t}}S_{NT,t-1}\right]-\gamma\,(1+r_t)\,(B_t+B_t^*)$
Deposit market clearing	$Q_{T,t}S_{T,t}+Q_{NT,t}S_{NT,t}=B_{t+1}+B_{t+1}^*+N_t$
Net foreign asset position	$(\xi_t B_{*,t+1}-B_{t+1}^*)+\frac{1}{2}\left[(C_t-\xi_t C_t^*)-(N_t-\xi_t N_t^*)\right]$ $=(\xi_t\,(1+r_t^*)\,B_{*,t}-(1+r_t)\,B_t^*)$ $+\frac{1}{2}\left(w_{T,t}L_{T,t}+w_{NT,t}L_{NT,t}-\xi_t\left(w_{T,t}^*L_{T,t}^*+w_{NT,t}^*L_{NT,t}^*\right)\right)$ $+\frac{1}{2}\left[\gamma(1+r_t)(Q_{T,t-1}K_{T,t}+Q_{NT,t-1}K_{NT,t}-N_{t-1})\right]$ $-\frac{1}{2}\xi_t\left[\gamma^*(1+r_t^*)(Q_{T,t-1}^*K_{T,t}^*+Q_{NT,t-1}^*K_{NT,t}^*-N_{t-1}^*)\right]-\frac{1}{2}(1-\delta)[Q_{T,t}e^{\psi_{T,t}}K_{T,t}$ $+Q_{NT,t}e^{\psi_{NT,t}}K_{NT,t}-\xi_t\left(Q_{T,t}^*e^{\psi_{T,t}^*}K_{T,t}^*+Q_{NT,t}^*e^{\psi_{NT,t}^*}K_{NT,t}^*\right)]$ $-\frac{1}{2}\left[I_{T,t}+I_{NT,t}-\xi_t(I_{T,t}^*+I_{NT,t}^*)\right]+\frac{1}{2}(1-\gamma-\varepsilon)[(Z_{T,t}+(1-\delta)\,Q_{T,t})\,e^{\psi_{T,t}}K_{T,t}$ $+\,(Z_{NT,t}+(1-\delta)\,Q_{NT,t})\,e^{\psi_{NT,t}}K_{NT,t}]$ $-\frac{1}{2}\xi_t(1-\gamma^*-\varepsilon)[\left(Z_{T,t}^*+(1-\delta)\,Q_{T,t}^*\right)e^{\psi_{T,t}^*}K_{T,t}^*$ $+\left(Z_{NT,t}^*+(1-\delta)\,Q_{NT,t}^*\right)e^{\psi_{NT,t}^*}K_{NT,t}^*]$

Table 1.3: Parameter Values

Parameter	*Value*		*Comments*
Discount factor	β	0.995	Standard RBC value
Risk aversion coefficient	ρ	2	Standard RBC value
Relative weight of labor in the utility	ϖ	5.584	Gertler and Kiyotaki (2010)
Inverse Frisch elasticity (T sector)	φ_1	0.276	Gertler and Karadi (2011)
Inverse Frisch elasticity (NT sector)	φ_2	0.276	Gertler and Karadi (2011)
Deposit adjustment	η	0.025	Standard RBC value
Inverse elasticity of substitution between Home and Foreign goods	ω	1.2	Standard RBC value
Inverse elasticity of substitution between traded and non-traded goods	κ	1	Drozd and Nosal (2010)
Investment adjustment	φ^K	5	Bernanke, Gertler, and Gilchrist (1999)
Depreciation	δ	0.025	Standard RBC value
Home bias	a_H	0.55	To match data properties
Share of tradable sector	a_T	0.55	To match data properties
Share of capital in production	α	0.33	Standard RBC value
Exit probability of banks	γ	0.975	Bank survival of 10 years
Fraction of start-up funds	ε	0.0001	To minimize the effect of banker entry-exit
Tradable sector asset diversion	λ_T	0.4126	To match a
Non-tradable sector asset diversion	λ_{NT}	0.2063	steady-state excess return in NT sector of 50 bps, in T sector of 100bps, when home leverage ratio is 4.

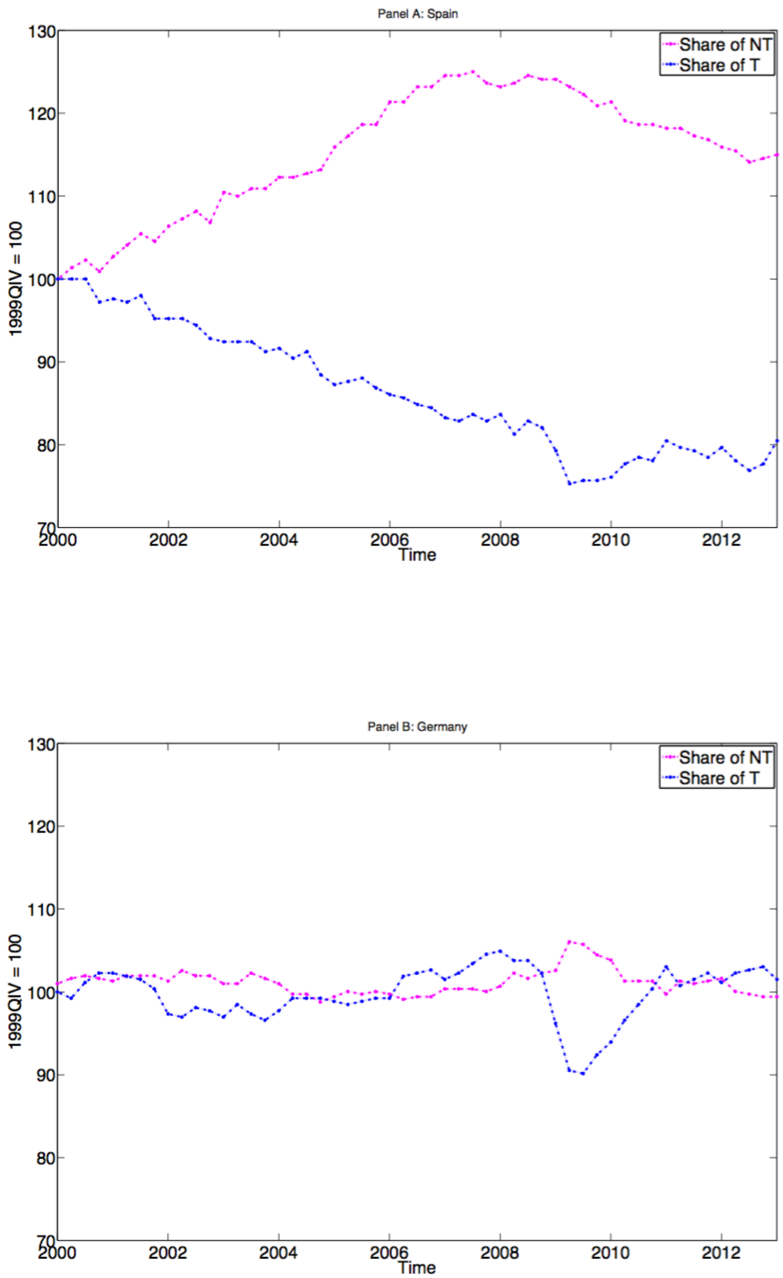
1.8 Figures

Figure 1.1: Change in Bank Lending (Levels)



Source: Bank of Spain and Bundesbank.

Figure 1.2: Shares of Sectors in Total Gross Value Added

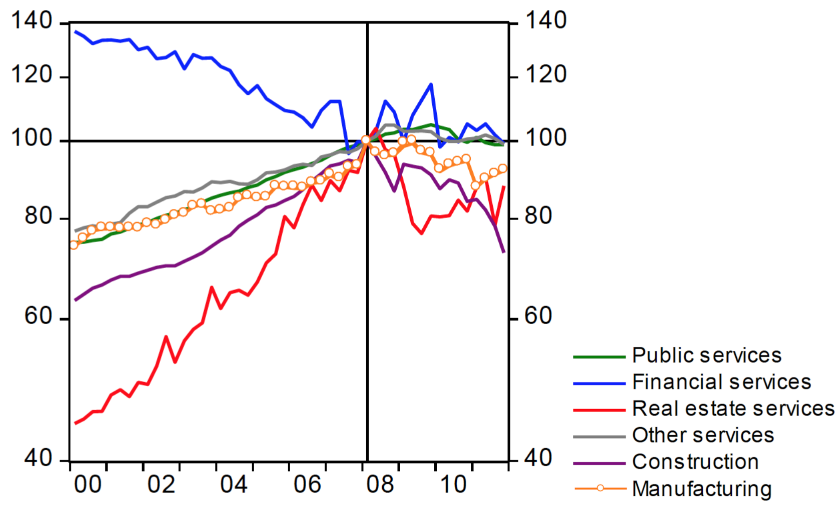


Source: Eurostat

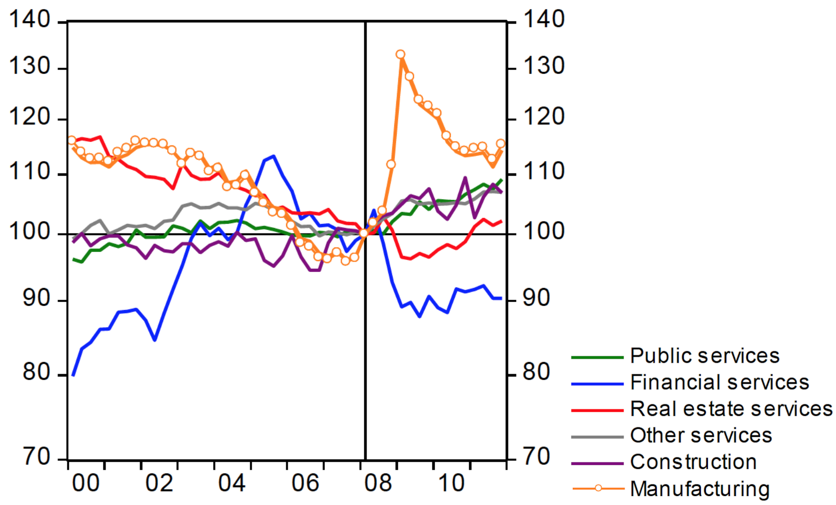
Notes: Non-tradable represents construction; wholesale and retail trade; transport, accommodation and food services. Tradable represents industry except construction.

Figure 1.3: Changes in Sectoral Unit Labor Costs

Panel A: Spain



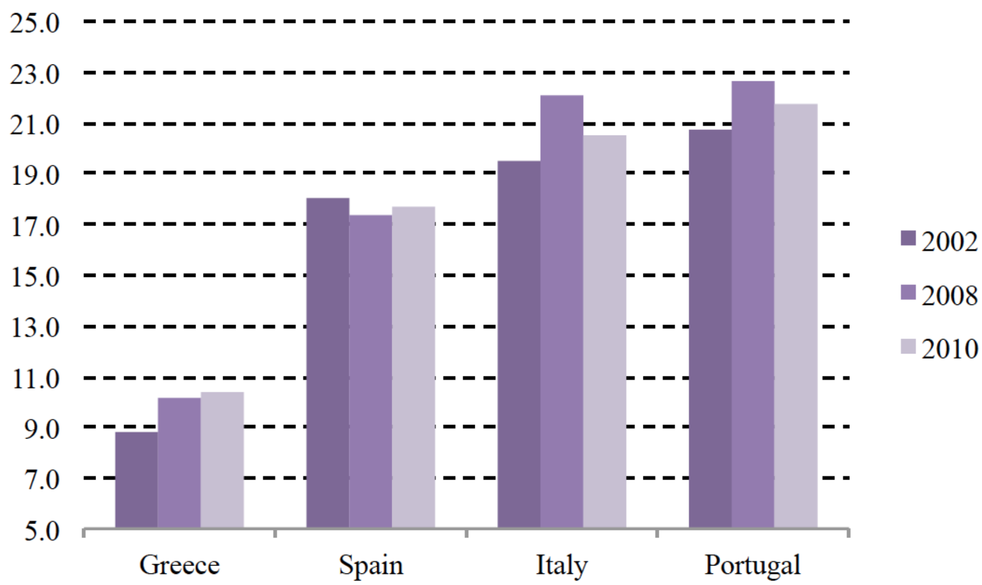
Panel B: Germany



Source: Darvas (2012).

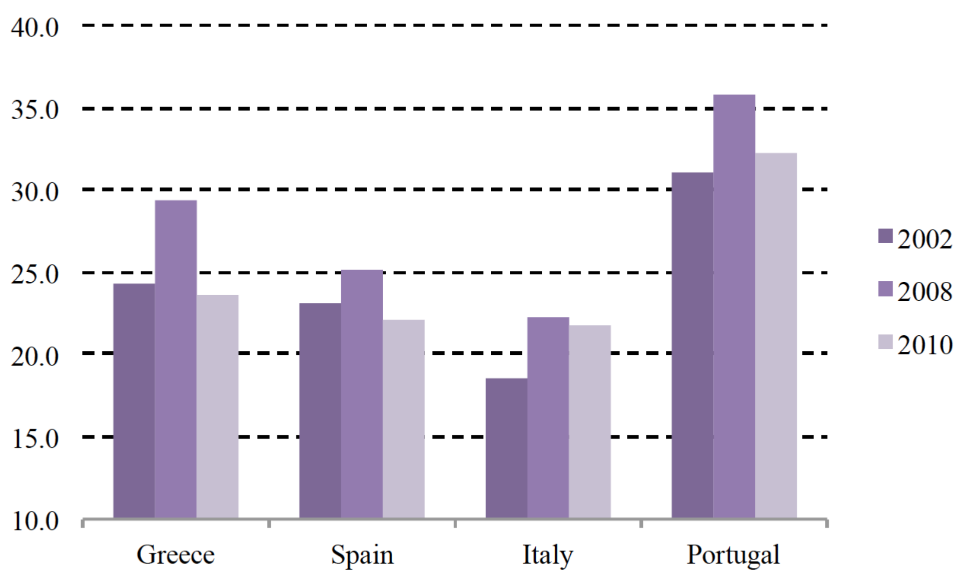
Figure 1.4: Eurozone exports and imports (in percent of GDP)

Panel A: Exports



Source: Eurostat

Panel B:Imports



Source: Eurostat

Figure 1.5: Sensitivity of Bank Leverage

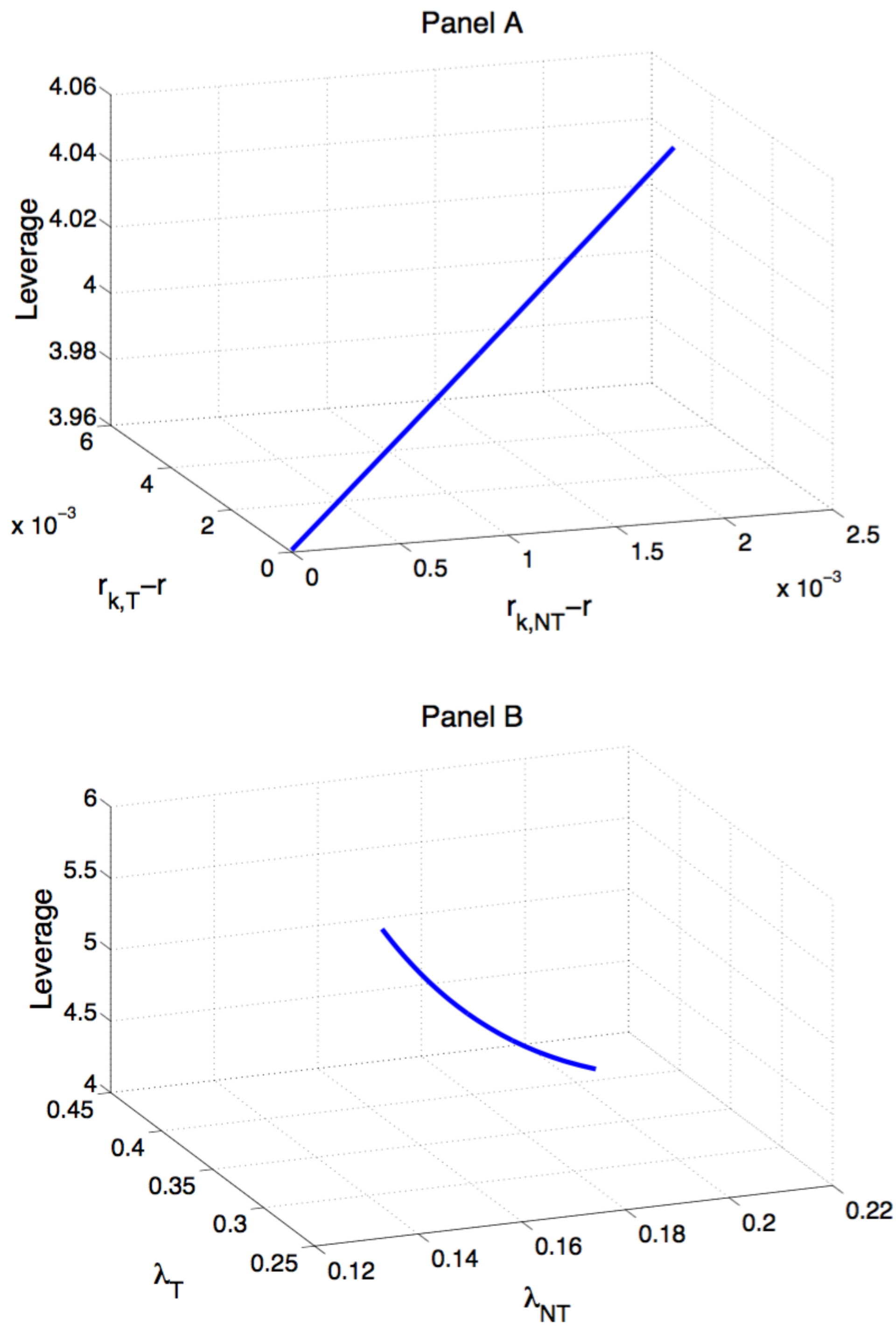
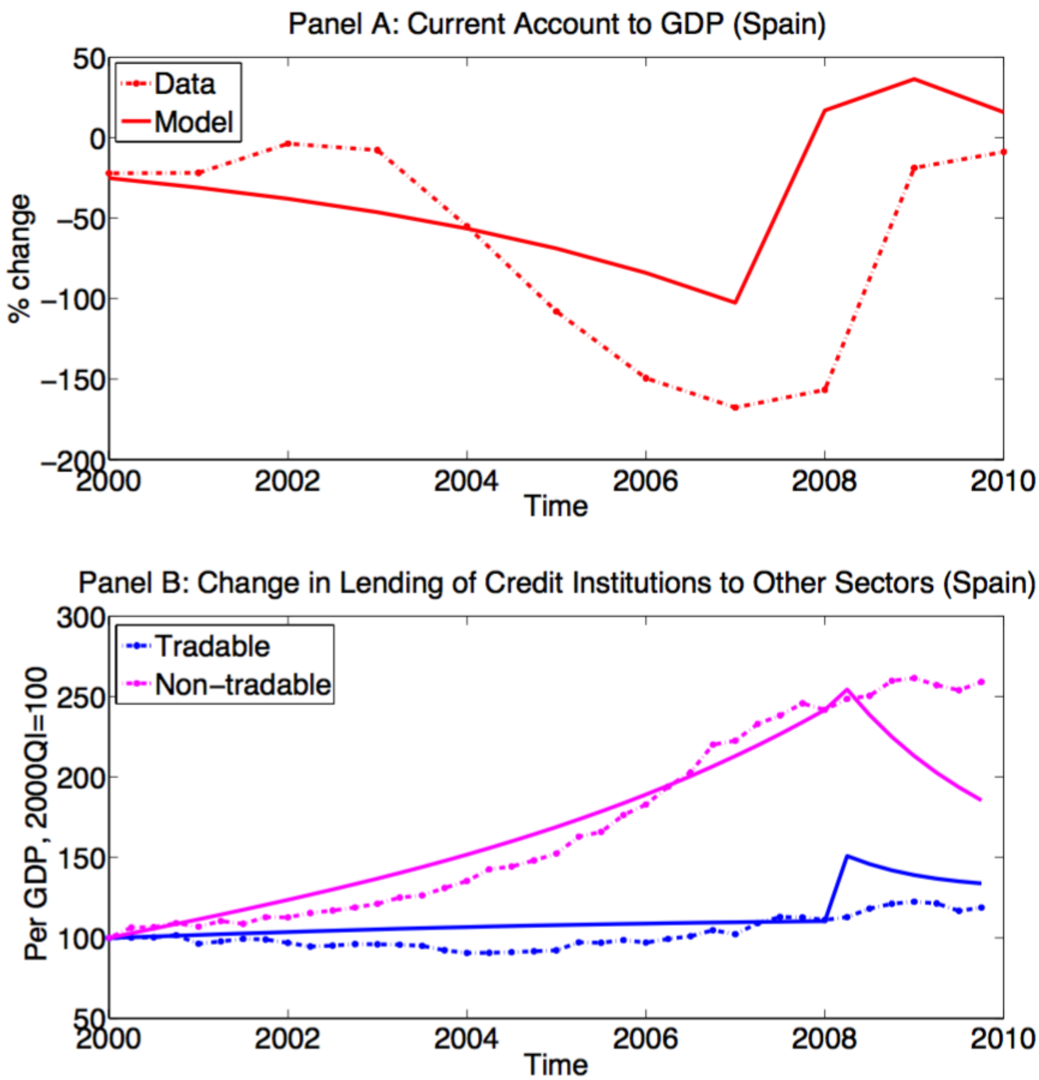


