

FINANCIAL INTERMEDIATION, RESOURCE ALLOCATION, AND MACROECONOMIC INTERDEPENDENCE

ONLINE APPENDIX

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Appendix A: Data description and sources

- **Balance of payments, current account, quarterly data - % of GDP:** Current account balance shows the difference between the sum of exports and income receivable and the sum of imports and income payable (exports and imports refer to both goods and services, while income refers to both primary and secondary income). The value of current account balance equals the saving-investment gap for the economy. Source: Eurostat.

- **Sectoral Gross Value Added, quarterly data, current prices, Million EUR:** Output value at basic prices less intermediate consumption valued at purchasers' prices. GVA is calculated before consumption of fixed capital. GVA is conceptually close to GDP (Gross domestic product), but unlike GDP available in a breakdown by branch of economic activity. The ESA 95 (European System of Accounts) regulation may be referred to for more specific explanations on methodology. Source: Eurostat.

– Calculation for the series in the paper: $i \in \{Construction, Services\}$ and $j \in \{Industry, Agriculture\}$.

$$\frac{Y_T}{Y_T + Y_{NT}} = \frac{\sum_i y_i}{\sum_i y_i + \sum_j y_j}, \quad \frac{Y_{NT}}{Y_T + Y_{NT}} = \frac{\sum_j y_j}{\sum_i y_i + \sum_j y_j}.$$

- **Lending of credit institutions to other resident sectors (breakdown by end-use), quarterly, EUR MILLIONS:** Financing of productive activities.

- Calculation for the series in the paper: $i \in \{Construction, Services\}$ and $j \in \{Industry, Agriculture\}$.

$$\frac{\sum_i credit_i}{Nominal\ GDP}, \quad \frac{\sum_j credit_j}{Nominal\ GDP} \ .$$

- **Real interest rates:**

- **Nominal interest rate, quarterly data:** Short-term nominal interest rate, in percents. Source: OECD Economic Outlook 101.
- **GDP deflator, quarterly data:** Price index at market prices (100=2010). Source: OECD Economic Outlook 101.
- **Inflation rate, quarterly data:** Computed as the 4-quarters difference in GDP deflator, in percents.

- **Interest rates on loans:**

- **Effective interest rates on loans to non-financial corporations (Germany):** Rates with a maturity of 1 year and up to 5. In percents.
Source: Bundesbank
- **Effective interest rates on housing loans (Germany):** Rates with a maturity of 1 year and up to 5. In percents.
Source: Bundesbank
- **Bank rate on loans to nonfinancial corporations (Spain):** The average rate of interest charged on 1 to 5 year loans by commercial banks to non financial corporations In percents.
Source: Bank of Spain
- **Average interest rates on mortgages (Spain):** In percents.
Source: Instituto Nacional de Estadística

Appendix B: Detailed Solution of Firms' Problems

Goods producers:

$$Y_{i,t} = K_{i,t}^\alpha L_{i,t}^{1-\alpha}$$

Expected discounted profits:

$$\begin{aligned} \mathbb{E}_t \sum_{s=t}^{\infty} \beta^s \Lambda_{s,s+1} [P_{ii,s+1} Y_{i,s+1} + Q_{i,s+1} (1 - \delta) K_{i,s+1} \\ - w_{i,s+1} L_{i,s+1} - (R_{k,i,s+1}) Q_{i,s} K_{i,s+1}] \end{aligned}$$

FOCs:

$$\beta \mathbb{E}_t [\Lambda_{t,t+1} (R_{i,k,t+1})] = \beta \mathbb{E}_t \left[\Lambda_{t,t+1} \left(\frac{P_{ii,t+1} \alpha \frac{Y_{i,t+1}}{K_{i,t+1}} + (1 - \delta) Q_{i,t+1}}{Q_{i,t}} \right) \right]$$

$$P_{ii,t+1} (1 - \alpha) \frac{Y_{i,t+1}}{L_{i,t+1}} = w_{i,t+1},$$

where $\Lambda_{t,t+1} = \frac{U_C(t+1)}{U_C(t)}$, and $i \in \{T, NT\}$ and $ii \in \{H, NT\}$.

Capital producers:

Objective:

$$Max_{I_{i,t}} \quad Q_{i,t} K_{i,t+1} - Q_{i,t} (1 - \delta) K_{i,t} - I_{i,t}$$

Constraint:

$$K_{i,t+1} = (1 - \delta) K_{i,t} + I_{i,t} - f \left(\frac{I_{i,t}}{K_{i,t}} \right) K_{i,t}$$

Q relation for investment:

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

Appendix C: Detailed Solution of Bankers' Problem

The program of the bank is as follows:

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

subject to

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

$$N_t(j) = R_{k,T,t} Q_{T,t-1} S_{T,t-1}(j) + R_{k,NT,t} Q_{NT,t-1} S_{NT,t-1}(j) - R_t^H B_t(j) - R_t^F B_t^*(j),$$

$$V_t(N_t(j)) \geq \lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)] + \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j)].$$

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

$$\begin{aligned} \mathcal{L} = & \mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) \{ (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} S_{T,t}(j) + (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t} S_{NT,t}(j) \\ & - (R_{t+1}^F - R_{t+1}^H) B_{t+1}^* + R_{t+1}^H N_t(j) \} + \gamma V_{t+1}(N_{t+1}(j))] \\ & + \mu_t [V_t(N_t(j)) - \lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)] - \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j)]] \end{aligned}$$

Necessary and sufficient conditions for an optimum are:

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

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

$$\frac{\partial \mathcal{L}}{\partial B_{t+1}^*} = -\mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{t+1}^F - R_{t+1}^H) Q_{NT,t} - \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}} \right] + \mu_t (\lambda_T + \lambda_{NT}) \iota_t = 0,$$

$$\mu_t (V_t(N_t(j)) - \lambda_T [Q_{T,t}S_{T,t}(j) - \iota_t B_{t+1}^*(j)] - \lambda_{NT} [Q_{NT,t}S_{NT,t}(j) - \iota_t B_{t+1}^*(j)]) = 0.$$

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

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

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

$$\frac{\partial V_{t+1}}{\partial B_{t+1}^*} = -\nu_{t+1}(R_{t+1}^F - R_{t+1}^H).$$

