Financial Globalization and Monetary Transmission*

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Abstract

This paper analyzes how international financial integration affects the impact of monetary policy in a standard theoretical open economy framework with financial frictions. The model extends a general New Keynesian model to a richer structure in financial markets, allowing for international asset trading in multiple assets and incomplete asset markets. The setup of the model enables not only an analysis of two different forms of financial integration, namely an increase in the level of gross foreign asset holdings and a decrease in the costs of international asset trading, but also an analysis of the interaction of financial integration with trade integration. The calibrated simulations show that none of the analyzed forms of financial integration materially affect monetary policy effectiveness. If anything, monetary policy is *more*, rather than *less,* effective as strengthened exhange rate and wealth channels more than offset a weakened interest rate channel of monetary policy transmission. The simulations also show that different forms of integration have different implications and that the effects of financial integration are amplified in an interaction with trade integration.

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1 Introduction

This paper analyzes how international financial integration affects the impact of monetary policy in a standard theoretical open economy framework with financial frictions. Financial integration has been one of the main developments in the world economy in recent decades and its potential implications for monetary policy transmission have raised several concerns. The basic concern is that financial integration has the potential to undermine monetary policy effectiveness, i.e. that in an environment of tightly integrated financial markets monetary policy might lose its control to affect aggregate output and inflation.[1] Despite an active debate there are relatively few formal analyses on this topic, especially in the theoretical literature, and existing contributions have focused on the implications of *real*, rather than *financial* integration.[2] Woodford (2007), for example, offers a theoretical analysis of the impact of international integration on monetary transmission and finds that integration is unlikely to weaken the ability of national central banks to control the dynamics of inflation. The focus of his analysis is, however, on goods and factor market integration. His model is not suited for an analysis of financial market integration as it is based on a special preference specification where asset markets and the degree of financial integration are basically irrelevant. This paper aims at addressing the limitations of existing contributions to capture the effects of *financial* integration. It extends Woodford's analysis to a model with a richer structure in financial markets.[3]

The model I develop is a two-country variant of Gali (2008)'s baseline New Keynesian model with sticky prices and wages but modified to allow for international asset trading in multiple assets and incomplete asset markets. The setup of the model enables an analysis of two different forms of international financial integration. The two crucial modeling choices are the inclusion of transaction costs for trading assets and the linearization of the model around an exogenous steady state asset portfolio. The transaction costs for trading assets are defined both with respect to deviation from the steady state level and with respect to changes from last period's holdings. The costs with respect to deviations from the steady state level are just a technical device introduced to ensure stationary responses to temporary shocks.[4] However, the costs with respect to changes from last period's holdings allow to analyze the impact of a decrease in the costs of international asset trading. A decrease in the costs for international asset trading can be seen as one form of international financial integration. The second crucial modeling choice, the linearization of the model around an exogenous state

[1] See e.g. Bernanke (2007), Gonzalez-Paramo (2007), Gudmundsson (2007), Mishkin (2007), Papademos (2007), Weber (2007), and Yellen (2006).

[2] See Romer (2007), Fisher (2006), Kohn (2006), Rogoff (2006), Bank for International Settlements (2006), IMF (2006), Kohn (2006), Fisher (2006), Wynne and Kersting (2007), White (2008), Guilloux and Kharroubi (2008), Calza (2008), and Mark Wynne on the occasion of the creation of the new Globalization and Monetary Policy Institute by the Federal Reserve Bank of Dallas (Federal Reserve Bank of Dallas, Southwest Economy, Issue 1, January /February 2008).

[3] Woodford's model is based on preferences with a unit elasticity of substitution between home and foreign goods. This assumption has the property of making asset markets complete, with both countries fully diversifying their consumption risk. Financial integration is thus irrelevant. A first crucial extension is therefore an alternative preference specification in which case the nature of asset markets matters.

[4] See Ghironi, Lee, and Rebucci (2007) and Schmitt-Grohé and Uribe (2003).

state asset portfolio, means that the steady state portfolio can be chosen exogenously as a particular solution among the set of feasible solutions. An alternative approach would be to solve for the portfolio endogenously in a fully optimizing framework.[5] However, the exogenous approach allows to choose an international portfolio that is in line with the empirical evidence without having to specify all the possible shocks in the economy and adjust the model in such a way that it delivers that portfolio.[6] This approach therefore allows to analyze scenarios differing with respect to the level of steady state gross foreign asset positions. An increase in steady state gross foreign asset positions can be seen as a second form of international financial integration.

The model thus enables an analysis of international financial integration both in the form of a decrease in the costs of international asset trading and in the form of an increase in gross foreign asset holdings. The impact of monetary policy can be affected by both forms of integration. The first analyzed form of integration, namely a decrease in the costs of international asset trading, could potentially have an impact on the transmission of monetary policy through different demand and supply side effects. While some of these effects are expected to weaken monetary policy transmission, others are expected to strengthen it. The combined impact of these effects is thus a priori ambiguous. On the demand side, a decrease in the costs of international asset trading could, on the one hand, weaken the interest rate channel. Domestic interest rates might become less relevant for domestic spending decisions as in an integrated world consumers' should theoretically be able to engage in more consumption smoothing with the rest of the world. If the costs for trading foreign assets are low agents will save and borrow more in the rest of the world to cushion the effects of shocks. A monetary policy-induced interest rate shock could thus have a lower impact on domestic spending decisions and aggregate demand. Furthermore, with globalized financial markets and tightened financial interdependence domestic interest rates might increasingly be influenced by foreign factors. There is evidence suggesting that there are important linkages between US and foreign long-term interest rates and that long-term rates seem to react less to changes in short-term rates than they used to.[7] On the other hand, a decrease in the costs of international asset trading could strengthen the exchange rate channel. The exchange rate channel could be strengthened as the tendency for exchange rates to react to monetary policy might arguably be more pronounced in tighter integrated markets where the costs for trading foreign assets are low and capital flows are more responsive to perceived interest rate differentials. If the economy is open to trade these reinforced exchange rate movements could in turn affect aggregate demand and output through their impact on the relative prices of domestic to foreign goods, i.e. net exports, and inflation through their direct impact via lower import prices. Furthermore, as discussed below, these exchange rate movements could have effects on domestic households' foreign wealth.[8] On the supply side, a decrease in the cost of international asset trading could potentially lead to a decline in the slope of the Phillips

[5] See e.g. Devereux and Sutherland (2006) and Tille and Van Wincoop (2009).

[6] See Tille (2008).

[7] See e.g. Ehrman, Fratzscher and Rigobon (2005), Faust, Rogers, Wang and Wright (2007), and Warnock and Warnock (2006).

[8] See e.g. Yellen (2006), Bernanke (2007), Weber (2007), Mishkin (2007), Papademos (2007), Gudmundsson (2007), and Gonzalez-Paramo (2007).

curve, i.e. a decrease in the sensitivity of domestic prices to domestic output gaps. A decline in the slope of the Phillips curve, in turn, could weaken monetary policy transmission as a control over domestic aggregate spending would not necessarily imply a control over domestic inflation as the domestic output gap would cease to be a significant determinant of domestic inflation.[9],[10] A decrease in the sensitivity of domestic prices to domestic output gaps could arguably be the result of the integration of international financial markets as this process has facilitated the access of domestic firms to a global labor supply through offshoring. The threat of offshoring could contribute to a decrease of the sensitivity of real wages to changes in domestic labor market conditions (i.e. a flattening of the wage-price Phillips curve) as firms might become less willing to grant wage increases that would impair their cost competitiveness and wages and prices would react less to domestic labor market and demand conditions.[11] Recent empirical research seems to suggest that the sensitivity of inflation to domestic output gaps has declined in many developed countries in the last two decades.[12] However, there is no consensus on the role of global forces in that process.[13] And there are factors other than (financial and real) globalization that might contribute to a lower sensitivity of prices to domestic output gaps. Flatter Phillips curves could be the result of better anchored inflation expectations and the global disinflation process in the last two decades. A lower inflationary environment implies that price adjustments are less frequent.[14] In the theoretical literature Razin and Yuen (2002) find that financial integration reduces the slope of the Phillips curve. However, as Woodford (2007) notes, their analysis is likely to overestimate the impact.[15]

The second analyzed form of integration, namely an increase in gross foreign asset holdings, could have an impact on the transmission of monetary policy through demand side effects, namely a strengthening of exchange-rate related wealth channels. This form of integration is thus a priori expected to strengthen monetary policy transmission. An increase in gross foreign assets could strengthen wealth channels as with an increasing share of domestic sav-

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[9] See Borio and Filardo (2007), IMF (2006), González-Páramo (2007), and Yellen (2006).

[10] Note that changes in Phillips curve parameters might not only affect monetary policy transmission and effectiveness, but also monetary authorities' incentives. A flattening of the Phillips curve would increase the output gains to be reached from any expansionary monetary policy impulse and could therefore decrease the incentives for policymakers to maintain low inflation rates.

[11] See Yellen (2006) and Gonzalez-Paramo (2007).

[12] See e.g. Loungani, Razin and Yuen (2001), IMF (2006), Kohn (2006), Borio and Filardo (2007), Ihrig, Kamin, Lindner, and Marquez (2007), Wynne and Kersting (2007), Guilloux and Kharroubi (2008), and Calza (2008).

[13] Rogoff (2003, 2006), for example, argues that trade integration should have increased rather than decreased the sensitivity of prices to domestic demand conditions. Greater competition should lead to lower profit margins and less room for maneuver for firms which should fasten firms' responses to changes in cost structures or demand conditions.

[14] See e.g. Gonzalez-Paramo (2007) and Yellen (2006).

[15] Woodford (2007: pp.58-9) notes that Razin and Yuen's assumption that under financial autarchy consumption in each period must fluctuate with domestic income neglects the effects of terms of trade changes. If the country is open to trade an increase in domestic output does not lead to an equal increase in the consumption of the world composite good (and, hence, the marginal utility of income and real wage demands of domestic households and, hence, the marginal costs of domestic firms) as the home country's terms of trades worsen as a consequence of the rise in domestic output. He argues that the degree to which financial integration affects the sensitivity of domestic marginal costs to domestic output, or the slope of the Phillips curve, is less pronounced than Razin and Yuen claim.

ings invested in international financial markets households' wealth and firms' balance sheets might become more sensitive to (monetary policy induced) fluctuations in exchange rates.[16] Exchange rate valuation effects might thus increase the impact of monetary policy on the wealth of domestic agents and thus their spending decisions and aggregate demand.[17]

The remainder of the paper analyzes the interplay of these and potential further effects of financial integration, as well as their interaction with the effects of trade integration, more formally in a theoretical general equilibrium framework. Section 2 outlines the model. Section 3 discusses the results, and the last section concludes.