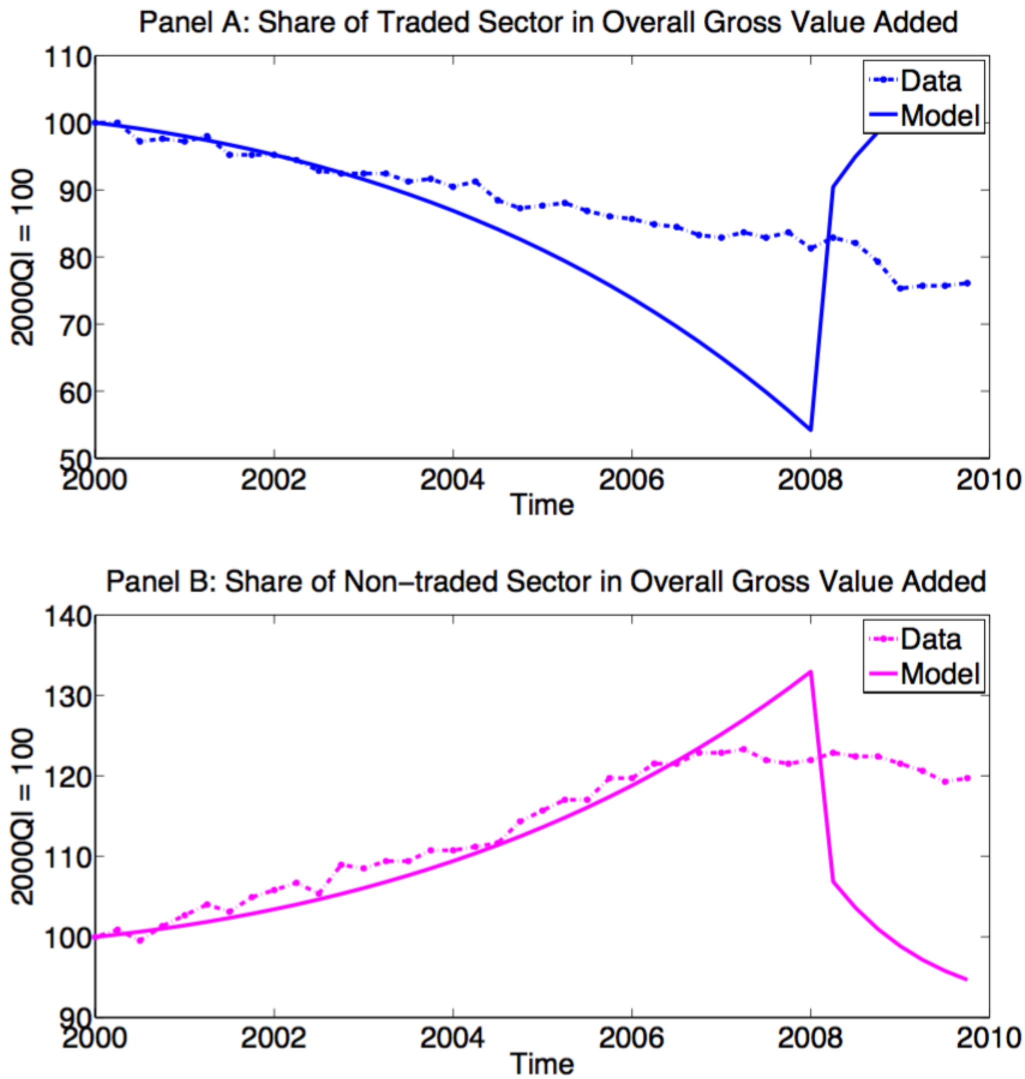
Figure 1.6: Model and Data (1)



Data source: Eurostat and Bank of Spain.

Note: Current account data indicate the percent deviations from 1995-2014 average. Current account model variables are percent deviations from the steady state. Panel B indicates the change in levels. Straight lines are paths of model variables whereas dotted lines belong to the data. Tradables (T) include industry (excluding construction), agriculture, and fisheries. Non-tradables (NT) include construction and services.

Figure 1.7: Model and Data (2)



Data source: Eurostat

Notes: Both panels show the changes in levels. Straight lines are paths of model variables whereas dotted lines belong to the data. Non-tradables (NT) include construction, wholesale and retail trade, transport, accommodation, food service and real estate activities. Tradables (T) include industry (excluding construction), agriculture, forestry and fishing.

Figure 8: Belief–driven business cycles: International Financial Autarky (with and without banks)

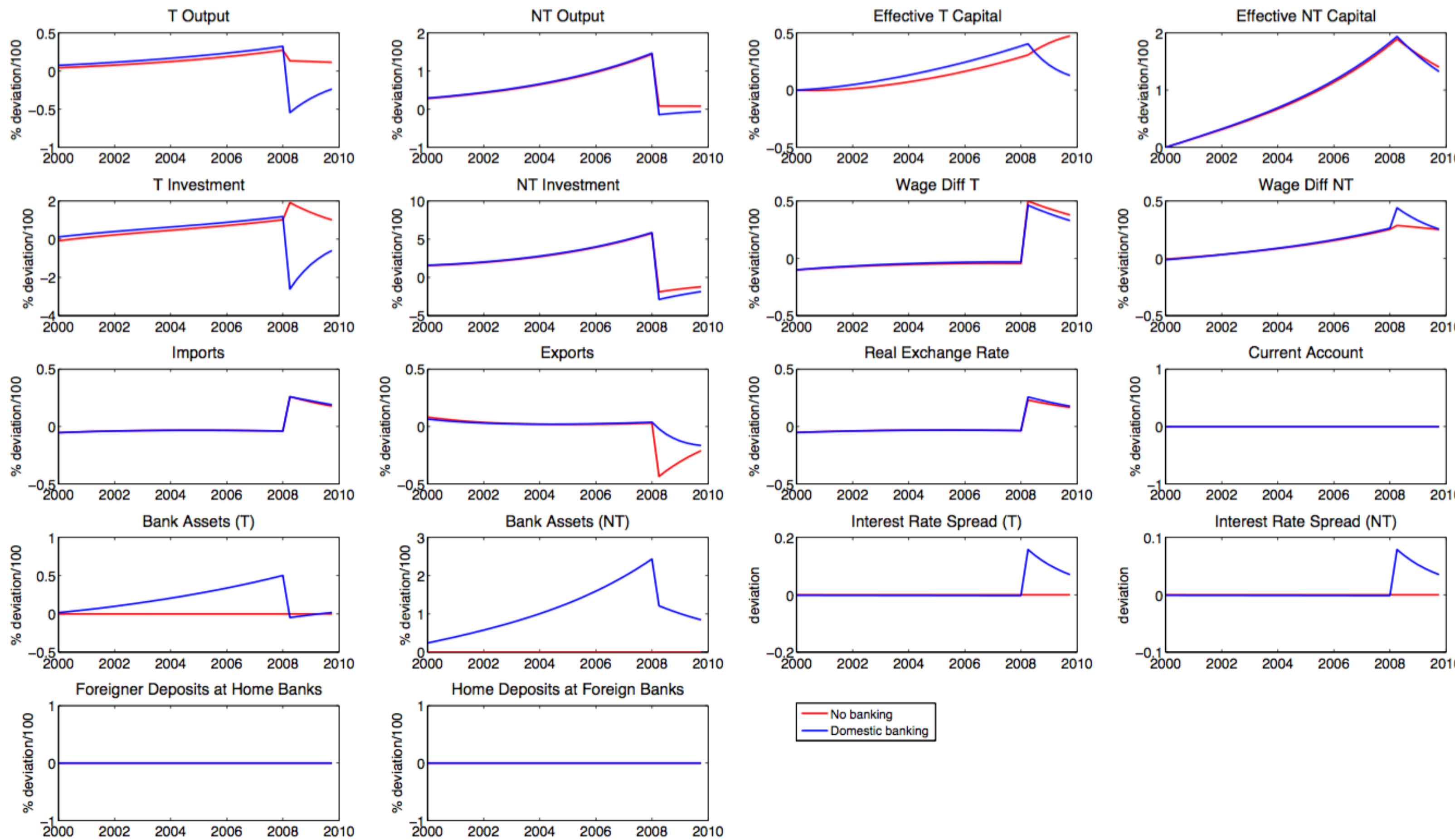


Figure 9: Belief–driven business cycles: Domestic banking vs international financial integration

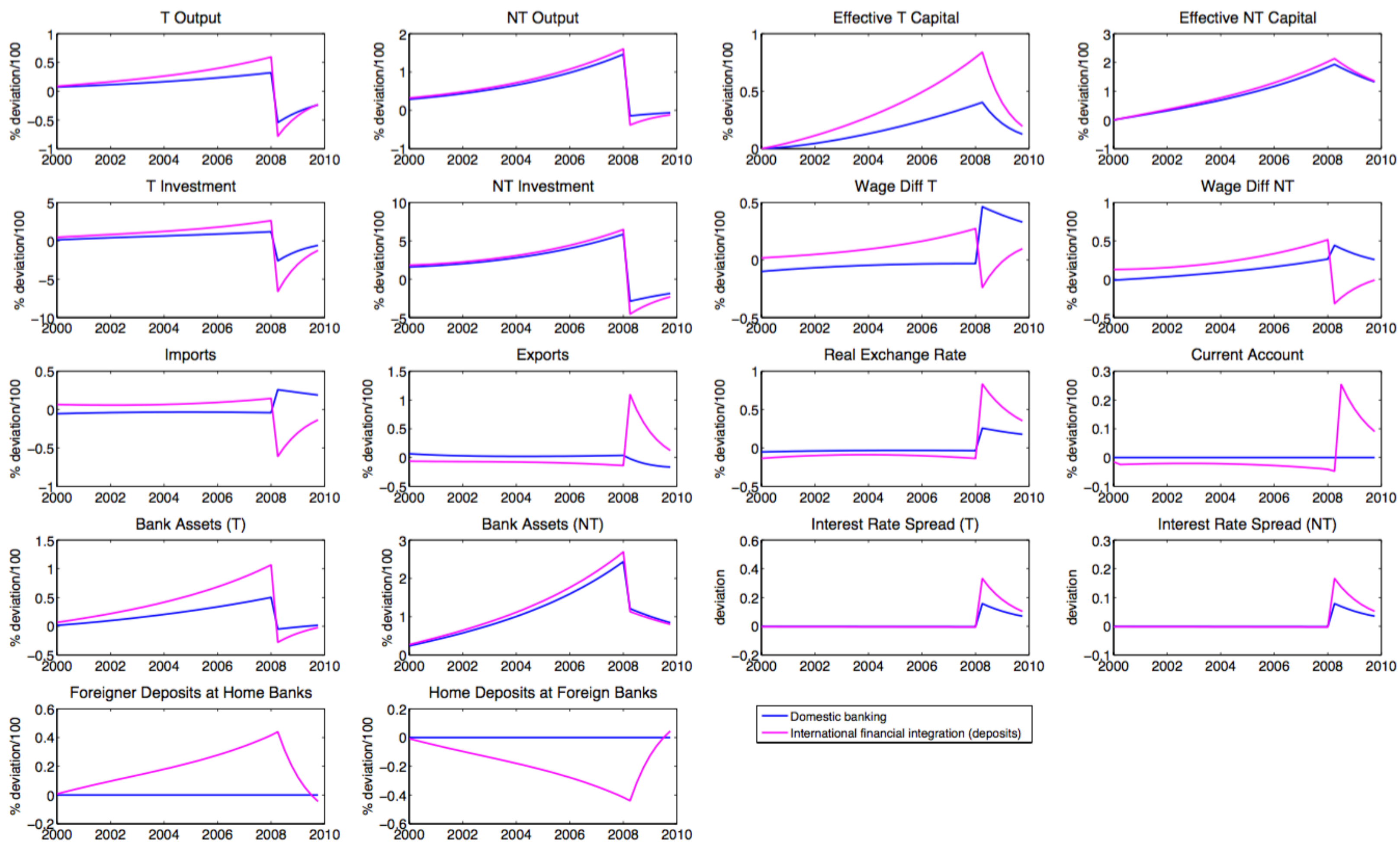


Figure 10: Propagation of fluctuations across sectors

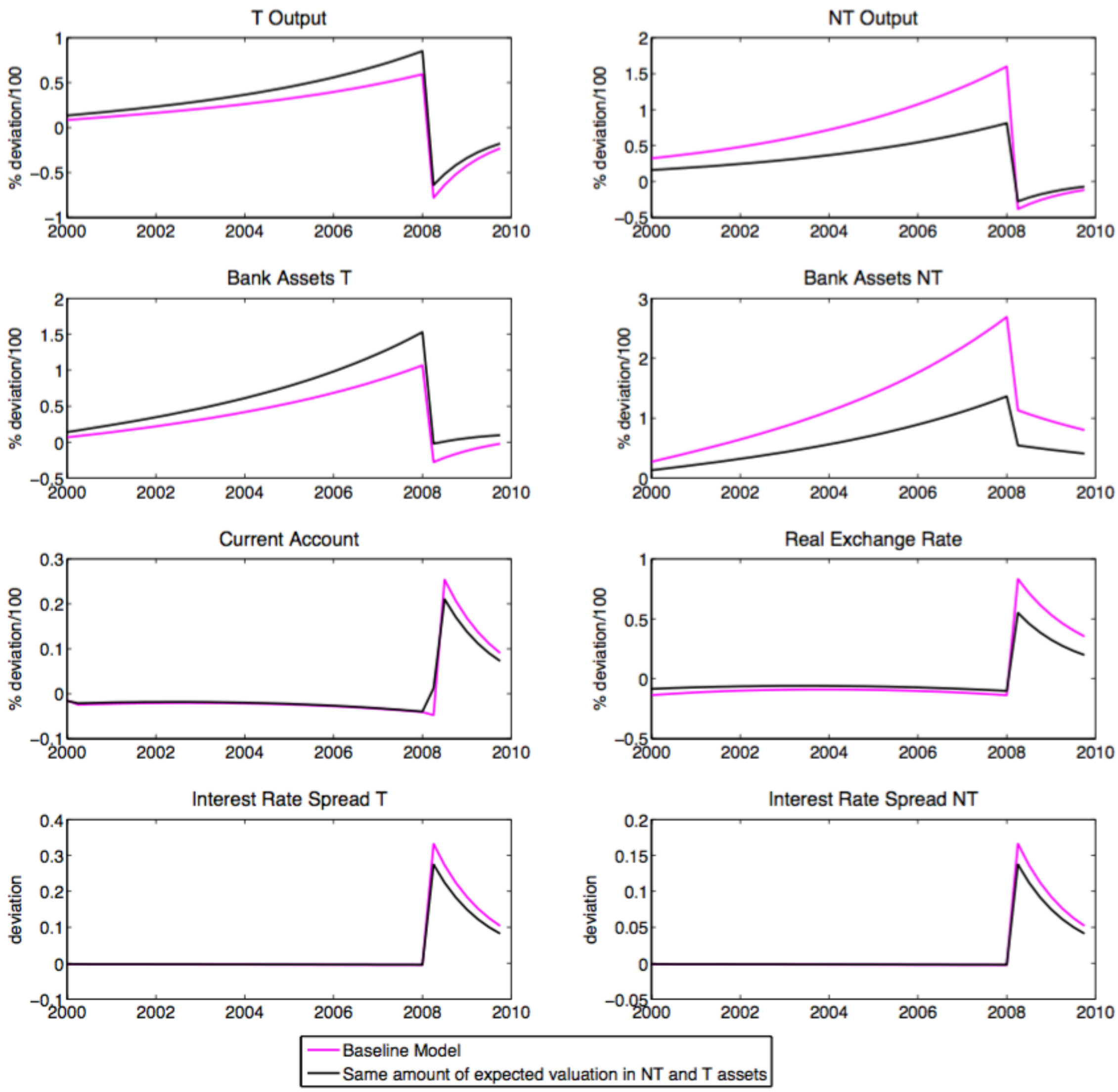
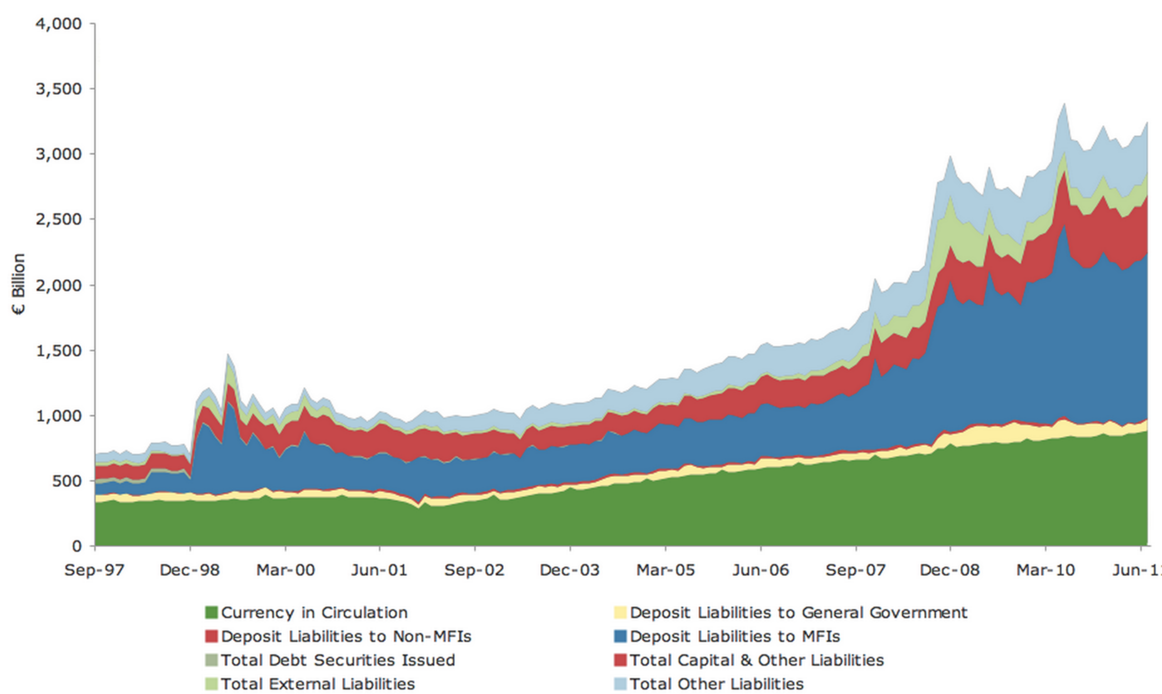


Figure 1.11: Composition of Eurosystem Liabilities (in billions of euros)



Source: ECB

Figure 1.12: Model and Data under Unconventional Policy (1)

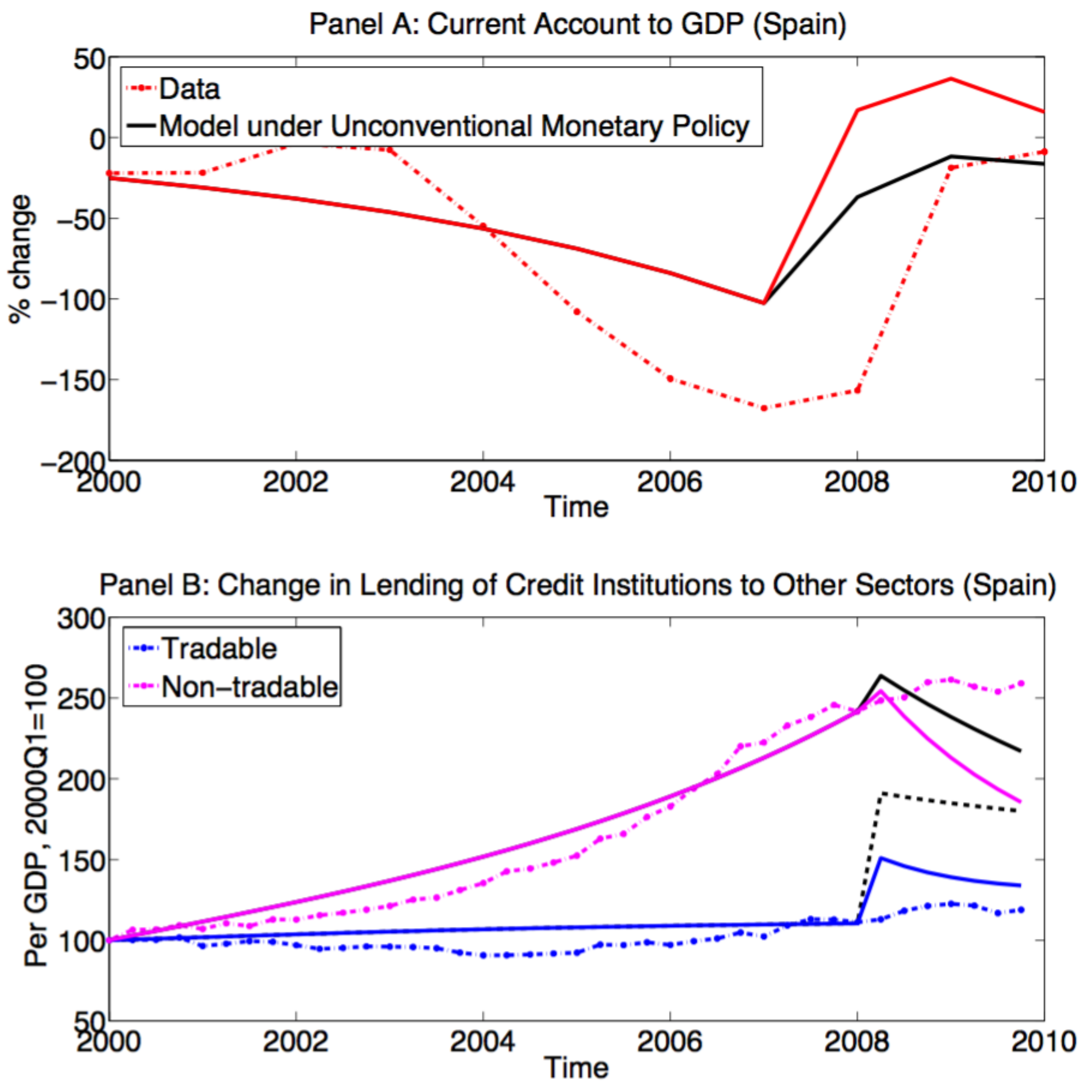


Figure 1.13: Model and Data under Unconventional Policy (2)