Thus, FOCs with respect to assets become:

$$\beta \mathbb{E}_t [A_{t,t+1} ((1 - \gamma) + \gamma \nu_{t+1}) (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t}] = \mu_t \lambda_T Q_{T,t}, \quad (1)$$

$$\beta \mathbb{E}_t [A_{t,t+1} ((1 - \gamma) + \gamma \nu_{t+1}) (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t}] = \mu_t \lambda_{NT} Q_{NT,t}. \quad (2)$$

$$\beta \mathbb{E}_t [A_{t,t+1} ((1 - \gamma) + \gamma \nu_{t+1}) (R_{t+1}^F - R_{t+1}^H)] = \mu_t (\lambda_T + \lambda_{NT}) \iota_t \quad (3)$$

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

$$\begin{aligned} V_t(N_t(j)) = \max_{S_{T,t}, S_{NT,t}, B_{t+1}^*} & \left\{ \sum_{i \in \{T, NT\}} \beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (R_{k,i,t+1} - R_{t+1}^H) Q_{i,t} S_{i,t}(j)] \right\} \\ & - \beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (R_{t+1}^F - R_{t+1}^H) B_{t+1}^*(j)] + \beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (R_{t+1}^H) N_t(j)] \end{aligned}$$

subject to

$$\sum_{i \in \{T, NT\}} [\lambda_i (Q_{i,t} S_{i,t}(j) - \iota_t B_{t+1}^*(j))] \leq \nu_t N_t(j).$$

Using above conditions and the complementary slackness condition, the value function

can be rewritten as:

$$\nu_t N_t(j) = \mu_t \nu_t N_t(j) + \beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} R_{t+1}^H N_t(j)].$$

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

$$\nu_t = \frac{\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} R_{t+1}^H]}{1 - \mu_t}. \quad (4)$$

From the complementary slackness condition, one can obtain:

$$\mu_t = \max \left\{ 1 - \left(\frac{\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} R_{t+1}^H]}{\lambda_T(Q_{T,t} S_{T,t} - \iota_t B_{t+1}^*) + \lambda_{NT}(Q_{NT,t} S_{NT,t} - \iota_t B_{t+1}^*)} \right), 0 \right\} < 1. \quad (5)$$

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

Aggregation:

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

$$N_t = N_{x,t} + N_{n,t}, \quad (6)$$

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

$$N_{x,t} = \gamma [(Z_{T,t} + (1 - \delta) Q_{T,t}) S_{T,t-1} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) S_{NT,t-1} - R_t^H B_t - R_t^F B_t^*]. \quad (7)$$

Entering bankers receive start-up funds from the household that they are a member of. These start-up funds are a fraction of the assets that the exiting bankers bring back to the household. Without loss of generality, let $\frac{\epsilon}{1-\gamma}$ of exiting bankers' assets are transferred to

entering bankers within the same household, and then new banker net worth becomes:

$$N_{n,t} = \varepsilon [(Z_{T,t} + (1 - \delta) Q_{T,t}) S_{T,t-1} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) S_{NT,t-1}] . \quad (8)$$

Now, equation (29) can be rewritten as:

$$\begin{aligned} N_t = & (\gamma + \varepsilon) [(Z_{T,t} + (1 - \delta) Q_{T,t}) S_{T,t-1} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) S_{NT,t-1}] \\ & - \gamma (R_t^H B_t + R_t^F B_t^*) \end{aligned} \quad (9)$$

Equation (9) tells that the ex-post returns on non-financial firm assets are the main sources of fluctuations in net worth. Moreover, in any sector, a change in the valuation of capital affects both the bank net worth directly through itself, and indirectly through its impact on the other sector's returns.

Appendix D: Derivation of the Net Foreign Asset Equation

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

$$T_t^f = (\eta/2) [\xi_t (B_{*,t+1})^2] \quad (10)$$

$$B_{t+1} = Q_{T,t} K_{T,t+1} + Q_{NT,t} K_{NT,t+1} - N_t - B_{t+1}^* \quad (11)$$

$$\Pi_{i,t} = Q_{i,t} K_{i,t+1} - Q_{i,t} (1 - \delta) K_{i,t} - I_{i,t} \quad i \in \{T, NT\} \quad (12)$$

$$\begin{aligned}\Pi_t^B = & (1 - \gamma - \varepsilon) \left[(Z_t^T + (1 - \delta)Q_{T,t}) K_{T,t} + (Z_t^{NT} + (1 - \delta)Q_{NT,t}) K_{NT,t} \right] \\ & - (1 - \gamma) \left[R_t^H B_t + R_t^F B_t^* \right].\end{aligned}\tag{13}$$

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:

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

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

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

$$\begin{aligned}
& (\xi_t B_{*,t+1} - B_{t+1}^*) + \frac{1}{2} [(C_t - \xi_t C_t^*) - (N_t - \xi_t N_t^*)] \\
& = \frac{1}{2} (\xi_t (R_t^{H*} + R_t^{F*}) B_{*,t} - (R_t^H + R_t^F) B_t^*) + \frac{1}{2} (w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t (w_{T,t}^* L_{T,t}^* + w_{NT,t}^* L_{NT,t}^*)) \\
& \quad + \frac{1}{2} [\gamma R_t^H (Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})] \\
& \quad - \frac{1}{2} \xi_t [R_t^{F*} \gamma^* (1 + r_t^*) (Q_{T,t-1}^* K_{T,t}^* + Q_{NT,t-1}^* K_{NT,t}^* - N_{t-1}^*)] \\
& \quad - \frac{1}{2} (1 - \delta) [Q_{T,t} K_{T,t} + Q_{NT,t} K_{NT,t} - \xi_t (Q_{T,t}^* K_{T,t}^* + Q_{NT,t}^* K_{NT,t}^*)] \\
& \quad - \frac{1}{2} [I_{T,t} + I_{NT,t} - \xi_t (I_{T,t}^* + I_{NT,t}^*)] \\
& \quad + \frac{1}{2} (1 - \gamma - \varepsilon) [(Z_{T,t} + (1 - \delta) Q_{T,t}) K_{T,t} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) K_{NT,t}] \\
& \quad - \frac{1}{2} \xi_t (1 - \gamma^* - \varepsilon) [(Z_{T,t}^* + (1 - \delta) Q_{T,t}^*) K_{T,t}^* + (Z_{NT,t}^* + (1 - \delta) Q_{NT,t}^*) K_{NT,t}^*] \\
& \quad - \frac{1}{2} [(R_t^H - R_t^F) B_t^* - \xi_t (R_t^{F*} - R_t^{H*}) B_{*,t}]
\end{aligned} \tag{14}$$