2 Theoretical model

The model is a two-country variant of Gali (2008)'s baseline new Keynesian model but modified to allow for international asset trading in both bond and equities. Asset markets are incomplete with asset trading being subject to transaction costs, following the approach of Ghironi, Lee and Rebucci, 2007. The model also includes investment in capital which is an additional production factor besides labor. Not only prices, but also wages are assumed to be sticky and the exchange rate is modelled in flexible manner following the approach of Corsetti and Pesenti (2005). In order to be able to replicate Woodford (2007)'s exercise of analyzing different degrees of "goods market integration" the consumption basket is divided into traded and nontraded goods following the approach of Obstfeld and Rogoff (2005).

This section outlines the main blocks of the model using the example of the Home country. Analogous equations hold in the Foreign country. To distinguish Home from Foreign variables, variables for the Foreign country are denoted with a star superscript. A more detailed derivation of the model is provided in the Appendix B. The section is structured into four different subsections describing the behavior of households, firms, and monetary authorities in turn, as well as the solution method of the model including the calibration.

2.1 Households

Each country is populated by a continuum of infinitely-lived, atomistic households indexed by j (and j^* respectively). Home households are assumed to be of a mass α while Foreign households are assumed to be of a mass $(1-\alpha)$. Households consume both Home and Foreign traded and domestic non-traded goods. In addition to consuming goods households also supply labor services.

An infinitely-lived representative Home household j maximizes the following utility function:

$$U(j) = E_0 \sum_{t=0}^{\infty} \beta^t \left[\frac{1}{1-\sigma} \left(C_t(j)\right)^{1-\sigma} - \frac{\kappa}{1+\varphi} \left(N_t(j)\right)^{1+\varphi} \right] \tag{1}$$

Following the approach of Obstfeld and Rogoff (2005) a fraction $\gamma \in [0,1]$ of brands consumed in a given country are traded goods. Furthermore, a fraction $\alpha \in [0,1]$ of the

[16] See Gonzalez-Paramo (2007).

[17] Note, however, that if a higher share of domestic wealth is invested in foriegn assets *domestic* wealth channels might become less effective.

traded goods are produced in the Home country. γ therefore denotes the weight of the traded goods basket in the overall consumption basket and α denotes the weight of Home tradables in the traded goods basket. Note that a large value of α means that the Home country supplies most of the tradables goods and not that few imported goods are consumed in either country. Such a parametrization is employed in order to be able to replicate Woodford (2007)'s exercise of analyzing different degrees of "goods market integration", namely the small open-economy limit ($\alpha = 0$), and the case of two countries of equal size ($\alpha = \frac{1}{2}$), and the interaction of "goods market" with "financial market integration".

The Home consumption basket is a standard CES consumption basket over Home and Foreign traded goods baskets and the Home non-traded goods basket:

$$C_t = \left[\gamma^{\frac{1}{\omega}} C_{Tt}^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} C_{Nt}^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}}$$

where C_{Nt} is the non-tradables basket and C_{Tt} the tradables basket. γ denotes the weight of the tradables basket and ω is the elasticity of substitution between tradable and nontradable goods.

The tradables basket is defined as:

$$C_{Tt} = \left[\alpha^{\frac{1}{\phi}} C_{HTt}^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} C_{FTt}^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}$$

where C_{HTt} is the consumption sub-basket of individual Home goods and C_{FTt} is the consumption sub-basket of individual foreign goods. α denotes the weight of Home tradables in the tradables basket and ϕ is the elasticity of substitution between Home and Foreign tradables.

The consumption sub-baskets C_{Nt}, C_{HTt}, and C_{FTt} are defined as CES aggregates respectively:

$$C_{HTt} = \left[\left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \int_0^{\alpha\gamma} \left(C_{HTt}(i)\right)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$$

$$C_{FTt} = \left[\left(\frac{1}{(1-\alpha)\gamma}\right)^{\frac{1}{\theta}} \int_{\alpha\gamma+\alpha(1-\gamma)}^{1-(1-\alpha)(1-\gamma)} \left(C_{FTt}(i)\right)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$$

$$C_{Nt} = \left[\left(\frac{1}{\alpha(1-\gamma)}\right)^{\frac{1}{\theta}} \int_{\alpha\gamma}^{\alpha\gamma+\alpha(1-\gamma)} \left(C_{Nt}(i)\right)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$$

where θ is the elasticity of substitution between the different brands within a sub-basket.

The following paragraphs outline the three optimization problems that a household faces: the allocation of expenditures across the different sectors and goods, the intertemporal consumption and asset allocation, and the wage setting.

2.1.1 Optimal allocation of expenditures

The solution of the optimal allocation of expenditures across different sectors and goods (see the Appendix for more details) leads to the following aggregate demand equations that a firm i faces. Note that in addition to the demand from households, firms' face the demand for an investment input, I_t, from installment firms (explained in more detail below):

$$Y_{HTt}(i) = \left(\frac{P_{HTt}^{Opt}(i)}{P_{HTt}}\right)^{-\theta} \left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi} \left(\frac{P_{Tt}}{P_t}\right)^{-\omega} (C_t + I_t) \tag{2}$$

$$Y_{HTt}^{*}(i) = \left(\frac{P_{HTt}^{Opt*}(i)S^{-\tau}}{P_{HTt}^{*}}\right)^{-\theta} \left(\frac{P_{HTt}^{*}}{P_{Tt}^{*}}\right)^{-\phi} \left(\frac{P_{Tt}^{*}}{P_t^{*}}\right)^{-\omega} (C_t^{*} + I_t^{*}) \tag{3}$$

$$Y_{Nt}(i) = \frac{1}{\alpha}\left(\frac{P_{Nt}^{Opt}(i)}{P_{Nt}}\right)^{-\theta} \left(\frac{P_{Nt}}{P_t}\right)^{-\omega} (C_t + I_t) \tag{4}$$

2.1.2 Optimal intertemporal allocation

Asset markets comprise four assets: two one-period nominal bonds, denominated in Home and Foreign currency respectively, and equity shares on Home and Foreign firms. The bond holdings are denoted B_H and B_F (B_H^* and B_F^* if held by Foreign households) and the Home and Foreign equity shares are denoted by Q_{Ht} and Q_{Ft} (Q_{Ht}^* and Q_{Ft}^* if held by Foreign households). Equity shares are assumed to be claims on firms' profits as explained in more detail in Appendix B. They are assumed to be a balanced portfolio across all firms in the respective country.

Households pay quadratic financial transaction fees to domestic financial intermediaries when they change their asset holdings. The financial intermediation costs are defined both in terms of changes from last period's holdings and in terms of deviations from the steady state levels. The definition of these transaction costs is analogous for all assets (with the subscript denoting the respective asset). Using the example of Home equity holdings they are:

$$\frac{\gamma_{Q_H}}{2} P_{Qt} \frac{\left(Q_{Ht+1}(j) - Q_{Ht}(j)\right)^2}{Y_t} \text{ and } \frac{\psi_{Q_H}}{2} P_{Qt} \frac{\left(Q_{Ht}(j) - \bar{Q}_H(j)\right)^2}{Y_t}$$

As mentioned above the transaction costs on changes from last period's holdings (see the first term in the above expression) ensure a well-defined demand of assets in a log-linearized version of the system and allow to study scenarios differing with respect to the ease of financial transactions. A decrease in the level of the costs for foreign assets, e.g. γ_{Q_F}, implies cheaper transaction costs for changing foreign asset holdings which can be seen as one form of international financial integration. The costs with respect to deviations from the level of steady state asset holding (see the second term in the above expression) are a technical device to ensure stationarity of the equilibrium dynamics.[18] As the financial intermediation costs are incurred on *changes* from last period's holdings and on *deviations from the steady state level*,

[18] See Ghironi, Lee, and Rebucci (2007) and Schmitt-Grohé and Uribe (2003).

the steady state of this model can be chosen exogenously as a particular solution among the set of feasible solutions. As mentioned above, this fact will be exploited to analyze a second form of international financial integration, namely an increase of gross foreign asset holdings.

The financial costs are paid to financial intermediaries who are assumed to be local, perfectly competitive firms owned by domestic households. The financial transaction fees are rebated to households as lump-sum transfers and are therefore not destroyed resources.

Given these definition the budget constraint of a Home household j is:

$$\begin{aligned}
& P_t C_t(j) \\
& +P_{Qt} Q_{Ht+1}(j) + \frac{\gamma_{Q_H}}{2} P_{Qt} \frac{(Q_{Ht+1}(j) - Q_{Ht}(j))^2}{Y_t} + \frac{\psi_{Q_H}}{2} P_{Qt} \frac{\left(Q_{Ht}(j) - \bar{Q}_H(j)\right)^2}{Y_t} \\
& +S_t P^*_{Qt} Q_{Ft+1}(j) + \frac{\gamma_{Q_F}}{2} S_t P^*_{Qt} \frac{(Q_{Ft+1}(j) - Q_{Ft}(j))^2}{Y^*_t} + \frac{\psi_{Q_F}}{2} S_t P^*_{Qt} \frac{\left(Q_{Ft}(j) - \bar{Q}_F(j)\right)^2}{Y^*_t} \\
& +B_{Ht+1}(j) + \frac{\gamma_{B_H}}{2} \frac{(B_{Ht+1}(j) - B_{Ht}(j))^2}{P_t Y_t} + \frac{\psi_{B_H}}{2} \frac{\left(B_{Ht}(j) - \bar{B}_H(j)\right)^2}{P_t Y_t} \\
& +S_t B_{Ft+1}(j) + \frac{\gamma_{B_F}}{2} S_t \frac{(B_{Ft+1}(j) - B_{Ft}(j))^2}{P^*_t Y^*_t} + \frac{\psi_{B_F}}{2} S_t \frac{\left(B_{Ft}(j) - \bar{B}_F(j)\right)^2}{P^*_t Y^*_t} \\
= \; & W_t N_t(j) + \left(P_{Qt} + \left(\frac{V_t}{\bar{Q}}\right)\right) Q_{Ht}(j) + S_t \left(P^*_{Qt} + \left(\frac{V^*_t}{\bar{Q}^*}\right)\right) Q_{Ft}(j) \\
& +(1+i_t) B_{Ht}(j) + S_t(1+i^*_t) B_{Ft}(j) + T_{It}(j) + T_{\gamma t}(j)
\end{aligned} \tag{5}$$

where P_{Qt} and P^*_{Qt} are the nominal prices of Home and Foreign equity shares respectively, and $\frac{V_t}{\bar{Q}}$, and $\frac{V^*_t}{\bar{Q}^*}$ the dividend yields in local currency with V_t and V^*_t denoting the aggregate profits and $\bar{Q}$ and $\bar{Q}^*$ aggregate equity shares. Aggregate equity shares are fixed and given by $\bar{Q} = Q_{Ht} + Q^*_{Ht}$ and $\bar{Q}^* = Q^*_{Ft} + Q_{Ft}$. γ_{Q_H},γ_{Q_F},γ_{B_H}, and γ_{B_F} are the financial intermediation costs for Home households which can differ across assets, i_t and i^*_t are the nominal interest rates, S_t is the nominal exchange rate (defined as units of Home currency per unit of Foreign currency), $T_{It}(j)$ are the lump-sum transfers from installment firms (the details are explained in Appendix B), and $T_{\gamma t}(j)$ are lump-sum transfers from financial intermediaries.