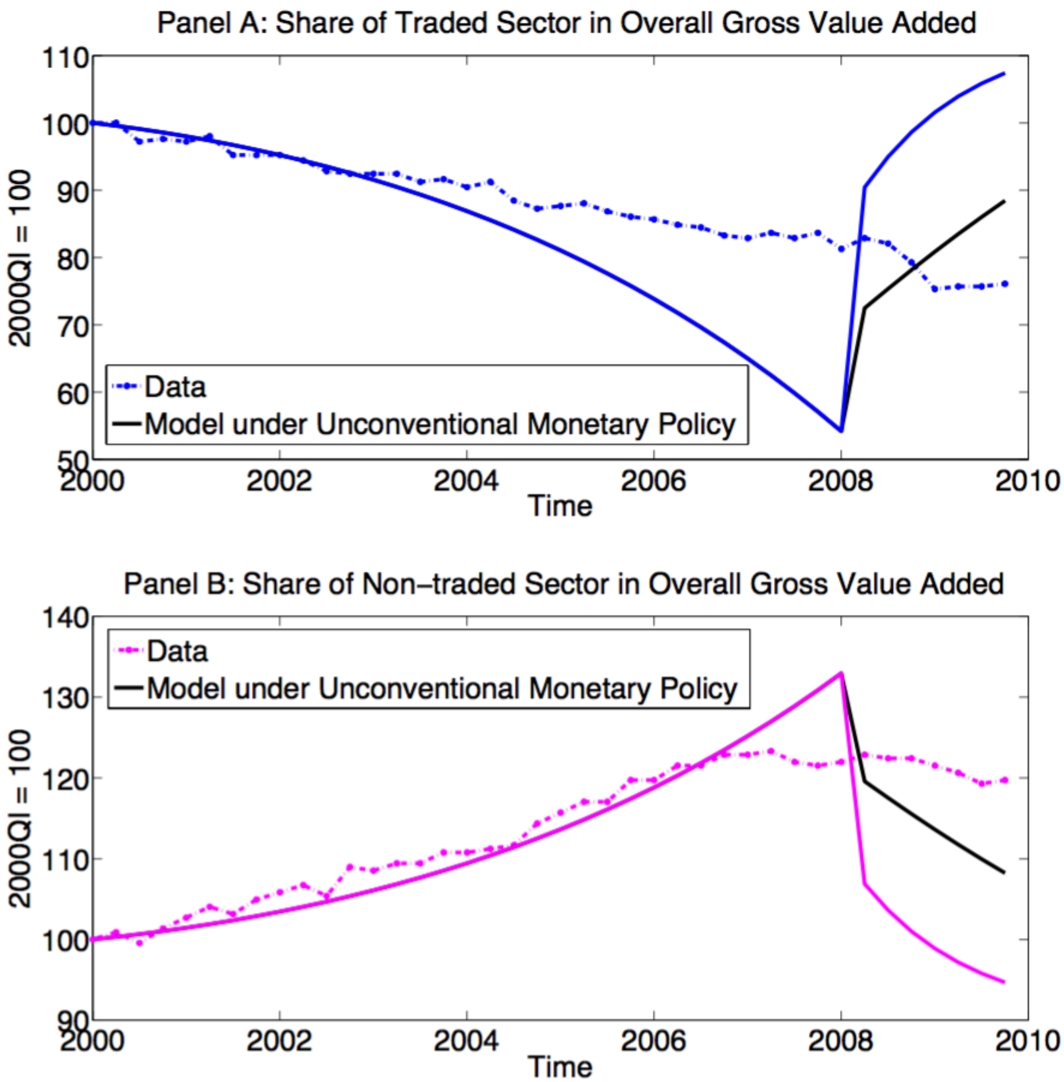


Figure 14: Central Bank Asset Purchases

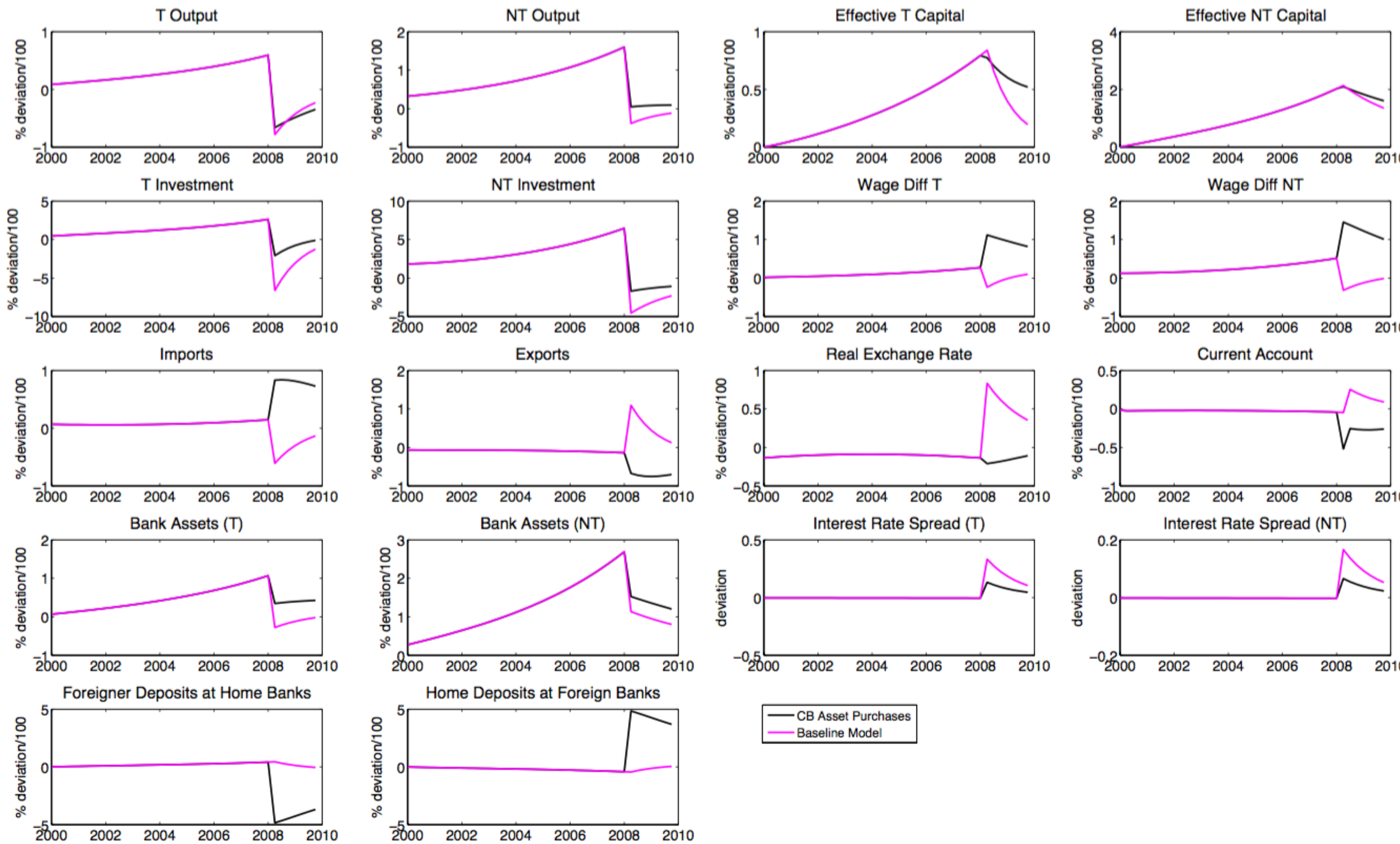


Figure 15: Asset Purchases vs Liquidity Facilities

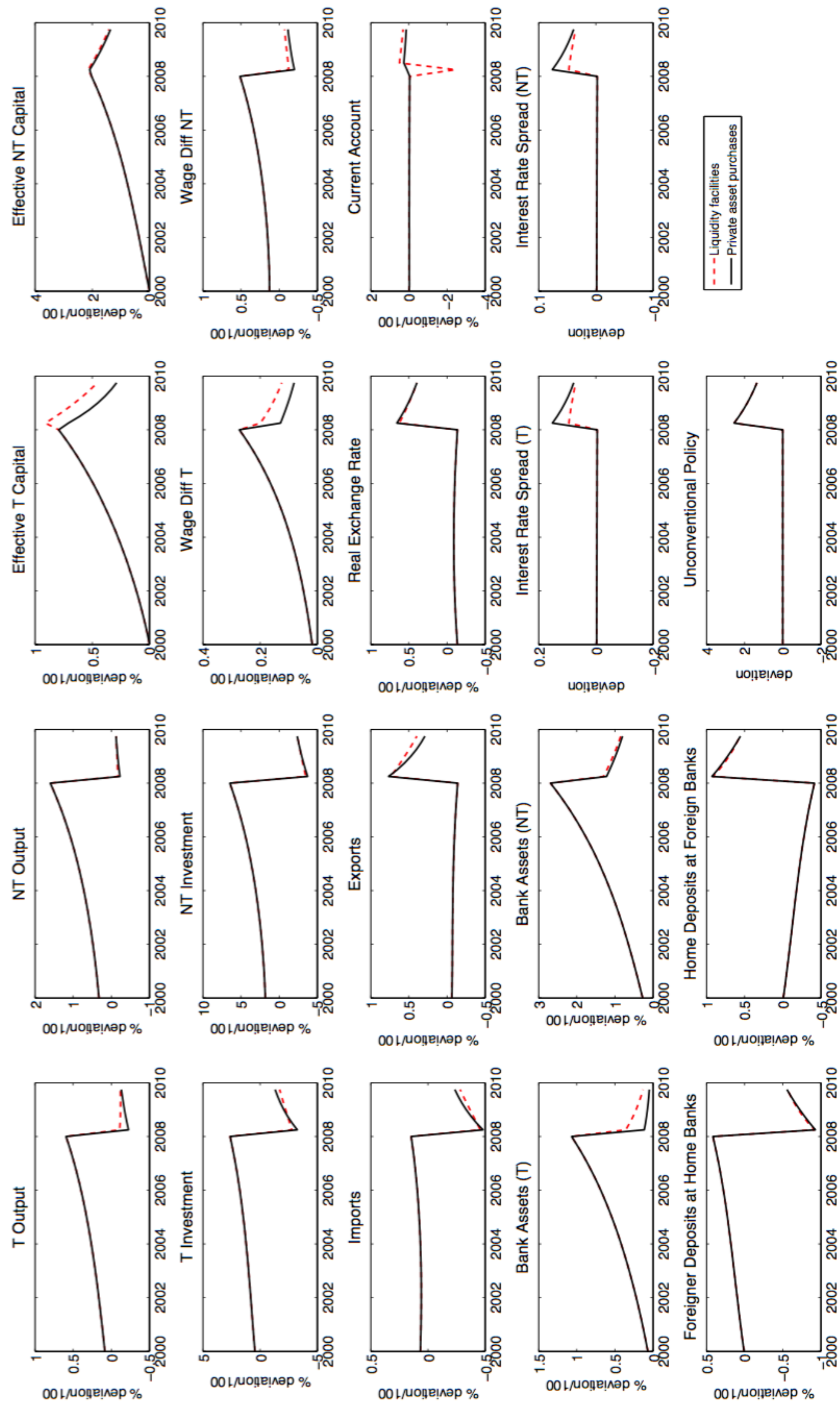
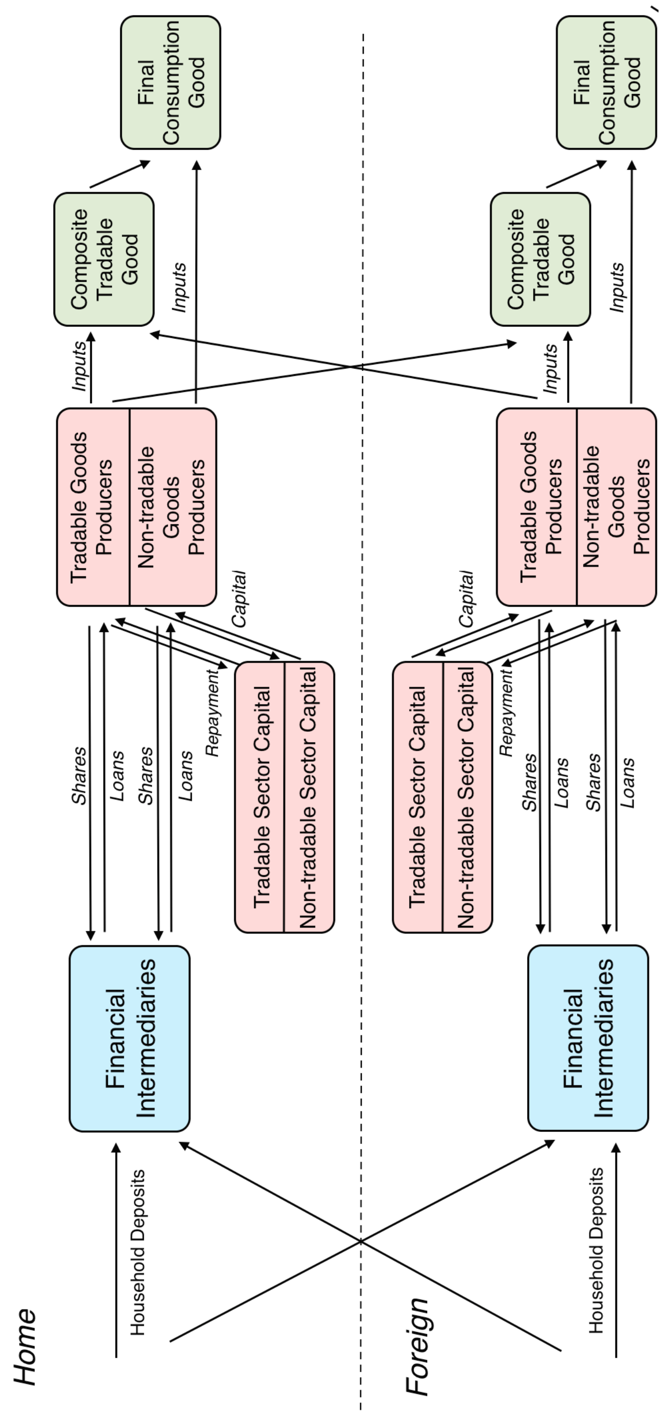


Figure 1.16: Model Structure



1.9 Appendices

Appendix A: Detailed Solution of the Bankers' Problem

The program of the bank is as follows:

$$V_{t-1}(N_{t-1}(j)) = \mathbb{E}_{t-1}\beta\Lambda_{t-1,t}\left\{(1-\gamma)\,N_t(j) + \gamma\left[Max_{S_{T,t},S_{NT,t}}Max_{B_{t+1},B^*_{t+1}}V_t(N_t(j))\right]\right\}$$

subject to

$$Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j) = B_{t+1}(j) + B^*_{t+1}(j) + N_t(j),$$

$$N_t(j) = (1+r_{k,T,t})Q_{T,t-1}S_{T,t-1}(j) + (1+r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j) - (1+r_t)\left(B_t(j) + B^*_t(j)\right),$$

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t}S_{T,t}(j) + \lambda_{NT}Q_{NT,t}S_{NT,t}(j).$$

Using the constraints, the Lagrangian of the above problem is set up:

$$\begin{aligned}\mathcal{L} = \mathbb{E}_t\beta\Lambda_{t,t+1}[(1-\gamma)\left\{(r_{k,T,t+1}-r_{t+1})Q_{T,t}S_{T,t}(j) + (r_{k,NT,t+1}-r_{t+1})Q_{NT,t}S_{NT,t}(j) + (1+r_{t+1})N_t(j)\right\} \\ +\gamma V_{t+1}(N_{t+1}(j))] + \mu_t\left[V_t(N_t(j)) - \lambda_T Q_{T,t}S_{T,t}(j) - \lambda_{NT}Q_{NT,t}S_{NT,t}(j)\right]\end{aligned}$$

Necessary and sufficient conditions for an optimum are:

$$\frac{\partial\mathcal{L}}{\partial S_{T,t}} = \mathbb{E}_t\beta\Lambda_{t,t+1}\left[(1-\gamma)\left(r_{k,T,t+1}-r_{t+1}\right)Q_{T,t} + \gamma\frac{\partial V_{t+1}}{\partial S_{T,t}}\right] - \mu_t\lambda_T Q_{T,t} = 0,$$

$$\frac{\partial\mathcal{L}}{\partial S_{NT,t}} = \mathbb{E}_t\beta\Lambda_{t,t+1}\left[(1-\gamma)\left(r_{k,NT,t+1}-r_{t+1}\right)Q_{NT,t} + \gamma\frac{\partial V_{t+1}}{\partial S_{NT,t}}\right] - \mu_t\lambda_{NT} Q_{NT,t} = 0,$$

$$\mu_t \left(V_t(N_t(j)) - \lambda_T Q_{T,t} S_{T,t}(j) - \lambda_{NT} Q_{NT,t} S_{NT,t}(j)\right) = 0.$$

I conjecture a solution to the above value function which is linear in bank net worth. i.e. $V_t(N_t(j)) = \nu_t N_t(j)$. Then, it is possible to express the derivative terms in the FOCs as:

$$\frac{\partial V_{t+1}}{\partial S_{T,t}} = \nu_{t+1}(r_{k,T,t+1} - r_{t+1})Q_{T,t},$$

$$\frac{\partial V_{t+1}}{\partial S_{NT,t}} = \nu_{t+1}(r_{k,NT,t+1} - r_{t+1})Q_{NT,t}.$$

Thus, FOCs with respect to assets become:

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left((1-\gamma) + \gamma \nu_{t+1}\right) (r_{k,T,t+1} - r_{t+1}) Q_{T,t}\right] = \mu_t \lambda_T Q_{T,t}, \tag{47}$$

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left((1-\gamma) + \gamma \nu_{t+1}\right) (r_{k,NT,t+1} - r_{t+1}) Q_{NT,t}\right] = \mu_t \lambda_{NT} Q_{NT,t.} \tag{48}$$

Define $\Omega_{t+1} \equiv 1 - \gamma + \gamma \nu_{t+1}$, substitute the guess into the bank's program, and use the law of motion for $N_{t+1}(j)$:

$$V_t(N_t(j)) = max_{S_{T,t} S_{NT,t}} \left\{ \textstyle\sum_{i \in \{T,NT\}} \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (r_{k,i,t+1} - r_{t+1}) Q_{i,t} S_{i,t}(j)\right] \right\} \\ + \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t(j)\right]$$

subject to

$$\sum_{i \in \{T,NT\}} \lambda_i Q_{i,t} S_{i,t} \leq \nu_t N_t(j).$$

Using above conditions and the complementary slackness condition, the value function can be rewritten as:

$$\nu_t N_t(j) = \mu_t \nu_t N_t(j) + \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t(j)\right].$$

Hence, we can express the marginal value of net worth as:

$$\nu_t = \frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) \right]}{1 - \mu_t}. \tag{49}$$

From the complementary slackness condition, one can obtain:

$$\mu_t = max \left\{ 1 - \left(\frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t \right]}{\lambda_T Q_{T,t} S_{T,t} + \lambda_{NT} Q_{NT,t} S_{NT,t}} \right), 0 \right\} < 1. \tag{50}$$

It is useful to note that bank leverage is same across all individual banks, and it is equal to $\frac{Q_{T,t} S_{T,t} + Q_{NT,t} S_{NT,t}}{N_t}$.