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

$$CA_t = \xi_t (B_{*,t+1} - B_{*,t}) - (B_{t+1}^* - B_t^*). \tag{15}$$

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

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

The program of the bank is as follows:

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

s.to

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

$$N_t(j) = R_{k,T,t} Q_{T,t-1} S_{NT,t-1}^p(j) + R_{k,NT,t} Q_{NT,t-1} S_{NT,t-1}^p(j) + R_t^g B_{t-1}^g(j) - R_t^H B_t(j) - R_t^F B_t^*(j),$$

$$V_t(N_t(j)) \geq \lambda_T [Q_{T,t} S_{T,t}^p(j) - \iota_t B_{t+1}^*(j)] + \lambda_{NT} [Q_{NT,t} S_{NT,t}^p(j) - \iota_t B_{t+1}^*(j)] + \lambda_{ECB} B_t^g(j).$$

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

$$\begin{aligned} \mathcal{L} = & \mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) \{ (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} S_{T,t}^p(j) + (R_{k,NT,t+1} - r_{t+1}) Q_{NT,t} S_{NT,t}^p(j) \\ & + (R_{gt+1} - R_{t+1}^H) B_t^g(j) - (R_{t+1}^F - R_{t+1}^H) B_{t+1}^* + R_{t+1}^H N_t(j) \} + \gamma V_{t+1}(N_{t+1}(j))] \\ & + \mu_t [V_t(N_t(j)) - \lambda_T [Q_{T,t} S_{T,t}^p(j) - \iota_t B_{t+1}^*(j)] - \lambda_{NT} [Q_{NT,t} S_{NT,t}^p(j) - \iota_t B_{t+1}^*(j)] - \lambda_{ECB} B_t^g(j)] \end{aligned}$$

When the incentive constraint is binding, the FONCs yield

$$\begin{aligned} \frac{\partial \mathcal{L}}{\partial S_{T,t}^p} &= \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} + \gamma \frac{\partial V_{t+1}}{\partial S_{T,t}^p} \right] - \mu_t \lambda_T Q_{T,t} = 0, \\ \frac{\partial \mathcal{L}}{\partial S_{NT,t}^p} &= \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t} + \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}^p} \right] - \mu_t \lambda_{NT} Q_{NT,t} = 0, \\ \frac{\partial \mathcal{L}}{\partial B_t^g} &= \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{g,t+1} - R_{t+1}^H) + \gamma \frac{\partial V_{t+1}}{\partial B_t^g} \right] - \mu_t \lambda_{ECB} = 0, \\ \frac{\partial \mathcal{L}}{\partial B_{t+1}^*} &= -\mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{t+1}^F - R_{t+1}^H) Q_{NT,t} - \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}^p} \right] + \mu_t (\lambda_T + \lambda_{NT}) \iota_t = 0, \\ \mu_t (V_t(N_t(j)) - \lambda_T [Q_{T,t} S_{T,t}^p(j) - \iota_t B_{t+1}^*(j)] - \lambda_{NT} [Q_{NT,t} S_{NT,t}^p(j) - \iota_t B_{t+1}^*(j)] - \lambda_{ECB} B_t^g(j)) &= 0. \end{aligned}$$

I conjecture a solution to the above value function which is linear in bank net worth. i.e.

$V_t(N_t(j)) = \nu_t N_t(j)$. Then, it is possible to express the derivative terms in the FONCs as:

$$\begin{aligned} \frac{\partial V_{t+1}}{\partial S_{T,t}^p} &= \nu_{t+1} (r_{k,T,t+1} - r_{t+1}) Q_{T,t}, \\ \frac{\partial V_{t+1}}{\partial S_{NT,t}^p} &= \nu_{t+1} (r_{k,NT,t+1} - r_{t+1}) Q_{NT,t}, \end{aligned}$$

$$\frac{\partial V_{t+1}}{\partial B_{t+1}^*} = -\nu_{t+1}(R_{t+1}^F - R_{t+1}^H).$$

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

Thus, FOCs with respect to assets become:

$$\mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) + \gamma \nu_{t+1}] (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} = \mu_t \lambda_T Q_{T,t}, \quad (16)$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) + \gamma \nu_{t+1}] (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t} = \mu_t \lambda_{NT} Q_{NT,t}, \quad (17)$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) + \gamma \nu_{t+1}] (R_{g,t+1} - R_{t+1}^H) = \mu_t \lambda_{ECB}. \quad (18)$$

$$\beta \mathbb{E}_t [\Lambda_{t,t+1} ((1 - \gamma) + \gamma \nu_{t+1}) (R_{t+1}^F - R_{t+1}^H)] = \mu_t (\lambda_T + \lambda_{NT}) \iota_t \quad (19)$$

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

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

subject to

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

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

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

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

$$\nu_t = \frac{\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} R_{t+1}^H]}{1 - \mu_t}. \quad (20)$$

From the complementary slackness condition, one can obtain:

$$\mu_t = \max \left\{ 1 - \left(\frac{\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t]}{\lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)] + \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j)] + \lambda_{ECB} B_t^g(j)} \right), 0 \right\} < 1. \quad (21)$$

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

The program of the bank is as follows:

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

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

$$N_t(j) = R_{k,T,t} Q_{T,t-1} S_{T,t-1}(j) + R_{k,NT,t} Q_{NT,t-1} S_{NT,t-1}(j) + R_t^g B_{t-1}^g(j) - R_t^H B_t(j) - R_t^F B_t^*(j) - R_{t+1}^m M_{t+1}(j),$$

$$V_t(N_t(j)) \geq \lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)] + \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j) - M_{t+1}(j)] \\ + \lambda_{ECB} (B_t^g(j) - M_{t+1}(j)).$$