The optimal intertemporal asset and consumption allocation leads to the following Euler equations in aggregate terms ($D_{t,t+1} = \beta \left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma} \frac{P_t}{P_{t+1}}$ denotes the discount factor):

for Home equity holdings:

$$\begin{aligned}
& \left(P_{Qt} + \gamma_{Q_H} P_{Qt} \frac{(Q_{Ht+1} - Q_{Ht})}{Y_t}\right) \\
= E_t & \left\{ D_{t,t+1}(j) \left(\begin{array}{c} \gamma_{Q_H} \frac{(Q_{Ht+2} - Q_{Ht+1})}{Y_{t+1}} - \psi_{Q_H} P_{Qt+1} \left(\frac{(Q_{Ht+1} - \bar{Q}_H)}{Y_{t+1}}\right) \\ + \left(P_{Qt+1} + \left(\frac{V_{t+1}}{\bar{Q}}\right)\right) \end{array} \right) \right\}
\end{aligned} \tag{6}$$

for Foreign equity holdings:

$$
\begin{aligned}
& \left(S_t P^*_{Qt} + \gamma_{_{QF}} S_t P^*_{Qt} \frac{(Q_{Ft+1} - Q_{Ft})}{Y_t} \right) \qquad (7) \\
= E_t & \left\{ D_{t,t+1}(j) \left(\begin{array}{c} \gamma_{_{Q_F}} S_{t+1} P^*_{Qt+1} \frac{(Q_{Ft+2} - Q_{Ft+1})}{Y_{t+1}} - \psi_{Q_H} S_{t+1} P^*_{Qt+1} \frac{(Q_{Ft+1} - \bar{Q}_F)}{Y_{t+1}} \\ + \left(S_{t+1} \left(P^*_{Qt+1} + \left(\frac{V^*_{t+1}}{Q^*} \right) \right) \right) \end{array} \right) \right\}
\end{aligned}
$$

for Home bond holdings:

$$
\begin{aligned}
& \left(1 + \gamma_{_{B_H}} \frac{(B_{Ht+1} - B_{Ht})}{Y_t} \right) \qquad (8) \\
= \quad & E_t \left\{ D_{t,t+1}(j) \left(\begin{array}{c} \gamma_{_{B_H}} \frac{(B_{Ht+2} - B_{Ht+1})}{Y_{t+1}} - \psi_{B_H} \left(\frac{(B_{Ht+1} - \bar{B}_H)}{Y_{t+1}} \right) \\ +(1 + i_{t+1}) \end{array} \right) \right\}
\end{aligned}
$$

and for Foreign bond holdings:

$$
\begin{aligned}
& \left(S_t + \gamma_{_{B_F}} S_t \frac{(B_{Ft+1} - B_{Ft})}{Y^*_t} \right) \qquad (9) \\
= E_t & \left\{ D_{t,t+1}(j) \left(\begin{array}{c} \gamma_{_{B_F}} S_{t+1} \frac{(B_{Ft+2} - B_{Ft+1})}{Y^*_t} - \psi_{_{B_F}} S_{t+1} \frac{(B_{Ft+1} - \bar{B}_F)}{Y^*_t} \\ +S_{t+1}(1 + i^*_t) \end{array} \right) \right\}
\end{aligned}
$$

The Euler equations represent the fact that for an intertemporal allocation to be optimal the cost in terms of foregone utility of acquiring an additional equity share or bond has to equal the discounted marginal utility of the increase in expected consumption derived from holding that additional asset. To gain a more detailed intuition for the Euler equations one can rewrite, for example, the Euler equation for Home bond holdings (equation (8)), as:

$$
\begin{aligned}
& E_t \left\{ \left(\frac{C_{t+1}(j)}{C_t(j)} \right) \right\}^{\sigma} \qquad (10) \\
= \quad & \beta E_t \left\{ \left(\frac{P_t}{P_{t+1}} \right) \left[(1 + i_{t+1}) + \gamma_{_{B_H}} \frac{(B_{Ht+2} - B_{Ht+1})}{Y_{t+1}} - \psi_{B_H} \left(\frac{(B_{Ht+1} - \bar{B}_H)}{Y_{t+1}} \right) \right] \right\} \\
& \left(\frac{1}{1 + \gamma_{_{B_H}} \frac{(B_{Ht+1} - B_{Ht})}{Y_t}} \right) \qquad (11)
\end{aligned}
$$

Equation (10) states that, all else equal, Home households will be more willing to postpone consumption to the next period (i.e. increase the ratio $\left(\frac{C_{t+1}(j)}{C_t(j)} \right)$ on the left hand side) the higher the opportunity costs for consumption today. These opportunity costs are higher: a) the lower expected inflation (first (...) on the right hand side, b) the higher the expected interest rate at Home (first term in [...] on the right hand side), c) the higher the marginal decrease in transaction costs for Home bond holdings tomorrow (second term in [...] on the right hand side) and the lower the transaction costs for deviations from the steady state today (third term in [...] on the right hand side), or d) the lower intermediation costs for Home bond holdings today (last (...) on the right hand side).

2.1.3 Optimal wage setting

In order to model sticky wages the labour market is assumed to be monopolistic.[19] Each household is specialized in a different type of labor, all of which are used by each firm. Each household has some monopoly power in the labor market and posts the (nominal) wage at which she or he is willing to supply specialized labor services to firms that demand them. Wages are sticky where wage setting is modelled as a staggered Calvo-type process where $(1-\theta_W)$ denotes the probability that a household can reset the wage in any given period.

A household that can reset its wage in period t (where $W_t^{Opt}(j)$ denotes the newly set wage) maximizes the discounted sum of utilities subject to the sequence of flow budget constraints and the firm's demand schedules (equations 2 to 4). The optimal wage at time t satisfies the following condition:

$$E_t \sum_{k=0}^{\infty} (\beta\theta_W)^k \left[N_{t+k|t}(j) \left(C_{t+k|t}(j)\right)^{-\sigma} \left[\frac{W_t^{Opt}}{P_{t+k}} - \mu_W \frac{\kappa \left(N_{t+k|t}\right)^{\varphi}}{\left(C_{t+k|t}\right)^{-\sigma}} \right] \right] = 0 \tag{12}$$

where

$$\mu_W \equiv \frac{\eta}{\eta - 1}$$

i.e. that the optimal real wage is a (constant) markup over all future expected marginal rates of substitution.

Taking account of wage stickiness the aggregate wage index (see also below in the section on firms) can be written as

$$W_t = \left(\theta_W W_{t-1}^{1-\eta} + (1-\theta_W) \left(W_t^{Opt} \right)^{1-\eta} \right)^{\frac{1}{1-\eta}} \tag{13}$$

i.e. that the wage index is a weighted average of last period's index and the optimal wage at time t.

2.2 Firms

In each country there are two types of firms."Installment firms" using the consumption good to produce capital and "Production firms" producing the consumption goods with a linear production technology using both labor and capital inputs.

The following paragraphs outline the optimal investment decision of installment firms and the optimal input demand and price setting decisions of production firms.

[19] See Gali (2008, chapter 6) for details.

2.2.1 Optimal investment

Installment firms are competitive, i.e. they take prices as given. They are owned by domestic households who receive any profits in the form of lump-sum transfers and are indexed by $I \in [0, \alpha]$ for the Home country and $I^* \in [\alpha, 1]$ for the Foreign country.

Installment firms purchase an investment good to produce new capital which they rent out to the production firms at the (nominal) rental rate $P_t r^k$. It is assumed that the investment good features the same composition as the consumption good, i.e. that the investment good is purchased in the goods market at a price P_t. Capital depreciates at a rate δ. Furthermore, the production technology for new capital involves non-linear capital-adjustment cost. These costs are introduced to smooth the investment dynamics. Note that equity shares are claims on profits not capital.

Capital accumulation takes the following form:

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\xi}{2}\frac{\left(K_{t+1}(I) - K_t(I)\right)^2}{K_t(I)} \tag{14}$$

An installment firm solves the following optimization problem (subject to 14)

$$\max_{K_{t+1}(I)} E_t \sum_{k=0}^{\infty} D_{t,t+k}(I)\left[P_{t+k} r_{t+k}^k K_{t+k.}(I) - P_{t+k} I_{t+k.}(I)\right]$$

i.e. that I assume that an installment firm I's discount factor reflects the intertemporal marginal rate of substitution of a representative Home household j. An alternative discount factor could be a weighted average of Home and Foreign household's marginal rate of substitutions. The optimality condition for investment in aggregate terms can be written as

$$\left(1 + \xi\frac{(K_{t+1} - K_t)}{K_t}\right) = \beta\left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma}\left[(1-\delta) + r_{t+1}^k + \frac{\xi}{2}\left(\frac{K_{t+2}^2 - K_{t+1}^2}{K_{t+1}^2}\right)\right] \tag{15}$$

The optimal investment decision equalizes the cost to increase today's capital stock by one unit and tomorrow's discounted marginal utility derived from this investment. Today's cost of an additional unit of capital consist of the unit itself and the marginal capital adjustment cost. Tomorrow's revenues of this investment consist of the increase in the non-depreciated capital stock itself , the expected real interest payment plus the expected decrease in capital adjustment costs.

The profits $T_I(j) = P_t r_t^k K_{t.} - P_t I_{t.}$ of Installment firms are assumed to be rebated to households as lump-sum transfers.

2.2.2 Optimal input demand

Production firms in the traded and non-traded goods are monopolistically competitive firms, i.e. each production firm is the sole producer of a differentiated brand. They are indexed by $i \in [0, \alpha\gamma + n(1-\gamma)]$ where $[0, \alpha\gamma]$ represents the Home traded goods sector and $[\alpha\gamma, \alpha(1-\gamma)]$ the nontraded goods sector. Foreign firms are distributed on the interval $i^* \in [\alpha\gamma + \alpha(1-\gamma), 1]$ with $[\alpha\gamma + \alpha(1-\gamma), \alpha\gamma + \alpha(1-\gamma) + (1-\alpha)\gamma]$ representing the Foreign traded goods sector and $[\alpha\gamma + n(1-\gamma) + (1-\alpha)\gamma, 1]$ the Foreign nontraded goods sector.