Appendix B: Derivation of the Net Foreign Asset Equation

When there is a market for international deposits, the trade is no longer balanced. In equilibrium, the market for deposits clear, and each country's net foreign assets entering period $t+1$ depend on interest income from deposit holdings at Home and Foreign banks entering period t, labor income and net investment income from traded and non-traded sectors, and the amount net worth that is brought by the exiting bankers net of start-up funds provided to new entrants. Equilibrium requires that the following conditions hold at Home:

$$T_t^f = (\eta/2) \left[\xi_t \left(B_{*,t+1} \right)^2 \right] \tag{51}$$

$$B_{t+1} = Q_{T,t} K_{T,t+1} + Q_{NT,t} K_{NT,t+1} - N_t - B_{t+1}^* \tag{52}$$

$$\Pi_{i,t} = Q_{i,t} K_{i,t+1} - Q_{i,t} (1 - \delta)(e^{\psi_t^i} K_{i,t}) - I_{i,t} \quad i \in \{T, NT\} \tag{53}$$

$$\Pi_t^B = (1-\gamma-\varepsilon)\left[\left(Z_t^T+(1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t}+\left(Z_t^{NT}+(1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t}\right]$$
$$-(1-\gamma)\left[(1+r_t)\left(B_t+B_t^*\right)\right]. \tag{54}$$

After imposing these conditions and their Foreign counterparts to Home and Foreign budget constraints, we can obtain the following identities for Home and Foreign households:

$$\xi_t B_{*,t+1}-B_{t+1}^*+C_t-N_t = \xi_t(1+r_t^*)B_{*,t}-(1+r_t)B_t^*+\gamma(1+r_t)(Q_{T,t-1}K_{T,t}+Q_{NT,t-1}K_{NT,t}$$
$$-N_{t-1})+w_{T,t}L_{T,t}+w_{NT,t}L_{NT,t}-(1-\delta)\left[Q_{T,t}e^{\psi_t^T}K_{T,t}+Q_{NT,t}e^{\psi_t^{NT}}K_{NT,t}\right]-(I_{T,t}+I_{NT,t})$$
$$+(1-\gamma-\varepsilon)\left[\left(Z_t^T+(1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t}+\left(Z_t^{NT}+(1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t}\right] \tag{55}$$

$$\frac{B_{t+1}^*}{\xi_t}-B_{*,t+1}+C_t^*-N_t^* = \frac{(1+r_t)B_t^*}{\xi_t}-(1+r_t^*)B_{*,t}+\gamma^*(1+r_t^*)(Q_{T,t-1}^*K_{T,t}^*+Q_{NT,t-1}^*K_{NT,t}^*$$
$$-N_{t-1}^*)+w_{T,t}^*L_{T,t}^*+w_{NT,t}^*L_{NT,t}^*-(1-\delta)\left[Q_{T,t}^*e^{\psi_t^{T*}}K_{T,t}^*+Q_{NT,t}^*e^{\psi_t^{NT*}}K_{NT,t}^*\right]-\left(I_{T,t}^*+I_{NT,t}^*\right)$$
$$+(1-\gamma^*-\varepsilon)\left[\left(Z_t^{T*}+(1-\delta)Q_{T,t}^*\right)e^{\psi_t^{T*}}K_{T,t}^*+\left(Z_t^{NT*}+(1-\delta)Q_{NT,t}^*\right)e^{\psi_t^{NT*}}K_{NT,t}^*\right] \tag{56}$$

Multiplying the Foreign condition with ξ_t, and subtracting it from (38) yields an expression for Home net foreign asset accumulation as a function of cross-country differentials of consumption, bank net worth, labor income, and profits of capital producers and banks:

$$
\begin{aligned}
&\left(\xi_t B_{*,t+1} - B^*_{t+1}\right) + \tfrac{1}{2}\left[(C_t - \xi_t C^*_t) - (N_t - \xi_t N^*_t)\right] \\
&\quad = \left(\xi_t \left(1 + r^*_t\right) B_{*,t} - \left(1 + r_t\right) B^*_t\right) + \tfrac{1}{2}\left(w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t \left(w^*_{T,t} L^*_{T,t} + w^*_{NT,t} L^*_{NT,t}\right)\right) \\
&\qquad + \tfrac{1}{2}\left[\gamma(1 + r_t)(Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})\right] \\
&\qquad - \tfrac{1}{2}\xi_t \left[\gamma^*(1 + r^*_t)(Q^*_{T,t-1} K^*_{T,t} + Q^*_{NT,t-1} K^*_{NT,t} - N^*_{t-1})\right] \\
&\qquad - \tfrac{1}{2}(1 - \delta)\left[Q_{T,t} e^{\psi_{T,t}} K_{T,t} + Q_{NT,t} e^{\psi_{NT,t}} K_{NT,t} - \xi_t \left(Q^*_{T,t} e^{\psi^*_{T,t}} K^*_{T,t} + Q^*_{NT,t} e^{\psi^*_{NT,t}} K^*_{NT,t}\right)\right] \\
&\qquad - \tfrac{1}{2}\left[I_{T,t} + I_{NT,t} - \xi_t (I^*_{T,t} + I^*_{NT,t})\right] \\
&\qquad + \tfrac{1}{2}(1 - \gamma - \varepsilon)\left[\left(Z_{T,t} + (1 - \delta) Q_{T,t}\right) e^{\psi_{T,t}} K_{T,t} + \left(Z_{NT,t} + (1 - \delta) Q_{NT,t}\right) e^{\psi_{NT,t}} K_{NT,t}\right] \\
&\qquad - \tfrac{1}{2}\xi_t (1 - \gamma^* - \varepsilon)\left[\left(Z^*_{T,t} + (1 - \delta) Q^*_{T,t}\right) e^{\psi^*_{T,t}} K^*_{T,t} + \left(Z^*_{NT,t} + (1 - \delta) Q^*_{NT,t}\right) e^{\psi^*_{NT,t}} K^*_{NT,t}\right]
\end{aligned}
\tag{57}
$$

And, the current account of Home economy by definition equals:

$$
CA_t = \xi_t \left(B_{*,t+1} - B_{*,t}\right) - \left(B^*_{t+1} - B^*_t\right). \tag{58}
$$

It is useful to note that when log-linearizing zero steady state variables, I evaluate them at the steady state of consumption levels.

Appendix C: Solution of the Bankers' Problem Under Central Bank's Asset Purchases

The program of the bank is as follows:

$$
V_{t-1}(N_{t-1}(j)) = \mathbb{E}_{t-1} \beta \Lambda_{t-1,t} \left\{ (1 - \gamma) N_t(j) + \gamma \left[Max_{S^p_{T,t}, S^p_{NT,t}, B^g_t} Max_{B_{t+1}, B^*_{t+1}} V_t(N_t(j)) \right] \right\}
$$

s.to

$$Q_{T,t}S^p_{T,t}(j) + Q_{NT,t}S^p_{NT,t}(j) + B^g_t(j) = B_{t+1}(j) + B^*_{t+1}(j) + N_t(j),$$

$$N_t(j) = (1+r_{k,T,t})Q_{T,t-1}S^p_{T,t-1}(j) + (1+r_{k,NT,t})Q_{NT,t-1}S^p_{NT,t-1}(j) + (1+r_{gt})B^g_{t-1}(j) - (1+r_t)\left(B_t(j) + B^*_t(j)\right),$$

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t}S^p_{T,t}(j) + \lambda_{NT}Q_{NT,t}S^p_{NT,t}(j) + \lambda_{ECB}B^g_t(j).$$

Using the constraints, the Lagrangian of the above problem is set up:

$$\mathcal{L} = \mathbb{E}_t\beta\Lambda_{t,t+1}[(1-\gamma)\left\{(r_{k,T,t+1} - r_{t+1})Q_{T,t}S^p_{T,t}(j) + (r_{k,NT,t+1} - r_{t+1})Q_{NT,t}S^p_{NT,t}(j) + (r_{gt+1} - r_{t+1})B^g_t(j)\right.$$
$$\left.+(1 + r_{t+1})N_t(j)\right\} + \gamma V_{t+1}(N_{t+1}(j))] + \mu_t\left[V_t(N_t(j)) - \lambda_T Q_{T,t}S^p_{T,t}(j) - \lambda_{NT}Q_{NT,t}S^p_{NT,t}(j) - \lambda_{ECB}B^g_t(j)\right]$$

When the incentive constraint is binding, the FONCs yield

$$\frac{\partial\mathcal{L}}{\partial S^p_{T,t}} = \mathbb{E}_t\beta\Lambda_{t,t+1}\left[(1-\gamma)\left(r_{k,T,t+1} - r_{t+1}\right)Q_{T,t} + \gamma\frac{\partial V_{t+1}}{\partial S^p_{T,t}}\right] - \mu_t\lambda_T Q_{T,t} = 0,$$

$$\frac{\partial\mathcal{L}}{\partial S^p_{NT,t}} = \mathbb{E}_t\beta\Lambda_{t,t+1}\left[(1-\gamma)\left(r_{k,NT,t+1} - r_{t+1}\right)Q_{NT,t} + \gamma\frac{\partial V_{t+1}}{\partial S^p_{NT,t}}\right] - \mu_t\lambda_{NT}Q_{NT,t} = 0,$$

$$\frac{\partial\mathcal{L}}{\partial B^g_t} = \mathbb{E}_t\beta\Lambda_{t,t+1}\left[(1-\gamma)\left(r_{g,t+1} - r_{t+1}\right) + \gamma\frac{\partial V_{t+1}}{\partial B^g_t}\right] - \mu_t\lambda_{ECB} = 0,$$

$$\frac{\partial\mathcal{L}}{\partial\mu_t} = V_t(N_t(j)) - \lambda_T Q_{T,t}S^p_{T,t}(j) - \lambda_{NT}Q_{NT,t}S^p_{NT,t}(j) - \lambda_{ECB}B^g_t(j) = 0.$$

I conjecture a solution to the above value function which is linear in bank net worth. i.e. $V_t(N_t(j)) = \nu_t N_t(j)$. Then, it is possible to express the derivative terms in the FONCs as:

$$\frac{\partial V_{t+1}}{\partial S^p_{T,t}} = \nu_{t+1}(r_{k,T,t+1} - r_{t+1})Q_{T,t},$$

$$\frac{\partial V_{t+1}}{\partial S^p_{NT,t}} = \nu_{t+1}(r_{k,NT,t+1} - r_{t+1})Q_{NT,t},$$

$$\frac{\partial V_{t+1}}{\partial B^g_t} = \nu_{t+1}(r_{g,t+1} - r_{t+1}).$$

Thus, FOCs with respect to assets become:

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{k,T,t+1} - r_{t+1}) Q_{T,t} \right] = \mu_t \lambda_T Q_{T,t}, \tag{59}$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{k,NT,t+1} - r_{t+1}) Q_{NT,t} \right] = \mu_t \lambda_{NT} Q_{NT,t}, \tag{60}$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{g,t+1} - r_{t+1}) \right] = \mu_t \lambda_{ECB}. \tag{61}$$

Define $\Omega_{t+1} \equiv 1 - \gamma + \gamma \nu_{t+1}$, substitute the guess into the bank's program, and use the law of motion for $N_{t+1}(j)$:

$$\begin{aligned} V_t(N_t(j)) = max_{S_{T,t} S_{NT,t}, B^g_t} \{ & \textstyle\sum_{i \in \{T,NT\}} \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (r_{k,i,t+1} - r_{t+1}) Q_{i,t} S_{i,t}(j) \right] \\ & + \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (r_{g,t+1} - r_{t+1}) B^g_t(j) \right] \} + \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t(j) \right] \end{aligned}$$

subject to

$$\sum_{i \in \{T,NT\}} \lambda_i Q_{i,t} S_{i,t}(j) + \lambda_{ECB} B^g_t(j) \leq \nu_t N_t(j).$$

Using above conditions, the value function can be rewritten as:

$$\nu_t N_t(j) = \mu_t \nu_t N_t(j) + \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t(j) \right].$$

Hence, we can express the marginal value of net worth as:

$$\nu_t = \frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) \right]}{1 - \mu_t}. \tag{62}$$

From the complementary slackness condition, one can obtain:

$$\mu_t = max\left\{1-\left(\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t\right]}{\lambda_T Q_{T,t}S^p_{T,t}+\lambda_{NT}Q_{NT,t}S^p_{NT,t}+\lambda_{ECB}B^g_t}\right),0\right\}<1. \tag{63}$$

Appendix D: Solution of the Bankers' Problem Under Central Bank's Liquidity Facilities

The program of the bank is as follows:

$$V_{t-1}(N_{t-1}(j)) = \mathbb{E}_{t-1}\beta\Lambda_{t-1,t}\left\{(1-\gamma)\,N_t(j)+\gamma\left[Max_{S_{T,t},S_{NT,t},B^g_t}Max_{B_{t+1},B^*_{t+1},M_{t+1}}V_t(N_t(j))\right]\right\}$$

s.to

$$Q_{T,t}S_{T,t}(j)+Q_{NT,t}S_{NT,t}(j)+B^g_t(j) = B_{t+1}(j)+B^*_{t+1}(j)+N_t(j)+M_{t+1}(j),$$

$$N_t(j) = (1+r_{k,T,t})Q_{T,t-1}S_{T,t-1}(j)+(1+r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j)+(1+r_{gt})B^g_{t-1}(j)$$
$$-(1+r_t)\left(B_t(j)+B^*_t(j)\right)-(1+r_{m,t})M_t(j),$$

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t}S_{T,t}(j)+\lambda_{NT}(Q_{NT,t}S_{NT,t}(j)-M_{t+1}(j))+\lambda_{ECB}(B^g_t(j)-M_{t+1}(j)).$$

Using the constraints, the Lagrangian of the above problem is set up:

$$\mathcal{L} = \mathbb{E}_t\beta\Lambda_{t,t+1}[(1-\gamma)\left\{(r_{k,T,t+1}-r_{t+1})Q_{T,t}S_{T,t}(j)+(r_{k,NT,t+1}-r_{t+1})Q_{NT,t}S_{NT,t}(j)+(r_{gt+1}-r_{t+1})B^g_t(j)\right.$$
$$\left.-(r_{m,t+1}-r_{t+1})M_{t+1}(j)+(1+r_{t+1})N_t(j)\right\}+\gamma V_{t+1}(N_{t+1}(j))]$$
$$+\mu_t\left[V_t(N_t(j))-\lambda_T Q_{T,t}S_{T,t}(j)-\lambda_{NT}(Q_{NT,t}S_{NT,t}(j)-M_{t+1}(j))-\lambda_{ECB}(B^g_t(j)-M_{t+1}(j))\right]$$

When the incentive constraint is binding, the FONCs yield

$$\frac{\partial \mathcal{L}}{\partial S_{T,t}} = \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1-\gamma)\left(r_{k,T,t+1} - r_{t+1}\right) Q_{T,t} + \gamma \frac{\partial V_{t+1}}{\partial S_{T,t}} \right] - \mu_t \lambda_T Q_{T,t} = 0,$$

$$\frac{\partial \mathcal{L}}{\partial S_{NT,t}} = \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1-\gamma)\left(r_{k,NT,t+1} - r_{t+1}\right) Q_{NT,t} + \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}} \right] - \mu_t \lambda_{NT} Q_{NT,t} = 0,$$

$$\frac{\partial \mathcal{L}}{\partial B_t^g} = \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1-\gamma)\left(r_{g,t+1} - r_{t+1}\right) + \gamma \frac{\partial V_{t+1}}{\partial B_t^g} \right] - \mu_t \lambda_{ECB} = 0,$$

$$\frac{\partial \mathcal{L}}{\partial M_{t+1}} = \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1-\gamma)(-1)(r_{m,t+1} - r_{t+1}) + \gamma \frac{\partial V_{t+1}}{\partial M_{t+1}} \right] + \mu_t (\lambda_{NT} + \lambda_{ECB}) = 0,$$

$$\frac{\partial \mathcal{L}}{\partial \mu_t} = V_t(N_t(j)) - \lambda_T Q_{T,t} S_{T,t}(j) - \lambda_{NT}(Q_{NT,t} S_{NT,t}(j) - M_{t+1}(j)) - \lambda_{ECB}(B_t^g(j) - M_{t+1}(j)) = 0.$$

I conjecture a solution to the above value function which is linear in bank net worth. i.e. $V_t(N_t(j)) = \nu_t N_t(j)$. Then, it is possible to express the derivative terms in the FONCs as

$$\frac{\partial V_{t+1}}{\partial S_{T,t}} = \nu_{t+1}(r_{k,T,t+1} - r_{t+1}) Q_{T,t},$$

$$\frac{\partial V_{t+1}}{\partial S_{NT,t}} = \nu_{t+1}(r_{k,NT,t+1} - r_{t+1}) Q_{NT,t},$$

$$\frac{\partial V_{t+1}}{\partial M_{t+1}} = -\nu_{t+1}(r_{m,t+1} - r_{t+1}),$$

$$\frac{\partial V_{t+1}}{\partial B_t^g} = \nu_{t+1}(r_{g,t+1} - r_{t+1}).$$

Thus, FOCs with respect to assets become:

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1}\right) \left(r_{k,T,t+1} - r_{t+1}\right) Q_{T,t} \right] = \mu_t \lambda_T Q_{T,t}, \tag{64}$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1}\right) \left(r_{k,NT,t+1} - r_{t+1}\right) Q_{NT,t} \right] = \mu_t \lambda_{NT} Q_{NT,t}, \tag{65}$$

$$\mathbb{E}_t\beta\Lambda_{t,t+1}\left[\left((1-\gamma)+\gamma\nu_{t+1}\right)\left(r_{m,t+1}-r_{t+1}\right)\right]=\mu_t(\lambda_{NT}+\lambda_{ECB}), \tag{66}$$

$$\mathbb{E}_t\beta\Lambda_{t,t+1}\left[\left((1-\gamma)+\gamma\nu_{t+1}\right)\left(r_{g,t+1}-r_{t+1}\right)\right]=\mu_t\lambda_{ECB}. \tag{67}$$

Define $\Omega_{t+1}\equiv 1-\gamma+\gamma\nu_{t+1}$, substitute the guess into the bank's program, and use the law of motion for $N_{t+1}(j)$:

$$V_t(N_t(j)) = max_{S_{T,t}S_{NT,t},B_t^g,M_{t+1}}\{\textstyle\sum_{i\in\{T,NT\}}\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,i,t+1}-r_{t+1})Q_{i,t}S_{i,t}(j)\right]$$
$$+\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}\left((r_{g,t+1}-r_{t+1})B_t^g(j)-(r_{m,t+1}-r_{t+1})M_{t+1}\right)\right]\} + \beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t(j)\right]$$

subject to

$$\sum_{i\in\{T,NT\}}\lambda_i Q_{i,t}S_{i,t}(j)+\lambda_{ECB}B_t^g(j)-(\lambda_{ECB}+\lambda_{NT})M_{t+1}(j)\leq\nu_t N_t(j).$$

Using above conditions, the value function can be rewritten as:

$$\nu_t N_t(j)=\mu_t\nu_t N_t(j)+\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t(j)\right].$$

Hence, we can express the marginal value of net worth as:

$$\nu_t=\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})\right]}{1-\mu_t}. \tag{68}$$

From the complementary slackness condition, one can obtain:

$$\mu_t = max\left\{1-\left(\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t\right]}{\lambda_T Q_{T,t}S_{T,t}+\lambda_{NT}Q_{NT,t}S_{NT,t}+\lambda_{ECB}B_t^g-(\lambda_{ECB}+\lambda_{NT})M_{t+1}}\right),0\right\}<1. \tag{69}$$

Appendix E: Modifications in the Net Foreign Asset Equation under Central Bank Asset Purchases

Equilibrium under central bank asset purchases requires that the following conditions hold at Home:

$$T_t^f = (\eta/2)\left[\xi_t\left(B_{*,t+1}\right)^2\right] \tag{70}$$

$$T_t = \frac{\left(r_{k,T,t} - r_{g,t}\right) Q_{T,t-1} S_{T,t-1} \varphi_{T,t-1}^{ump} + \left(r_{k,NT,t} - r_{g,t}\right) Q_{NT,t-1} S_{NT,t-1} \varphi_{NT,t-1}^{ump} - \Upsilon_{t-1}}{2}, \tag{71}$$

$$B_{t+1} = (1 - \varphi_{T,t}^{ump}) Q_{T,t} K_{T,t+1} + (1 - \varphi_{NT,t}^{ump}) Q_{NT,t} K_{NT,t+1} + B_t^g - N_t - B_{t+1}^*, \tag{72}$$

$$B_t^g = \frac{\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1}}{2}, \tag{73}$$

$$\Pi_{i,t} = Q_{i,t} K_{i,t+1} - Q_{i,t}(1-\delta)(e^{\psi_t^i} K_{i,t}) - I_{i,t} \quad i \in \{T, NT\} \tag{74}$$

$$\begin{aligned}
\Pi_{B,t} \; &= (1-\gamma-\varepsilon)[\left(Z_t^T + (1-\delta)Q_{T,t}\right) e^{\psi_t^T} K_{T,t} + \left(Z_t^{NT} + (1-\delta)Q_{NT,t}\right) e^{\psi_t^{NT}} K_{NT,t} \\
&-\varphi_{T,t}^{ump}\left(Z_t^T + (1-\delta)Q_{T,t}\right) e^{\psi_t^T} K_{T,t} - \varphi_{NT,t}^{ump}\left(Z_t^{NT} + (1-\delta)Q_{NT,t}\right) e^{\psi_t^{NT}} K_{NT,t} \\
&+(1+r_{g,t})\tfrac{\varphi_{T,t-1}^{ump} Q_{T,t-1} K_{T,t} + \varphi_{NT,t-1}^{ump} Q_{NT,t-1} K_{NT,t}}{2}] - (1-\gamma)\left[(1+r_t)\left(B_t + B_t^*\right)\right]
\end{aligned} \tag{75}$$

Conditions that apply to Foreign are as in Appendix B. After imposing these conditions to Home budget constraint one can obtain:

$$\begin{aligned}
&\xi_t B_{*,t+1} - B_{t+1}^* + C_t - N_t - \tfrac{\left(\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1}\right)}{2} \\
= \; &\xi_t (1+r_t^*) B_{*,t} - (1+r_t) B_t^* - \gamma(1+r_t) N_{t-1} - (I_{T,t} + I_{NT,t}) + w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} + T_t \\
&+Q_{T,t-1} K_{T,t}[\gamma(1+r_t) + (1-\gamma-\varepsilon)(1+r_{k,T,t}) - (1-\delta) e^{\psi_t^T} \tfrac{Q_{T,t}}{Q_{T,t-1}} \\
&+\varphi_{T,t-1}^{ump}\left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{2} - (1-\gamma-\varepsilon)(1+r_{k,T,t})\right)] \\
&+Q_{NT,t-1} K_{NT,t}[\gamma(1+r_t) + (1-\gamma-\varepsilon)(1+r_{k,NT,t}) - (1-\delta) e^{\psi_t^{NT}} \tfrac{Q_{NT,t}}{Q_{NT,t-1}} \\
&+\varphi_{NT,t-1}^{ump}\left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{2} - (1-\gamma-\varepsilon)(1+r_{k,NT,t})\right)].
\end{aligned} \tag{76}$$