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

$$\mathcal{L} = \mathbb{E}_t \beta A_{t,t+1} [(1 - \gamma) \{ (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} S_{T,t}^p(j) + (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t} S_{NT,t}^p(j) \\ + (R_{gt+1} - R_{t+1}^H) B_t^g(j) - (R_{t+1}^F - R_{t+1}^H) B_{t+1}^* + R_{t+1}^H N_t(j) \\ - (R_{t+1}^m - R_{t+1}^H) M_{t+1}(j) \} + \gamma V_{t+1}(N_{t+1}(j))] + \mu_t [V_t(N_t(j)) - \lambda_T [Q_{T,t} S_{T,t}^p(j) - \iota_t B_{t+1}^*(j)] \\ - \lambda_{NT} [Q_{NT,t} S_{NT,t}^p(j) - \iota_t B_{t+1}^*(j) - M_{t+1}(j)] - \lambda_{ECB} (B_t^g(j) - M_{t+1}(j))]$$

When the incentive constraint is binding, the FONCs yield

$$\begin{aligned}
\frac{\partial \mathcal{L}}{\partial S_{T,t}} &= \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} + \gamma \frac{\partial V_{t+1}}{\partial S_{T,t}} \right] - \mu_t \lambda_T Q_{T,t} = 0, \\
\frac{\partial \mathcal{L}}{\partial S_{NT,t}} &= \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t} + \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}} \right] - \mu_t \lambda_{NT} Q_{NT,t} = 0, \\
\frac{\partial \mathcal{L}}{\partial B_t^g} &= \mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{g,t+1} - R_{t+1}^H) + \gamma \frac{\partial V_{t+1}}{\partial B_t^g} \right] - \mu_t \lambda_{ECB} = 0, \\
\frac{\partial \mathcal{L}}{\partial B_{t+1}^*} &= -\mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{t+1}^F - R_{t+1}^H) Q_{NT,t} - \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}} \right] + \mu_t (\lambda_T + \lambda_{NT}) \iota_t = 0, \\
\frac{\partial \mathcal{L}}{\partial M_{t+1}} &= -\mathbb{E}_t \beta \Lambda_{t,t+1} \left[(1 - \gamma) (R_{t+1}^m - R_{t+1}^H) Q_{NT,t} - \gamma \frac{\partial V_{t+1}}{\partial S_{NT,t}} \right] + \mu_t (\lambda_{ECB} + \lambda_{NT}) = 0, \\
\mu_t (V_t(N_t(j)) - \lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)] - \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j) - M_{t+1}(j)] \\
&\quad - \lambda_{ECB} (B_t^g(j) - M_{t+1}(j))) = 0.
\end{aligned}$$

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

$$\begin{aligned}
\frac{\partial V_{t+1}}{\partial S_{T,t}} &= \nu_{t+1} (r_{k,T,t+1} - r_{t+1}) Q_{T,t}, \\
\frac{\partial V_{t+1}}{\partial S_{NT,t}} &= \nu_{t+1} (r_{k,NT,t+1} - r_{t+1}) Q_{NT,t}, \\
\frac{\partial V_{t+1}}{\partial B_{t+1}^*} &= -\nu_{t+1} (R_{t+1}^F - R_{t+1}^H), \\
\frac{\partial V_{t+1}}{\partial M_{t+1}} &= -\nu_{t+1} (R_{t+1}^m - R_{t+1}^H), \\
\frac{\partial V_{t+1}}{\partial B_t^g} &= \nu_{t+1} (R_{g,t+1} - R_{t+1}^H).
\end{aligned}$$

Thus, FOCs with respect to assets become:

$$\mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) + \gamma \nu_{t+1}] (R_{k,T,t+1} - R_{t+1}^H) Q_{T,t} = \mu_t \lambda_T Q_{T,t}, \quad (22)$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) + \gamma \nu_{t+1}] (R_{k,NT,t+1} - R_{t+1}^H) Q_{NT,t} = \mu_t \lambda_{NT} Q_{NT,t}, \quad (23)$$

$$\mathbb{E}_t \beta \Lambda_{t,t+1} [(1 - \gamma) + \gamma \nu_{t+1}] (R_{g,t+1} - R_{t+1}^H) = \mu_t \lambda_{ECB}. \quad (24)$$

$$\beta \mathbb{E}_t [\Lambda_{t,t+1} ((1 - \gamma) + \gamma \nu_{t+1}) (R_{t+1}^F - R_{t+1}^H)] = \mu_t (\lambda_T + \lambda_{NT}) \iota_t \quad (25)$$

$$\beta \mathbb{E}_t [\Lambda_{t,t+1} ((1 - \gamma) + \gamma \nu_{t+1}) (R_{t+1}^m - R_{t+1}^H)] = \mu_t (\lambda_{ECB} + \lambda_{NT}). \quad (26)$$

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

$$\begin{aligned} V_t(N_t(j)) = \max_{S_{T,t}, S_{NT,t}, B_t^g} & \left\{ \sum_{i \in \{T, NT\}} \beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} (R_{k,i,t+1} - R_{t+1}^H) Q_{i,t} S_{i,t}(j)] \right\} \\ & + \beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} (R_{g,t+1} - R_{t+1}^H) B_{g,t+1}(j)] - \beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} (R_{t+1}^m - R_{t+1}^H) M_{t+1}(j)] \\ & - \beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} (R_{t+1}^F - R_{t+1}^H) B_{t+1}^*(j)] + \beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} R_{t+1}^H N_t(j)] \end{aligned}$$

subject to

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

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

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

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

$$\nu_t = \frac{\beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} R_{t+1}^H]}{1 - \mu_t}. \quad (27)$$

From the complementary slackness condition, one can obtain:

$$\mu_t = \max \left\{ 1 - \left(\frac{\beta \mathbb{E}_t [\Lambda_{t,t+1} \Omega_{t+1} (1 + r_{t+1}) N_t]}{\lambda_T [Q_{T,t} S_{T,t}(j) - \iota_t B_{t+1}^*(j)] + \lambda_{NT} [Q_{NT,t} S_{NT,t}(j) - \iota_t B_{t+1}^*(j) - M_{t+1}(j)] + \lambda_{ECB} (B_t^g(j) - M_{t+1}(j))} \right), 0 \right\} < 1. \quad (28)$$