A representative Home production firm i (both in the traded and nontraded goods sector) produces under the following Cobb-Douglas constant-returns-to-scale technology:

$$Y_t(i) = A_t \left(K_t(i)\right)^{1-\mu} \left(N_t(i)\right)^{\mu}$$

where A_t is an exogenous technology parameter, $K_t(i)$ is the capital input used by firm i , μ is the share of labor used in the production process and $N_t(i)$ is an index of the differentiated labor inputs used by firm i:

$$N(i) \equiv \left[\int_0^{\alpha} N_t(i,j)^{\frac{\eta-1}{\eta}} dj\right]^{\frac{\eta}{\eta-1}}$$

where $N_t(i,j)$ denotes the quantity of type-j labor employed by firm i. η is the elasticity of substitution among the differentiated labor services

The solution of the cost minimization problem of a representative Home firm i with respect to differentiated labor services for a given level of the aggregate labor index is:

$$N_t(i,j) = \left(\frac{W_t(j)}{W_t}\right)^{-\eta} N_t(i)$$

The solution of the cost minimization problem of a representative Home firm i with respect to aggregate factor inputs $N_t(i)$ and $K_t(i)$ can (in aggregate terms) be written as

$$N_{HTt} = \frac{\mu MC_t}{W_t} Y_{HTt} \tag{16}$$

$$N_{Nt} = \frac{\mu MC_t}{W_t} Y_{Nt} \tag{17}$$

$$K_{HTt} = \frac{(1-\mu)\, MC_t}{P_t.r_t^k} Y_{HTt} \tag{18}$$

$$K_{Nt} = \frac{(1-\mu)\, MC_t}{P_t.r_t^k} Y_{Nt} \tag{19}$$

2.2.3 Optimal price setting

Prices are sticky where price setting is modelled as a staggered Calvo-type process where $(1-\theta_P)$ denotes the probability that a firm can reset its price in any given period.[20] The prices that Home consumers pay in Home currency for Home traded, Foreign traded and non-traded goods are denoted by $P_{HTt}(i), P_{FTt}(i)$ and $P_{Nt}(i)$, respectively, whereas the prices that Foreign consumers pay in Foreign currency for Home traded, Foreign traded and non-traded

[20] θ_P can therefore be interpreted as a measure of price stickiness.

goods are denoted by a star superscript, namely, by $P^*_{HTt}(i), P^*_{FTt}(i)$ and $P^*_{Nt}(i)$, respectively. The prices that Home producers set are denoted by $P^{Opt}_{HTt}(i)$ for the Home market, $P^{Opt*}_{HTt}(i)$ for the Foreign market and $P^{Opt}_{Nt}(i)$, respectively, whereas the prices that Foreign producers set are denoted by $P^{Opt*}_{FTt}(i)$ for the Foreign market, $P^{Opt}_{FTt}(i)$ for the Home market and $P^{*Opt}_{Nt}(i)$.

To be able to analyze various degrees of exchange rate pass-through a flexible approach following Corsetti and Pesenti (2005) is adopted. In particular, it is assumed that the degree of pass-through elasticity, τ, is exogenous and constant within a period and across producers. It varies between 0 and 1 such that both the case of complete exchange rate pass-through ("producer currency pricing" or PCP), $\tau = 1$, and the case of zero exchange rate pass-through ("local currency pricing" or LCP), $\tau = 0$, can be obtained as particular cases of a unified parametrization.

The Foreign-currency price of a Home traded goods brand, $P^*_{HT}(i)$, is defined as:

$$P^*_{HTt}(i) = \frac{P^{Opt*}_{HTt}}{S^{\tau}_t}$$

Given this definition the price received by a Home firm from an export sales unit to the Foreign market is[21]

$$P^{Opt*}_{HTt}(i) S^{1-\tau}_t$$

A representative firm in the Home traded goods sector sets prices $\left\{P^{Opt}_{HTt+k}(i), P^{Opt*}_{HTt+k}(i)\right\}_{k=0}^{\infty}$ that maximize its expected discounted future profits while these prices remain effective. Formally, it solves the following problem:

$$\max_{P^{Opt}_{HTt}(i), P^{Opt*}_{HTt}(i)} \sum_{k=0}^{\infty} \theta^k_P E_t \left\{ \begin{array}{c} D_{t,t+k}(j) \\ \left(\begin{array}{c} \left(P^{Opt}_{HTt}(i) - MC_{t+k|t}\right) Y_{HTt+k|t} \\ + \left(P^{Opt*}_{HTt}(i) S^{1-\tau}_t - MC_{t+k|t}\right) Y^*_{HTt+k|t} \end{array} \right) \end{array} \right\}$$

subject to the respective demand schedules of Home households and installment firms, where $D_{t,t+k}(j)$ denotes the discount factor:

$$D_{t,t+k}(j) = \beta^k \left(\frac{(C_{t+k}(j))}{(C_t(j))} \right)^{-\sigma} \frac{P_t}{P_{t+k}}$$

i.e. that it is assumed that a representative Home firm's discount factor represents the intertemporal marginal rate of substitution of a representative Home household j, and where MC_t denotes the (nominal) marginal cost function (see equation (**??**) above).[22]

Optimal prices in the three sectors at time t satisfy the following conditions:

[21] Similarly, the Home-currency price of a Foreign traded goods brand, $P_{FTt}(i)$, is $P_{FTt}(i) = P^{Opt}_{FTt}(i) S^{\tau}_t$ and the price received by a Foreign firm from an export sales unit to the Home market is $P^{Opt}_{FTt}(i) S^{\tau-1}_t$.

[22] A representative firm in the nontraded goods sector solves an analogous problem.

$$\sum_{k=0}^{\infty} \theta_P^k E_t \left\{ D_{t,t+k} Y_{HTt+k|t}(i) \left(P_{HTt}^{Opt} - \mu_P MC_{t+k} \right) \right\} = 0 \tag{20}$$

$$\sum_{k=0}^{\infty} \theta_P^k E_t \left\{ D_{t,t+k} Y_{HTt+k|t}^*(i) \left(S_t^{1-\tau} P_{HTt}^{Opt*} - \mu_P MC_{t+k} \right) \right\} = 0 \tag{21}$$

$$\sum_{k=0}^{\infty} \theta_P^k E_t \left\{ D_{t,t+k} Y_{Nt+k|t}(i) \left(P_{Nt}^{Opt} - \mu_P MC_{t+k} \right) \right\} = 0 \tag{22}$$

where

$$\mu_P = \frac{\theta}{\theta - 1}$$

i.e. that the prices received by Home firms are a (constant) markup over all expected future marginal costs.

2.3 Monetary policy

In order to close the model a behavioral rule for the monetary authorities needs to be defined. The monetary policy rule of the Home central bank is defined as

$$1 + i_t = (1 + i_{t-1})^{\rho} \left(\left(\frac{P_t}{P_{t-1}} \right)^{\phi_\pi} (Y_t)^{\phi_y} \right)^{(1-\rho)} R_t \tag{23}$$

where ρ captures the degree of interest-rate smoothing and R_t represents a time-varying,exogenous monetary policy shock that may, for example, represent changes in the inflation target. Innovations in R_t are and their propagation on the other variables in the model are used as experiments to analyze the transmission of monetary policy. The monetary policy rule of the Foreign central bank is defined as analogously.

2.4 Solution of the model

The model is defined by equations (2) to (23) together with the analogous equations for the foreign economy and the market clearing conditions in the goods and asset markets. The model is solved by a linearization of these equations around a symmetric steady state where the net foreign asset positions of both countries, inflation and technological progress are zero. As mentioned above, to ensure a stationary steady state financial intermediation costs are imposed on both the changes in asset holdings as well as deviations from the steady state. Furthermore, all Home and Foreign nominal variables are scaled by the Home and Foreign CPIs, respectively, and the CPIs and the nominal exchange rate are linearized in first differences. Appendix B outlines the whole system of equations as well as a detailed derivation of the steady state and the linearized system. As no analytical solution of the model can be obtained the linearized model is solved and simulated numerically.[23] The particular interest

[23] The model is with Dynare (see Adjemian et al., 2011).

is in impulse response functions to monetary policy shocks, namely exogenous interest rate shocks on R_t, as defined above in the Taylor rule (equation 23). The impact of financial market integration is analyzed by comparing impulse response functions to such monetary policy shocks in scenarios that differ with respect to the degree of financial market integration. The calibration of the baseline and the integration scenarios is explained in the following paragraphs.

2.4.1 Baseline calibration

The baseline calibration is listed in Table 1. The calibration of the model parameters closely follows the standard values assumed in the New Keynesian and Real Business Cycle literature.[24] I assume a period length of one quarter and equal model parameters for both countries.

β	0.99	α	0.5	μ	0.6	ρ_r	0.6
σ	2	ϕ	2	δ	0.026	$\frac{\bar{P}_Q^* \bar{Q}_F}{\bar{P}^* \bar{Y}^*}, \frac{\bar{B}_F}{\bar{P}^* \bar{Y}^*}$	0.3
κ	1	θ	6	θ_P	0.66	$\gamma_{B_H}, \gamma_{Q_H}$	1
φ	1	θ_W	0.75	τ	0.5	$\gamma_{B_F}, \gamma_{Q_F}$	3
γ	0.25	η	21	ϕ_π	1.5	$\psi_{\dots}$	0.005
ω	2	ξ	8	ϕ_y	0.125		

Table 1: Baseline calibration

The calibration of the discount factor β implies a steady state annual return on financial assets of about four percent. The assumption on the relative risk aversion coefficient σ implies a non-log-utility function. A labour supply elasticity coefficient φ of 1 implies a non-linear cost of effort. The calibration of the elasticity of substitution between different brands within a sub-basket θ implies a steady state markup of prices over marginal costs of 20 percent. Similarly, an elasticity of substitution among differentiated labour services η of 21 implies a steady state markup of wages over the cost of effort of 5 percent. A depreciation rate δ of 0.026 implies an annual deprecation rate of about 10 percent. Setting the production function parameter μ to 0.6 implies a ratio of wage earnings to GDP of 60 percent. The adjustment costs in investment are set such that the volatility of investment amounts to about four times the volatility of GDP. A price stickiness parameter θ_P of 0.66 implies an average price duration of three quarters. The interest rate rule coefficients ϕ_π and ϕ_y are roughly consistent with observed variations in the Federal Funds rate over the Greenspan area. A value of $\rho_r = 0.9$ implies a relatively high persistence of the interest rate shock. The steady state technology

[24] The calibration of the discount factor β and the elasticity of substitution between different brands within a sub-basket θ is equal to the one in Gali (2008) and Ghironi et al. (2008). The elasticity of substitution between Home and Foreign tradables ϕ follows the calibrations of Obstfeld and Rogoff (2005), Coeurdacier, Kollman, and Martins (2008), and Ghironi et al. (2008). The parameters related to the modeling of the consumption basket, i.e. the weight of the tradables basket in the overall consumption basket γ, and the elasticity of substitution between tradables and non-tradables ω are calibrated according to Obstfeld and Rogoff (2005). The calibration of the relative risk aversion coefficient σ is in line with Coeurdacier et al. (2008) and Ghironi et al. (2008). The depreciation rate δ, the labour share μ folllow Coeurdacier et al. (2008)'s calibrations. The calibration of the labour supply elasticity coefficient φ, and the elasticity of substitution among differentiated labour services η follows Tille (2008). The price and wage stickiness parameters θ_P and θ_W, as well as and the interest rate rule coefficients ϕ_π and ϕ_y are calibrated in line with Gali (2008).

levels in both countries are normalized to 1. In the baseline simulations both countries are assumed to be of equal size, i.e. that they have equal shares in the traded goods sector. α is therefore set to 0.5. The exchange rate elasiticity is assumed to be 0.5, i.e. that half of the change in exchange rates are passed on to the local prices of imported goods.