Multiplying the Foreign condition in (65) with RER_t, and subtracting it from (106), imposing $T_t = \xi_t T_t^*$, and dividing the resulting identity by 2 yields an expression for Home net foreign asset accumulation as a function of cross-country differentials of consumption, bank net worth, labor income, profits of capital producers and banks, and central bank transfers:

$$\begin{aligned}
&\left(\xi_t B_{*,t+1} - B^*_{t+1}\right) + \tfrac{1}{2}\left[(C_t - \xi_t C^*_t) - (N_t - \xi_t N^*_t)\right] - \tfrac{\left(\varphi^{ump}_{T,t} Q_{T,t} K_{T,t+1} + \varphi^{ump}_{NT,t} Q_{NT,t} K_{NT,t+1}\right)}{4} \\
&\quad = \left(\xi_t \left(1 + r^*_t\right) B_{*,t} - \left(1 + r_t\right) B^*_t\right) + \tfrac{1}{2}\left(w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t \left(w^*_{T,t} L^*_{T,t} + w^*_{NT,t} L^*_{NT,t}\right)\right) \\
&\qquad + \tfrac{1}{2}\left[\gamma(1 + r_t)(Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})\right] \\
&\qquad - \tfrac{1}{2}\xi_t\left[\gamma^*(1 + r^*_t)(Q^*_{T,t-1} K^*_{T,t} + Q^*_{NT,t-1} K^*_{NT,t} - N^*_{t-1})\right] \\
&\qquad - \tfrac{1}{2}(1 - \delta)\left[Q_{T,t} e^{\psi_{T,t}} K_{T,t} + Q_{NT,t} e^{\psi_{NT,t}} K_{NT,t} - \xi_t \left(Q^*_{T,t} e^{\psi^*_{T,t}} K^*_{T,t} + Q^*_{NT,t} e^{\psi^*_{NT,t}} K^*_{NT,t}\right)\right] \\
&\qquad - \tfrac{1}{2}\left[I_{T,t} + I_{NT,t} - \xi_t(I^*_{T,t} + I^*_{NT,t})\right] \\
&\qquad + \varphi^{ump}_{T,t-1} Q_{T,t-1} K_{T,t} \left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{4} - \tfrac{(1-\gamma-\varepsilon)(1+r_{k,T,t})}{2}\right) \\
&\qquad + \varphi^{ump}_{NT,t-1} Q_{NT,t-1} K_{NT,t} \left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{4} - \tfrac{(1-\gamma-\varepsilon)(1+r_{k,NT,t})}{2}\right) \\
&\qquad + \tfrac{1}{2}(1 - \gamma - \varepsilon)\left[\left(Z_{T,t} + (1 - \delta) Q_{T,t}\right) e^{\psi_{T,t}} K_{T,t} + \left(Z_{NT,t} + (1 - \delta) Q_{NT,t}\right) e^{\psi_{NT,t}} K_{NT,t}\right] \\
&\qquad - \tfrac{1}{2}\xi_t(1 - \gamma^* - \varepsilon)\left[\left(Z^*_{T,t} + (1 - \delta) Q^*_{T,t}\right) e^{\psi^*_{T,t}} K^*_{T,t} + \left(Z^*_{NT,t} + (1 - \delta) Q^*_{NT,t}\right) e^{\psi^*_{NT,t}} K^*_{NT,t}\right]
\end{aligned} \tag{77}$$

Appendix F: Modifications in the Net Foreign Asset Equation under Central Bank Liquidity Facilities

Under liquidity facilities, similarly,

$$T_t = \frac{\left(r_{m,t} - r_{g,t}\right) Q_{T,t-1} S_{T,t-1} \varphi^{ump}_{T,t-1} + \left(r_{m,t} - r_{g,t}\right) Q_{NT,t-1} S_{NT,t-1} \varphi^{ump}_{NT,t-1} - \Upsilon_{t-1}}{2}, \tag{78}$$

$$B_{t+1} = Q K_{T,t+1} + Q_{NT,t} K_{NT,t+1} + B^g_t - N_t - M_{t+1} - B^*_{t+1}, \tag{79}$$

$$\Pi_{B,t} = (1-\gamma-\varepsilon)[\left(Z_t^T+(1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t}+\left(Z_t^{NT}+(1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t}$$
$$+(1+r_{g,t})\frac{\varphi_{T,t-1}^{ump}Q_{T,t-1}K_{T,t}+\varphi_{NT,t-1}^{ump}Q_{NT,t-1}K_{NT,t}}{2}]$$
$$-(1-\gamma)\left[(1+r_t)\left(B_t+B_t^*\right)+(1+r_{m,t})(\varphi_{T,t-1}^{ump}Q_{T,t-1}K_{T,t}+\varphi_{NT,t-1}^{ump}Q_{NT,t-1}K_{NT,t})\right] \tag{80}$$

with

$$M_{t+1}-B_t^g=\frac{\varphi_{T,t}^{ump}Q_{T,t}K_{T,t+1}+\varphi_{NT,t}^{ump}Q_{NT,t}K_{NT,t+1}}{2}. \tag{81}$$

And the above conditions modify (108) as follows:

$$\left(\xi_t B_{*,t+1}-B_{t+1}^*\right)+\frac{1}{2}\left[(C_t-\xi_t C_t^*)-(N_t-\xi_t N_t^*)\right]-\frac{\left(\varphi_{T,t}^{ump}Q_{T,t}K_{T,t+1}+\varphi_{NT,t}^{ump}Q_{NT,t}K_{NT,t+1}\right)}{4}$$
$$=\left(\xi_t\left(1+r_t^*\right)B_{*,t}-\left(1+r_t\right)B_t^*\right)+\frac{1}{2}\left(w_{T,t}L_{T,t}+w_{NT,t}L_{NT,t}-\xi_t\left(w_{T,t}^*L_{T,t}^*+w_{NT,t}^*L_{NT,t}^*\right)\right)$$
$$+\frac{1}{2}\left[\gamma(1+r_t)(Q_{T,t-1}K_{T,t}+Q_{NT,t-1}K_{NT,t}-N_{t-1})\right]$$
$$-\frac{1}{2}\xi_t\left[\gamma^*(1+r_t^*)(Q_{T,t-1}^*K_{T,t}^*+Q_{NT,t-1}^*K_{NT,t}^*-N_{t-1}^*)\right]$$
$$-\frac{1}{2}(1-\delta)\left[Q_{T,t}e^{\psi_{T,t}}K_{T,t}+Q_{NT,t}e^{\psi_{NT,t}}K_{NT,t}-\xi_t\left(Q_{T,t}^*e^{\psi_{T,t}^*}K_{T,t}^*+Q_{NT,t}^*e^{\psi_{NT,t}^*}K_{NT,t}^*\right)\right]$$
$$-\frac{1}{2}\left[I_{T,t}+I_{NT,t}-\xi_t(I_{T,t}^*+I_{NT,t}^*)\right]$$
$$+\varphi_{T,t-1}^{ump}Q_{T,t-1}K_{T,t}\left(\frac{(1-\gamma-\varepsilon)(1+r_{gt})-\gamma(1+r_t)}{4}-\frac{(1-\gamma)(1+r_{m,t})}{2}\right)$$
$$+\varphi_{NT,t-1}^{ump}Q_{NT,t-1}K_{NT,t}\left(\frac{(1-\gamma-\varepsilon)(1+r_{gt})-\gamma(1+r_t)}{4}-\frac{(1-\gamma)(1+r_{m,t})}{2}\right)$$
$$+\frac{1}{2}(1-\gamma-\varepsilon)\left[\left(Z_{T,t}+(1-\delta)\,Q_{T,t}\right)e^{\psi_{T,t}}K_{T,t}+\left(Z_{NT,t}+(1-\delta)\,Q_{NT,t}\right)e^{\psi_{NT,t}}K_{NT,t}\right]$$
$$-\frac{1}{2}\xi_t(1-\gamma^*-\varepsilon)\left[\left(Z_{T,t}^*+(1-\delta)\,Q_{T,t}^*\right)e^{\psi_{T,t}^*}K_{T,t}^*+\left(Z_{NT,t}^*+(1-\delta)\,Q_{NT,t}^*\right)e^{\psi_{NT,t}^*}K_{NT,t}^*\right]. \tag{82}$$

Appendix G: Experiments under Unanticipated Fundamental Shocks

In this subsection, I conduct experiments with physical shocks to capital quality such as those studied by Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). As in those papers, my experiment is with a five percent capital quality shock with a persistence level of 0.66. However, I am looking at the effects of a shock that hits only the non-traded sector, instead of hitting the whole economy.

Figure 17 shows the model dynamics under Version I and Version II, when the adverse shock described above hits the economy. It can be observed that sectoral co-movement of variables is maintained when the banking sector is in place (Version II). The financial accelerator mechanism works as previously described because the responses of investment and output are stronger under domestic banking. A decrease in the value of non-traded sector capital stimulates a fall in asset prices, and the leverage constraint of banks amplifies the effects through a second round effect, leading to a further shrinkage of the bank balance sheets. Bank net worth collapses, and banks cut lending to the private sector. Borrowing becomes more costly for these firms as the spreads between return to assets and the risk-free rate fall.

The effect of the international financial integration is seen in Figure 18. As bank deposits are carried from Home banks to Foreign banks, balance sheets shrink more than in the domestic banking case and bank net worth and credit extended to the private sector fall sharply. We observe a higher magnitude in the fall of investment, labor and output, as the shrinkage of the bank balance sheets is greater. A stronger financial accelerator and bank spillover channel are at work, as before. Depreciation of the real exchange rate and drops in income are indicative of the drop in imports.

Finally Figure 19 compares the dynamics under five percent positive and negative shocks to the value of non-traded sector capital. Model dynamics are asymmetric due to presence of occasionally binding constraints. In the positive shock case leverage constraints do not bind, where as they bind in the negative shock case. This leads to an asymmetry in the model behavior even there are no news-led fluctuations.

1.10 Additional Figures

Figure 17: Impulse Response Functions (Gertler–Karadi type NT Sector Capital Quality Shock, Financial Autarky)

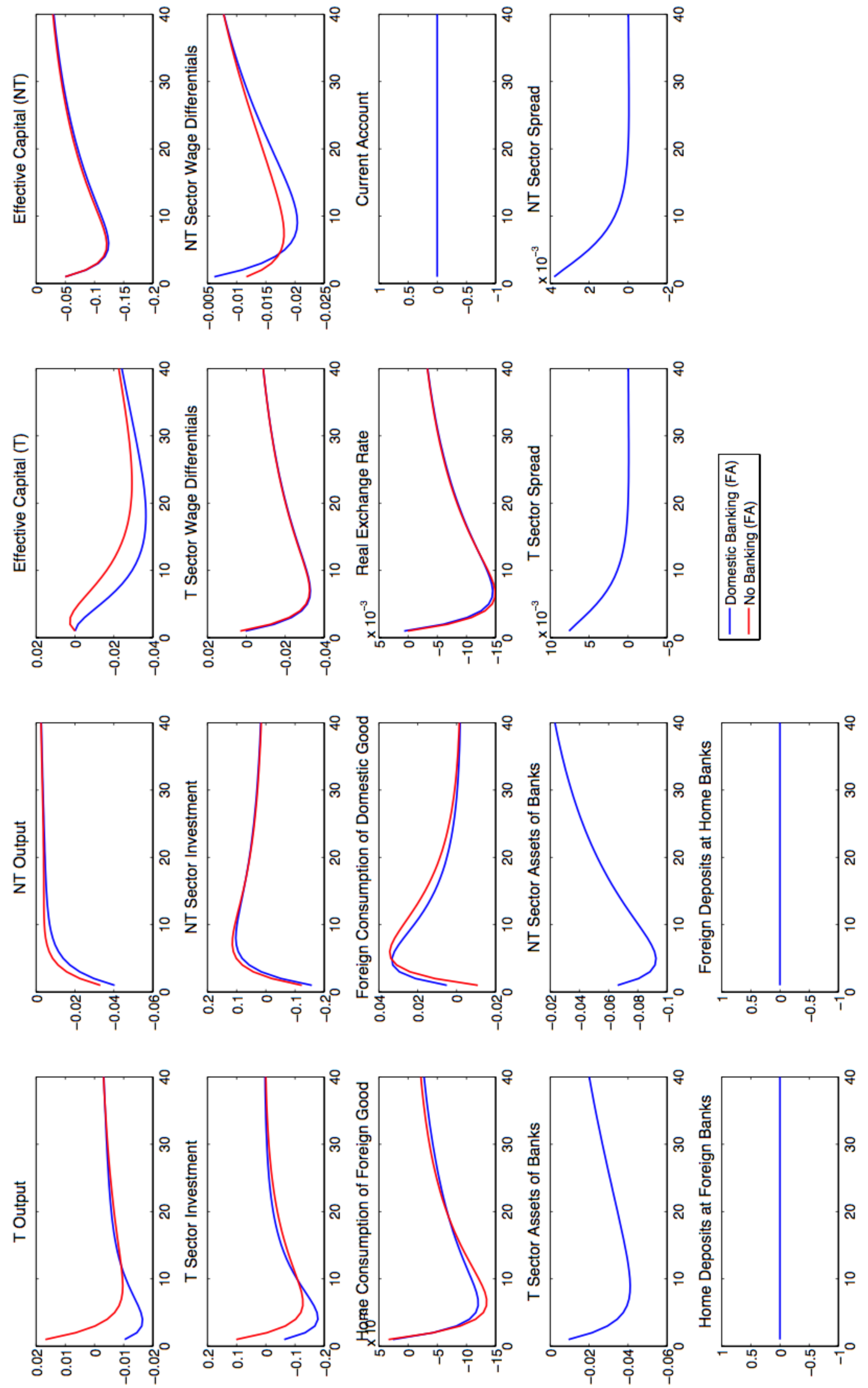


Figure 18: Impulse Response Functions (Gertler−Karadi type NT Sector Capital Quality Shock, International Financial Integration)

