Staff Working Paper/Document de travail du personnel — 2021-66

Last updated: December 23, 2021

News-Driven International Credit Cycles

by Galip Kemal Ozhan

Canadian Economic Analysis Department
Bank of Canada, Ottawa, Ontario, Canada K1A 0G9

kozhan@bankofcanada.ca

ISSN 1701-9397

Acknowledgements

I would like to thank Oliver de Groot, Fabio Ghironi, and an anonymous referee for comments and suggestions. I also thank seminar and conference participants at the Bank of Lithuania and University of Liverpool–Journal of Macroeconomics Conference on Monetary Policy for discussions. This paper supersedes the August 2017 "Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence." All remaining errors are mine.

Abstract

How does news about future economic fundamentals affect within-country and cross-country credit allocation? How effective is unconventional policy when financial crises are driven by unfulfilled favorable news? I study these questions by employing a two-sector, two-country macroeconomic model with a financial sector in which financial crises are associated with occasionally binding leverage constraints. In response to positive news on the valuation of non-traded sector capital that turns out to be incorrect at a later date, the model captures the patterns of financial flows and current account dynamics in Spain between 2000-2010, including the changes in the sectoral allocation of bank credit and movements in cross-country borrowing during the boom and the bust. When there are unconventional policies by a common authority in response to unfulfilled favorable news, liquidity injections perform better in ameliorating the downturn than direct assets purchases from the non-traded sector.

Topics: Credit and credit aggregates; Economic models; Financial stability; Sectoral balance sheet; Recent economic and financial developments

JEL codes: E44, F32, F41, G15, G21

1 Introduction

The consensus narrative of the economic crisis in the eurozone in the 2000s is that it was a "sudden stop" crisis (Baldwin and Giavazzi, 2015). Bank credit expanded massively in the European periphery with the announcement of the euro, which was fed by foreign borrowing by financial institutions (see Giavazzi and Spaventa (2010)). A major slice of these loans were toward the non-traded sectors of the economy (among others, see Ozhan (2020)). The surge in capital flows ended with the Global Financial Crisis (GFC), which is linked with a loss of confidence. Capital flows reversed, bank balance sheets shrank, investment and output collapsed, and credit spreads of non-financial firms rose steeply.[1]

Economists and policymakers often conjecture that the surge in borrowing and expansion of output in the aftermath of the inauguration of the euro resulted from expectations of a future favorable state of the economy related with the entry in the eurozone (Blanchard (2006), Blanchard and Giavazzi (2002), and Constâncio (2005)).[2] Indeed, several empirical studies indicate that an increase in firm valuations started after the European Council's decision in 1998 with the announcement of the news about which countries were allowed to enter the final phase of Europe's Economic and Monetary Union (EMU) (see Bris, Koskinen, and Nilsson, 2009, 2012), before the inauguration of the euro. The results are stronger for firms in construction and service industries than for those in manufacturing. Regarding the divergence of valuations between sectors, Santos (2014) argues that the close link between politicians and financial institutions led to a belief in public that non-traded sectors will gain more from the benefits of the single currency as it is easier for politicians to be reelected by riding short-term prosperity delivered from non-traded sectors.

Against this background, I present an open economy model of financial intermediation in which I study financial crises associated with occasionally binding leverage constraints. The model follows the structure of Ozhan (2020). Financial intermediaries extend credit to domestic traded and non-traded non-financial sectors, and borrow from both domestic and international markets. The ability of intermediation is limited due to a moral hazard problem that places an endogenous restriction on bank leverage ratios. The key difference from Ozhan (2020) is the non-linear model solution

[1] See Gilchrist and Mojon (2014) for the credit risk indicators for the euro area.

[2] Blanchard and Giavazzi (2002) argue that the countries that experienced the ERM crisis of 1992-93 perceived adoption of the single currency as elimination of future crises.

that allows for the endogenous leverage constraints to be occasionally binding depending on the level of net worth of financial intermediaries. I also focus on news about economic fundamentals as the key source of fluctuations (in contrast with Ozhan (2020)). Specifically, optimistic news on the valuation of non-traded sector assets triggers the boom part of the cycle, and later unfulfillment of this optimism induces the bust. Hence, the boom-bust period is expectation-driven.[3]

A calibrated version of the model reasonably captures the pattern of the changes in the current account and the asymmetric boom and the bust in bank credit in Spain between 2000-10. Following a positive news shock on the future value of non-traded sector assets, the model generates a skewed allocation of bank credit and investment toward non-traded sectors with a persistent and climbing current account deficit. When expectations are not met, private capital flows suddenly reverse, aggregate output and bank credit collapse with a jump in borrowing costs of non-financials. A huge correction in the current account takes place. The disproportionate allocation of foreign borrowing toward the non-traded sectors makes the external accounts more stringent, because past foreign liabilities do not match with expected surpluses.

To disentangle the contribution of bank balance sheets and cross-country capital flows, I further compare the baseline model with two other model versions: the version with perfect intermediation and the version with international financial autarky.[4] Comparison of model versions with banks and lack thereof shows that inclusion of banks does not matter significantly in the boom regime. Bank net worth is sufficiently high in good times and the financial frictions do not apply in these periods. However, when expectations turn out to be incorrect, in the version with financial frictions, sudden reversal of capital flows brings the economy into the financial crisis regime (*i.e.*, banks' constraints start to bind). Under binding constraints, bank balance sheets transmit fluctuations across sectors and spread the recession to the overall economy, although the boom regime was mainly driven by the non-traded sector. I call this the *intra*-national spillover channel. When I compare the baseline model with the version under international financial autarky, I show that the cross-country capital flows contribute significantly to the dynamics both during the boom and the bust regimes. Bank

[3]This mechanism is closely related with Keynes's (1936) notion of animal spirits as it relates to waves of beliefs about the future states of the economy to main drivers of the fluctuations.

[4] It is not possible to disentangle these channels under financial shocks, which are the main drivers of fluctuations in Ozhan (2020). When leverage constraints are slack, there is no effect of a financial shock on model dynamics.

balance sheets get larger in the case of international integration, and the leverage constraints are more effective in generating financial amplification and the intra-national spillover. It is also important to note that the deviation in the uncovered interest parity condition due to financial imperfections is key to generate data-consistent dynamics in the baseline version.

I study unconventional policy in the form of direct asset purchases from non-financials and/or liquidity injections to the banking sector. First, the model does a quantitatively better job in capturing the bust periods when policy is in place, suggesting that the European Central Bank's (ECB's) response to the early phase of the eurozone crisis was effective. Under policy, the correction in the current account is milder because private outflows are replaced by public inflows. Second, the model also suggests that liquidity facilities directed toward the banking sector perform better at ameliorating the downturn than direct asset purchases. The reason that liquidity injections are more effective is due to the occasionally binding constraints that push the spreads between lending and borrowing rates up when there is dissappointment in positive news. Positive spreads enable the government to lend to financial intermediaries at a penalty rate, and the proceedings from government lending are effectively distributed between the sectors (in contrast to purchasing assets only from the non-traded sector).

The main contributions of this paper are as follows. The first contribution is providing a quantitative, model-based analysis of a news-based assessment of the eurozone boom-bust cycle. In a concurrent work, Siena (2021) studies the role of news shocks in generating current account deficits abstracting from financial frictions. This paper also studies the regime switching between the build-up of imbalances and the crisis, instead of studying only the boom regime.[5]

The second contribution of this paper is disentangling the role of bank balance sheets and international financial integration in transmission of news shocks under occasionally binding constraints. Görtz et al. (2021) highlight the amplified effects of news shocks by financial frictions. In this paper, I further study how unmaterialized news can bring the economy into the crisis regime and show the quantitative contribution of the international capital account in generating this outcome. The literature on news-driven business cycles also faced major challenges in generating empirically

[5]The literature focusing on the eurozone crisis also mostly conducts analysis with financial and productivity shocks and abstracts from a microfounded financial sector. Jaccard and Smets (2020) focus on common shocks in a parameter-wise asymmetric two-country model to study eurozone current account imbalances. Gopinath et al. (2017) study the impact of capital flows on firms within the manufacturing sector in Spain. Moreover, Coimbra (2010), Ferrero (2014), and Reis (2013) introduce models with exogenous finacial frictions.

plausible co-movement of aggregate variables within the economy.[6] 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.

The third contribution is studying unconventional policies in response to unfulfillment of favorable news. To the best of my knowledge, there is no paper that studies the effects of unconventional policies under such a scenario.[7] I also compare liquidity injections from direct asset purchases. Another paper that compares these two unconventional policies is Ozhan (2020). He finds that asset purchases are more favorable to liquidity injections when crises are associated with tightening of financial constraints. This paper shows that opposite results may emerge when crises are associated with occasionally binding constraints.

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 discusses the outcome of the model without policy, when calibrated to a standard open economy. Section 4 describes the policy authority's unconventional policy and discusses its results. Section 5 concludes.

2 The Model

The core framework is a two-sector, two-country model with international incomplete markets. To this end, the core of the model resembles Benigno and Thoenissen (2008) and Corsetti et al. (2008). Law of one price holds. Home bias in preferences and the existence of non-traded sector imply deviations from purchasing power parity and therefore real exchange rate fluctuations.

To this setting, I add financial intermediaries that transfer funds between households (savers) and non-financial firms (borrowers). Financial intermediaries obtain deposits from households in both countries, and they extend credit to domestic traded and non-traded sectors. Bankers' ability of intermediation is limited due to a moral hazard problem, which will be explained in detail in the following sections.

There are six types of agents in each county: households, financial intermediaries, non-financial goods producers in traded and non-traded sectors, and producers of sector specific capital. More-

[6] For the literature on news-driven business cycles, see Beaudry and Portier (2004), Christiano, Ilut, Motto, and Rostagno (2008), Jaimovich and Rebelo (2009), Kanik and Xiao (2014), Lambertini, Mendicino, and Punzi (2013). For a comprehensive review, see Beaudry and Portier (2014) and references therein.

[7] In introducing unconventional policies, I follow the seminal papers of Gertler and Karadi (2011 and 2013) who study unconventional policies in a closed economy. Dedola, Karadi, and Lombardo (2013) study cooperation of unconventional policies across the border in a single-good model.

over, there is a policy authority that conducts unconventional policy. For the ease of notation, I avoid individual specific indexing except in the banking sector.

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

2.1 Households

There is a continuum of atomistic households that have three types of members. In each country, a fraction g of households are bankers, and $1-g$ workers who supply labor to traded and non-traded sectors. Bankers raise funds from the households that they are not related with only by offering non-contingent risk-less short-term debt (deposits). There is also perfect consumption insurance within the household.

Over time, an individual can switch occupation every period with constant probability, $1-\gamma$. Therefore, every period, $(1-\gamma)g$ bankers exit and a similar number of workers become bankers. Exiting bankers leave the earnings to the household that they belong to, and the household provides start-up funds to new bankers.

The whole family jointly maximizes an inter-temporal utility function that derives utility from the household's consumption of a 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:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{C_t^{1-\rho}}{1-\rho} - \varpi \left(\frac{L_{T,t}^{1+\varphi_1}}{1+\varphi_1} + \frac{L_{NT,t}^{1+\varphi_2}}{1+\varphi_2} \right) \right) \tag{1}$$

with $0 < \beta < 1$ and $\chi, \varphi_1, \varphi_2 > 0$.