By means of different calibrations of the remaining two parameter blocks, namely steady state gross asset holdings and financial intermediation costs, different scenarios of international financial integration can be analyzed. In the benchmark scenario (total) steady state gross foreign asset holdings amount to 60 percent of GDP (steady state net foreign asset are assumed to be zero in all scenarios).[25] Such a calibration is roughly in line with the average gross foreign asset positions for both industrial and emerging and developing economies between 1970 and 1990 as reported in Lane and Milesi-Ferretti (2007).

Financial intermediation costs are calibrated such that the excess returns across different assets lie in a reasonable range. In a log-linearized version of the system the excess return for Home agents of, for example, Foreign with respect to Home bond holdings can be derived by combining the log-linearized versions of the respective Euler equations (equations 9 and 8 above):

$$\left(\widehat{xret}_{B_F}\right)_t \approx E_t\left\{\widehat{\Delta s}_{t+1}\right\} + E_t\left\{\hat{\imath}^*_{t+1}\right\} - E_t\left\{\hat{\imath}_{t+1}\right\} \tag{24}$$

$$\approx \gamma_{B_F}\left(E_t\left\{\hat{b}_{Ft+1}\right\} - \hat{b}_{Ft}\right) - \beta\begin{pmatrix} \gamma_{B_F} E_t\left\{\hat{b}_{Ft+2} - \hat{b}_{Ft+1}\right\} \\ -\psi_{B_F} E_t\left\{\hat{b}_{Ft+1}\right\}\end{pmatrix}$$

$$-\left[\gamma_{B_H}\left(E_t\left\{\hat{b}_{Ht+1}\right\} - \hat{b}_{Ht}\right) - \beta\begin{pmatrix} \gamma_{B_H} E_t\left\{\hat{b}_{Ht+2} - \hat{b}_{Ht+1}\right\} \\ -\psi_{B_H} E_t\left\{\hat{b}_{Ht+1}\right\}\end{pmatrix}\right]$$

If the differences across assets in actual and expected changes of holdings (here $\left(\hat{b}_{Ft+1} - \hat{b}_{Ht+1}\right)$ and

$E_t\left[\left(\hat{b}_{Ft+2} - \hat{b}_{Ft+1}\right) - \left(\hat{b}_{Ht+2} - \hat{b}_{Ht+1}\right)\right]$) are assumed to be about 10 percent then excess returns of about 15 basispoints would seem reasonable. Given that the costs with respect to the deviations from the steady state are just a technical device to induce stationarity they are kept close to zero, namely $\psi_{...} = 0.005$. Equation 24 then implies transaction costs for changing holdings of $\gamma_{B_F} = \gamma_{B_H} = 1$:

$$\underbrace{[0.0015]}_{\text{Excess return (LHS of above equations)}} \approx \underbrace{[(1^*0.1) - (0.99^*((1*0.1) - (0.005^*0.1)))]}_{\text{RHS of above equations}}$$

In other words, if Home households decide to adjust their Foreign bond holdings by 10 percent of GDP more than their Home bond holdings, they need to get an excess return on Foreign

[25] Note that with the assumption that total net foreign assets are zero, i.e. the condition $\bar{S}\bar{P}^*_Q\bar{Q}_F - \bar{P}_Q\bar{Q}^*_H + \bar{S}\bar{B}_F - \bar{B}^*_H = 0$, together with the four asset market clearing conditions only three cross border holdings have to be determined. The fourth cross-border holding and all domestic holdings can then be determined residually. The total gross foreign asset holdings are split evenly between the two asset categories. As mentioned above bonds are in zero net supply and the total amount of equity holdings are fixed.

versus Home bond holdings of about 15 basispoints. Thus, in the scenario with low transaction costs, in line with this reasoning, I set the financial intermediation costs at $\gamma_{B_H} = \gamma_{B_F} = \gamma_{Q_H} = \gamma_{Q_F} = \gamma_{B_H^*} = \gamma_{B_F^*} = \gamma_{Q_H^*} = \gamma_{Q_F^*} = 1$. In the "pre-integration" baseline scenario the costs for foreign assets, i.e. the costs for Home (Foreign) agents of changing Foreign (Home) bonds and equity holdings, are increased threefold to a level of $\gamma_{B_F} = \gamma_{B_H^*} = \gamma_{Q_F} = \gamma_{Q_H^*} = 3$. In such a scenario for the decision to adjust Foreign bond holdings by 10 percent more than Home bond holdings to be optimal, the excess return would need to be about 54 basispoints.[26] An alternative way to check the validity of the calibration of transaction costs is to look at the actual response of excess returns to an interest rate shock. Figure 1 shows the response of the excess return of Foreign over Home bonds to a 25 basispoints one-off exogenous positive shock on the nominal interest rate in the Home country in the Baseline scenario.[27] The excess returns is around 6 basispoints on impact which appears to be reasonable.

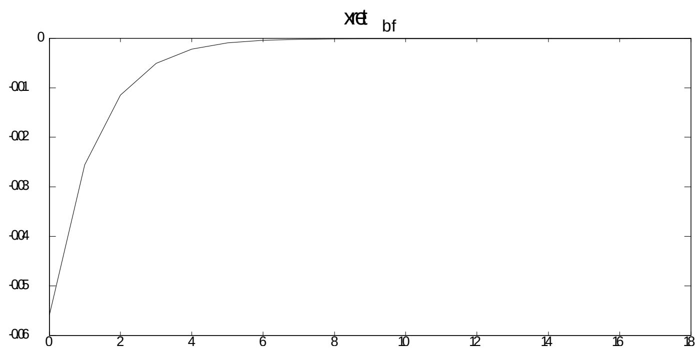

Figure 1: Response of excess return to an interest rate shock in the Baseline scenario

The impulse response is shown in percentage point deviations from the steady state.

2.4.2 Calibration of financial market integration and other scenarios

Moving away from this baseline calibration I study, in a first step, two different scenarios which I label "Higher gross foreign asset holdings" and "Lower foreign transaction costs". In the "Higher gross foreign asset holdings" experiment, the level of (total) gross foreign steady state asset holdings is increased to 200 percent of GDP which corresponds to about a threefold increase of the baseline calibration and is roughly in line with the average gross foreign asset holdings of industrial economies between 1990 and 2004 documented in Lane and Milesi-Ferretti (2007). In the second experiment, the "Lower foreign transaction costs" scenario, the transaction costs of changing foreign asset positions are reduced to the level of the costs for changing domestic asset holdings (for both Home and Foreign agents), i.e.

[26] $[0.0054] \approx [(3^*0.2) - (0.99^*((3*0.2) - (0.005^*0.2)))] - [(1^*0.1) - (0.99^*((1*0.1) - (0.005^*0.1)))]$.

[27] Without any further changes induced by the Taylor rule this would correspond to an annualized increase in the policy rate of 100 basispoints on impact.

$\gamma_{B_F} = \gamma_{B_H^*} = \gamma_{Q_F} = \gamma_{Q_H^*} = 1$. The robustness of both experiments is checked by additional variations of the parameters and both experiments are analyzed separately as well as in a combined experiment together.

In addition to analyzing these financial market integration experiments I study goods market integration and its interaction with the two forms of financial market integration. The calibration of "goods market integration" follows Woodford (2007) by lowering the share of traded goods produced in the Home country. In the "integrated", "small open economy", scenario the share of Home traded goods in the overall traded goods basket, i.e. α, is lowered to 0.1.

3 Results

The simulations of the different experiments are reported in Figures A1 to A10 in Appendix A. All impulse response functions show the dynamic reaction to a 25 basispoints one-off exogenous positive shock on the nominal interest rate in the Home country.[28] To conserve space I do not report the dynamics of all variables of the model. In each scenario I report the impulse responses of 20 variables including the main macroeconomic variables of the model plus some additional variables such the dynamics of the current account (CA), its decomposition into the trade balance (TB) and net asset income (NAI), the terms of trade (TOT), as well as the net foreign asset position (NFA), and the decomposition of the change in the net foreign assets position (ΔNFA) into the current account (CA), the change in local currency asset prices (ΔLCAP), and exchange rate valuation (EV) (see Appendix B for a detailed derivation). In the "Baseline" scenario, for intuitive purposes, an additional Figure reports a few further variables.