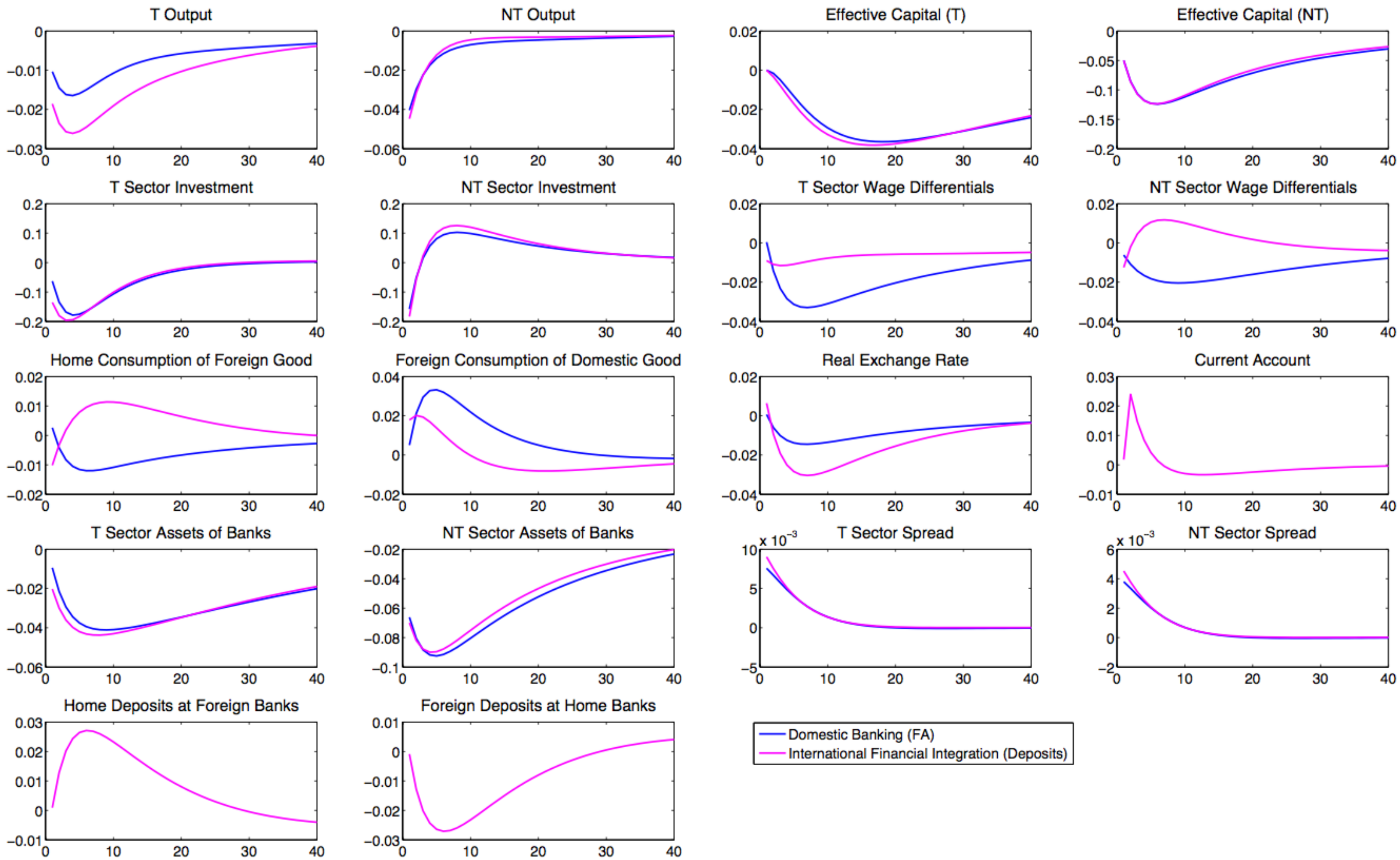


Figure 19: Asymmetric Responses Under Fundamental Shocks

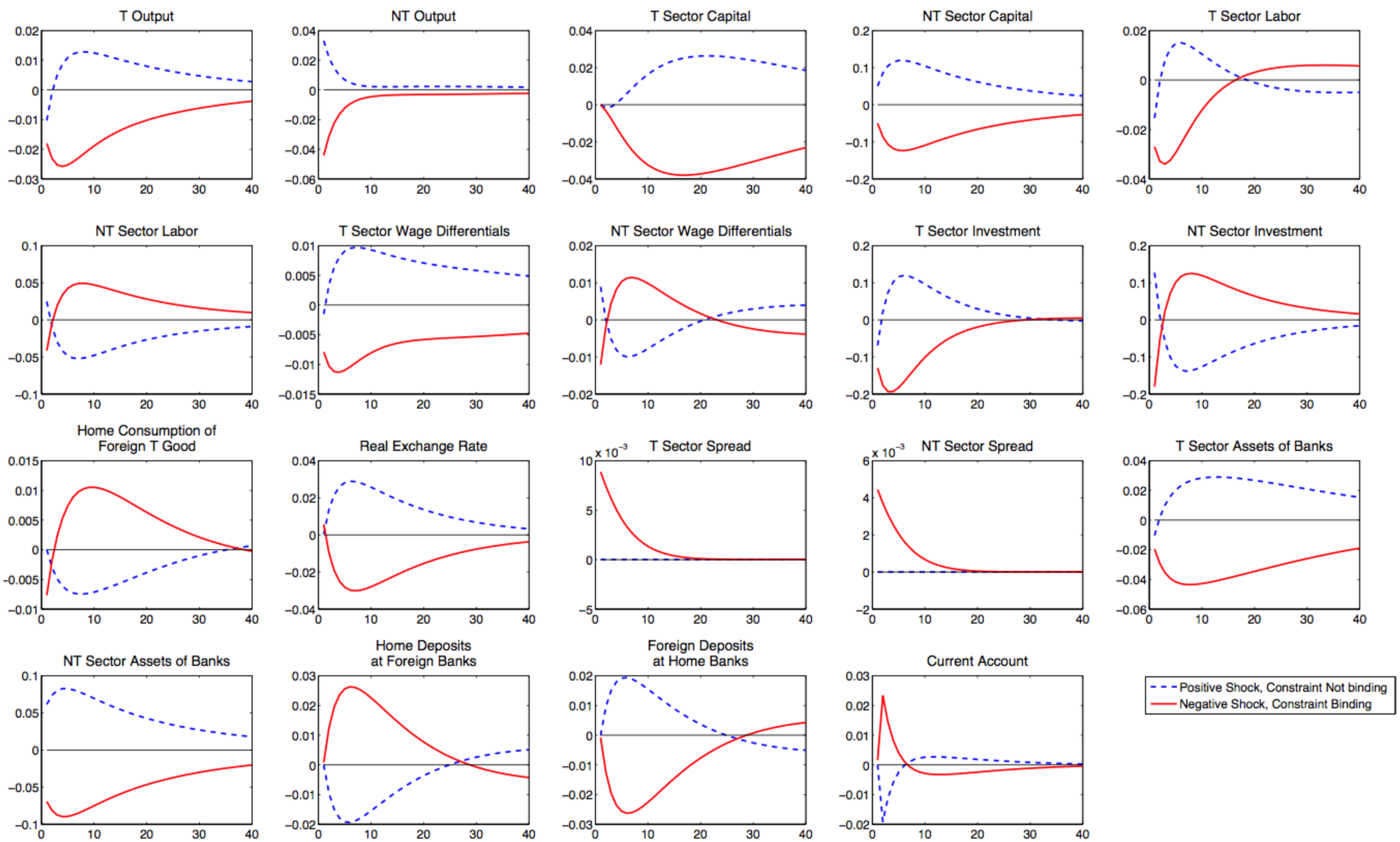
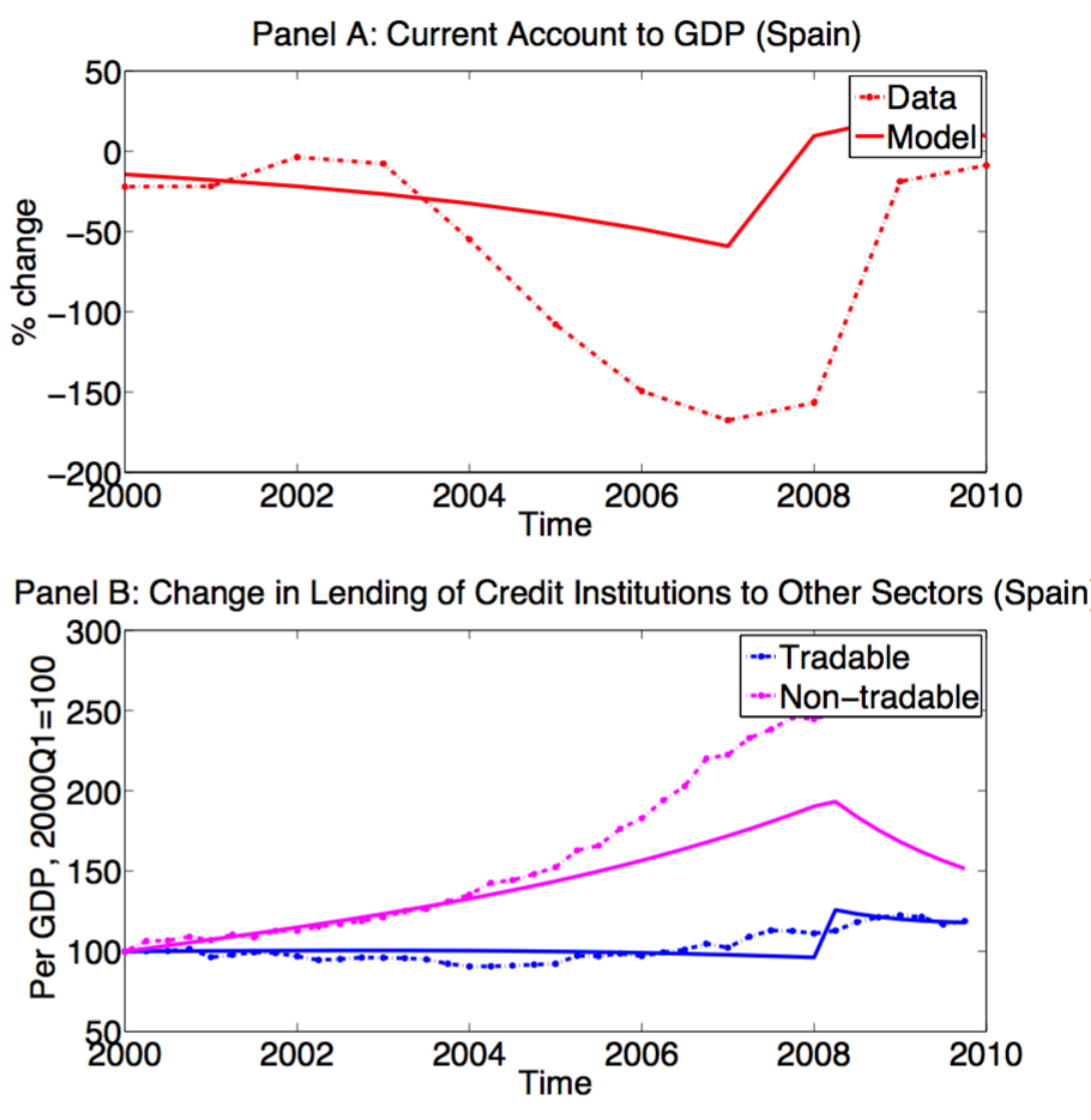
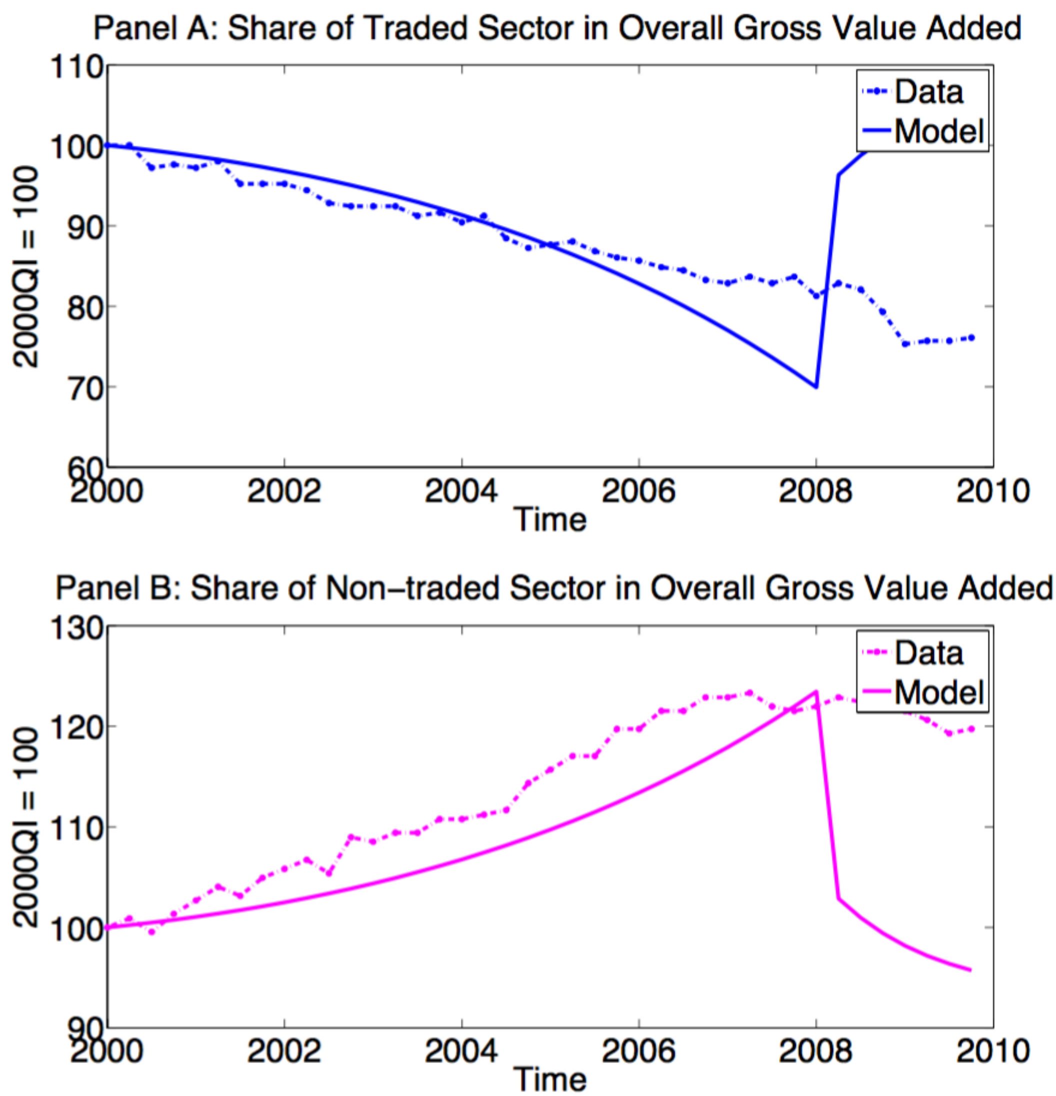


Figure 1.20: Model and Data (Conservative calibration, 1)



Notes: The model dynamics are generated after feeding in the model with shocks to the value of capital in traded and non-traded sector, such that cumulative change in Tobin's q ratios in the model match the cumulative increase in price-to-book-ratios of the industrial firms listed in the IBEX35 index between 1999:QIV and 2008:QI. The tickers for the non-traded sector firms are: ANA, ACS, FCC, FER, SYV, OHL. The tickers for other industrial firms used in calibration are: GAM, ITX, ACX, ABG. The data shows that there was a cumulative increase in the non-traded and traded IBEX listed firms by 32.5% and 11.3%, between 1999-2007 (only annual data is available). I used the 2008 shares of these firms in the overall IBEX35 index when calculating cumulative changes.

Figure 1.21: Model and Data (Conservative calibration, 2)



Chapter 2

Interest Rate Uncertainty as a Policy Tool [35]

2.1 Introduction

This paper studies the implications of using the volatility of domestic interest rate as a policy instrument in a small open economy.

Starting with the colonial pattern of foreign investment in 19th century,[36] emerging and developing nations have been subject to ebbs and flows of capital, affecting their economic management. However, the recent episode distinguishes itself with a surge in the size and volatility of flows with the development of financial markets and with the exceptionally expansionary advanced economy policies after the Global Financial Crisis (GFC).[37],[38] Figure 22 exhibits the change in the portfolio flows to Emerging Markets Economies (EMEs) between 2006-2014. This recent surge in the size and volatility of inflows can cause dislocations —mainly, financial stability concerns and inflationary pressures (Obstfeld, 2015). Hence, the conduct of monetary policy in EMEs has become a very modern contrivance and intended to prevent the adverse effects of feast-famine order of capital flows.[39],[40] The central bankers

[35] This is a joint work with Professor Ghironi.

[36] See Nurkse (1954) for a comparison of 19th century vs early 20th century capital flows.

[37] Among others, see Ahmed and Zlate (2013) and Rajan (2013).

[38] The change in the size and volatility of capital flows recently raised eyebrows on the applicability of independent monetary policy (given flexible exchange rates) in recipient countries. On the one hand, Rey (2013) argues that independent monetary policy is not possible without capital controls, and on the other, Woodford (2010) implies financial globalization does not affect the ability of domestic monetary policy to control inflation. Besides, Taylor (2015) claims that the volatility of capital flows would be ex-ante lower, if there were no deviations from rules-based monetary policy, but only Obstfeld (2015) provides a middle ground, and highlights that the monetary authorities have multiple goals in reality, and the surge in the volatility of capital flows affect the trade-off that authorities face between macro objectives and other targets, instead of making monetary policy ineffective.

[39] See IMF (2013) for a summary on the policy responses of several EMEs to capital inflows.

[40] Calvo et al. (1996) also argue that the countries that had been the most successful in managing capital flows during the Tequila crisis introduced a set of policy options instead of relying on a single instrument.

who are working under multiple mandates are forced to be even more "innovative" when facing similar challenges.

The recent unorthodox policy experiment of the Central Bank of the Republic of Turkey (CBRT) provides an example for the innovative policy response to the changing nature of capital flows, while aiming to achieve its multiple mandates of contributing to financial strength and maintaining price stability:[41] In response to intense capital inflows, the interest rate corridor[42] widened from below to discourage carry trade and channel inflows towards long-term foreign direct investments (FDI), and in response to powerful capital outflows, the interest rate corridor was narrowed by raising overnight borrowing rates, with an aim of preventing excessive outflows (see Başçı, 2012). In Figure 23, the period between November 2010 and October 2011 coincides with the horizon of the above policy.[43] However, to the best of our knowledge, there is no structural model that studies such unorthodox attempt.

This paper fills this gap by providing a laboratory for thinking about the effectiveness of the above policy on distinguishing short-term capital flows from long-term investment flows, and identifies the trade-offs that are faced in navigating financial strength and price stability. We build a small open economy model in which the central bank uses time-varying domestic interest rate volatility[44] as a policy tool, and we study the implications of such policy on short run security flows and long-run FDI. The model ingredients include global investors outside of the small economy, who have the opportunity to invest in one-period international or small open economy securities that promise to pay non-contingent returns,

[41] The Turkish Central Bank Law, which was amended in 2001, provides the Bank with the instrumental independence to contribute to financial stability, in addition to its primary mandate of achieving price stability.

[42] Interest rate corridor refers to the window between overnight lending and borrowing rates.

[43] Figure 24 exhibits an increase in FDI inflows during the application of interest rate corridor policy, however it is uncertain that whether the increase is due to a mean reversion of inflows after the GFC, or due to the success of the policy.

[44] The changes in the size of the interest rate corridor implies a change in the variance of domestic interest rate.

in addition to having the opportunity to sell productive capital to the producers in the small open economy.[45] To capture the long-run nature of productive investment, we impose a time-to-build capital requirement for global investors a‘ la Kydland and Prescott (1982).[46] By doing so, the model links the short-rate volatility to long-run interest rates that are used to discount the cost of investment for the capital to be installed in the small open economy.

In the next step, we introduce market imperfections by introducing price stickiness as in the standard New Keynesian models, and study the implications of time-varying volatility of domestic interest rate on the trade-off between discouraging short-term and attracting long-term flows. When computing the impulse responses, we employ a third-order perturbation method as in Fernández- Villaverde et al. (2011).[47] The simulations triggered by volatility shocks tend to move the ergodic distribution of the endogenous variables of the model from their deterministic steady-state, and therefore, we calculate impulse responses from the stochastic steady state of the model.

The model version with relatively less sticky prices exhibits a fall in short-term capital flows while capturing a tiny increase in the amount of FDI received by the small open economy after a volatility shock to the domestic interest rate. Importantly, the dynamics are generated without an exogenous change in the level of the domestic interest rate. Under our calibration, precautionary savings decrease consumption and increase investment, including a jump in the demand for foreign investment. However, short-term debt of the small open economy becomes more risky and the global investors move away from this economy's short-term assets by changing their portfolio composition.

When prices are more sticky, the model generates a comovement of consumption, invest-

[45]Selling productive capital abroad is consistent with the IMF definition of Foreign Direct Investment: "... a category of international investment ... (that) involves both the initial transaction between the two entities and all subsequent capital transactions between them ..."

[46]More recently, Tsoukalas (2011).

[47]For changes in the volatility to have a separate role, a third-order Taylor expansion of the solution of the model should be considered. See the discussion in Fernández-Villaverde et al. (2011).

ment, and output. An increase in the uncertainty of the domestic interest rate path generates a precautionary escalation in the labor supply as in the previous version. However, marginal costs fall faster than the price adjustments, and generate a higher mark-up. Higher mark-ups cause a simultaneous decline in consumption and investment, including foreign investment. The time-to-build condition in foreign investment implies a smaller change in the volatility of long-run rates and causes a smaller decline in foreign investment than domestic investment. Having the same mechanism at work, the demand on the short-run securities of the small open economy declines more pronounced than the decline in foreign investment.

Our contribution is three-fold. First, we contribute to the literature that study the effects of uncertainty shocks on economic activity.[48] The most significant contribution of this paper to this literature is introducing uncertainty as a policy tool, instead of a taken-as-given economic phenomenon. Hence, the results are of first-order importance to several policymakers of today. Our paper is also the first that studies the effects of uncertainty on different types of capital flows. Furthermore, given our motivation from the case of CBRT, we study the effects of one-sided volatility shocks, and therefore assume a change in the variance of a random variable that has a bimodal distribution, instead of the standard assumption of Normal distribution in the literature.

Second,we contribute to the literature that study capital flows to the EMEs.[49] We differentiate from those that study an economy integrated into international financial markets by distinguishing long-term flows from short-term by a time-to-build FDI assumption, rather than allowing for portfolio holdings that consist one-period securities. Moreover, we do not

[48]This is a recently growing literature with papers by Andreasen (2012), Bachmann and Bayer (2013), Basu and Bundick (2014), Bloom (2009), Born and Pfeifer (2014a), Born and Pfeifer (2014b), Cesa-Bianchi and Fernandez- Corugedo (2014), Fernández-Villaverde et al. (2011), Fernández-Villaverde et al. (2015), and Justiniano and Primiceri (2008).

[49]The literature is still expanding with the recent contributions of Agénor et al. (2014), Ahmed and Zlate (2013), Aoki et al. (2015), Banerjee et al. (2015), Devereux and Sutherland (2009), Ghironi et al. (2015), Gourinchas et al. (2016).

attempt to capture an "original sin"[50] phenomenon through the market for bank liabilities as foreign exchange deposits constitute a small amount in the balance sheets of Turkish banks; although the model can be extended to that direction easily. Finally, none of the papers in this literature study the effects of uncertainty on economic activity.[51]

The rest of the paper is organized as follows. Section 2.2 presents the model. Section 2.3 discusses the calibration and model simulation with and without sticky prices. Section 2.4 concludes.

2.2 The model

The focus is on a small open economy in which short-term financial flows are distinguished carefully from long-term investment flows.

2.2.1 Households

The economy is populated by a unit mass of atomistic households that maximize expected inter-temporal utility from consumption, C_t, net of disutility from supplying labor to intermediate good producers, L_t:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(C_t, L_t) \tag{83}$$

where $U(C_t, L_t) = \frac{C_t^{1-\rho}}{1-\rho} - \chi \frac{L_t^{1+\varphi}}{1+\varphi}$.

Households can hold one-period securities supplied by domestic and international agents, B and ξB_*, where ξ represents the nominal exchange rate. They receive gross income on securities and labor income after entering period t, and allocate these resources between consumption and purchases of securities to be carried into the next period. The flow budget

[50] See Eichengreen and Hausmann (1999) and Eichengreen et al. (2007), and more recently Aoki et al. (2015).

[51] An exception is Fernández-Villaverde et al. (2011) but they only show how changes in the volatility of the foreign real interest rate affect other variables in Mendoza (1991).

constraint of the household can be written as:

$$P_tC_t + B_{t+1} + \xi_t B_{*,t+1} + \frac{\eta}{2}\xi_t P_t^*(\frac{B_{*,t+1}}{P_t^*})^2 = (1+i_t)B_t + \xi_t(1+i_t^*)B_{*,t} + W_tL_t + \Pi_t + T_t^{f*}, \quad (84)$$

where $\frac{\eta}{2}\xi_t(B_{*,t+1})^2$ is the cost of adjusting holdings of internationally traded securities, T_t^{f*} is a fee rebate, taken as given by the household, and equal to $\frac{\eta}{2}\xi_t(B_{*,t+1})^2$ in the equilibrium. Introducing convex adjustment costs ensures that zero international security holding is the unique steady state, and hence the economy goes back to their initial position after temporary shocks. Π_t represents the profits obtained from engagements in production.

The household maximizes (83) subject to (84). The Euler equations for the holdings of international and domestic securities are as follows:

$$1 + \eta\frac{B_{*,t+1}}{P_t^*} = \beta(1+i_{t+1}^*)\mathbb{E}_t\left[\frac{P_t}{P_{t+1}}\frac{\xi_{t+1}}{\xi_t}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}\right], \quad (85)$$

$$1 = \beta(1+i_{t+1})\mathbb{E}_t\left[\frac{P_t}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}\right]. \quad (86)$$

We omit the transversality conditions for deposit holdings. With $\eta > 0$, no-arbitrage condition implies:

$$\frac{1+i_{t+1}}{1+i_{t+1}^*} = \frac{\mathbb{E}_t[\frac{P_t}{P_{t+1}}\frac{\xi_{t+1}}{\xi_t}C_{t+1}^{-\rho}]}{(1+\eta B_{*,t+1})\mathbb{E}_t[\frac{P_t}{P_{t+1}}C_{t+1}^{-\rho}]}.$$

The intratemporal dimension of the household's problem is captured by the consumption-labor trade-off, which equates marginal rate of substitution between labor and consumption to the real wage:

$$\frac{W_t}{P_t} = \chi\frac{L_t^{\varphi}}{C_t^{-\rho}}. \quad (87)$$

2.2.2 Firms

There are three types of firms in the small open economy: intermediate good producers, capital producers, and monopolistically competitive retail firms.

Intermediate good producers

The production technology at time t is a constant returns to scale function, which combines capital and labor:

$$F(K_t^H, K_t^F, L_t) = A_t \left(K_t^H\right)^{\alpha_1} \left(K_t^F\right)^{\alpha_2} {L_t}^{1-\alpha_1-\alpha_2} \tag{88}$$

where α_1, α_2, and $\alpha_1 + \alpha_2 \in (0,1)$. Each intermediate good is produced from domestic and foreign capital (FDI), and labor.

Firms finance their capital expenditures by issuing equities, S_t^H and S_t^F, and selling them to domestic and foreign entities from prices Q_t^H and Q_t^F, in terms of the domestic currency. Having resources, firms buy capital that will be used in the next period, K_{t+1}^i, where $i \in \{H, F\}$. By the assumption of no-arbitrage, value of claims issued for each type of capital is equal to the value of capital bought:

$$Q_t^H S_t^H = Q_t^H K_{t+1}^H, \tag{89}$$

$$Q_t^F S_t^F = Q_t^F K_{t+1}^F. \tag{90}$$

The gross profits per unit of domestic and foreign capital can be written as:

$$Z_t^H = \frac{P_{m,t} F(K_t^H, K_t^F, L_t) - W_t L_t - Z_t^F K_t^F}{K_t^H}, \tag{91}$$

$$Z_t^F = \frac{P_{m,t}F(K_t^H, K_t^F, L_t) - W_t L_t - Z_t^H K_t^H}{K_t^F}. \tag{92}$$

where P_m is the price of intermediate output.

Intermediate good producing firms obtain zero profits state-by-state, and the return on capital is fully paid out to the owners of the firm equity. The period t payoff of domestic capital is

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(1 + i_{kt+1}\right)\right] = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{Z_{t+1}^H + (1-\delta)Q_{t+1}^H}{Q_t^H}\right)\right].$$

with $\beta^s \Lambda_{t,t+s}$ being the stochastic discount factor with $\Lambda_{s,s+1} = \frac{U_C(s+1)}{U_C(s)}$. The interest paid out on the loan varies with the marginal product of capital and with the fluctuations in prices.