Appendix G: 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:

$$T_t^f = (\eta/2) [\xi_t (B_{*,t+1})^2] \quad (29)$$

$$T_t = \frac{(R_{k,T,t} - R_{g,t}) Q_{T,t-1} S_{T,t-1} \varphi_{T,t-1}^{ump} + (R_{k,NT,t} - R_{g,t}) Q_{NT,t-1} S_{NT,t-1} \varphi_{NT,t-1}^{ump} - \Upsilon_{t-1}}{2}, \quad (30)$$

$$B_{t+1} = (1 - \varphi_{T,t}^{ump}) Q_{T,t} K_{T,t+1} + (1 - \varphi_{NT,t}^{ump}) Q_{NT,t} K_{NT,t+1} + B_t^g - N_t - B_{t+1}^*, \quad (31)$$

$$B_t^g = \frac{\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1}}{2}, \quad (32)$$

$$\Pi_{i,t} = Q_{i,t} K_{i,t+1} - Q_{i,t} (1 - \delta) (K_{i,t}) - I_{i,t} \quad i \in \{T, NT\} \quad (33)$$

$$\begin{aligned} \Pi_{B,t} &= (1 - \gamma - \varepsilon) [(Z_t^T + (1 - \delta) Q_{T,t}) K_{T,t} + (Z_t^{NT} + (1 - \delta) Q_{NT,t}) K_{NT,t} \\ &\quad - \varphi_{T,t}^{ump} (Z_t^T + (1 - \delta) Q_{T,t}) e^{\psi_t^T} K_{T,t} - \varphi_{NT,t}^{ump} (Z_t^{NT} + (1 - \delta) Q_{NT,t}) e^{\psi_t^{NT}} K_{NT,t} \\ &\quad + R_{g,t} \frac{\varphi_{T,t-1}^{ump} Q_{T,t-1} K_{T,t} + \varphi_{NT,t-1}^{ump} Q_{NT,t-1} K_{NT,t}}{2}] - (1 - \gamma) [R_t^H B_t + R_t^F B_t^*] \end{aligned} \quad (34)$$

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

$$\begin{aligned} &\xi_t B_{*,t+1} - B_{t+1}^* + C_t - N_t - \frac{(\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1})}{2} \\ &= \xi_t R_t^{H*} B_{*,t} - R_t^H B_t^* - \gamma R_t^H N_{t-1} - (I_{T,t} + I_{NT,t}) + w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} + T_t \\ &\quad + Q_{T,t-1} K_{T,t} [\gamma R_t^H + (1 - \gamma - \varepsilon) R_{k,T,t} - (1 - \delta) \frac{Q_{T,t}}{Q_{T,t-1}} \\ &\quad + \varphi_{T,t-1}^{ump} \left(\frac{(1 - \gamma - \varepsilon) R_{gt} - \gamma R_t^H}{2} - (1 - \gamma - \varepsilon) R_{k,T,t} \right)] \\ &\quad + Q_{NT,t-1} K_{NT,t} [\gamma (1 + r_t) + (1 - \gamma - \varepsilon) (1 + r_{k,NT,t}) - (1 - \delta) e^{\psi_t^{NT}} \frac{Q_{NT,t}}{Q_{NT,t-1}} \\ &\quad + \varphi_{NT,t-1}^{ump} \left(\frac{(1 - \gamma - \varepsilon) R_{gt} - \gamma R_t^H}{2} - (1 - \gamma - \varepsilon) R_{k,NT,t} \right)] + (1 - \gamma) (R_t^H - R_t^F) B_t^*. \end{aligned} \quad (35)$$

Multiplying the Foreign condition with ξ_t , and subtracting it from (35), 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:

$$\begin{aligned}
& (\xi_t B_{*,t+1} - B_{*,t+1}^*) + \frac{1}{2} [(C_t - \xi_t C_t^*) - (N_t - \xi_t N_t^*)] - \frac{(\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1})}{4} \\
& = \frac{1}{2} (\xi_t (R_t^H + R_t^F) B_{*,t} - (R_t^H + R_t^F) B_t^*) + \frac{1}{2} (w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t (w_{T,t}^* L_{T,t}^* + w_{NT,t}^* L_{NT,t}^*)) \\
& + \frac{1}{2} [\gamma R_t^H (Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})] \\
& - \frac{1}{2} \xi_t [\gamma^* R_t^{F*} (Q_{T,t-1}^* K_{T,t}^* + Q_{NT,t-1}^* K_{NT,t}^* - N_{t-1}^*)] \\
& - \frac{1}{2} (1 - \delta) [Q_{T,t} K_{T,t} + Q_{NT,t} K_{NT,t} - \xi_t (Q_{T,t}^* K_{T,t}^* + Q_{NT,t}^* K_{NT,t}^*)] \\
& - \frac{1}{2} [I_{T,t} + I_{NT,t} - \xi_t (I_{T,t}^* + I_{NT,t}^*)] \\
& + \varphi_{T,t-1}^{ump} Q_{T,t-1} K_{T,t} \left(\frac{(1-\gamma-\varepsilon) R_{gt} - \gamma R_t^H}{4} - \frac{(1-\gamma-\varepsilon) R_{k,T,t}}{2} \right) \\
& + \varphi_{NT,t-1}^{ump} Q_{NT,t-1} K_{NT,t} \left(\frac{(1-\gamma-\varepsilon) R_{gt} - \gamma R_t^H}{4} - \frac{(1-\gamma-\varepsilon) R_{k,NT,t}}{2} \right) \\
& + \frac{1}{2} (1 - \gamma - \varepsilon) [(Z_{T,t} + (1 - \delta) Q_{T,t}) K_{T,t} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) K_{NT,t}] \\
& - \frac{1}{2} \xi_t (1 - \gamma^* - \varepsilon) [(Z_{T,t}^* + (1 - \delta) Q_{T,t}^*) K_{T,t}^* + (Z_{NT,t}^* + (1 - \delta) Q_{NT,t}^*) K_{NT,t}^*] \\
& - \frac{1}{2} [(R_t^H - R_t^F) B_t^* - \xi_t (R_t^{F*} - R_t^{H*}) B_{*,t}].
\end{aligned} \tag{36}$$