The dynamic reaction of the model is as expected and intuitive. Figure A1 and A2 show the results for the "Baseline" scenario. The contractionary monetary policy shock leads to a reduction of Home inflation of about 0.5% on impact. As a consequence of the increase of the Home interest rate the Home nominal (and real) exchange rate fall on impact (i.e. the Home currency appreciates) after depreciating to the new equilibrium. This is in line with some form of an uncovered interest rate parity condition which can be derived from the Euler equations. The increase in the Home nominal (and real) interest rate induces Home households to reduce their domestic consumption spending, in line with the Euler equations. Home households also reduce their import spending, thus income-absorption effects more than offset expenditure-switching effects. Expenditure-switching effects, however, also reduce exports, and as the fall in exports more than offsets the fall in imports, net exports fall as well. The negative demand shock stemming from the reduction in both consumption and exports leads to a fall in the return on investment and therefore investment itself. The combined fall in consumption,

[28] Without any further changes induced by the Taylor rule this would correspond to an annualized increase in the policy rate of 100 basispoints on impact. Impulse response functions are shown in percentage point deviations from the steady state. Inflation, and interest rates are shown in annualized rates (i.e. multiplied by four). Note that as the model is linearized around stationary variables all variables except inflation and nominal exchange and interest rates are real variables, i.e. scaled by the Home and Foreign CPIs, respectively. For variables where the steady state is equal to zero, i.e. the trade balance, net foreign income, and net foreign assets the impulse responses for nominal and real variables are equivalent.

net exports, and investment leads to a fall in Home output by around 0.4%. In order to cushion the contractionary monetary policy shock and smooth consumption over time, Home consumers borrow from Foreign agents in all four asset categories (as can be seen in the reduction of both Home and Foreign bond and equity holdings reported in the fourth row). As a consequence, net asset income and the current account fall, as do net foreign assets. The change in net foreign assets (as can be seen from the decomposition in the fifth row) is not only due to increased borrowing but mainly due to negative exchange rate valuation effects stemming from the appreciation of the Home currency. Figure A2 reports the reaction of some additional variables in the "Baseline" scenario. As a consequence of the negative demand shock, Home firms reduce their labor and capital input demand, which leads to a reduction of both wages and rental rates of capital and therefore investment (as reported in Figure A). The fall in wages and rental rates of capital in turn leads to a reduction in marginal costs, and as prices are sticky and cannot react immediately, this leads to an increase in Home profits. Over time firms' adjust their price setting to the reduction in marginal costs which, as reported in Figure, leads to a fall in Home inflation. Due to the increase in Home interest rates and to restore asset market equilibrium, equity prices fall. Furthermore, as a consequence of the appreciation of the Home currency and the fall in Home output, the Home terms of trade increase. For completeness, the third row reports the reaction of the main Foreign variables. As all the reactions are very low, almost insignificant, they are not further discussed.

The first international financial integration experiment shows that integration in the form of lower transaction costs for trading foreign assets indeed weakens part of the interest rate channel due to an increase in consumption smoothing and a reduced reaction of consumer spending and investment. However, in case an economy is open to trade higher consumption smoothing also applies to import spending which, together with a strengthened exchange rate channel, intensifies the reaction of net exports and the overall impact of monetary policy on output and inflation. Figure A3 reports the impulse responses, in particular the differences in the responses of the main variables between the "Lower Costs" and the "Baseline" scenarios (note that there are no qualitative differences in the reaction of any variables in the two scenarios). A reduction in transaction costs for trading foreign assets leads to a boost in consumption smoothing by Home households and therefore a higher increase in borrowing from abroad and a lower reduction in consumption and investment spending. However, it also leads to a lower reduction in import spending. And as Home households don't reduce their import spending as much as before, i.e. the fall in imports is higher than before, and as exports are reduced by more due to a higher appreciation of the Home currency, net exports fall more. The higher exchange rate appreciation could be the result of lower transaction costs and more integrated asset markets in which exchange rates react more to interest rate differentials. Overall, the higher fall in net exports offsets the lower reduction in consumption, and investment and there is a slightly higher reduction in output (about 1% of the initial response), as well as inflation (about 4% of the initial response). Thus, even though monetary policy loses some control over consumption and investment due to the fact that Home consumers can borrow more easily from the rest of the world, the impact on net exports, output and inflation are higher in an economy where assets can be traded more easily with the rest of the world. It is important to get a sense of how the calibration of transaction costs affects the robustness of this result. Figure A4 reports the sensitivity of the impulse responses to the calibration of transaction costs. The response functions are shown for the period of the shock as a function of $\gamma_{B_F}, \gamma_{Q_F}, \gamma_{B_H^*}, \gamma_{Q_H^*}$. Thus, as before, transaction costs for different categories of foreign assets are the same and symmetric for the two countries. As found before, the lower the transaction costs on foreign assets the more consumers can engage in consumption smoothing with the rest of the world and therefore the higher the reduction in asset holdings and the lower the reaction of consumption, investment and imports. Exports, the trade balance and output react more. The sensitivity of the reactions to the level of transaction costs is very low. Even if costs are reduced by a factor of 10, the responses of inflation and output are affected by only 0.05 and 0.02 percent, respectively.

The second international financial integration experiment shows that integration in the form of higher gross foreign asset holdings strengthens wealth channels of monetary transmission and thereby, despite a slight weakening of the exchange rate channel, reinforces the impact of monetary policy on consumption and output. Figure A5 reports the impulse responses, in particular the differences in the reaction of the main variables between the "Higher gross foreign asset holdings" and the "Baseline" scenario. Note that there are again no qualitative differences in the responses of any variable. The fall in consumption, investment, and output are higher - as is the fall in imports. The intensification in the fall in consumption occurs despite the fact that in an integrated scenario Home agents' boost their consumption smoothing, i.e. increase their borrowings from foreigners (as can be seen by the higher reduction in asset holdings). The higher fall in consumption and imports is mainly due to much higher negative shocks on domestic agents wealth, i.e. net foreign income and assets (the responses are increased by a factor of around three and two, respectively). These dynamics in turn are a consequence of higher negative exchange rate valuation effects (as well as a lower current account). Despite a lower appreciation of the Home currency, exchange rate valuation effects are much higher as they affect much higher steady state gross positions. The response of inflation is slightly moderated on impact (5% of the initial response), due to a lower impact appreciation of the exchange rate, but it is more persistent. Only the impact of monetary policy on net exports is reduced. The negative impact on net exports is reduced as a lower impact appreciation of the Home currency lowers the reduction in exports and increases the reduction in imports. However, despite a lower impact on net exports, the overall impact on output is increased by about 2.5% percent of the initial response. Figure A6 reports the sensitivity of the impulse responses to the calibration of the level of steady state gross foreign asset positions. The response functions are shown for the period of the shock as a function of $\frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}, \frac{\bar{B}_H^*}{\bar{P}\bar{Y}}, \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}, \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H^*}{\bar{Y}}$. Thus, as before, transaction costs for different categories of foreign assets are the same and symmetric for the two countries. As found before, the higher gross foreign asset holdings the higher the negative reaction of consumption, investment and imports. Exports and the trade balance and inflation react less the higher gross foreign asset holdings. Note that, if gross foreign asset holdings are more than 350% of GDP, the real exchange rate depreciates on impact which leads to a positive reaction of net exports and net foreign assets. The sensitivity of the reactions to the level of gross foreign assets is again low. Even if holdings are increased by a factor of 15, the responses of output and inflation are affected by only 0.05 and 0.2 percent, respectively.

The experiment interacting both forms of financial market integration, i.e. a reduction of transaction costs for trading foreign assets combined with an increase in the level of gross foreign assets, increases the impact of monetary policy on both output and inflation as the effects in the two individual scenarios reinforce each other. Figure A7 reports the difference in the impulse responses in the two scenarios. A higher impact appreciation of the Home currency (arguably due to lower transaction costs, i.e. more integrated international asset markets, which make exchange rates more responsive to interest rate differentials) now has a higher negative exchange rate valuation effect on Home households' wealth, which, in turn, has a higher negative impact on consumption, imports, output and inflation. The real exchange rate appreciates slightly more on impact, but is less persistent thereafter which leads to a lower reduction of exports and the trade balance. Overall, even a combined form of financial integration increases rather than decreases monetary policy effectiveness as a higher impact appreciation and strengthened exchange rate valuation effects interact with higher gross foreign asset holdings and thereby reinforce the wealth channels of monetary policy transmission.

The goods market integration experiment (displayed in Figure A8) shows that a reduction in the Home country's share in the overall traded goods sector leads to very similar effects as an increase in gross foreign asset holdings. The experiment confirms Woodford (2007)'s results that monetary policy retains its leverage over output and inflation even in an environment of highly integrated goods markets and despite the fact that its leverage over the trade balance is reduced. The leverage over the trade balance is again reduced as in the experiment of increasing gross foreign asset holdings, a lower appreciation of the exchange rate reduces the impact on exports and together with higher negative wealth shocks increase the (negative) impact on imports. Figure A9 reports the experiment interacting goods market integration with both forms of financial integration combined. As the difference in the impulse responses show, an interaction of all forms of integration leads to the highest positive impact on monetary policy effectiveness. Furthermore, the combined effect is not just the sum of all individual effects, but the interaction of financial and trade integration actually leads to an amplification of the effects. Despite the fact that there is a lower impact appreciation of the Home currency and a lower reaction of the trade balance, there is a much larger reduction in net foreign income and assets due to a much larger increase in borrowing abroad and a larger negative exchange rate valuation effect. This negative wealth shocks in turn lead to a much larger reduction in consumption and investment which in turn leads to a much larger reduction in output and inflation (around 12% and 2% of the initial responses, respectively). Strengthened wealth channels thus more than offset weakened exchange rate and interest rate channels of monetary transmission. Thus, to sum up all experiments, it is difficult to construct scenarios in which financial integration or an interaction of financial with other forms of integration materially weaken the impact of monetary policy.[29]

[29] Also an experiment with an interaction of financial integration with a decrease in the exchange rate pass-through, which could arguably be lower in more integrated financial and goods markets, does not show any material impact and is therefore not reported.

4 Conclusions

The simulations of the model show that none of the analyzed forms of international financial integration undermine the impact of monetary policy on output and inflation. Thus, Woodford (2007)'s results for goods and factor market integration also apply to financial market integration. Neither a decrease in transaction costs for trading foreign assets nor an increase of gross foreign asset holdings nor a combination of the two and an interaction with trade integration materially affect monetary policy effectiveness. If anything, monetary policy is *more* rather than *less* effective.

The simulations show three different aspects of the impact of financial integration on the transmission of monetary policy. First, the two forms of international financial integration have opposite effects on the impact of monetary policy on domestic spending decisions. On the one hand, integration in the form of lower transaction costs reduces monetary policy's control over domestic spending decisions as it increases the ability of domestic agents to smooth their consumption over time by borrowing from the rest of the world. This form of integration thus weakens the interest rate channel of monetary policy transmission. On the other hand, integration in the form of an increase of gross foreign asset holdings increases monetary policy's control over domestic spending decisions as it strengthens the effect of (monetary policy induced) exchange rate valuation effects on domestic agent's wealth. This form of integration thus strengthens wealth channels of monetary policy transmission. Second, the effects of both forms of integration on the impact of monetary policy on domestic spending decisions are offset by the effects of integration on the impact of monetary policy on the trade balance. Under financial integration in the form of a reduction in transaction costs a weakened interest rate channel reduces the impact not only on domestic spending but also import spending which in turn *increases* the leverage over net exports. Under financial integration in the form of higher gross foreign assets a strengthened wealth channel increases the impact not only on domestic spending but also in import spending which in turn *reduces* the leverage over net exports (this effect is, however, not strong enough to offset the higher impact on domestic consumption). One conclusion that could be drawn from these offsetting impacts of integration is that an economy that is open to trade is less prone to a reduction in monetary policy effectiveness due to financial integration in the form of lower transaction costs for international asset trading. Third, overall, in such a model, weakened interest rate channels are always more than offset by strengthened wealth or exchange rate channels. None of the experiments lead to a material erosion of the impact of monetary policy. On the contrary, in an interaction of financial and real integration the positive effects of integration on monetary policy effectiveness are amplified, i.e. integration leads to a non-negligible *increase* of the impact of monetary policy on output and inflation.