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

$$C_t = \left[a_T^{1/\kappa} C_{T,t}^{(\kappa-1)/\kappa} + (1-a_T)^{1/\kappa} C_{NT,t}^{(\kappa-1)/\kappa} \right]^{\kappa/(\kappa-1)}, \tag{2}$$

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 intra-temporal 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:

$$C_{T,t} = \left[a_H^{1/\omega} C_{H,t}^{(\omega-1)/\omega} + (1-a_H)^{1/\omega} C_{F,t}^{(\omega-1)/\omega}\right]^{\omega/(\omega-1)}, \tag{3}$$

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 intra-temporal elasticity of substitution between Home and Foreign goods, and there is home-bias in consumption if $a_H > \frac{1}{2}$.

Households hold one-period deposits from domestic and foreign banks. 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.[8] 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 Home consumption) is

$$\begin{aligned} &C_t + B_{t+1} + \xi_t B_{*,t+1} + \tfrac{\eta}{2}\xi_t (B_{*,t+1})^2 \\ &\quad = (1+r_t)B_t + \xi_t(1+r_t^*)B_{*,t} + w_{T,t}L_{T,t} + w_{NT,t}L_{NT,t} + \Pi_{T,t} + \Pi_{NT,t} + \Pi_{B,t} + T_t^{f*} + T_t, \end{aligned} \tag{4}$$

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 fluctuations. $\Pi_{T,t}$, $\Pi_{NT,t}$, and $\Pi_{B,t}$ represent the profits back to household by traded and non-traded sector workers and bankers, respectively.

Home households maximize (1) subject to (4). The Euler equations for deposit holdings at Foreign and Home banks are

$$C_t^{-\rho}\left[1 + \eta B_{*,t+1}\right] = \beta(1+r_{t+1}^*)\mathbb{E}_t\left[\frac{\xi_{t+1}}{\xi_t} C_{t+1}^{-\rho}\right], \tag{5}$$

[8] 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.

$$C_t^{-\rho} = \beta(1 + r_{t+1})\mathbb{E}_t \left[C_{t+1}^{-\rho} \right]. \tag{6}$$

With $\eta > 0$, the no-arbitrage condition implies:

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

Real wages are equal to the marginal rate of substitution between consumption and leisure:

$$w_{T,t} = \frac{\varpi L_{T,t}^{\varphi_1}}{C_t^{-\rho}}, \quad w_{NT,t} = \frac{\varpi L_{NT,t}^{\varphi_2}}{C_t^{-\rho}}. \tag{7}$$

From (2) and (3), I derive the standard demand curves for traded Home goods as follows:

$$C_{H,t} = a_H \left(\frac{RP_{H,t}}{RP_{T,t}} \right)^{-\omega} C_{T,t} \quad and \quad C^*_{H,t} = (1 - a_H) \left(\frac{RP_{H,t}}{\xi_t RP^*_{T,t}} \right)^{-\omega} C^*_{T,t}, \tag{8}$$

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 curves for Home non-traded and composite traded goods are as follows:

$$C_{NT,t} = (1 - a_T) (RP_{NT,t})^{-\kappa} C_t \quad and \quad C_{T,t} = a_T (RP_{T,t})^{-\kappa} C_t. \tag{9}$$

2.2 Financial intermediaries

Financial intermediaries lend to domestic firms operating in traded and non-traded sectors and obtain funds from both Home and Foreign households. Moreover, intermediaries can extend lending by using their own net worth, which is accumulated through their earnings.

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. Let $S_{T,t}(j)$ and $S_{NT,t}(j)$ be the amount of state-contingent claims of bank j from traded and non-traded sectors. $Q_{i,t}$ is the relative price of each claim. $B_{t+1}(j)$ and $B^*_{t+1}(j)$ are deposits, which the intermediary obtains from Home and Foreign households. $N_t(j)$ is the net worth of the intermediary at the end of period t.

The intermediary balance sheet takes the following form:

$$\underbrace{Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j)}_{\text{Assets}} = \underbrace{B_{t+1}(j) + B^*_{t+1}(j)}_{\text{Liabilities}} + \underbrace{N_t(j)}_{\text{Net worth}} \tag{10}$$

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:

$$N_t(j) = (1+r_{k,T,t})Q_{T,t-1}S_{T,t-1}(j) + (1+r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j) - (1+r_t)\left(B_t(j) + B^*_t(j)\right) \tag{11}$$

The bankers' objective is to maximize their terminal net worth before they exit:

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

As in Gertler and Karadi (2011), Gertler and Kiyotaki (2010), and earlier in Holmström and Tirole (1997), there exists an agency problem between banks and households. After collecting deposits, banks can run away with the funds. In this case, it is possible to 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.

Let $V_t(N_t(j))$ be the maximized value of V_t, given banks' period retained earnings. The following incentive constraint prevents bankers from diverting their assets:

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t}S_{T,t}(j) + \lambda_{NT}Q_{NT,t}S_{NT,t}(j). \tag{12}$$

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.

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

$$V_{t-1}(N_{t-1}(j)) = \mathbb{E}_{t-1}\left[\beta\Lambda_{t-1,t}\left\{(1-\gamma)\,N_t(j) + \gamma\left(Max_{S_{T,t},S_{NT,t}}\left(Max_{B_{t+1},B^*_{t+1}}V_t(N_t(j))\right)\right)\right\}\right] \tag{13}$$

subject to (10), (11), and (12).

I make a guess 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 conditions for the intermediary's problem lead to:

$$\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,T,t+1} - r_{t+1})\right] = \mu_t\lambda_T, \tag{14}$$

$$\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,NT,t+1} - r_{t+1})\right] = \mu_t\lambda_{NT}, \tag{15}$$

with

$$\mu_t = max\left\{1 - \left(\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1 + r_{t+1})\right]N_t}{\lambda_T Q_{T,t}S_{T,t} + \lambda_{NT}Q_{NT,t}S_{NT,t}}\right), 0\right\}, \tag{16}$$

where 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.[9]

When the bankers' incentive constraint does not bind, $\mu_t = 0$, they acquire deposits until the discounted cost of deposits is equal to the gain from lending to non-financial firms. The difference between non-tradable sector and tradable sector firm financing disappears. When $\mu_t > 0$, the spreads between the gains from lending to non-financial firms and the cost of borrowing from households are positive in equilibrium, and they are scaled by the divertable proportion of assets in each sector.

The linear value function implies that the incentive constraint can be expressed in the following form:

$$\frac{Q_{T,t}S_{T,t}(j) + \frac{\lambda_{NT}}{\lambda_T}Q_{NT,t}S_{NT,t}(j)}{N_t(j)} \leq \frac{\nu_t}{\lambda_T}. \tag{17}$$

The above constraint implies that the total amount of lending to non-financial firms is limited by the intermediary's net worth. The ease of divertibilty also depends on the asset class and is captured by the $\frac{\lambda_{NT}}{\lambda_T}$ term.

Finally, we learn that the marginal value of an additional bank net worth is as follows:

$$\nu_t = \frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1 + r_{t+1})\right]}{1 - \mu_t}. \tag{18}$$

[9] A detailed solution of the banker's problem can be found in the online appendix.

2.2.1 Aggregation

Aggregating the leverage constraint in (17), I obtain:

$$\frac{Q_{T,t}S_{T,t}+\frac{\lambda_{NT}}{\lambda_T}Q_{NT,t}S_{NT,t}}{N_t}\leq\frac{\nu_t}{\lambda_T}. \tag{19}$$

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

$$N_t = N_{x,t}+N_{n,t}, \tag{20}$$

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 the previous period net of the cost of deposits, with a continuation probability of γ:

$$N_{x,t}=\gamma\left[(1+r_{k,T,t})Q_{T,t-1}S_{T,t-1}+(1+r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j)-(1+r_t)\left(B_t+B_t^*\right)\right]. \tag{21}$$

New bankers receive start-up funds from their own household. 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 be transferred to entering bankers within the same household, and then new banker net worth becomes:

$$N_{n,t}=\varepsilon\left[(1+r_{k,T,t})Q_{T,t-1}S_{T,t-1}+(1+r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j)\right]. \tag{22}$$

Using equation (20), we have:

$$\begin{aligned} N_t = \quad & (\gamma+\varepsilon)\left[(1+r_{k,T,t})Q_{T,t-1}S_{T,t-1}+(1+r_{k,NT,t})Q_{NT,t-1}S_{NT,t-1}(j)\right] \\ & -\gamma\left(1+r_t\right)\left(B_t+B_t^*\right). \end{aligned} \tag{23}$$

A change in the valuation of capital in one sector affects bank net worth not only directly, but also indirectly through its impact on the returns from the other sector. The latter is at work through equations (14) and (15), causing a stronger accelerator mechanism than in standard models.

2.3 Firms

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

2.3.1 Goods Producers

Goods are produced under perfect competition in both sectors. The production technology at time t is a Cobb-Douglas function that combines capital and labor:

$$Y_{i,t} = F(K_{i,t}, L_{i,t}) = (e^{\psi_{i,t}} K_{i,t})^{\alpha} {L_{i,t}}^{1-\alpha} \quad i \in \{T, NT\}, \tag{24}$$

where T denotes the tradable sector variables, and NT denotes non-tradable sector counterparts. $e^{\psi_{i,t}}$ denotes a capital quality shock in sector i that follows a log-normal processes. This shock can be thought of as capturing some form of increase in valuation or obsolescence, in good and bad times, respectively.

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 price of a unit of capital Q_t. By the assumption of no-arbitrage, the value of claims issued should be equal to the value of capital bought by non-financials:

$$Q_{i,t} K_{i,t+1} = Q_{i,t} S_{i,t} \quad i \in \{T, NT\}. \tag{25}$$

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:

$$Z_{i,t} \equiv \frac{RP_{ii,t} Y_{i,t} - w_{i,t} L_{i,t}}{K_{i,t}} = RP_{ii,t} F_{K_{i,t}}(K_{i,t}, L_{i,t}), \tag{26}$$

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

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:

$$w_{i,t} = RP_{ii,t} F_{L_i}(K_{i,t}, L_{i,t}). \tag{27}$$

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

Banks can perfectly monitor and evaluate the non-financial firms, and hence, every financial contract between the non-financials and banks delivers on 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 payoffs of capital in tradable and non-tradable sectors are:

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(1 + r_{i,k,t+1} \right) \right] = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{Z_{i,t+1} + (1-\delta) e^{\psi_{i,t+1}} Q_{i,t+1}}{Q_{i,t}} \right) \right], \tag{28}$$

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

2.3.2 Capital Producers

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:

$$K_{i,t+1} = (1-\delta) e^{\psi_{i,t}} K_{i,t} + I_{i,t} - f\left(\frac{I_{i,t}}{e^{\psi_{i,t}} K_{i,t}}\right) e^{\psi_{i,t}} K_{i,t} \quad i \in \{T, NT\}, \tag{29}$$

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

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

$$Q_{i,t} = \frac{1}{1 - f_I\left(\frac{I_{i,t}}{e^{\psi_{i,t}} K_{i,t}}\right) e^{\psi_{i,t}} K_{i,t}}. \tag{30}$$

There is a net profit transfer from capital producers and banks to the parent household. Profit transfers affect the household's budget constraint in equilibrium and therefore the determination of the law of motion of net foreign assets.[10]

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

2.4 Equilibrium

Market clearing conditions in securities, deposits, goods, and labor markets are required to close the model.