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

Under liquidity facilities, similarly,

$$T_t = \frac{(R_{m,t} - R_{g,t}) Q_{T,t-1} S_{T,t-1} \varphi_{T,t-1}^{ump} + (R_{m,t} - R_{g,t}) Q_{NT,t-1} S_{NT,t-1} \varphi_{NT,t-1}^{ump} - \Upsilon_{t-1}}{2}, \tag{37}$$

$$B_{t+1} = Q_{T,t} K_{T,t+1} + Q_{NT,t} K_{NT,t+1} + B_t^g - N_t - M_{t+1} - B_{t+1}^*, \tag{38}$$

$$\begin{aligned}
\Pi_{B,t} & = (1 - \gamma - \varepsilon) [(Z_t^T + (1 - \delta) Q_{T,t}) K_{T,t} + (Z_t^{NT} + (1 - \delta) Q_{NT,t}) K_{NT,t} \\
& + R_{g,t}) \frac{\varphi_{T,t-1}^{ump} Q_{T,t-1} K_{T,t} + \varphi_{NT,t-1}^{ump} Q_{NT,t-1} K_{NT,t}}{2}] \\
& - (1 - \gamma) [(R_t^H B_t + R_t^F B_t^*) + R_{m,t} (\varphi_{T,t-1}^{ump} Q_{T,t-1} K_{T,t} + \varphi_{NT,t-1}^{ump} Q_{NT,t-1} K_{NT,t})]
\end{aligned} \tag{39}$$

with

$$M_{t+1} - B_t^g = \frac{\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1}}{2}. \quad (40)$$

And the above conditions lead to:

$$\begin{aligned} & (\xi_t B_{*,t+1} - B_{t+1}^*) + \frac{1}{2} [(C_t - \xi_t C_t^*) - (N_t - \xi_t N_t^*)] - \frac{(\varphi_{T,t}^{ump} Q_{T,t} K_{T,t+1} + \varphi_{NT,t}^{ump} Q_{NT,t} K_{NT,t+1})}{4} \\ &= \frac{1}{2} (\xi_t (R_t^{H*} + R_t^{F*}) B_{*,t} - (R_t^H + R_t^F) B_t^*) + \frac{1}{2} (w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t (w_{T,t}^* L_{T,t}^* + w_{NT,t}^* L_{NT,t}^*)) \\ &+ \frac{1}{2} [\gamma R_t^H (Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})] \\ &- \frac{1}{2} \xi_t [\gamma^* R_t^{F*} (Q_{T,t-1}^* K_{T,t}^* + Q_{NT,t-1}^* K_{NT,t}^* - N_{t-1}^*)] \\ &- \frac{1}{2} (1 - \delta) [Q_{T,t} K_{T,t} + Q_{NT,t} K_{NT,t} - \xi_t (Q_{T,t}^* K_{T,t}^* + Q_{NT,t}^* K_{NT,t}^*)] \\ &- \frac{1}{2} [I_{T,t} + I_{NT,t} - \xi_t (I_{T,t}^* + I_{NT,t}^*)] \\ &+ \varphi_{T,t-1}^{ump} Q_{T,t-1} K_{T,t} \left(\frac{(1-\gamma-\varepsilon) R_{gt} - \gamma R_t^H}{4} - \frac{(1-\gamma) R_t^m}{2} \right) \\ &+ \varphi_{NT,t-1}^{ump} Q_{NT,t-1} K_{NT,t} \left(\frac{(1-\gamma-\varepsilon) R_{gt} - \gamma R_t^H}{4} - \frac{(1-\gamma) R_t^m}{2} \right) \\ &+ \frac{1}{2} (1 - \gamma - \varepsilon) [(Z_{T,t} + (1 - \delta) Q_{T,t}) K_{T,t} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) K_{NT,t}] \\ &- \frac{1}{2} \xi_t (1 - \gamma^* - \varepsilon) [(Z_{T,t}^* + (1 - \delta) Q_{T,t}^*) K_{T,t}^* + (Z_{NT,t}^* + (1 - \delta) Q_{NT,t}^*) K_{NT,t}^*] \\ &- \frac{1}{2} [(R_t^H - R_t^F) B_t^* - \xi_t (R_t^{F*} - R_t^{H*}) B_{*,t}]. \end{aligned} \quad (41)$$

Tables

Table 1: Quantitative Model Summary

Euler equation, domestic deposits	$C_t^{-\rho} = \beta R_{t+1}^H \mathbb{E}_t [C_{t+1}^{-\rho}]$
Euler equation, deposits abroad	$C_t^{-\rho} [1 + \eta B_{*,t+1}] = \beta R_{t+1}^{H*} \mathbb{E}_t \left[\frac{RER_{t+1}}{RER_t} C_{t+1}^{-\rho} \right]$
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	$C_{H,t} = a_H \left(\frac{RP_{H,t}}{RP_{T,t}} \right)^{-\omega} C_{T,t}$ $C_{F,t} = (1 - a_H) \left(\frac{RP_{F,t}}{RP_{T,t}} \right)^{-\omega} C_{T,t}$ $C_{T,t} = a_T (RP_{T,t})^{-\kappa} C_t$ $C_{NT,t} = (1 - a_T) (RP_{NT,t})^{-\kappa} C_t$
Price indexes	$P_{T,t}^{1-\omega} = a_H P_{H,t}^{1-\omega} + (1 - a_H) P_{F,t}^{1-\omega}$ $1 = a_T P_{T,t}^{1-\kappa} + (1 - a_T) P_{NT,t}^{1-\kappa}$
Labor Demand	$\frac{w_{T,t}}{RP_{H,t}} = (1 - \alpha) e^{a_{T,t}} K_{T,t}^{\alpha} L_{T,t}^{-\alpha}$ $\frac{w_{NT,t}}{RP_{NT,t}} = (1 - \alpha) K_{NT,t}^{\alpha} L_{NT,t}^{-\alpha}$
Gross profits per unit of capital	$Z_{T,t} = \alpha RP_{H,t} K_{T,t}^{\alpha-1} L_{T,t}^{1-\alpha}$ $Z_{NT,t} = \alpha RP_{NT,t} K_{NT,t}^{\alpha-1} L_{NT,t}^{1-\alpha}$
Ex-post Return to Capital	$\beta \mathbb{E}_t [A_{t,t+1} R_{k,T,t+1}] = \beta \mathbb{E}_t \left[A_{t,t+1} \frac{Z_{T,t} + Q_{T,t+1}(1-\delta)}{Q_{T,t}} \right]$ $\beta \mathbb{E}_t [A_{t,t+1} R_{k,NT,t+1}] = \beta \mathbb{E}_t \left[A_{t,t+1} \frac{Z_{NT,t} + Q_{NT,t+1}(1-\delta)}{Q_{NT,t}} \right]$
Tobin's Q	$Q_{T,t} = \frac{1}{1 - f_I \left(\frac{I_{T,t}}{e^{\psi_{T,t}} K_{T,t}} \right) K_{T,t}}$ $Q_{NT,t} = \frac{1}{1 - f_I \left(\frac{I_{NT,t}}{e^{\psi_{NT,t}} K_{NT,t}} \right) K_{NT,t}}$
Resource constraints	$K_{T,t}^{\alpha} L_{T,t}^{1-\alpha} = C_{H,t} + C_{H,t}^* + I_{T,t}$ $K_{NT,t}^{\alpha} L_{NT,t}^{1-\alpha} = C_{NT,t} + I_{NT,t}$
Laws of motion of capital	$K_{T,t+1} = (1 - \delta) K_{T,t} + I_{T,t} - f \left(\frac{I_{T,t}}{K_{T,t}} \right) K_{T,t}$ $K_{NT,t+1} = (1 - \delta) K_{NT,t} + I_{NT,t} - f \left(\frac{I_{NT,t}}{K_{NT,t}} \right) K_{NT,t}$
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	$\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (R_{k,T,t+1} - R_{t+1}^H)] = \lambda_T \mu_t$