This paper is only a first step in the analysis of the implications of international financial integration for the transmission of monetary policy. The focus of this paper is on a standard New Keynesian framework in which non-neoclassical channels, such as bank- and balance sheet-based channels, cannot be analyzed. The role of non-neoclassical channels in the transmission of monetary policy remains a very important open question for research.[30]

[30] See Boivin, Kiley and Mishkin (2010).

Furthermore, the analysis of this paper is based on a calibration exercise. This approach has to be complemented not only by an estimation of the model but also by a less structural data-driven approach in a vector autoregression framework and a combination of the two along the lines of Boivin and Giannoni (2002).[31] Finally, this paper shows that even if international financial integration does not erode the impact of monetary policy it changes the relative roles of different monetary policy transmission channels. The functioning of these different channels in a global environment with integrated financial markets warrants a more detailed analysis, both theoretically and empirically.

[31] This is the topic of a separate related paper of mine (see Meier, 2011).

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Appendix A: Impulse response functions

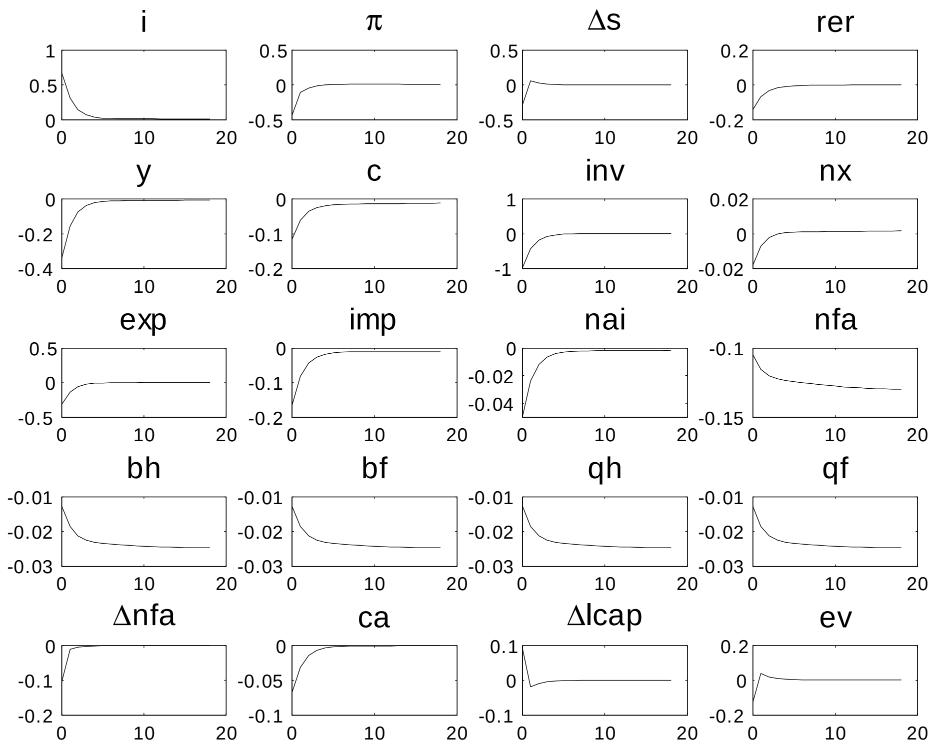

Figure A1: "Baseline"

Impulse responses are reported in percentage point deviations from the steady state.

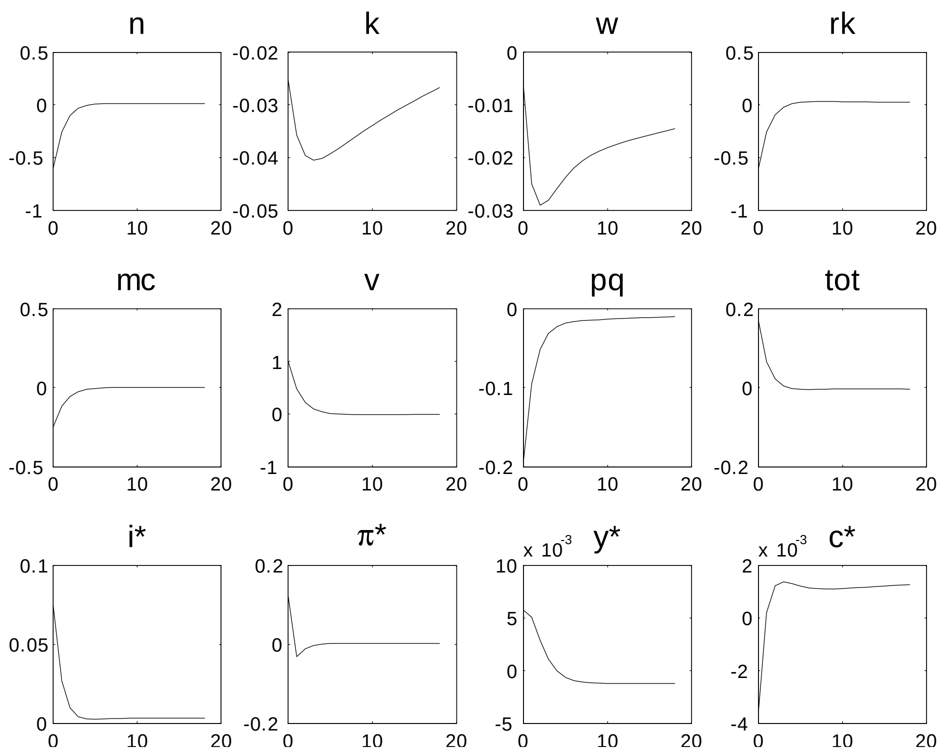

Figure A2: "Baseline"

Impulse responses are reported in percentage point deviations from the steady state.

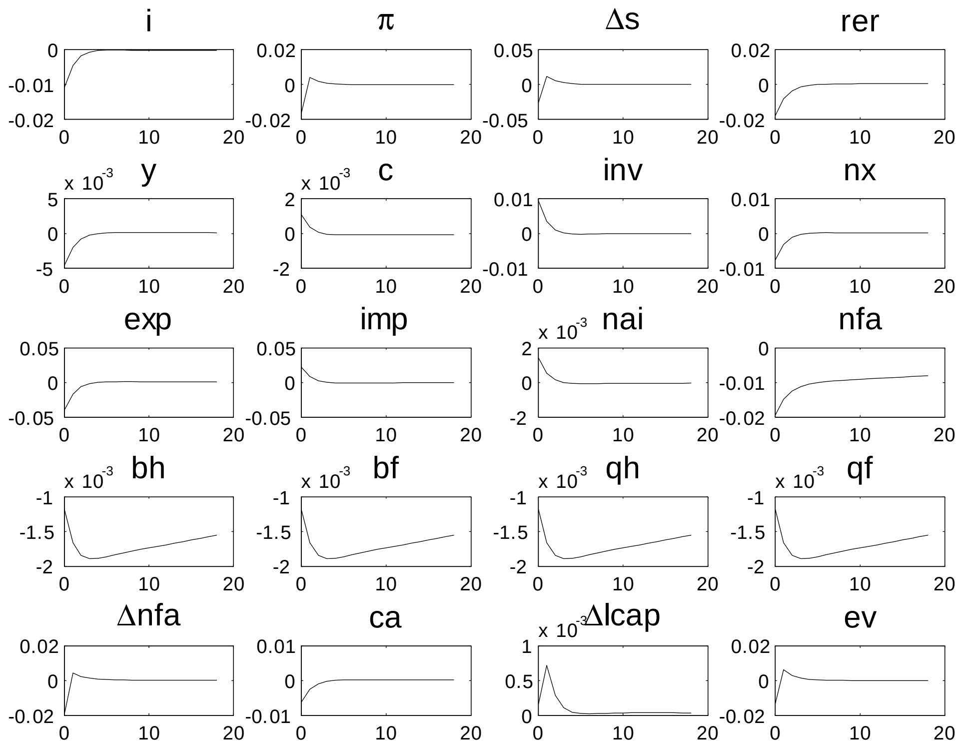

Figure A3: Difference "Lower Costs" to "Baseline"

Impulse responses are reported in percentage point deviations from the steady state. Here the differences in the responses between the "Lower Costs" and the "Baseline" scenarios are reorted.

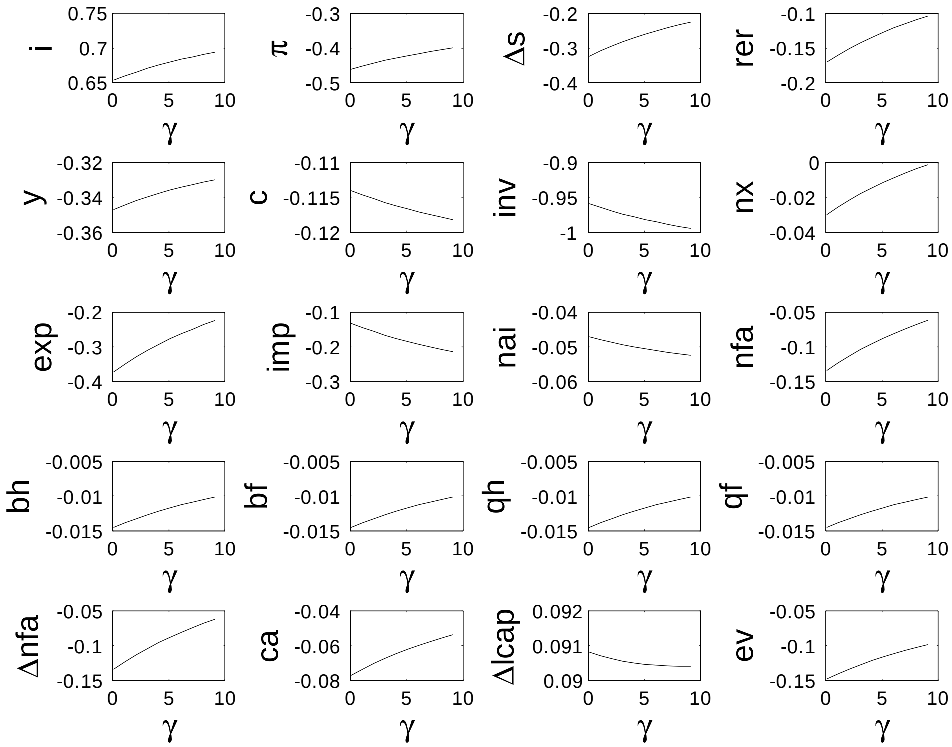

Figure A4: "Lower Costs"

Impulse responses are reported in percentage point deviations from the steady state. Here the respones in the period of the shock are reported as functions of the level of transaction costs.