Market clearing for securities imply that the total supply of firm securities should be equal to the total amount of capital bought within the respective sectors, as given in (25).

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:

$$B_{t+1} + B^*_{t+1} = Q_{T,t}S_{T,t} + Q_{NT,t}S_{NT,t} - N_t. \tag{31}$$

And, labor demand equals sectoral labor supply, implying:

$$RP_{ii,t}(1-\alpha)(e^{\psi_{i,t}}K_{i,t})^{\alpha}{L_{i,t}}^{-\alpha} = \varpi \frac{L^{\varphi}_{i,t}}{C_t^{-\rho}}. \tag{32}$$

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

$$Y_{T,t} = C_{H,t} + C^*_{H,t} + I_{T,t} \quad and \quad Y_{NT,t} = C_{NT,t} + I_{NT,t}. \tag{33}$$

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 the online appendix.

The equations (5, 6, 7, 8, 9, 14, 15, 16, 18, 23, 24, 25, 26, 27, 28, 29, 30, 31, 33) together with respective price equations, and their Foreign counterparts, in which (24, 25, 26, 27, 28, 29, 30) 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 ($I_{T,t-1}$, $I_{NT,t-1}$, $K_{T,t}$, $K_{NT,t}$, $(1+r_t)B_t$, $(1+r_t)B_{*,t}$, $e^{\psi_{T,t}}$, $e^{\psi_{NT,t}}$)

and their Foreign counterparts, together with the exogenous shock processes. A summary of the equilibrium conditions is available in Table 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.

3.1 Calibration

To begin with the conventional parameters, I set the depreciation rate, δ, the capital share, α, and households' discount factor, β, to their standard values in the literature. I set them to 0.025, 0.333, and 0.995, respectively. With 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 fluctuations are transitory.[11] Moreover, in line with the RBC literature, I set the inverse of the inter-temporal elasticity of substitution from consumption, ρ, to 2, and follow Gertler and Karadi (2011) to set the inverse of the Frisch elasticities in traded and non-traded sectors, φ_1 to 0.276, and φ_2 to 0.276. I 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.

I again use the conventional values in the literature regarding the parameters that are important for international dynamics. I set the elasticity of substitution between Home and Foreign produced traded goods, ω, to 1.2 as in Ghironi (2006) among others, and I follow Obstfeld and Rogoff (2000) to set the elasticity of substitution between traded and non-traded goods in the assembly of final consumption good, κ, to 1. In line with the eurozone data, I set the share of home-produced intermediate inputs in the tradable intermediate input, a_H, to 0.55, and the share of tradables in the final consumption, a_T, to 0.55.

Regarding the financial sector parameters, the moral hazard parameters, λ_T and λ_{NT} are sector

[11] Although my goal is to minimize such exogenous costs associated with cross-border deposit holdings, it is important to highlight that making deposits "sticky" by increasing the adjustment parameter would imply milder reversal of capital flows in crisis regimes. This, in turn, would imply a less pronounced exchange rate depreciation during the crises. I thank an anonymous referee for highlighting this point.

specific, and they capture the heterogeneity between the traded and non-traded sector claims. Following Ozhan (2020) and Müller and Verner (2021), I pick these parameters to verify the higher financial fragility related with lending to non-tradable sectors.[12] I pick these parameters to hit the following targets: a home steady state interest rate spread in the non-tradable sector of 50 bps and a steady state interest rate spread in the tradable sector of 40 bps.[13] The model dynamics are not crucially dependent on the choice of these parameters.[14] I use the steady state leverage ratios that are in the range of used values in the literature and set them to 4 and 6 for Home and Foreign. 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, my choices of the proportional transfers to entering bankers, ε, and the survival probability of bankers, γ, are in line with the literature. I set ε to 0.0001 and I follow Gertler and Kiyotaki (2010) to set an average horizon of 10 years for bankers, fixing γ to 0.975.

Table 2 summarizes the parametrization of the model.

3.2 Belief-Driven Dynamics

In what follows, I will discuss the performance of the model with respect to its abilities of capturing the Spanish data, and I will identify the underlying channels at work by comparing dynamics of several layers of the model.

3.2.1 Specification

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

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

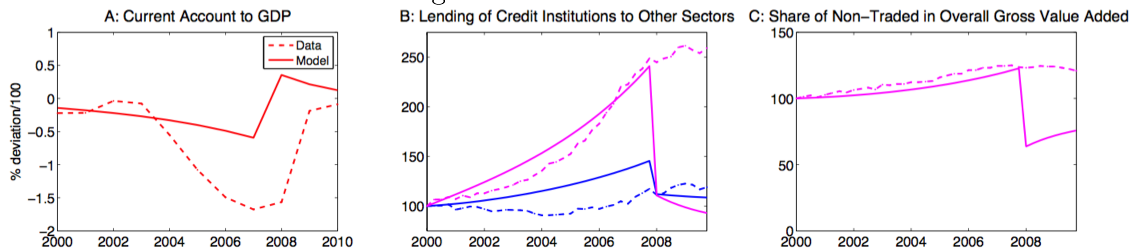
where $\varepsilon_{i,t}$ represents a white noise error in forecasting $\psi_{i,t}$ that is based on its own past. $u^A_{i,t-n}$ is a news shock about $\psi_{i,t}$ that is revealed n periods beforehand, and $u^U_{i,t}$ is the unanticipated component

[12] Ozhan (2020) argues that it is harder for banks to monitor assets in non-traded sectors due to intensive securitization. Müller and Verner (2021) empirically show that credit expansions toward the non-tradable sectors are associated with a higher likelihood of future systemic banking crises, highlighting the severity of financial frictions related with these sectors.

[13] Due to limited access to sector specific credit spread data, my choice is suggestive.

[14] Qualitative properties of the main results are the same. As will be discussed in more detail in Subsection 3.2.3, the ratio of λ_T/λ_{NT} alters the magnitude of the transmission of fluctuations from non-traded to traded sectors through the bank balance sheet. The transmission mechanism is at work independent of the set values for λ_{NT} and λ_T. See also Ozhan (2016).

Figure 1: Model and data



of the white noise. 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 (unexpectedly) not realized. In line with my motivation from the recent boom-bust period in Spain, 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 only expectation-driven.

3.2.2 Model Performance

I compare the model dynamics with the Spanish data.[15] I adjust the expected valuation in assets to match the cumulative changes in each sector's Tobin's Q in the model to the cumulative increase in price-to-book-ratios of the industrial firms listed in the IBEX35 index between 1999:QIV and 2008:QI.[16] The adjustment implies 14.98 percent and 7.34 percent increase in expected valuations in non-traded and traded sector assets, respectively.[17,18]

Figure 1A plots Spain's current account-to-GDP ratio over the period 1999:IV to 2010:I versus the model outcome, and Figure 1B does the same for the credit extended to tradable and non-

[15] I solve the model following Guerrieri and Iacoviello (2015) method that links the first-order approximation of the model around the same steady state under both boom and bust regimes. Online appendices compare the model solution under occasionally binding constraints vs. under always binding constraints. As can be seen there, the non-linear model solution is crucial for capturing reasonable boom regime dynamics.

[16] 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 show 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 are available). I used the 2008 shares of these firms in the overall IBEX35 index when calculating cumulative changes.

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

[18] 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 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).

tradable sectors. Figure 1C compares the share of non-traded sectors in overall gross value added versus the model counterparts.[19] In Figure 1A, I normalize the steady state current account-to-GDP ratio to the 1995-2014 average. In Figure 1B and 1C, dynamics show the increase in levels starting from the year 2000 (normalized at 100). The anticipation of an increase in the value of capital drives country borrowing and generates an expansion in the credit extended to the non-traded sector. 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. When I introduce policy into the model in the next section, the model does a better a job in capturing the post-crisis period, suggesting that one of the missing elements in the bust regime is the policy intervention. The model is, again, doing well in capturing the relative growth in the non-traded sector until 2008. A collapse in non-traded sector funding after the unfulfillment of expectations shrinks the non-traded portion of the economy faster in the model. Again, as is shown in the next section, after introducing policy interventions, the bust regime dynamics are milder in the model.

3.2.3 Three Model Versions

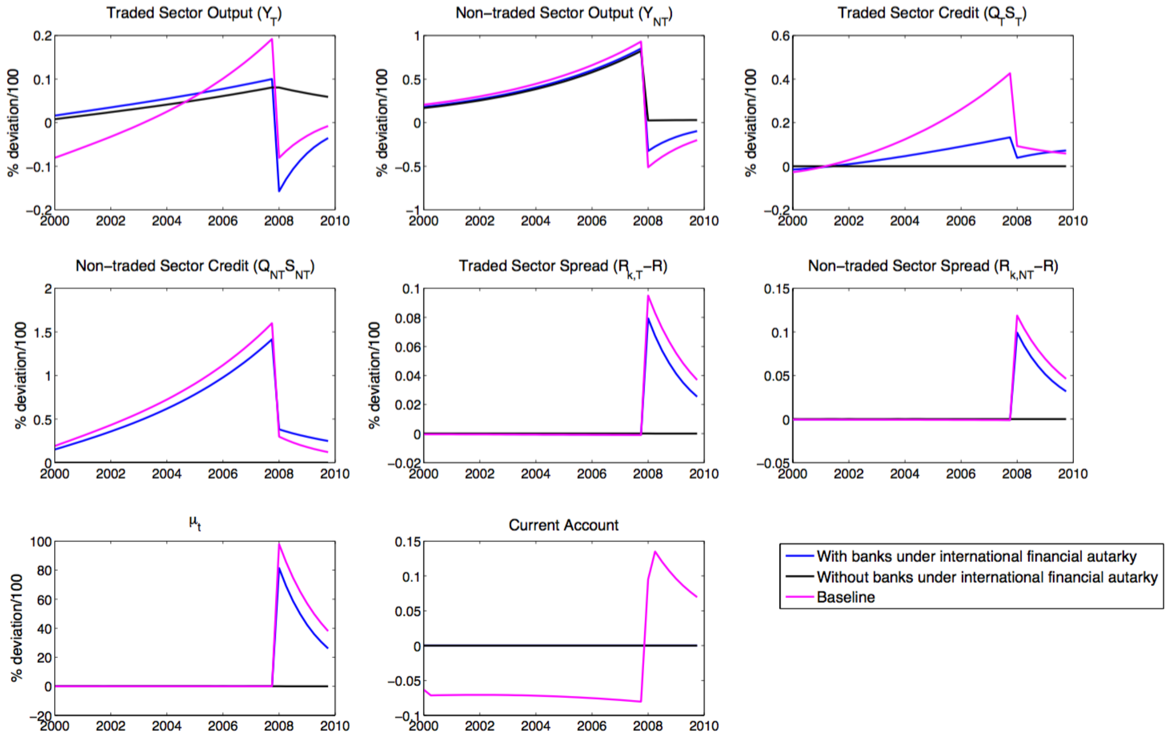
To identify the channels of shock transmission, I build up the final model through three layers. The first layer is a standard two-sector, two-country model, in which there is no international financial asset trade (*i.e.,* version I). This layer is able to demonstrate some principles of belief-driven fluctuations when international financial markets are incomplete, such as low international consumption correlations, and the wealth effect driven changes in import demand.[20] Then, I introduce financial intermediaries in the second layer to separate the impact of state-dependent financial frictions (*i.e.,* version II). Finally, in the last layer, I include the integration of deposit markets to understand the role played by capital flows (*i.e.,* baseline model).