Table 1: Quantitative Model Summary (Continued)

	$\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (R_{k,NT,t+1} - R_{t+1}^H)] = \lambda_{NT} \mu_t$
	$\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} (R_{t+1}^F - R_{t+1}^H)] = \iota_t (\lambda_T + \lambda_{NT}) \mu_t$
Shadow marginal value of net worth	$\Omega_t \equiv (1 - \gamma + \gamma \nu_t)$
Marginal value of banks' net worth	$\nu_t = \frac{\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} R_{t+1}^H]}{1 - \mu_t}$
Banks' Lagrange multiplier	$\mu_t = 1 - \left(\frac{\beta \mathbb{E}_t [A_{t,t+1} \Omega_{t+1} R_{t+1}^H N_t]}{\lambda_T (Q_{T,t} S_{T,t} - \iota_t B_{t+1}^*) + \lambda_{NT} (Q_{NT,t} S_{NT,t} - \iota_t B_{t+1}^*)} \right)$
Aggregate net worth	$N_t = (\gamma + \varepsilon) [(Z_{T,t} + (1 - \delta) Q_{T,t}) S_{T,t-1} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) S_{NT,t-1}] - \gamma (R_t^H B_t + R_t^F B_t^*)$
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	$(\xi_t B_{*,t+1} - B_{t+1}^*) + \frac{1}{2} [(C_t - \xi_t C_t^*) - (N_t - \xi_t N_t^*)]$ $= \frac{1}{2} (\xi_t (R_t^{H*} + R_t^{F*}) B_{*,t} - (R_t^H + R_t^F) B_t^*) + \frac{1}{2} (w_{T,t} L_{T,t} + w_{NT,t} L_{NT,t} - \xi_t (w_{T,t}^* L_{T,t}^* + w_{NT,t}^* L_{NT,t}^*))$ $+ \frac{1}{2} [\gamma R_t^H (Q_{T,t-1} K_{T,t} + Q_{NT,t-1} K_{NT,t} - N_{t-1})]$ $- \frac{1}{2} \xi_t [R_t^{F*} \gamma^* (1 + r_t^*) (Q_{T,t-1}^* K_{T,t}^* + Q_{NT,t-1}^* K_{NT,t}^* - N_{t-1}^*)]$ $- \frac{1}{2} (1 - \delta) [Q_{T,t} K_{T,t} + Q_{NT,t} K_{NT,t} - \xi_t (Q_{T,t}^* K_{T,t}^* + Q_{NT,t}^* K_{NT,t}^*)]$ $- \frac{1}{2} [I_{T,t} + I_{NT,t} - \xi_t (I_{T,t}^* + I_{NT,t}^*)]$ $+ \frac{1}{2} (1 - \gamma - \varepsilon) [(Z_{T,t} + (1 - \delta) Q_{T,t}) K_{T,t} + (Z_{NT,t} + (1 - \delta) Q_{NT,t}) K_{NT,t}]$ $- \frac{1}{2} \xi_t (1 - \gamma^* - \varepsilon) [(Z_{T,t}^* + (1 - \delta) Q_{T,t}^*) K_{T,t}^* + (Z_{NT,t}^* + (1 - \delta) Q_{NT,t}^*) K_{NT,t}^*]$ $- \frac{1}{2} [(R_t^H - R_t^F) B_t^* - \xi_t (R_t^{F*} - R_t^{H*}) B_{*,t}]$