Under perfect domestic capital markets assumption,

$$\mathbb{E}_t \left[\Lambda_{t,t+1} \left(1 + i_{kt+1}\right)\right] = \left(1 + i_{t+1}\right) \mathbb{E}_t \left[\Lambda_{t,t+1}\right]. \tag{93}$$

Finally, the standard labor demand equation states that the marginal product of labor is equal to the wage rate:

$$W_t = P_{m,t} F_{L_t}(K_t^H, K_t^F, L_t). \tag{94}$$

Capital producers

Capital producers produce new capital that will be used by intermediate good producers in the subsequent period. They maximize their profits, which consist of revenues from selling new capital to intermediate good producers net of buy-back of used capital and investment costs:

$$Q_t^H K_{t+1}^H - Q_t^H (1-\delta) K_t^H - P_t I_t \tag{95}$$

subject to the law of motion of capital:

$$K_{t+1}^{H} = (1-\delta)K_t^H + I_t - f\left(\frac{I_t}{K_t^H}\right)K_t^H. \tag{96}$$

Their optimization problem indicates that the price of capital is equal to the marginal cost of investment good production, and yields a Tobin's Q relationship:

$$\frac{Q_t}{P_t} = \frac{1}{1 - f_I(\frac{I_t}{K_t})K_t}. \tag{97}$$

It is useful to note that capital producers obtain non-zero profits due to presence of convex adjustment costs of capital.

Retailers

Retailers simply re-package intermediate output, and final output, Y_t, is produced through a CES aggregate of a continuum of mass unity of differentiated retailer goods:

$$Y_t = \left(\int_0^1 Y_{rt}^{\frac{\epsilon-1}{\epsilon}}\,dr\right)^{\frac{\epsilon}{\epsilon-1}},$$

where Y_{rt} is the retailer output.

Final good producers maximize profit:

$$\Pi_t = P_t\left(\int_0^1 Y_{rt}^{\frac{\epsilon-1}{\epsilon}}\,dr\right)^{\frac{\epsilon}{\epsilon-1}} - \int_0^1 P_{rt}Y_{rt}dr,$$

and relative demand for the retail firm r is a function of its relative price, with ϵ being the price elasticity of demand, and is proportional to aggregate output Y_t:

$$Y_{rt} = \left(\frac{P_{rt}}{P_t}\right)^{-\epsilon} Y_t, \tag{98}$$

with

$$P_t = \left(\int_0^1 P_{rt}^{1-\epsilon} dr\right)^{\frac{1}{1-\epsilon}}. \tag{99}$$

Retail producer uses the intermediate good as the sole input, and hence the price of intermediate output is the marginal cost of re-packaging. Real profits of retailers are

$$\Pi_t^r = \frac{P_{rt}}{P_t} Y_{rt} - \frac{P_{mt}}{P_t} Y_{rt}.$$

Retail firms are not able to adjust their prices freely. Following a Calvo-Yun mechanism, each period there is a fixed probability of $1-\phi$ that a retailer can set a new price. The dynamic problem of a firm updating its price can be written as:

$$Max_{P_{rt}}\ \mathbb{E}_t \sum_{s=0}^{\infty} (\beta\phi)^s \Lambda_{t,t+s} \left(\frac{P_{rt}}{P_{t+s}} \left(\frac{P_{rt}}{P_{t+s}}\right)^{-\epsilon} Y_{t+s} - \frac{P_{mt}}{P_{t+s}} \left(\frac{P_{rt}}{P_{t+s}}\right)^{-\epsilon} Y_{t+s}\right). \tag{100}$$

The first order condition to the above problem leads to an expression for the reset price:

$$P_{rt} = \frac{\epsilon}{\epsilon - 1} \frac{\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\phi)^s (C_{t+s})^{-\rho} P_{mt+s} P_{t+s}^{\epsilon-1} Y_{t+s}}{\mathbb{E}_t \sum_{s=0}^{\infty} (\beta\phi)^s (C_{t+s})^{-\rho} P_{t+s}^{\epsilon-1} Y_{t+s}}.$$

All updating firms will reset to the same price, therefore the expression can be rewritten as:

$$P_t^{\#} = \frac{\epsilon}{\epsilon - 1} \frac{X_{1,t}}{X_{2,t}} \tag{101}$$

where

$$\begin{aligned} X_{1,t} = & \quad (C_t)^{-\rho} P_{mt} P_t^{\epsilon-1} Y_t + \beta\phi \mathbb{E}_t X_{1,t+1}, \\ X_{2,t} = & \quad (C_t)^{-\rho} P_t^{\epsilon-1} Y_t + \beta\phi \mathbb{E}_t X_{2,t+1}. \end{aligned} \tag{102}$$

To get rid of heterogeneity in the equilibrium, rewrite the price level as

$$\begin{aligned} P_t^{1-\epsilon} &= \int_0^{1-\phi} \left(P_t^{\#}\right)^{1-\epsilon} dr + \int_{1-\phi}^{1} \left(P_{rt-1}\right)^{1-\epsilon} dr \\ &= (1-\phi)\left(P_t^{\#}\right)^{1-\epsilon} + \phi P_{t-1}^{1-\epsilon}. \end{aligned} \tag{103}$$

2.2.3 Global investors

There is a large number global investors which can invest in one-period global market securities and in short-run securities of the emerging economy that are outlined above. In addition, global investors can establish a lasting interest[52] in emerging market intermediate good producers through direct capital holdings. They can buy small open economy intermediary firm equity but they are subject to extra management costs, $\frac{\varsigma}{2}\left(K_t^F\right)^2$, in order to receive the same payoff that small open economy bankers obtain.

Global investors accumulate capital through investment which requires time-to-build. It takes J periods to build new productive capital. This type of technology implies that each period investors initiate projects that will be completed in J periods, and complete partially finished projects that are initiated in previous periods. Therefore, the long-run nature of capital installments is captured by the assumption of time-to-build new capital on the investment technology. In small open economy consumption units, total investment and capital accumulation can be expressed as follows:

[52]The IMF glossary defines the "lasting interest" as "the existence of a long-term relationship between the direct investor and the enterprise and a significant degree of influence by the direct investor on the management of the direct investment enterprise."

$$I_t^* = \sum_{i=1}^{J} \varphi_i s_{it}^*, \tag{104}$$

$$s_{it}^* = s_{i-1t+1}^*, \qquad \forall i \in \{2, .., J\}, \tag{105}$$

$$K_{t+1}^F = (1-\delta)K_t^F + s_{1t}^*. \tag{106}$$

with $0 \leq \varphi_i \leq 1$, and $\sum_{i=1}^{J} \varphi_i = 1$. The parameter, φ_i, determines the fixed fraction of total investment expenditures allocated to projects that are i periods away from completion. s_{Jt}^* is the project that is initiated in period t,and J periods away from completion.

The global investors maximize expected intertemporal utility from consumption (C_t^*):

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left((C_t^*)^{1-\rho} - 1\right)}{1-\rho}, \tag{107}$$

where β is the subjective discount factor, and ρ is the inverse of the intertemporal elasticity of substitution. Every period, they consume, invest in securities, invest in productive capital to be installed in the emerging market economy, and obtain income from previous period investments in securities, and capital, in addition to their endowment.

Global investors' budget constraint can be written as:

$$P_t^* C_t^* + B_{*,t+1}^* + \frac{B_{t+1}^*}{\xi_t} + \frac{\eta}{2}\frac{P_t}{\xi_t}\left(\frac{B_{t+1}^*}{P_t}\right)^2 + \frac{P_t}{\xi_t} I_t^* + \frac{P_t}{\xi_t}\frac{\eta^K}{2}\left(\frac{s_{Jt}^*}{s_J^*} - \delta\right)^2 s_{Jt}^* + \frac{Q_t^F K_{t+1}^F}{\xi_t} + \frac{\varsigma}{2}\frac{P_t\left(K_t^F\right)^2}{\xi_t}$$
$$= (1+i_t^*)B_{*,t}^* + (1+i_t)\frac{B_t^*}{\xi_t} + \frac{\left(Z_t^F + (1-\delta)Q_t^F\right)}{\xi_t} K_t^F + \frac{Q_t^F s_{1,t}^*}{\xi_t} + P_t^* Y_t^{e*} + T_t^{f*}. \tag{108}$$

Assume $J = 2$. The first order conditions to the global investors' problem with respect to C_t^*, s_{Jt}^*, K_{t+1}^F, B_{t+1}^*, and $B_{*,t+1}^*$ yield following conditions:

$$1 + \eta\frac{B_{t+1}^*}{P_t} = \beta(1+i_{t+1})\mathbb{E}_t\left[\frac{P_t^*}{P_{t+1}^*}\frac{\xi_t}{\xi_{t+1}}\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-\rho}\right], \tag{109}$$

$$1 = \beta(1 + i^*_{t+1})\mathbb{E}_t \left[\frac{P^*_t}{P^*_{t+1}} \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\rho} \right], \tag{110}$$

$$1 = \mathbb{E}_t \left[\frac{P^*_t}{P^*_{t+1}} \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\rho} \left(\frac{Z^F_{t+1} + (1-\delta)Q^F_{t+1}}{Q^F_t + \varsigma K^F_{t+1}} \right) \frac{\xi_t}{\xi_{t+1}} \right], \tag{111}$$

$$\underbrace{\frac{P_t}{\xi_t}\mathbb{E}_t \left[\varphi_2 + \eta^K \left(\frac{s^*_{1t+1}}{s^*_2} - 1 \right) \frac{s^*_{1t+1}}{s^*_2} + \frac{\eta^K}{2} \left(\frac{s^*_{1t+1}}{s^*_2} - 1 \right)^2 \right]}_{\text{Cost of current investment project}} + \underbrace{\beta\mathbb{E}_t \left[\frac{P^*_t}{P^*_{t+1}} \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\rho} \frac{P_{t+1}}{\xi_{t+1}}\varphi_1 \right]}_{\text{Discounted cost of next period project}}$$
$$= \underbrace{\beta\mathbb{E}_t \left[\frac{P^*_t}{P^*_{t+1}} \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\rho} \frac{Q^F_{t+1}}{\xi_{t+1}} \right]}_{\text{Discounted revenue from the FDI}} \tag{112}$$

Equations (27) and (28) are Euler equations associated with global and emerging market bond holdings. Equation (29) tells that discounted return from the emerging economy equity holdings is equal to one. Finally, (30) links the discounted revenue from investing capital in the emerging economy to the current period and next period costs associated with the investment.

2.2.4 Monetary policy rule

We assume a cashless economy where the monetary authority of the small open economy sets the domestic interest rate according to a Taylor rule that attributes weight on inflation and output growth:

$$log(1+i_{t+1}) = \rho_i log(1+i_t) + (1-\rho_i) \left(log(1+i) + \rho_\pi log(\frac{\pi_t}{\pi}) + \rho_y log(\frac{Y_t}{Y_{t-1}}) \right) + \sigma^e_t e_t, \tag{113}$$

where

$$log(\sigma^e_t) = \rho_\sigma log(\sigma^e_{t-1}) + (1-\rho_\sigma) log(\sigma^e) + \eta_\sigma e^\sigma_t. \tag{114}$$

Both e_t and e_t^σ are normally distributed variables with zero mean and unit variance. The first innovation changes the level of the rate, while the second innovation causes fluctuations in the standard deviation of e_t. Thus, the process of domestic interest rate follows a stochastic volatility process.

2.2.5 Equilibrium

Small open economy output is either consumed or invested net of imports received:

$$Y_t = C_t + I_t - \frac{Q_t^F K_t^F}{P_t}. \tag{115}$$

Global investor's endowment is also equal to her consumption and the amount invested for the capital holdings in the emerging market economy together with managing FDI:

$$Y_t^{e*} = C_t^* + \frac{\varphi_1 s_{1t}^* + \varphi_2 s_{1t+1}^* + \frac{\eta^K}{2}\left(\frac{s_{1t+1}^*}{s_2^*} - 1\right)^2 s_{1t+1}^* + \frac{\varsigma}{2}\left(K_t^F\right)^2}{RER_t}. \tag{116}$$

Real exchange rate, RER, is defined as $RER = \frac{\xi P^*}{P}$.

Net foreign assets, which equals to the net foreign debt of EME households, evolves through income, consumption, and investment differentials, and through repayment of previous period borrowing:

$$\begin{aligned} &\tfrac{C_t - RER_t C_t^*}{2} + b_{t+1} + RER_t b_{*,t+1} - \tfrac{Q_t^F K_{t+1}^F}{2P_t} \\ &= \tfrac{(1+i_t)}{(1+\pi_t)} b_t + \tfrac{RER_t(1+i_t^*)}{(1+\pi_t^*)} b_{*,t} - \tfrac{Z_t^F + (1-\delta)Q_t^F}{2P_t} K_t^F + \tfrac{Q_t^H I_t - Q_t^F s_{1t}^*}{2P_t} - \tfrac{I_t - \varphi_1 s_{1t}^* - \varphi_2 s_{1t+1}^*}{2} - \tilde{d}_t \end{aligned} \tag{117}$$

where $\tilde{d}_t = \frac{w_t L_t + Y_t(1 - RP_{mt} v_t^p) - RER_t Y_t^{e*}}{2}$ indicates the income differentials.

The model consists of 29 equations with 29 endogenous variables. A summary is provided in the appendices.

2.3 Model Calibration and Simulations

In this section, we illustrate the model dynamics and highlight the role of sticky prices under interest rate volatility shocks.

2.3.1 Calibration

The calibration follows the standard values in the previous literature. We set the depreciation rate, δ, shares of domestic and foreign capital in the EME production function, α_1 and α_2, discount factor, β, to standard values in literature. We set them to 0.025, 0.17, 0.17, and 0.995, respectively. As regards to the convex adjustment costs of foreign security holdings to the household, η, We use 0.025 as in Ghironi and Melitz (2005). Hence, the cost of adjusting has no substantial effect except pinning down the non-stochastic steady state under transitory shocks. Following the standard RBC literature, we set the inverse of the elasticity of substitution in the EME and in the Global Investor's utility, ρ, to 2. We follow Gertler and Kiyotaki (2010) when setting the inverse of the Frisch elasticity in the EME, φ, to 0.276, and the relative weight of labor in the utility, χ, to 5.584. For capital adjustment costs in the EME, we follow Bernanke, Gertler, and Gilchrist (1999), and set φ^K to 5. The relative disadvantage of the Global Investor in holding EME capital is 0.001

Regarding the monopolistically competitive final producers, the inverse elasticity of substitution in their production function across intermediate good producers, ϵ, is set to 10 as standard in the literature. And finally the relative weights in the Taylor rule on inflation and output growth, ρ_π and ρ_y, are set to 1.5 and 0.5, respectively.

2.3.2 Solution method

We solve the model using third-order perturbation techniques. A first order approximation will be certainty equivalent and will neglect higher order effects. A model solution under a second order approximation will not be able to study the direct effects of a volatility change, as the model solution includes cross-products of exogenous volatility and level variables. Hence, to separate the individual effects of volatility shocks, a third order approximation of the model is needed.

Moreover, it is previously shown in the literature that time-varying volatility moves the ergodic distribution of the endogenous variables away from their non-stochastic steady states (among others, see Fernandez-Villaverde et al. (2011)). Thus, we calculate impulse responses from the stochastic steady states of the endogenous variables. Following Juillard and Kamenik (2005), we define the stochastic steady state as the point of the state space, where the agents would choose to remain in absence of shocks but taking future volatility into account.

To calculate impulse response functions in this manner, we follow the methodology in Koop et al. (1996). We draw a series of random shocks for 140 periods for each variable and perform simulations. Then, we add one standard deviation to the simulated series for interest rate volatility shock in period 101, and perform another set of simulations. We calculate the impulse response of variables as the difference between first and second set of simulations between periods 101 and 140. Since the results will be affected by other shocks in addition to the volatility shock in period 101, we average over the effects of other shocks and perform 50 replications along these lines.

As the experiment we would like to conduct is the effects of interest rate volatility shocks without affecting the level of the interest rate, we conduct simulations conditional on the realization of the level shock being always zero.

2.3.3 Model dynamics

We conduct experiments by inducing a temporary change in the stochastic volatility of domestic interest rate, and investigate the effects on short-run and long-run capital flows. In order to do so, we calculate IRFs that are variant to rescaling and follow the procedure explained above.

Figure 26 exhibits the dynamics obtained after a 90% increase in the volatility of the interest rate set by the EME central bank under less sticky prices (*i.e.* $\phi = 0.25$). Following an increase in the volatility, the country experiences a gradual decline in the amount of short term capital flows coming from the global investor. By the end of 40th quarter, the cumulative decline is approximately .8%. Whereas, there is a tiny increase in the amount of FDI received by the EME, the change is minuscule. A fall in consumption is also observed with the increase in the volatility, and its gradual inclination towards the stochastic steady state, while the volatility shock is fading away. The output in the emerging economy also declines gradually following the uncertainty in the domestic monetary policy.

For the intuition behind these dynamics, it is useful to start with EME households Euler equation for the domestic security holdings:

$$1 = \beta(1 + i_{t+1})\mathbb{E}_t \left[\frac{P_t}{P_{t+1}} \left(\frac{C_{t+1}}{C_t} \right)^{-\rho} \right].$$

Following an amplification in the volatility, the exogenous level of the policy rate stays constant, but an increase in the volatility of the future consumption implies a higher future marginal value from consumption. Keeping the exogenous component of the interest rate level constant, it contributes to an increase in the price level. The specified Taylor rule responds to the increase in price level and the level of the policy rate escalates. However, an increase in the overall price level is transmitted to exchange rates with a depreciation.

$$1 + \eta \frac{B^*_{t+1}}{P_t} = \beta(1 + i_{t+1})\mathbb{E}_t \left[\frac{P^*_t}{P^*_{t+1}} \frac{\xi_t}{\xi_{t+1}} \left(\frac{C^*_{t+1}}{C^*_t} \right)^{-\rho} \right]$$

Following the Global Investors' Euler equation for the EME security holdings, we see that a depreciation in EME currency with the zero inflation assumption in the rest of the world leads to a decline in the Global Investors' holdings of short-term EME securities.

As the EME's short term foreign debt is declining, labor supply and investment increases in the economy. Due to complementary nature of FDI to domestic investment, the demand for foreign capital increases and the economy experiences a slight increase in the amount FDI it receives.

The mechanics suggest a standard precautionary savings motive following an increase in the domestic policy risk.

Figure 27 displays impulse responses from the same model with a higher degree of price stickiness. The model generates again a decline in short-term foreign debt, but this time with an accompanying decline in the amount of FDI the EME receives. There is also a smaller negative effect on consumption and output vis-a-vis to the previous case.

The intuition is, with a greater degree of price stickiness, a precautionary savings motive increases the investment and labor supply with a faster increase in markups: Marginal cost of the intermediate good falls faster than the adjustments in prices. There is a second round effect on labor supply from declining real wages due to greater changes in markups. As the labor supply falls, the demand for capital —both domestic and foreign— declines as well, and this contributes to a fall in the FDI the EME receives.

We can still observe this mechanism from the above Euler equations. With a greater degree of price stickiness, EME price level responds less, and the nominal exchange rate depreciates less than the previous case. With less pronounced fluctuations in nominal exchange rates, the return on FDI moves relatively smaller vis-a-vis to the previous case:

$$1 = \mathbb{E}_t \left[\frac{P_t^*}{P_{t+1}^*} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\rho} \left(\frac{Z_{t+1}^F + (1-\delta) Q_{t+1}^F}{Q_t^F + \varsigma K_{t+1}^F} \right) \frac{\xi_t}{\xi_{t+1}} \right].$$

The above Euler equation of the Global Investor suggests a fall in FDI together with its return to accompany the nominal exchange rate fluctuations. Hence, a comovement in long-run FDI and short-run security flows is generated.

2.4 Conclusions

This paper presents an open economy model in which using domestic interest rate risk as a policy has different implications on short-term and long-term capital flows. If the model economy prices are less sticky, it is possible to attract long-run foreign investment while discouraging short-term capital inflows with an increase in policy uncertainty. However, as the prices become more sticky, a rise in the uncertainty of domestic interest rate is followed with a decline in foreign investment together with a decline in short-run capital inflows. Moreover, increasing policy uncertainty comes at a cost of higher inflation. Hence, the trade-offs from navigating between attracting long-run investment while discouraging short-term capital inflows and stabilizing inflation is more costly as the economy is subject to higher Calvo type frictions.

An extension of the model that will capture important EME features will be to introduce domestic financial imperfections in this open economy. In this case, policy uncertainty will have an effect on the tightness of the financial constraints and can induce an additional channel that would help to evaluate such policy. We leave this extension for the next version of the paper.