Figure 2 compares all three versions of the model. Black lines represent the dynamics from version I, and blue lines indicate dynamics from version II. Purple lines are representative for

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

[20] In models with a 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).

Figure 2: Comparison of model versions under international financial autarky and no banking



the baseline model. Boom regime dynamics from version I and II are similar. Banks' leverage constraint does not bind and there are no domestic financial imperfections under model versions I and II. There is also balanced international trade in these versions, and the current account is always zero. There is slightly more pronounced boom in both tradable and non-tradable output until 2008 under version II (with respect to version I). This is because banks lend combining deposits with their net worth in financing investment, whereas there is no bank net worth under model version I.

Bust regime dynamics from versions I and II show stark differences. When optimistic expectations are not met, the economy switches into the crisis regime under version II. There is a collapse in bank net worth and the banks' contraint starts to bind. This 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 in one-sector models, implying a stronger accelerator effect. Furthermore, the fall in tradable sector output is more pronounced in version II. The reason is that the immediate response of the traded sector downturn is combined with a spillover effect that arises when leverage constraints bind. Rewriting equation (19) in the bust regime (when the incentive constraint binds) 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 greater magnitude. The collapse in the non-traded sector asset prices leads to a fall in bank net worth, and then to a further collapse in traded sector asset prices. An *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 smaller the ratio of divertability of non-traded sector assets to divertability of traded sector assets, the stronger is the intra-national spillover effect (from non-traded to traded sectors).

When I compare version II with the baseline, it is easily noted that both the boom and the bust regime dynamics are more pronounced when there is international financial integration through bank deposits. Expansion in foreign liabilities in response to favorable news translates into a further expansion of credit toward tradable and non-tradable non-financial sectors. Expansion in the Home economy decreases domestic price levels, and a persistent appreciation in the real exchange rate contributes to a persistent and climbing current account deficit. The disappointment in expectations causes a sudden reversal of capital flows and switches the economy into the crisis regime. Bank credit to traded and non-traded non-financials collapses in a more pronounced manner as the borrowing costs jump higher in this case. An *international spillover channel* arises. Sudden reversals of capital flows imply a tighter leverage constraint, and the amplification mechanism is stronger in this case. In addition, 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 collapses and the Home economy experiences a persistent recession. The real exchange rate depreciates severely, and the current account sharply corrects itself.

4 Unconventional Policies

A policy authority can increase the demand on non-financial private sector assets or inject liquidity to the banking sector to overcome the restriction on the size of banks' portfolio of assets over their internal equity.

For the policy intervention to be effective, it has to *ex-ante* justify its relative advantage in transferring resources with respect to a no intervention case when banking sector frictions apply. One way of doing this is by introducing a privileged policy authority in raising funds in bad times for its policy applications.[21] I also assume that the policy authority always honors its debt and can raise funds by issuing interest bearing short-term claims to private financial intermediaries.[22] The relative efficiency of the policy authority in intermediation during the bust regime makes the unconventional policy non-neutral.[23] There is limitation for Home banks to raise funds from households to finance the global policy authority'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 Home banks' ability to divert ECB assets in such an occasion. It is a realistic case, as there were policy discussions about the potential exit of Greece from the eurozone during the crisis.

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

4.1 Asset Purchases

The ECB initiated its private asset purchase program in the aftermath of the crisis to fight the downturn in periphery countries. Their policies mainly targeted non-traded sector assets.[24] Against this background, the global policy authority in this model 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 (*i.e.*, $S^g_{T,t} \equiv \varphi^{ump}_{T,t} S_{T,t}$, or $S^g_{NT,t} \equiv \varphi^{ump}_{NT,t} S_{NT,t}$). The private assets intermediated by the financial intermediaries are denoted by $S^p_{T,t}$ and $S^p_{NT,t}$, and hence $S^p_{T,t} \equiv (1 - \varphi^{ump}_{T,t}) S_{T,t}$, and $S^p_{NT,t} \equiv (1 - \varphi^{ump}_{NT,t}) S_{NT,t}$. I specify the fractions of the assets intermediated by the policy authority as autoregressive processes with an innovation that occurs at the same time as the realization of unfulfillment of news on the

[21] The policy authority in this model is always subject to fixed costs when intermediating funds, making its intervention during the boom regime inefficient.

[22] This is a more realistic design of unconventional policy in the eurozone because deposit liabilities of the Eurosystem from monetary and financial institutions increased significantly after the conduct of ECB's unconventional policies.

[23] The irrelevance result is closely related with the Ricardian equivalence proposition 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.

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

value of capital, at $t = 33$. That is:

$$\hat{\varphi}^{ump}_{i,t} = \rho_{\varphi_i^{ump}} \hat{\varphi}^{ump}_{i,t-1} + u^{ump}_{i,t}, \tag{34}$$

where $u^{ump}_{i,t}$ has zero mean and standard deviation of $\sigma_{u_i^{ump}} = \kappa^{ump} \sigma_{\varepsilon^U}$ with $i \in \{T, NT\}$.[25]

The policy authority finances these purchases by issuing equal amounts of debt to banks in each region. The policy authority's balance sheet reads as follows:

$$Q_{T,t} S^g_{T,t} + Q_{NT,t} S^g_{NT,t} = B^g_t + \xi_t B^{*g}_{*,t},$$

where $B^g_t = \xi_t B^{*g}_{*,t}$.

By holding deposits at the policy authority's account, banks earn a gross rate of $1 + r_{g,t+1}$. Banks fund this activity by issuing deposits to households at the risk-free rate.

Under policy, a financial intermediary balance sheet takes the following form:

$$\underbrace{Q_{T,t} S^p_{T,t}(j) + Q_{NT,t} S^p_{NT,t}(j)}_{\text{Private Assets}} + \underbrace{B^g_t(j)}_{\text{Interest Bearing Claims}} = \underbrace{B_{t+1}(j) + B^*_{t+1}(j)}_{\text{Liabilities}} + \underbrace{N_t(j)}_{\text{Net Worth}} . \tag{35}$$

In addition, intermediaries can divert some proportion of interest bearing reserves, and I modify the incentive constraint as follows:

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t} S_{T,t}(j) + \lambda_{NT} Q_{NT,t} S_{NT,t}(j) + \lambda_{ECB} B^g_t(j), \tag{36}$$

where $\lambda_{ECB} < \lambda_T$.

The above setting implies that policy authority intermediation is not efficient, but less inefficient than the private intermediation. I show in the appendices that the interest rate on reserves satisfies the following condition:[26]

$$\mathbb{E}_t \beta \Lambda_{t,t+1} \Omega_{t+1} (r_{k,T,t+1} - r_{t+1}) = \frac{\lambda_T}{\lambda_{ECB}} \mathbb{E}_t \beta \Lambda_{t,t+1} \Omega_{t+1} (r_{g,t+1} - r_{t+1}). \tag{37}$$

[25] Simliar to Ozhan (2020), the parameter value of $\rho_{\varphi_i^{ump}}$ ensures that the policy authority balance sheet is sterilized in 12 years. Capped variables indicate the deviations from their non-stochastic steady state.

[26] A detailed solution of the banks' problem when there is unconventional policy can be found in the online appendices.

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

$$(1-\varphi_{T,t}^{ump})Q_{T,t}S_{T,t} + \frac{\lambda_{NT}}{\lambda_T}(1-\varphi_{NT,t}^{ump})Q_{NT,t}S_{NT,t} + \frac{\lambda_{ECB}}{\lambda_T}B_t^g \leq \frac{\nu_t}{\lambda_T}N_t. \tag{38}$$

In this case, the Langrangian multiplier associated with the bankers' program can be expressed as follows:

$$\mu_t = max\left\{1 - \frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t\right]}{\lambda_T Q_{T,t}S_{T,t}^p + \lambda_{NT}Q_{NT,t}S_{NT,t}^p + \lambda_{ECB}B_t^g}\right), 0\right\} \tag{39}$$

If the constraint is not binding, the unconventional policy is inefficient. However, if the constraint is binding, the policy intervention can loosen the constraints if the decrease in the proportion of privately intermediated assets (*i.e.*, $\lambda_T Q_{T,t}S_{T,t}^p + \lambda_{NT}Q_{NT,t}S_{NT,t}^p$) offsets the additional friction borne from the interest bearing claims (*i.e.*, $\lambda_{ECB}B_t^g$). The acquisition of non-traded assets will free up bank capital by a factor of $\frac{\lambda_{NT}}{\lambda_T}$ vis-à-vis the acquisition of traded sector assets.

Finally, it should be noted that the possible profits obtained by policy authority intervention are distributed back to households in Home and Foreign, in equal amounts, implying $T_t = \xi_t T_t^*$ in equilibrium.[27] Balanced budget of the policy authority implies:

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

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

[27]By the acquisition of underpriced assets in bad times, the policy authority generates positive profits in the subsequent periods as asset prices arise.

4.2 Liquidity Facilities

In addition to asset purchases, liquidity facilities were also conducted to ameliorate the economic downturn in the eurozone.[28] To capture this exercise, I introduce the option for the policy authority to lend funds to intermediaries.

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

Under the policy of liquidity facilities, the policy authority holds non-contingent claims at intermediaries, M_{t+1}, at a rate, $1 + r_{m,t+1}$, which is known in period t. The intermediary balance sheet takes the following form:

$$Q_{T,t}S_{T,t}(j) + Q_{NT,t}S_{NT,t}(j) + B_t^g(j) = B_{t+1}(j) + B_{t+1}^*(j) + \underbrace{M_{t+1}(j)}_{\text{Discount Window Lending}} + N_t(j). \tag{40}$$

Intermediaries cannot divert any non-tradable sector firm assets and interest bearing reserves that are funded by policy authority liquidity facilities. This assumption is in line with the fact that intermediaries' assets from the non-traded sector and the interest bearing reserves are eligible colllateral to receive policy funding.

$$V_t(N_t(j)) \geq \lambda_T Q_{T,t}S_{T,t}(j) + \lambda_{NT}(Q_{NT,t}S_{NT,t}(j) - M_{t+1}(j)) + \lambda_{ECB}(B_t^g(j) - M_{t+1}(j)). \tag{41}$$

As shown in the appendices, the interest rate on additional liquidity satisfies the following condition:

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1}\Omega_{t+1}(r_{k,NT,t+1} - r_{t+1})\right] = \frac{\lambda_{NT}}{\lambda_{ECB} + \lambda_{NT}} \beta \mathbb{E}_t \left[\Lambda_{t,t+1}\Omega_{t+1}(r_{m,t+1} - r_{t+1})\right]. \tag{42}$$

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

[28] Between April 2008 and October 2011, the ECB conducted twenty LTROs with six-month maturity. ECB's announcements can be found in their website: https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html

is

$$Q_{T,t}S_{T,t} + \frac{\lambda_{NT}}{\lambda_T}Q_{NT,t}S_{NT,t} + \frac{\lambda_{ECB}}{\lambda_T}B^g_t \leq \frac{\nu_t}{\lambda_T}_t N_t + \frac{\lambda_{ECB} + \lambda_{NT}}{\lambda_T}M_{t+1}, \tag{43}$$

while the Langrangian multiplier associated with the bankers' program is:

$$\mu_t = max\left\{1 - \left(\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t\right]}{\lambda_T Q_{T,t}S_{T,t} + \lambda_{NT}Q_{NT,t}S_{NT,t} + \lambda_{ECB}B^g_t - (\lambda_{ECB} + \lambda_{NT})M_{t+1}}\right), 0\right\}. \tag{44}$$

The amount of liquidity facilities are specified by a similar rule as in the case of private asset purchases:

$$M_{t+1} \equiv \varphi^{ump}_{T,t}Q_{T,t}S_{T,t} + \varphi^{ump}_{NT,t}Q_{NT,t}S_{NT,t}, \tag{45}$$

where $\varphi^{ump}_{T,t}$ and$\varphi^{ump}_{NT,t}$ are given by (34).