Figures

Figure 1: Model Architecture

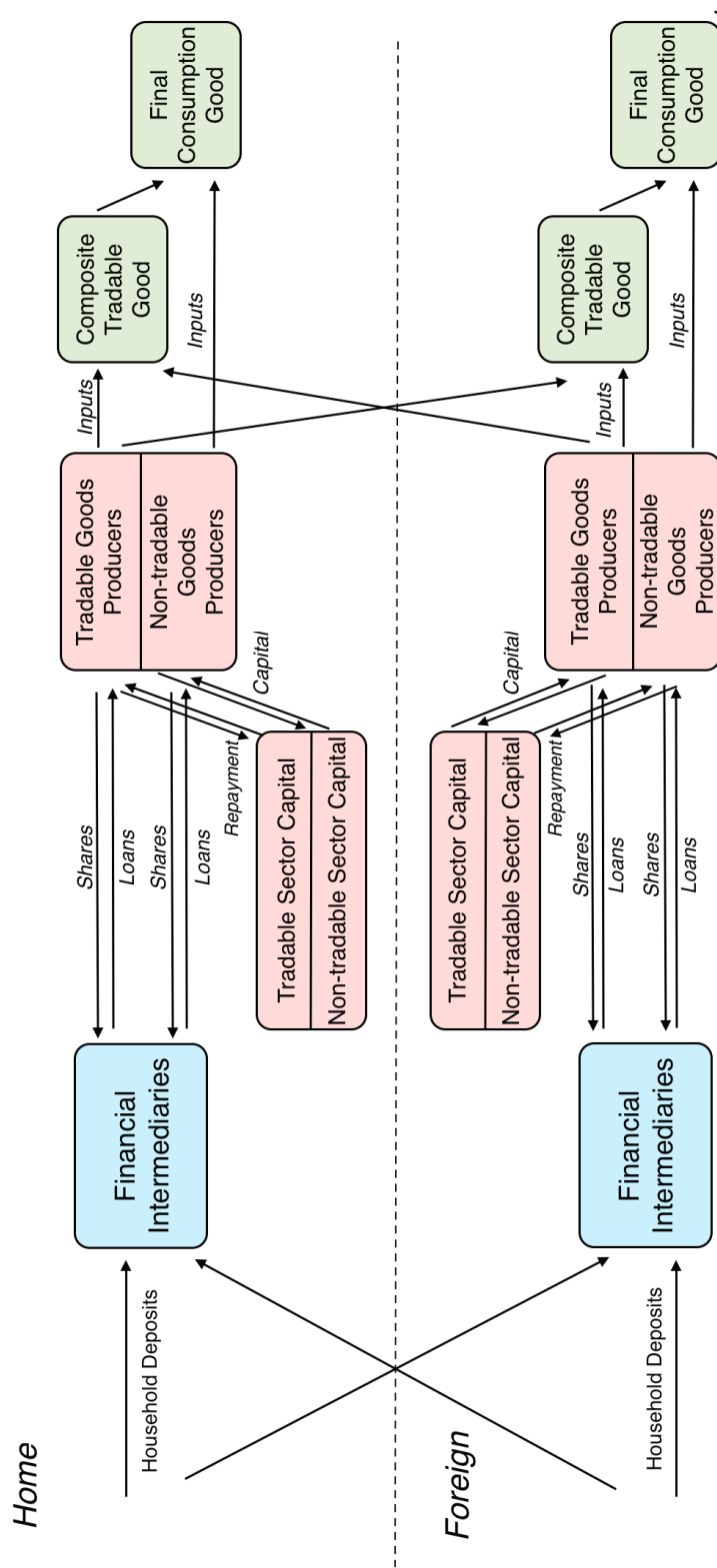


Figure 2: Illustration of Asset Purchases Program

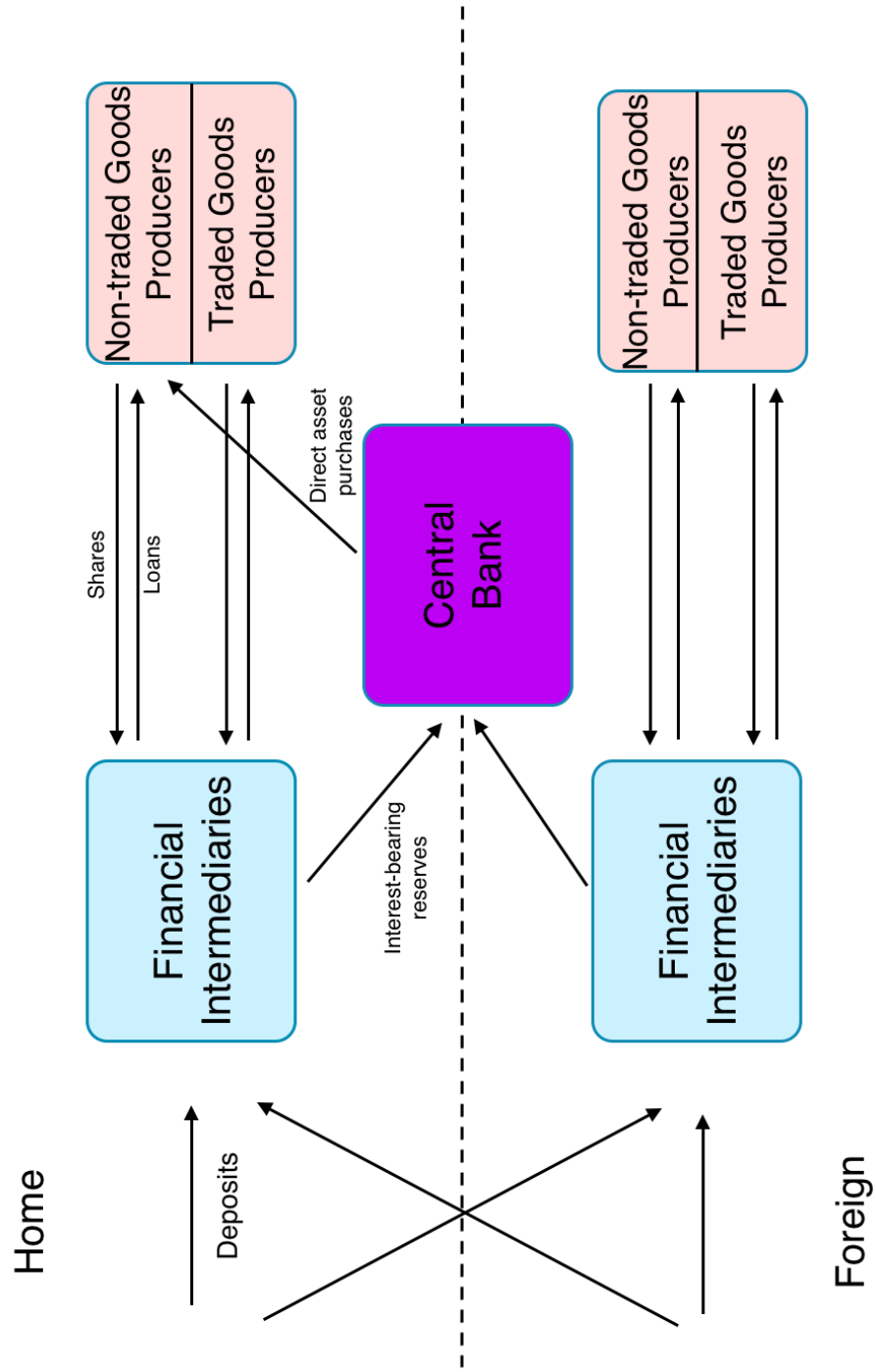


Figure 3: Illustration of Liquidity Facilities Program