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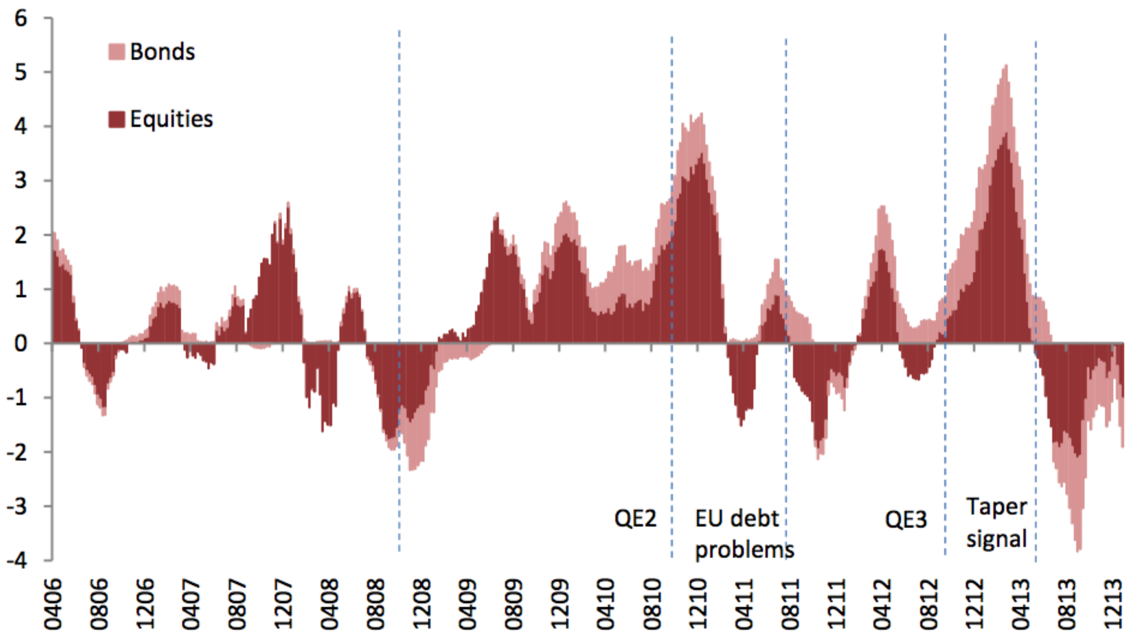
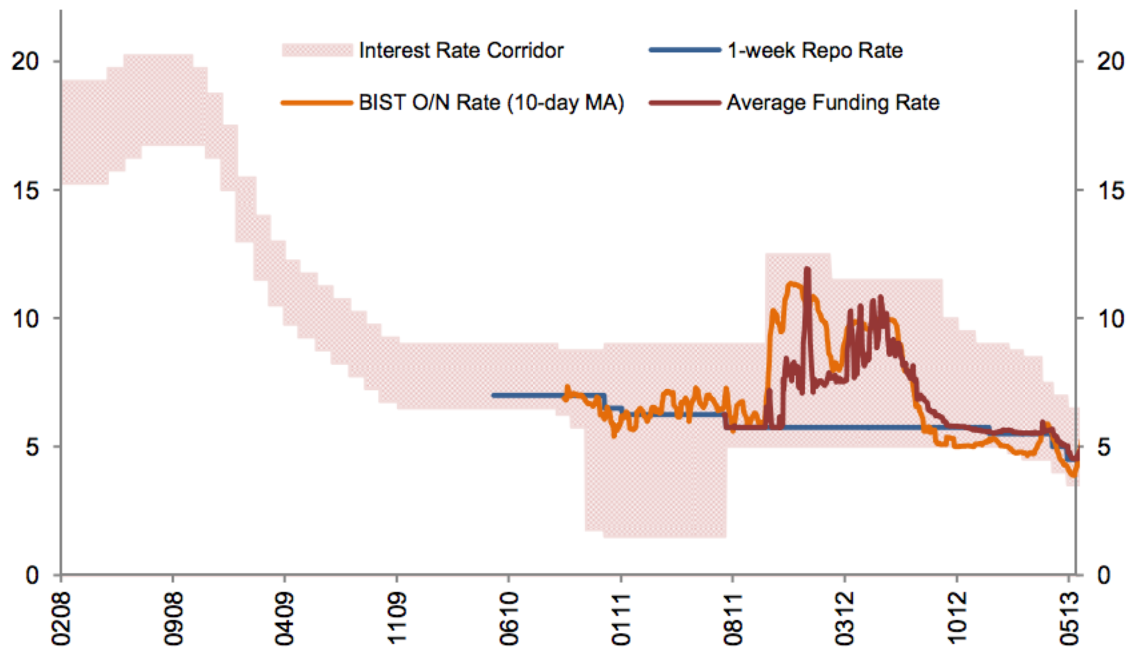
2.6 Figures

Figure 2.1: Portfolio Flows to Emerging Markets (13-week moving average, bn USD)



Source: CBRT

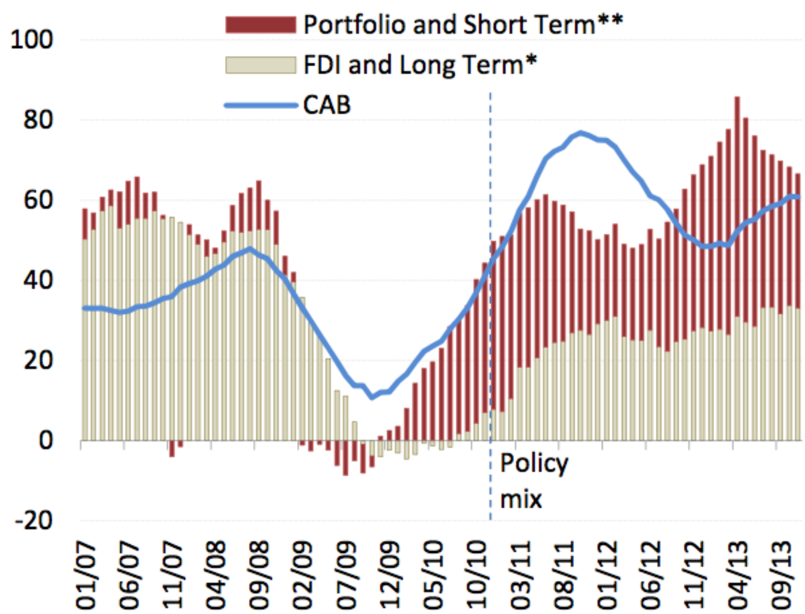
Figure 2.2: Interest rate corridor and average funding cost, Turkey



Notes: Vertical axis in percentages. BIST is the shorthand for Borsa Istanbul (Istanbul Stock Exchange)

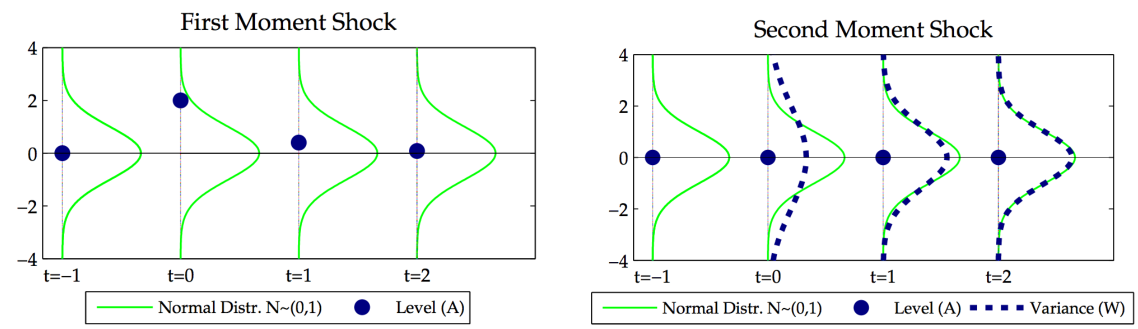
Source: CBRT

Figure 2.3: Financing the current account, Turkey (12-month cumulative, bn USD)



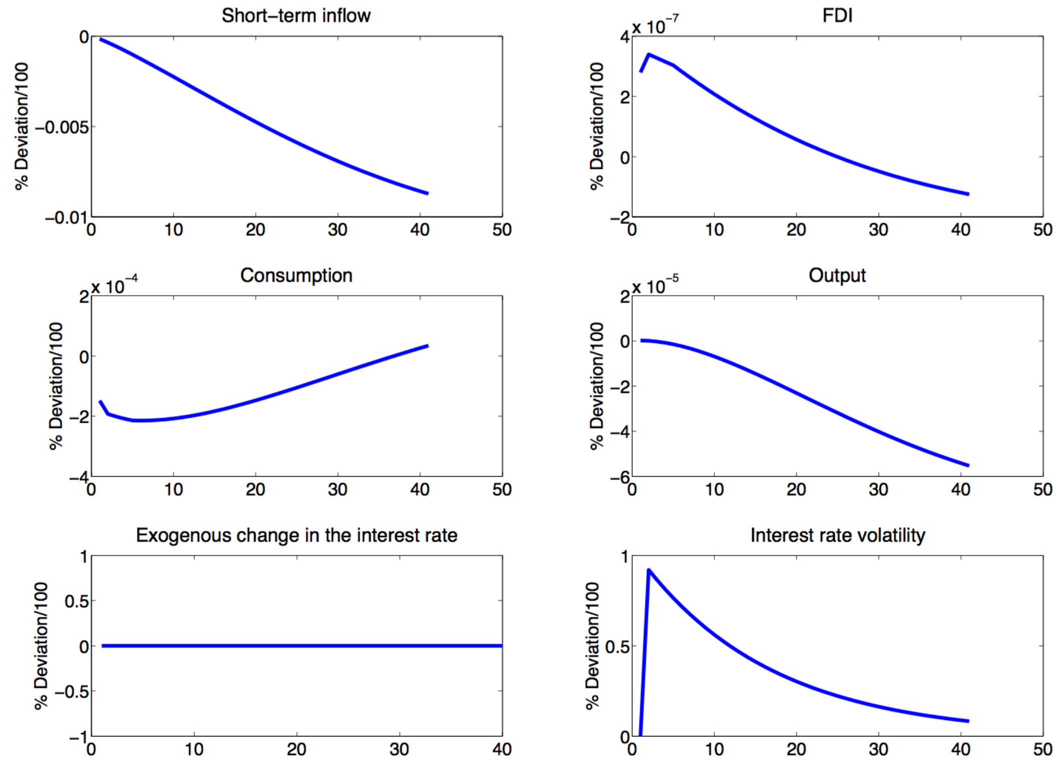
Source: CBRT

Figure 2.4: Illustration of first moment and second moment shocks



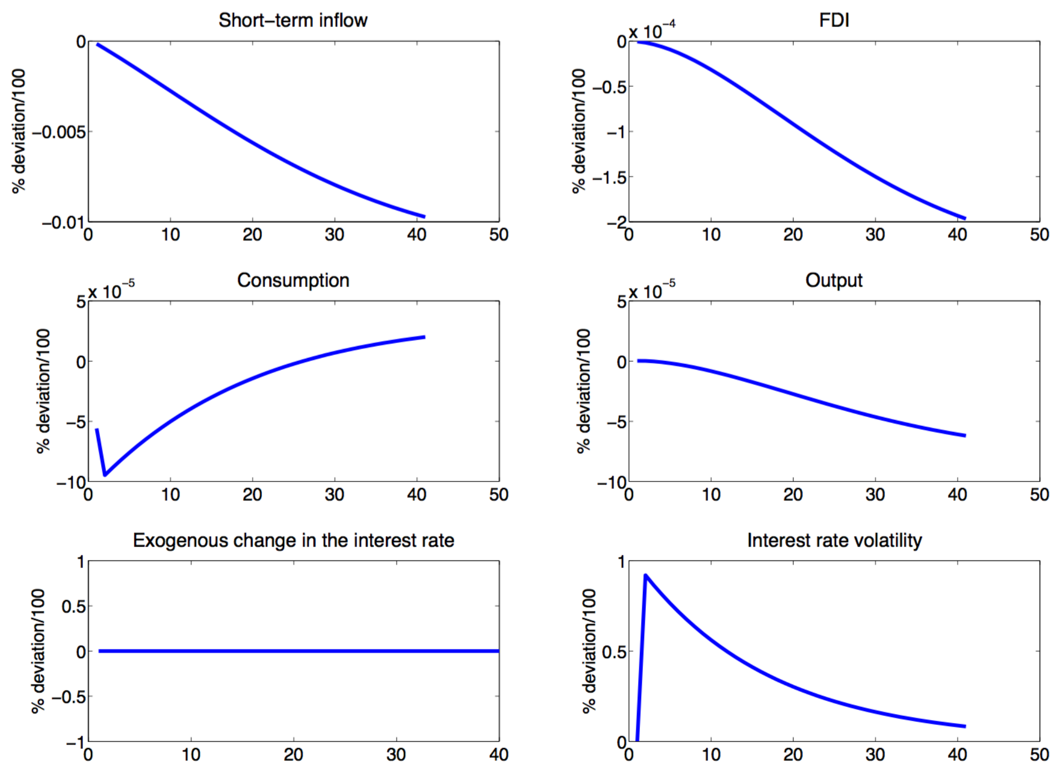
Source: Cesa-Bianchi and Fernandez-Corugedo (2014)

Figure 2.5: Model Outcome, $\phi = 0.25$



Notes: Vertical axis represents percent deviations from the steady state values. Horizontal axis represents quarters.

Figure 2.6: Model Outcome, $\phi = 0.75$



Notes: Vertical axis represents percent deviations from the steady state values. Horizontal axis represents quarters.

2.7 Appendices

Model Summary

$$1+\eta\frac{B_{*,t+1}}{P_t^*}=\beta(1+i_{t+1}^*)\mathbb{E}_t\left[\frac{P_t}{P_{t+1}}\frac{\xi_{t+1}}{\xi_t}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}\right] \tag{118}$$

$$1=\beta(1+i_{t+1})\mathbb{E}_t\left[\frac{P_t}{P_{t+1}}\left(\frac{C_{t+1}}{C_t}\right)^{-\rho}\right] \tag{119}$$

$$\frac{W_t}{P_t}=\chi\frac{L_t^{\varphi}}{C_t^{-\rho}} \tag{120}$$

$$W_t=P_{m,t}F_{L_t}(K_t^H,K_t^F,L_t) \tag{121}$$

$$\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\left(1+i_{kt+1}\right)\right]=\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\left(\frac{P_{m,t+1}F_{K_{t+1}}(K_t^H,K_t^F,L_t)+(1-\delta)Q_{t+1}}{Q_t}\right)\right] \tag{122}$$

$$1=\mathbb{E}_t\left[\frac{P_t^*}{P_{t+1}^*}\left(\frac{C_{t+1}^*}{C_t^*}\right)^{-\rho}\left(\frac{Z_{t+1}^F+(1-\delta)Q_{t+1}^F}{Q_t^F+\varsigma K_{t+1}^F}\right)\frac{\xi_t}{\xi_{t+1}}\right] \tag{123}$$

$$\mathbb{E}_t\left[\Lambda_{t,t+1}\left(1+i_{kt+1}\right)\right]=\left(1+i_{t+1}\right)\mathbb{E}_t\left[\Lambda_{t,t+1}\right] \tag{124}$$

$$\frac{Q_t}{P_t}=\frac{1}{1-f_I(\frac{I_t}{K_t^H})K_t^H}, \tag{125}$$

$$P_t^{1-\epsilon}=(1-\phi)\left(P_t^{\#}\right)^{1-\epsilon}+\phi P_{t-1}^{1-\epsilon} \tag{126}$$

$$v_t^p=(1-\phi)(\frac{P_t^{\#}}{P_{t-1}})^{-\epsilon}(\frac{P_t}{P_{t-1}})^{\epsilon}+\phi(\frac{P_t}{P_{t-1}})^{\epsilon}v_{t-1}^p \tag{127}$$

$$(K_t^H)^{\alpha_1}(K_t^F)^{\alpha_2}L_t^{1-\alpha_1-\alpha_2}=Y_tv_t^p \tag{128}$$

$$(\frac{P_t^{\#}}{P_{t-1}})^{1-\epsilon}=\frac{\epsilon}{\epsilon-1}(\frac{P_t}{P_{t-1}})\frac{X_{1,t}}{X_{2,t}} \tag{129}$$

$$X_{1,t}=(C_t)^{-\rho}P_{mt}P_t^{\epsilon-1}Y_t+\beta\phi\mathbb{E}_tX_{1,t+1} \tag{130}$$

$$X_{2,t} = (C_t)^{-\rho} P_t^{\epsilon-1} Y_t + \beta\phi \mathbb{E}_t X_{2,t+1} \tag{131}$$

$$1 + \eta \frac{B_{t+1}^*}{P_t} = \beta(1+i_{t+1})\mathbb{E}_t \left[\frac{P_t^*}{P_{t+1}^*} \frac{\xi_t}{\xi_{t+1}} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\rho} \right], \tag{132}$$

$$1 = \beta(1+i_{t+1}^*)\mathbb{E}_t \left[\frac{P_t^*}{P_{t+1}^*} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\rho} \right], \tag{133}$$

$$\frac{P_t}{\xi_t}\mathbb{E}_t \left[\varphi_2 + \eta^K \left(\frac{s_{1t+1}^*}{s_2^*} - 1 \right) \frac{s_{1t+1}^*}{s_2^*} + \frac{\eta^K}{2} \left(\frac{s_{1t+1}^*}{s_2^*} - 1 \right)^2 \right] = \mathbb{E}_t \left[\frac{P_t^*}{P_{t+1}^*} \left(\frac{C_{t+1}^*}{C_t^*} \right)^{-\rho} \left(\frac{Q_{t+1}^F}{\xi_{t+1}} - \frac{P_{t+1}}{\xi_{t+1}} \varphi_1 \right) \right] \tag{134}$$

$$K_{t+1}^* = (1-\delta)K_t^* + s_{1t}^*, \tag{135}$$

$$K_{t+1} = (1-\delta)K_t + I_t - f\left(\frac{I_t}{K_t}\right) K_t, \tag{136}$$

$$B_t^* + B_t = 0 \tag{137}$$

$$B_{*,t}^* + B_{*,t} = 0 \tag{138}$$

$$\begin{aligned} &\tfrac{C_t - RER_t C_t^*}{2} + b_{t+1} + RER_t b_{*,t+1} - \tfrac{Q_t^F K_{t+1}^F}{2P_t} \\ &\quad = \tfrac{(1+i_t)}{(1+\pi_t)} b_t + \tfrac{RER_t(1+i_t^*)}{(1+\pi_t^*)} b_{*,t} - \tfrac{Z_t^F + (1-\delta)Q_t^F}{2P_t} K_t^F + \tfrac{Q_t^H I_t - Q_t^F s_{1t}^*}{2P_t} - \tfrac{I_t - \varphi_1 s_{1t}^* - \varphi_2 s_{1t+1}^*}{2} - \tilde{d}_t \end{aligned} \tag{139}$$

$$Y_t = C_t + I_t - \frac{Q_t^F K_t^F}{P_t}, \tag{140}$$

$$Y_t^{*e} = C_t^* + \frac{P_t(\varphi_1 s_{1t}^* + \varphi_2 s_{1t+1}^* + \frac{\eta^K}{2}\left(\frac{s_{1t+1}^*}{s_2^*} - 1\right)^2 s_{1t+1}^* + \frac{\varsigma}{2}\left(K_t^F\right)^2)}{\xi_t P_t} \tag{141}$$

and domestic interest rate rule, foreign monetary rule (i.e. $P_t^* = 1$), together with an endowment process for the global investor. The 27 endogenous variables are the determined by the above system of 27 equations.

Derivation of Net Foreign Assets

Impose following equilibrium conditions to the home budget constraint:

$$T_t^f = \frac{\eta}{2}\xi_t P_t^*(\frac{B_{*,t+1}}{P_t^*})^2 + f\left(\frac{I_t}{K_t}\right)K_t,$$

$$\Pi_t = Q_t K_{t+1}^H - Q_t(1-\delta)K_t^H - P_t I_t + (P_t^\# - P_{mt})Y_t,$$

$$K_{t+1}^H = (1-\delta)K_t^H + I_t - f\left(\frac{I_t}{K_t^H}\right)K_t^H,$$

and obtain the following identity:

$$P_t C_t + B_{t+1} + \xi_t B_{*,t+1} = (1+i_t)B_t + \xi_t(1+i_t^*)B_{*,t} + W_t L_t + Q_t I_t - P_t I_t + (P_t^\# - P_{mt})Y_t. \quad (142)$$

Similarly, after imposing the following equilibrium conditions

$$T_t^f = \frac{\eta}{2}\frac{P_t}{\xi t}\left(\frac{B_{t+1}^*}{P_t}\right)^2 + \frac{P_t}{\xi_t}I_t^* + \frac{P_t}{\xi_t}\frac{\eta^K}{2}\left(\frac{s_{Jt}^*}{s_J^*} - \delta\right)^2 s_{Jt}^*,$$

$$I_t^* = \varphi_1 s_{1t}^* + \varphi_2 s_{2t}^*,$$

$$K_{t+1}^F = (1-\delta)K_t^F + s_{1t}^*,$$

global investor's budget constraint can be re-written as:

$$P_t^* C_t^* + B_{*,t+1}^* + \frac{B_{t+1}^*}{\xi_t} + P_t^*\varphi_1(s_{1t}^* + \varphi_2 s_{2t}^*) = (1+i_t^*)B_{*,t}^* + (1+i_t)\frac{B_t^*}{\xi_t} + Q_t^* s_{1t}^* + Y_t^{e*}. \quad (143)$$

Impose further the security market clearing conditions:

$$\begin{aligned} B_t^* + B_t &= 0 \\ B_{*,t}^* + B_{*,t} &= 0 \end{aligned} \quad (144)$$

and multiply (143) with ξ_t, subtract it from (142) to obtain the emerging market economy's net foreign asset accumulation as a function of interest income on securities and of the cross-country differentials between gains and costs of investment, consumption, and other income $(\tilde{d}_t)$:

$$\frac{C_t - RER_t C_t^*}{2} + b_{t+1} + RER_t b_{*,t+1} - \frac{Q_t^F K_{t+1}^F}{2P_t}$$
$$= \frac{(1+i_t)}{(1+\pi_t)} b_t + \frac{RER_t(1+i_t^*)}{(1+\pi_t^*)} b_{*,t} - \frac{Z_t^F + (1-\delta)Q_t^F}{2P_t} K_t^F + \frac{Q_t^H I_t - Q_t^F s_{1t}^*}{2P_t} - \frac{I_t - \varphi_1 s_{1t}^* - \varphi_2 s_{1t+1}^*}{2} - \tilde{d}_t \quad (145)$$

with $\tilde{d}_t = \frac{w_t L_t + Y_t(1 - RP_{mt} v_t^p) - RER_t Y_t^{e*}}{2}$.

Vita

Galip Kemal Ozhan will be joining University of St. Andrews in September 2016 after completing his Ph.D. in Economics at the University of Washington. He was a research associate at the Brookings Institution from January 2012 to September 2013. He holds an M.Sc. in Finance from Imperial College London, and an M.A. in Economics and a B.Sc. in Industrial Engineering from Bilkent University. His main research interests are in international finance, macroeconomics, and monetary economics.