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

4.3 Experiments under unconventional policies

When running simulations, I set $\varphi^{ump}_{T,t} = 0$ and $\kappa^{ump} = 7$. Hence, I investigate the policy's contribution to model performance when it is conducted in response to non-traded sector variables.

Figure 3 exhibits the model's performance with respect to the Spanish data, when the combination of the policy authority asset purchase program and liquidity facilities is in place. As discussed in Section 3.2.2, including policy in the model improves the model's post-crisis performance. The collapse in bank credit is less pronounced under unconventional policies. These policies help leverage constraints to relax, and banks start to reallocate more capital toward tradable sector firms, as returns from there are higher. However, the model still exaggerates the crisis regime. This might be due to the absence of possible frictions, such as information asymmetries between firms and banks, and sticky deposits.

Global policy authority 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 in line with the case observed in the eurozone as documented by Hale (2013).

Figure 3: Model and data under unconventional policies

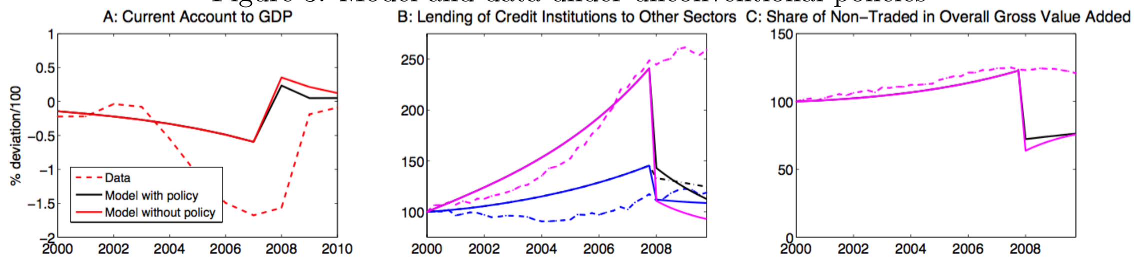


Figure 4: Comparison of unconventional policies

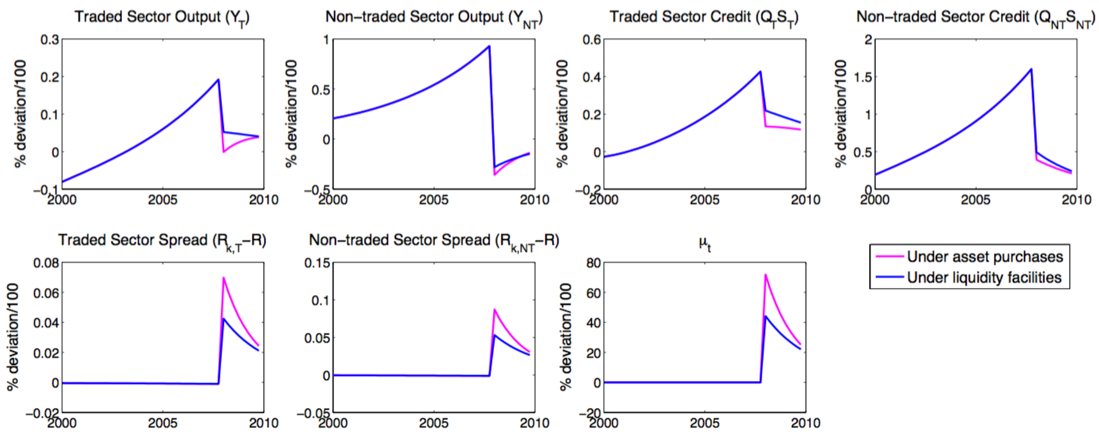


Figure 4 compares model dynamics under asset purchases and liquidity facilities, separately. The figure shows that liquidity facilities are more effective at ameliorating the downturn than direct asset purchases from the non-traded sector. The fall in output and credit, and the rise in credit spreads are milder under liquidity facilities.

These results are in contrast with Ozhan (2020). The reason is that the policy in this model is generated in response to a positive deviation of interest rate spreads from their steady state values. In Ozhan (2020), tightening of financial constraints during the crisis did not push the deviation of interest rate spread from its steady state to the positive territory. Positive deviations imply that liquidity facilities are conducted at a penalty rate and do not crowd out private deposits. Conducting liquidity injections following Bagehot (1873) (*i.e.*, against eligible collateral and at a penalty rate) implies that banks allocated funds effectively between the sectors and contributed to a faster amelioration. The assumption of absence of information asymmetry between banks and firms is also essential in generating this outcome. However, when the policy authority directly purchases assets from the non-traded sector, it relaxes bank constraints in a smaller amount, because it does not replicate the desired portfolio allocation of credit.

5 Conclusions

I examined the implications of positive news about future asset values that are eventually not materialized in an open economy model with banking. I further studied and compared unconventional policies in the forms of sector specific asset purchases and liquidity injections in response to reversals of capital flows.

During the boom regime, banks' net worth is high enough that banks are not constrained in extending credit. When expectations turn out to be incorrect, capital flows reverse and bank net worth collapses. The fall in credit contributes to a spike in spreads and fall in asset prices, which further causes bank net worth to go down. Bank balance sheets transmit fluctuations in the non-traded sector to the traded sector, pushing the economy into an overall recession. International borrowing contributes to higher bank leverage ratios and further amplifies the effects of financial frictions.

A common policy authority, financed by interest bearing reserves from banks operating in each country, can use the proceedings to help the economy that suffers from capital flow reversals. In light of this result, I argue that absent the ECB's unconventional policies, Southern European countries would have gone into deeper recessions during the crisis of 2008. I further find that liquidity injections into illiquid banks prove to be more effective than directly purchasing assets from the non-traded sector.

The results indicate that news about economic fundamentals may play a crucial role in generating swings in international capital flows through the banking sector. The results are relevant for the design of unconventional policy.

An extension of this model with government debt in bank balance sheets and an associated default risk might help to explain the dynamics in the eurozone between 2010-12. I leave this extension for future work.

References

[1] Akerlof, G. and R. Shiller (2015): *Phishing for Phools: The Economics of Manipulation and Deception*, Princeton University Press.

[2] Bagehot, W. (1873): "Lombard Street: A Description of the Money Market," H. S. King, London, U.K.

[3] Baldwin, R. and F. Giavazzi (2015): "Introduction," in R. Baldwin and F. Giavazzi (eds.). In The eurozone crisis: A consensus view of the causes and a few possible solutions. VoxEU ebook.

[4] Beaudry, P., and F. Portier (2004): "An Exploration into Pigou's Theory of Cycles," *Journal of Monetary Economics*, 51: 1183-216.

[5] Beaudry, P., and F. Portier (2014): "News-Driven Business Cycles: Insights and Challenges," *Journal of Economic Literature*, 52(4), 993-1074.

[6] Benigno, G. and C. Thoenissen (2008): "Consumption and Real Exchange Rates with Incomplete Markets and Non-traded Goods," *Journal of International Money and Finance*, 27, 926-948.

[7] Bernanke, B., M. Gertler and S. Gilchrist (1999): "The Financial Accelerator in a Quantitative Business Cycle Framework," in Taylor, J. B., Woodford, M. (Eds.), *Handbook of Macroeconomics. Vol. 1 of Handbook of Macroeconomics*, Ch. 21, 1341-1393.

[8] Blanchard, O. (2006): "Adjustment within the Euro: The Difficult Case of Portugal," MIT Economics Working Paper No. 06-04 (Cambridge, Massachusetts, Massachusetts Institute of Technology).

[9] Blanchard O. and F. Giavazzi (2002): "Current account deficits in the Euro area: the end of the Feldstein-Horioka puzzle?" *Brookings Pap Econ* Act 2: 147–209.

[10] Bris, A., Y. Koskinen, and M. Nilsson (2009): "The Euro and Corporate Valuations," *Review of Financial Studies* 22, 3171–3209.

[11] Bris, A., Y. Koskinen, and M. Nilsson (2014): "The Euro and Corporate Financing Before the Crisis," *Journal of Financial Economics* 114 (2014) 554–575.

[12] Christiano, L., C. Ilut, R. Motto, and M. Rostagno. (2010): "Monetary Policy and Stock Market Booms," in *Macroeconomic Challenges: The Decade Ahead, Federal Reserve Bank of Kansas City, Policy Symposium, Jackson Hole Wyoming.*

[13] Coimbra, N. (2010): "An Iberian Disease? On Current Account Imbalances within a Monetary Union," Unpublished Manuscript, London Business School.

[14] Constâncio V. (2005): "European Monetary Integration and the Portuguese case," in Detken C., Gaspar V. and Noblet G. (eds). The new EU member states; convergence and stability. European Central Bank, October.

[15] Corsetti, G., L. Dedola, and S. Leduc (2008): "International Risk Sharing and the Transmission of Productivity Shocks," *Review of Economic Studies*, 75, 443-473.

[16] Dedola, L., P. Karadi, and G. Lombardo (2013): "Global Implications of National Unconventional Policies," *Journal of Monetary Economics*, 60(1): 66-85.

[17] Ferrero, A. (2014): "House Price Booms, Current Account Deficits, and Low Interest Rates," Unpublished Manuscript, University of Oxford.

[18] Gertler, M. and P. Karadi (2011): "A Model of Unconventional Monetary Policy," *Journal of Monetary Economics* 58, 17-34.

[19] Gertler, M. and P. Karadi (2013): "QE1 vs. 2 vs. 3: A Framework to Analyze Large Scale Asset Purchases as a Monetary Policy Tool," *International Journal of Central Banking*, 9(S1): 5-53.

[20] Gertler, M. and N. Kiyotaki (2010): "Financial Intermediation and Credit Policy in Business Cycle Analysis," in Friedman B. M., Woodford, M. (Eds.), *Handbook of Monetary Economics. Vol. 3 of Handbook of Monetary Economics*, Ch. 11, 547-599.

[21] Ghironi F. (2006): "Macroeconomic Interdependence under Incomplete Markets," *J. Int. Econ.*, 70 (2006), pp. 428-450.

[22] Ghironi, F. and M. Melitz (2005): "International Trade and Macroeconomic Dynamics with Heterogeneous Firms," *Quarterly Journal of Economics CXX*, 865-915

[23] Giavazzi, F. and L. Spaventa (2010): "Why the current account matters in a monetary union: lessons from the financial crisis in the euro area," CEPR Discussion Paper No. 8008.

[24] Gilchrist, S., and B. Mojon (2018): "Credit Risk in the Euro Area," *The Economic Journal*, 128, 608: 118-158.

[25] Gopinath, G., S. Kalemli-Ozcan, L. Karabarbounis, and C. Villegas-Sanchez (2017): "Capital Allocation and Productivity in South Europe," *The Quarterly Journal of Economics*, 132(4): 1915–1967.

[26] Görtz, C., J. Tsoukalas, and F. Zanetti (forthcoming): "News Shocks under Financial Frictions," *American Economic Journal: Macroeconomics*.

[27] Guerrieri, L., and M. Iacoviello (2015) "Occbin: A Toolkit to Solve Models with Occasionally Binding Constraints Easily," *Journal of Monetary Economics*, 70, pp. 22-38.

[28] Hale, G. (2013): "Balance of Payment in the European Periphery," FRBSF Economic Letters 2013-01, January.

[29] Holmström, B. and J. Tirole (1997): "Financial intermediation, loanable funds, and the real sector," *Quarterly Journal of Economics*: 663-692.

[30] Jaccard, I. and F. Smets (2014): "Capital Flows, Intermediation Frictions and the Adjustment to Common Shocks," Unpublished Manuscript, European Central Bank.

[31] Jaimovich, N., and S. Rebelo (2009): "Can News about the Future Drive the Business Cycle," *American Economic Review*, 99(4): 1097-1118.

[32] Kanik B. and W. Xiao (2014): "News, Housing Boom-Bust Cycles, and Monetary Policy" *International Journal of Central Banking*, 10 (4): 249-98.

[33] Keynes, J. M. (1936): *The General Theory of Employment, Interest and Money,* Macmillan Cambridge University Press (1936).

[34] Lambertini L., C. Mendicino, M.T. Punzi (2006): "Leaning against boom-bust cycles in credit and housing prices" *J. Econ. Dyn. Control*, 37 (8) (2006), pp. 1500-1522.

[35] McKinsey Global Institute (2010): "Debt and Deleveraging: The Global Credit Bubble and Its Economic Consequences," January.

[36] Merton, R.C. (1973): "An inter-temporal capital asset pricing model," *Econometrica.*

[37] Müller, K. and E. Verner (2021): "Credit Allocation and Macroeconomic Fluctuations," *mimeo*, Princeton University and Massachusetts Institute of Technology.

[38] Obstfeld, M. and K. Rogoff (1996): *Foundations of International Macroeconomics.* Cambridge, MA: The MIT Press.

[39] Obstfeld, M. and K. Rogoff (2000): "New directions for stochastic open economy models," *Journal of International Economics* 50: 117-153.

[40] Ozhan, G. K. (2016): "Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence," ESRB Working Paper No.28, October.

[41] Ozhan, G. K. (2020): "Financial Intermediation, Resource Allocation, and Macroeconomic Interdependence," *Journal of Monetary Economics* 115: 265-278.

[42] Reis, R. (2013): "The Portuguese Slump and Crash and the Euro Crisis," *Brookings Papers on Economic Activity*, 1, 143-210.

[43] Santos, T. (2014): "Antes del Diluvio: The Spanish Banking System in the First Decade of Euro," Working Paper, Columbia Business School.

[44] Sargent T.J., N. Wallace (1982): "The Real Bills Doctrine versus the Quantity Theory of Money," *J. Political Econ.*

[45] Siena, D. (2021): "The euro area periphery and imbalances: Is it an Anticipation Story?" *Review of Economic Dynamics*, 40: 278-308.

[46] Wallace, N. (1981): "A Modigliani-Miller Theorem for Open Market Operations," *American Economic Review* 71: 267-274.

Tables

Table 1: 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: 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	$\nu_t=\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})\right]}{1-\mu_t}$
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	$(\xi_t B_{*,t+1}-B_{t+1}^*)+\frac{1}{2}\left[(C_t-\xi_t C_t^*)-(N_t-\xi_t N_t^*)\right]$ $=(\xi_t(1+r_t^*)B_{*,t}-(1+r_t)B_t^*)$ $+\frac{1}{2}\left(w_{T,t}L_{T,t}+w_{NT,t}L_{NT,t}-\xi_t\left(w_{T,t}^*L_{T,t}^*+w_{NT,t}^*L_{NT,t}^*\right)\right)$ $+\frac{1}{2}\left[\gamma(1+r_t)(Q_{T,t-1}K_{T,t}+Q_{NT,t-1}K_{NT,t}-N_{t-1})\right]$ $-\frac{1}{2}\xi_t\left[\gamma^*(1+r_t^*)(Q_{T,t-1}^*K_{T,t}^*+Q_{NT,t-1}^*K_{NT,t}^*-N_{t-1}^*)\right]-\frac{1}{2}(1-\delta)[Q_{T,t}e^{\psi_{T,t}}K_{T,t}$ $+Q_{NT,t}e^{\psi_{NT,t}}K_{NT,t}-\xi_t\left(Q_{T,t}^*e^{\psi_{T,t}^*}K_{T,t}^*+Q_{NT,t}^*e^{\psi_{NT,t}^*}K_{NT,t}^*\right)]$ $-\frac{1}{2}\left[I_{T,t}+I_{NT,t}-\xi_t(I_{T,t}^*+I_{NT,t}^*)\right]+\frac{1}{2}(1-\gamma-\varepsilon)[(Z_{T,t}+(1-\delta)Q_{T,t})e^{\psi_{T,t}}K_{T,t}$ $+(Z_{NT,t}+(1-\delta)Q_{NT,t})e^{\psi_{NT,t}}K_{NT,t}]$ $-\frac{1}{2}\xi_t(1-\gamma^*-\varepsilon)[\left(Z_{T,t}^*+(1-\delta)Q_{T,t}^*\right)e^{\psi_{T,t}^*}K_{T,t}^*$ $+(Z_{NT,t}^*+(1-\delta)Q_{NT,t}^*)e^{\psi_{NT,t}^*}K_{NT,t}^*]$

Table 2: 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	Obstfeld and Rogoff (2000)
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	Small effect of banker entry-exit
Tradable sector asset diversion	λ_{NT}	0.3714	To match a
Non-tradable sector asset diversion	λ_T	0.2971	steady state excess return in NT sector of 50 bps, in T sector of 40 bps, when home leverage ratio is 4.

Appendices (For Online Publication Only)

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:

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

Necessary and sufficient conditions for an optimum are:

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

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

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

I conjecture a solution to the above value function that 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:

$$\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{k,T,t+1} - r_{t+1}) Q_{T,t} \right] = \mu_t \lambda_T Q_{T,t}, \tag{46}$$

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

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 the 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:

$$\nu_t = \frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) \right]}{1 - \mu_t}. \tag{48}$$

From the complementary slackness condition, one can obtain:

$$\mu_t = max \left\{ 1 - \left(\frac{\beta \mathbb{E}_t \left[\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t \right]}{\lambda_T Q_{T,t} S_{T,t} + \lambda_{NT} Q_{NT,t} S_{NT,t}} \right), 0 \right\} < 1. \tag{49}$$

It is useful to note that bank leverage is the 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 markets for deposits is 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 of 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:

$$T_t^f = (\eta/2)\left[\xi_t\left(B_{*,t+1}\right)^2\right] \tag{50}$$

$$B_{t+1} = Q_{T,t}K_{T,t+1} + Q_{NT,t}K_{NT,t+1} - N_t - B_{t+1}^* \tag{51}$$

$$\Pi_{i,t} = Q_{i,t}K_{i,t+1} - Q_{i,t}(1-\delta)(e^{\ \ i}_{\ \ t}K_{i,t}) - I_{i,t} \quad i \in \{T, NT\} \tag{52}$$

$$\begin{aligned} \Pi_t^B = \; & (1-\gamma-\varepsilon)\left[\left(Z_t^T + (1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t} + \left(Z_t^{NT} + (1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t}\right] \\ & -(1-\gamma)\left[(1+r_t)\left(B_t + B_t^*\right)\right]. \end{aligned} \tag{53}$$

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:

$$\begin{aligned} \xi_t B_{*,t+1} - B_{t+1}^* + C_t - N_t = \; & \xi_t(1+r_t^*)B_{*,t} - (1+r_t)B_t^* + \gamma(1+r_t)(Q_{T,t-1}K_{T,t} + Q_{NT,t-1}K_{NT,t} \\ & -N_{t-1}) + w_{T,t}L_{T,t} + w_{NT,t}L_{NT,t} - (1-\delta)\left[Q_{T,t}e^{\psi_t^T}K_{T,t} + Q_{NT,t}e^{\psi_t^{NT}}K_{NT,t}\right] - (I_{T,t} + I_{NT,t}) \\ & +(1-\gamma-\varepsilon)\left[\left(Z_t^T + (1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t} + \left(Z_t^{NT} + (1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t}\right] \end{aligned} \tag{54}$$

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

Multiplying the Foreign condition by 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:

$$
\begin{aligned}
&\left(\xi_t B_{*,t+1} - B^*_{t+1}\right) + \tfrac{1}{2}\left[\left(C_t - \xi_t C^*_t\right) - \left(N_t - \xi_t N^*_t\right)\right] \\
&\quad = \left(\xi_t \left(1+r^*_t\right) B_{*,t} - \left(1+r_t\right) B^*_t\right) + \tfrac{1}{2}\left(w_{T,t}L_{T,t} + w_{NT,t}L_{NT,t} - \xi_t\left(w^*_{T,t}L^*_{T,t} + w^*_{NT,t}L^*_{NT,t}\right)\right) \\
&\qquad + \tfrac{1}{2}\left[\gamma(1+r_t)(Q_{T,t-1}K_{T,t} + Q_{NT,t-1}K_{NT,t} - N_{t-1})\right] \\
&\qquad - \tfrac{1}{2}\xi_t\left[\gamma^*(1+r^*_t)(Q^*_{T,t-1}K^*_{T,t} + Q^*_{NT,t-1}K^*_{NT,t} - N^*_{t-1})\right] \\
&\qquad - \tfrac{1}{2}(1-\delta)\left[Q_{T,t}e^{\psi_{T,t}}K_{T,t} + Q_{NT,t}e^{\psi_{NT,t}}K_{NT,t} - \xi_t\left(Q^*_{T,t}e^{\psi^*_{T,t}}K^*_{T,t} + Q^*_{NT,t}e^{\psi^*_{NT,t}}K^*_{NT,t}\right)\right] \\
&\qquad - \tfrac{1}{2}\left[I_{T,t} + I_{NT,t} - \xi_t(I^*_{T,t} + I^*_{NT,t})\right] \\
&\qquad + \tfrac{1}{2}(1-\gamma-\varepsilon)\left[\left(Z_{T,t} + (1-\delta)\,Q_{T,t}\right)e^{\psi_{T,t}}K_{T,t} + \left(Z_{NT,t} + (1-\delta)\,Q_{NT,t}\right)e^{\psi_{NT,t}}K_{NT,t}\right] \\
&\qquad - \tfrac{1}{2}\xi_t(1-\gamma^*-\varepsilon)\left[\left(Z^*_{T,t} + (1-\delta)\,Q^*_{T,t}\right)e^{\psi^*_{T,t}}K^*_{T,t} + \left(Z^*_{NT,t} + (1-\delta)\,Q^*_{NT,t}\right)e^{\psi^*_{NT,t}}K^*_{NT,t}\right]
\end{aligned}
\tag{56}
$$

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

$$CA_t = \xi_t\left(B_{*,t+1} - B_{*,t}\right) - \left(B^*_{t+1} - B^*_t\right). \tag{57}$$

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:

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

subject 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:

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

When the incentive constraint is binding, the FONCs yield

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

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

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

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

I conjecture a solution to the above value function that 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:

$$\mathbb{E}_t\beta\Lambda_{t,t+1}\left[((1-\gamma) + \gamma\nu_{t+1})(r_{k,T,t+1} - r_{t+1})Q_{T,t}\right] = \mu_t\lambda_T Q_{T,t}, \tag{58}$$

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

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

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 $N_{t+1}(j)$:

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

subject to

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

Using the 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:

$$\nu_t = \frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})\right]}{1-\mu_t}. \tag{61}$$

From the complementary slackness condition, one can obtain:

$$\mu_t = max\left\{1-\left(\frac{\beta\mathbb{E}_t\left[\Lambda_{t,t+1}\Omega_{t+1}(1+r_{t+1})N_t\right]}{\lambda_T Q_{T,t}S_{T,t}^p+\lambda_{NT}Q_{NT,t}S_{NT,t}^p+\lambda_{ECB}B_t^g}\right),0\right\} < 1. \tag{62}$$

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

The program of the bank is as follows:

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

subject to

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

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

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

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

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

When the incentive constraint is binding, the FONCs yield

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

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

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

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

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

I conjecture a solution to the above value function that 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

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

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

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

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

Thus, FOCs with respect to assets become:

$$\mathbb{E}_t \beta \mathit{\Lambda}_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{k,T,t+1} - r_{t+1}) Q_{T,t} \right] = \mu_t \lambda_T Q_{T,t}, \tag{63}$$

$$\mathbb{E}_t \beta \mathit{\Lambda}_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{k,NT,t+1} - r_{t+1}) Q_{NT,t} \right] = \mu_t \lambda_{NT} Q_{NT,t}, \tag{64}$$

$$\mathbb{E}_t \beta \mathit{\Lambda}_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{m,t+1} - r_{t+1}) \right] = \mu_t (\lambda_{NT} + \lambda_{ECB}), \tag{65}$$

$$\mathbb{E}_t \beta \mathit{\Lambda}_{t,t+1} \left[\left((1-\gamma) + \gamma \nu_{t+1} \right) (r_{g,t+1} - r_{t+1}) \right] = \mu_t \lambda_{ECB}. \tag{66}$$

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 $N_{t+1}(j)$:

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

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

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

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

$$\nu_t = \frac{\beta \mathbb{E}_t \left[\mathit{\Lambda}_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) \right]}{1 - \mu_t}. \tag{67}$$

From the complementary slackness condition, one can obtain:

$$\mu_t = max \left\{ 1 - \left(\frac{\beta \mathbb{E}_t \left[\mathit{\Lambda}_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t \right]}{\lambda_T Q_{T,t} S_{T,t} + \lambda_{NT} Q_{NT,t} S_{NT,t} + \lambda_{ECB} B_t^g - (\lambda_{ECB} + \lambda_{NT}) M_{t+1}} \right), 0 \right\} < 1. \tag{68}$$

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:

$$T_t^f = (\eta/2)\left[\xi_t\left(B_{*,t+1}\right)^2\right] \tag{69}$$

$$T_t = \frac{\left(r_{k,T,t}-r_{g,t}\right)Q_{T,t-1}S_{T,t-1}\varphi^{ump}_{T,t-1} + \left(r_{k,NT,t}-r_{g,t}\right)Q_{NT,t-1}S_{NT,t-1}\varphi^{ump}_{NT,t-1} - \Upsilon_{t-1}}{2}, \tag{70}$$

$$B_{t+1} = (1-\varphi^{ump}_{T,t})Q_{T,t}K_{T,t+1} + (1-\varphi^{ump}_{NT,t})Q_{NT,t}K_{NT,t+1} + B_t^g - N_t - B^*_{t+1}, \tag{71}$$

$$B_t^g = \frac{\varphi^{ump}_{T,t}Q_{T,t}K_{T,t+1} + \varphi^{ump}_{NT,t}Q_{NT,t}K_{NT,t+1}}{2}, \tag{72}$$

$$\Pi_{i,t} = Q_{i,t}K_{i,t+1} - Q_{i,t}(1-\delta)(e^{\psi_t^i}K_{i,t}) - I_{i,t} \quad i \in \{T, NT\} \tag{73}$$

$$\begin{aligned}
\Pi_{B,t} \quad &= (1-\gamma-\varepsilon)[\left(Z_t^T + (1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t} + \left(Z_t^{NT} + (1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t} \\
&\quad -\varphi^{ump}_{T,t}\left(Z_t^T + (1-\delta)Q_{T,t}\right)e^{\psi_t^T}K_{T,t} - \varphi^{ump}_{NT,t}\left(Z_t^{NT} + (1-\delta)Q_{NT,t}\right)e^{\psi_t^{NT}}K_{NT,t} \\
&\quad +(1+r_{g,t})\tfrac{\varphi^{ump}_{T,t-1}Q_{T,t-1}K_{T,t}+\varphi^{ump}_{NT,t-1}Q_{NT,t-1}K_{NT,t}}{2}] - (1-\gamma)\left[(1+r_t)\left(B_t+B_t^*\right)\right]
\end{aligned} \tag{74}$$

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

$$\begin{aligned}
&\xi_t B_{*,t+1} - B^*_{t+1} + C_t - N_t - \tfrac{\left(\varphi^{ump}_{T,t}Q_{T,t}K_{T,t+1}+\varphi^{ump}_{NT,t}Q_{NT,t}K_{NT,t+1}\right)}{2} \\
= \;& \xi_t(1+r_t^*)B_{*,t} - (1+r_t)B_t^* - \gamma(1+r_t)N_{t-1} - (I_{T,t}+I_{NT,t}) + w_{T,t}L_{T,t} + w_{NT,t}L_{NT,t} + T_t \\
&+Q_{T,t-1}K_{T,t}[\gamma(1+r_t) + (1-\gamma-\varepsilon)(1+r_{k,T,t}) - (1-\delta)e^{\psi_t^T}\tfrac{Q_{T,t}}{Q_{T,t-1}} \\
&+\varphi^{ump}_{T,t-1}\left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt})-\gamma(1+r_t)}{2} - (1-\gamma-\varepsilon)(1+r_{k,T,t})\right)] \\
&+Q_{NT,t-1}K_{NT,t}[\gamma(1+r_t) + (1-\gamma-\varepsilon)(1+r_{k,NT,t}) - (1-\delta)e^{\psi_t^{NT}}\tfrac{Q_{NT,t}}{Q_{NT,t-1}} \\
&+\varphi^{ump}_{NT,t-1}\left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt})-\gamma(1+r_t)}{2} - (1-\gamma-\varepsilon)(1+r_{k,NT,t})\right)].
\end{aligned} \tag{75}$$

Multiplying the Foreign condition with RER_t, and subtracting it from (75), 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:

$$
\begin{aligned}
&\left(\xi_t B_{*,t+1} - B^*_{t+1}\right) + \tfrac{1}{2}\left[(C_t - \xi_t C^*_t) - (N_t - \xi_t N^*_t)\right] - \tfrac{\left(\varphi^{ump}_{T,t} Q_{T,t} K_{T,t+1} + \varphi^{ump}_{NT,t} Q_{NT,t} K_{NT,t+1}\right)}{4} \\
&\quad = \left(\xi_t \left(1+r^*_t\right) B_{*,t} - \left(1+r_t\right) B^*_t\right) + \tfrac{1}{2}\left(w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t \left(w^*_{T,t} L^*_{T,t} + w^*_{NT,t} L^*_{NT,t}\right)\right) \\
&\qquad + \tfrac{1}{2}\left[\gamma(1+r_t)(Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})\right] \\
&\qquad - \tfrac{1}{2}\xi_t \left[\gamma^*(1+r^*_t)(Q^*_{T,t-1} K^*_{T,t} + Q^*_{NT,t-1} K^*_{NT,t} - N^*_{t-1})\right] \\
&\qquad - \tfrac{1}{2}(1-\delta)\left[Q_{T,t} e^{\psi_{T,t}} K_{T,t} + Q_{NT,t} e^{\psi_{NT,t}} K_{NT,t} - \xi_t \left(Q^*_{T,t} e^{\psi^*_{T,t}} K^*_{T,t} + Q^*_{NT,t} e^{\psi^*_{NT,t}} K^*_{NT,t}\right)\right] \\
&\qquad - \tfrac{1}{2}\left[I_{T,t} + I_{NT,t} - \xi_t (I^*_{T,t} + I^*_{NT,t})\right] \\
&\qquad + \varphi^{ump}_{T,t-1} Q_{T,t-1} K_{T,t} \left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{4} - \tfrac{(1-\gamma-\varepsilon)(1+r_{k,T,t})}{2}\right) \\
&\qquad + \varphi^{ump}_{NT,t-1} Q_{NT,t-1} K_{NT,t} \left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{4} - \tfrac{(1-\gamma-\varepsilon)(1+r_{k,NT,t})}{2}\right) \\
&\qquad + \tfrac{1}{2}(1-\gamma-\varepsilon)\left[\left(Z_{T,t} + (1-\delta) Q_{T,t}\right) e^{\psi_{T,t}} K_{T,t} + \left(Z_{NT,t} + (1-\delta) Q_{NT,t}\right) e^{\psi_{NT,t}} K_{NT,t}\right] \\
&\qquad - \tfrac{1}{2}\xi_t (1-\gamma^*-\varepsilon)\left[\left(Z^*_{T,t} + (1-\delta) Q^*_{T,t}\right) e^{\psi^*_{T,t}} K^*_{T,t} + \left(Z^*_{NT,t} + (1-\delta) Q^*_{NT,t}\right) e^{\psi^*_{NT,t}} K^*_{NT,t}\right]
\end{aligned} \tag{76}
$$

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

Under liquidity facilities, similarly,

$$
T_t = \frac{\left(r_{m,t} - r_{g,t}\right) Q_{T,t-1} S_{T,t-1} \varphi^{ump}_{T,t-1} + \left(r_{m,t} - r_{g,t}\right) Q_{NT,t-1} S_{NT,t-1} \varphi^{ump}_{NT,t-1} - \Upsilon_{t-1}}{2}, \tag{77}
$$

$$
B_{t+1} = Q K_{T,t+1} + Q_{NT,t} K_{NT,t+1} + B^g_t - N_t - M_{t+1} - B^*_{t+1}, \tag{78}
$$

$$
\begin{aligned}
\Pi_{B,t} \quad &= (1-\gamma-\varepsilon)[\left(Z^T_t + (1-\delta) Q_{T,t}\right) e^{\psi^T_t} K_{T,t} + \left(Z^{NT}_t + (1-\delta) Q_{NT,t}\right) e^{\psi^{NT}_t} K_{NT,t} \\
&\qquad + (1+r_{g,t}) \tfrac{\varphi^{ump}_{T,t-1} Q_{T,t-1} K_{T,t} + \varphi^{ump}_{NT,t-1} Q_{NT,t-1} K_{NT,t}}{2}] \\
&- (1-\gamma)\left[(1+r_t)\left(B_t + B^*_t\right) + (1+r_{m,t})(\varphi^{ump}_{T,t-1} Q_{T,t-1} K_{T,t} + \varphi^{ump}_{NT,t-1} Q_{NT,t-1} K_{NT,t})\right]
\end{aligned} \tag{79}
$$

with

$$
M_{t+1} - B^g_t = \frac{\varphi^{ump}_{T,t} Q_{T,t} K_{T,t+1} + \varphi^{ump}_{NT,t} Q_{NT,t} K_{NT,t+1}}{2}. \tag{80}
$$

And the above conditions modify (76) as follows:

$$\begin{aligned}
&\left(\xi_t B_{*,t+1} - B^*_{t+1}\right) + \tfrac{1}{2}\left[(C_t - \xi_t C^*_t) - (N_t - \xi_t N^*_t)\right] - \tfrac{\left(\varphi^{ump}_{T,t} Q_{T,t} K_{T,t+1} + \varphi^{ump}_{NT,t} Q_{NT,t} K_{NT,t+1}\right)}{4} \\
&\quad = \left(\xi_t\left(1+r^*_t\right) B_{*,t} - \left(1+r_t\right) B^*_t\right) + \tfrac{1}{2}\left(w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t\left(w^*_{T,t} L^*_{T,t} + w^*_{NT,t} L^*_{NT,t}\right)\right) \\
&\qquad + \tfrac{1}{2}\left[\gamma(1+r_t)(Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})\right] \\
&\qquad - \tfrac{1}{2}\xi_t\left[\gamma^*(1+r^*_t)(Q^*_{T,t-1} K^*_{T,t} + Q^*_{NT,t-1} K^*_{NT,t} - N^*_{t-1})\right] \\
&\qquad - \tfrac{1}{2}(1-\delta)\left[Q_{T,t} e^{\psi_{T,t}} K_{T,t} + Q_{NT,t} e^{\psi_{NT,t}} K_{NT,t} - \xi_t\left(Q^*_{T,t} e^{\psi^*_{T,t}} K^*_{T,t} + Q^*_{NT,t} e^{\psi^*_{NT,t}} K^*_{NT,t}\right)\right] \\
&\qquad - \tfrac{1}{2}\left[I_{T,t} + I_{NT,t} - \xi_t(I^*_{T,t} + I^*_{NT,t})\right] \\
&\qquad + \varphi^{ump}_{T,t-1} Q_{T,t-1} K_{T,t}\left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{4} - \tfrac{(1-\gamma)(1+r_{m,t})}{2}\right) \\
&\qquad + \varphi^{ump}_{NT,t-1} Q_{NT,t-1} K_{NT,t}\left(\tfrac{(1-\gamma-\varepsilon)(1+r_{gt}) - \gamma(1+r_t)}{4} - \tfrac{(1-\gamma)(1+r_{m,t})}{2}\right) \\
&\qquad + \tfrac{1}{2}(1-\gamma-\varepsilon)\left[\left(Z_{T,t} + \left(1-\delta\right) Q_{T,t}\right) e^{\psi_{T,t}} K_{T,t} + \left(Z_{NT,t} + \left(1-\delta\right) Q_{NT,t}\right) e^{\psi_{NT,t}} K_{NT,t}\right] \\
&\qquad - \tfrac{1}{2}\xi_t(1-\gamma^*-\varepsilon)\left[\left(Z^*_{T,t} + \left(1-\delta\right) Q^*_{T,t}\right) e^{\psi^*_{T,t}} K^*_{T,t} + \left(Z^*_{NT,t} + \left(1-\delta\right) Q^*_{NT,t}\right) e^{\psi^*_{NT,t}} K^*_{NT,t}\right].
\end{aligned} \tag{81}$$

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 5 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 5 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 6. 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 7 compares the dynamics under 5 percent positive and negative shocks to the value of non-traded sector capital. Model dynamics are asymmetric due to the presence of occasionally binding constraints. In the positive shock case, leverage constraints do not bind, whereas they do bind in the negative shock case. This leads to an asymmetry in the model behavior even though there are no news-led fluctuations.

Additional Figures

Figure 5: Impulse Response Functions (Gertler-Karadi type NT Sector Capital Quality Shock, Financial Autarky)

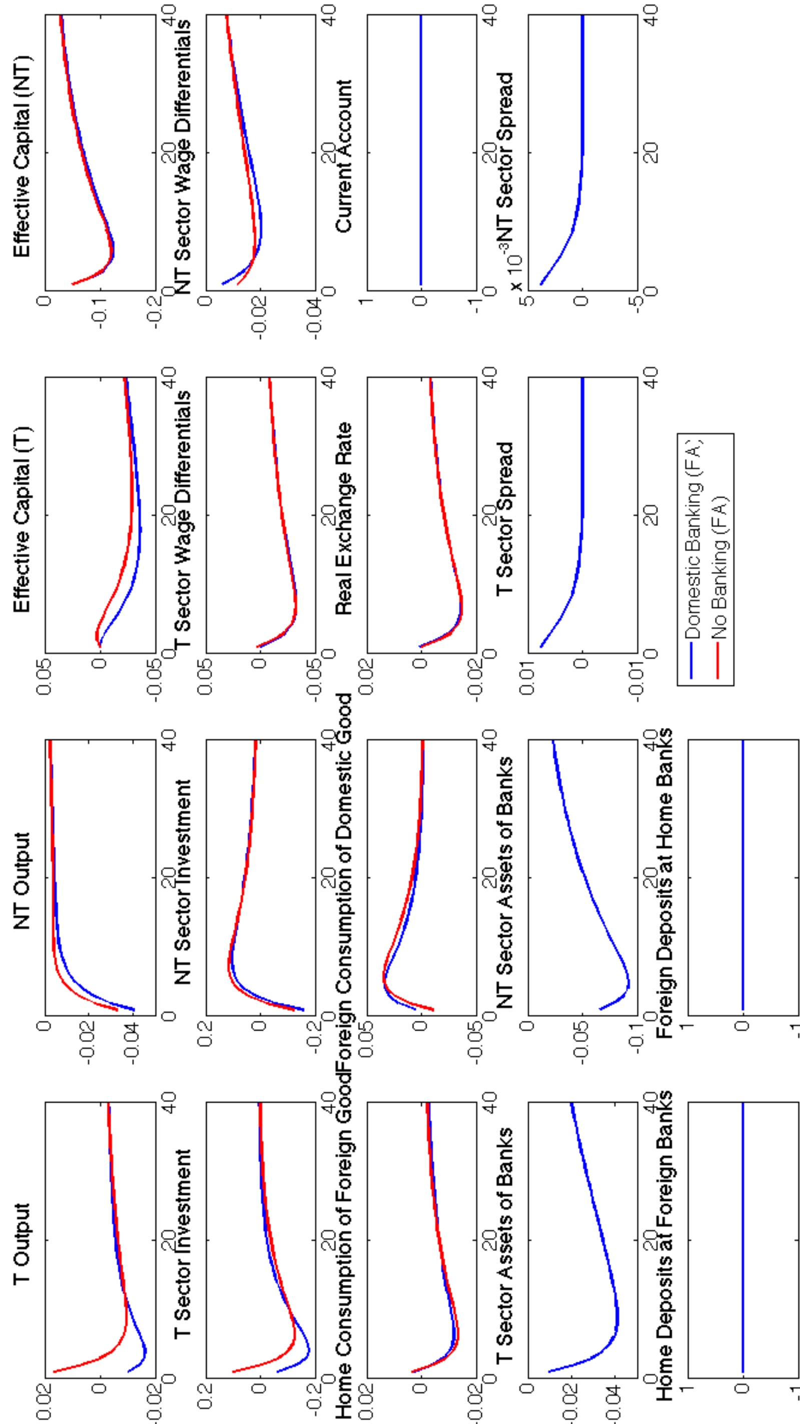


Figure 6: Impulse Response Functions (Gertler-Karadi type NT Sector Capital Quality Shock, International Financial Integration)

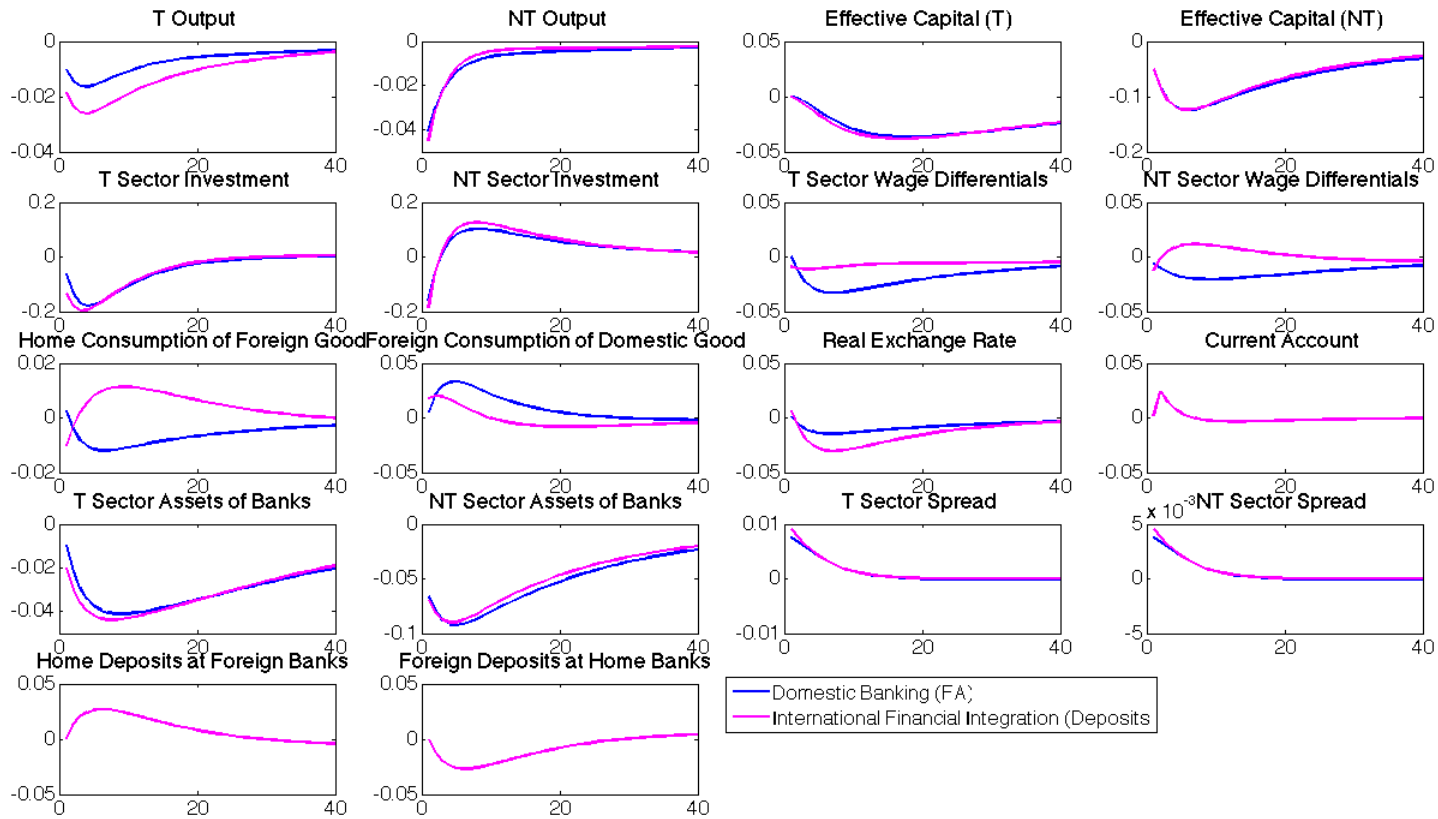


Figure 7: Asymmetric Responses Under Fundamental Shocks