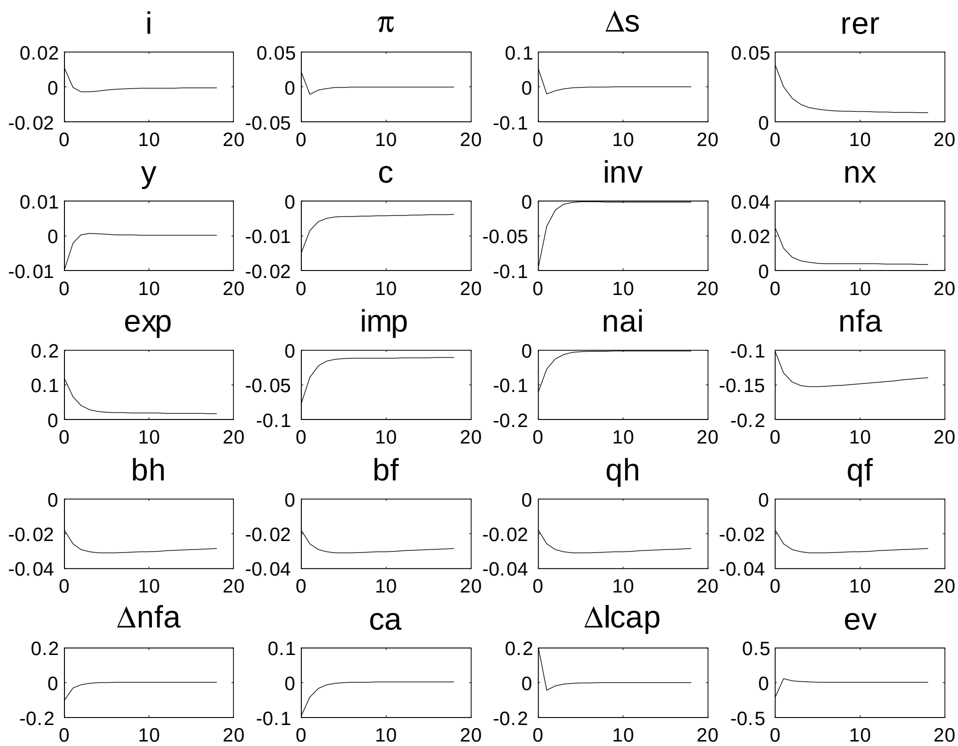

Figure A5: Difference "Higher GFA" to "Baseline"

Impulse responses are reported in percentage point deviations from the steady state. Here the differences between the "Higher GFA" and the "Baseline" scenarios are reported.

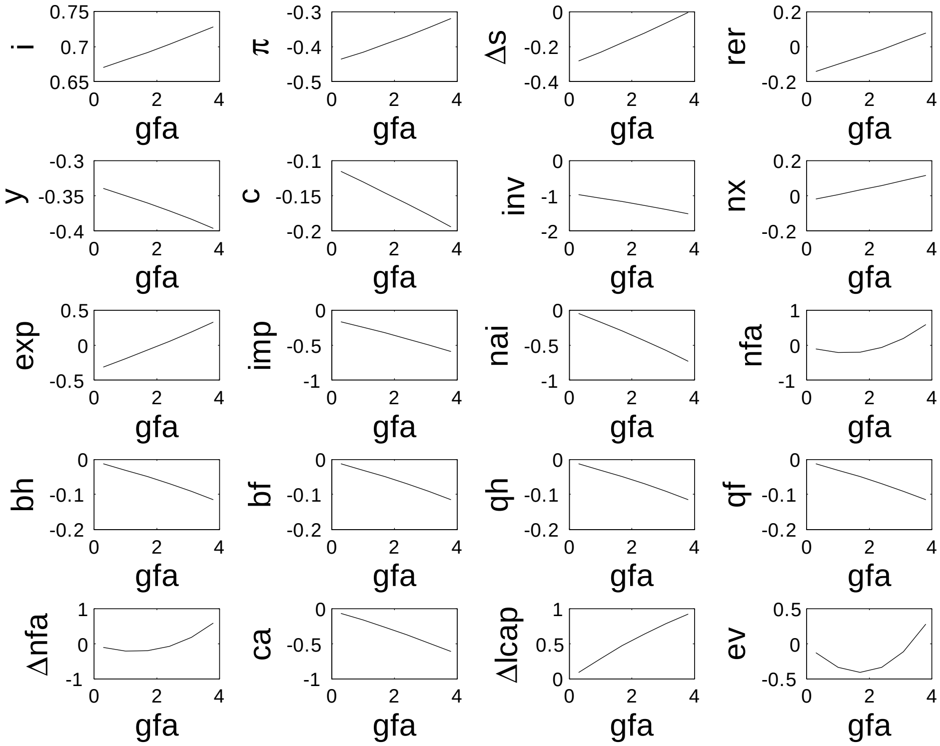

Figure A6: "Higher GFA"

Impulse responses are reported in percentage point deviations from the steady state. Here the responses in the period of the shock are reported as functions of the level of steady state gross foreign assets.

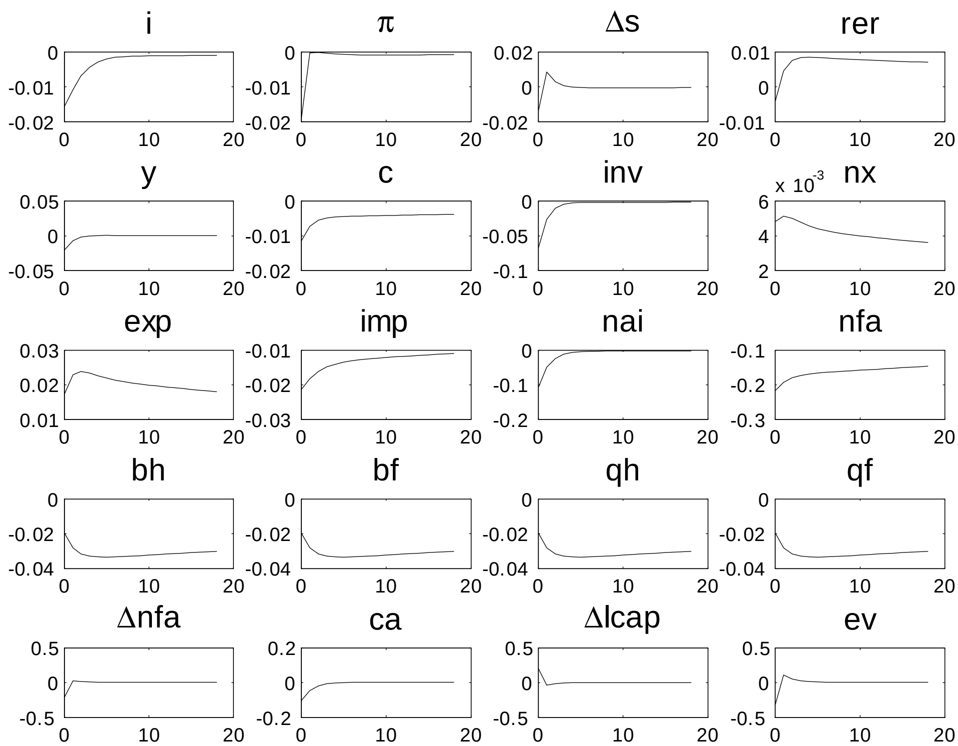

Figure A7: Difference "Higher GFA and Lower Costs" to "Baseline"

Impulse responses are reported in percentage point deviations from the steady state. Here the differences in the responses between the "Higher GFA and Lower Costs" and the "Baseline" sceanrios are reported.

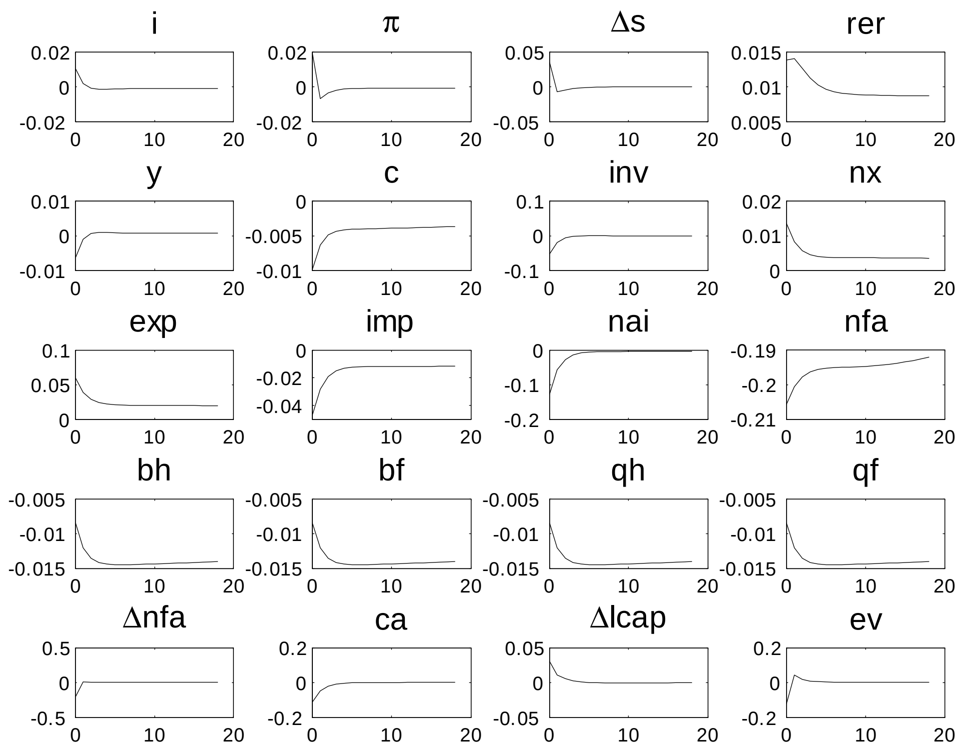

Figure A8: Difference "Higher goods market integration" to "Baseline"

Impulse responses are reported in percentage point deviations from the steady state. Here the differences in the responses between the "Higher goods market integration" and the "Baseline" scenarios are reported.

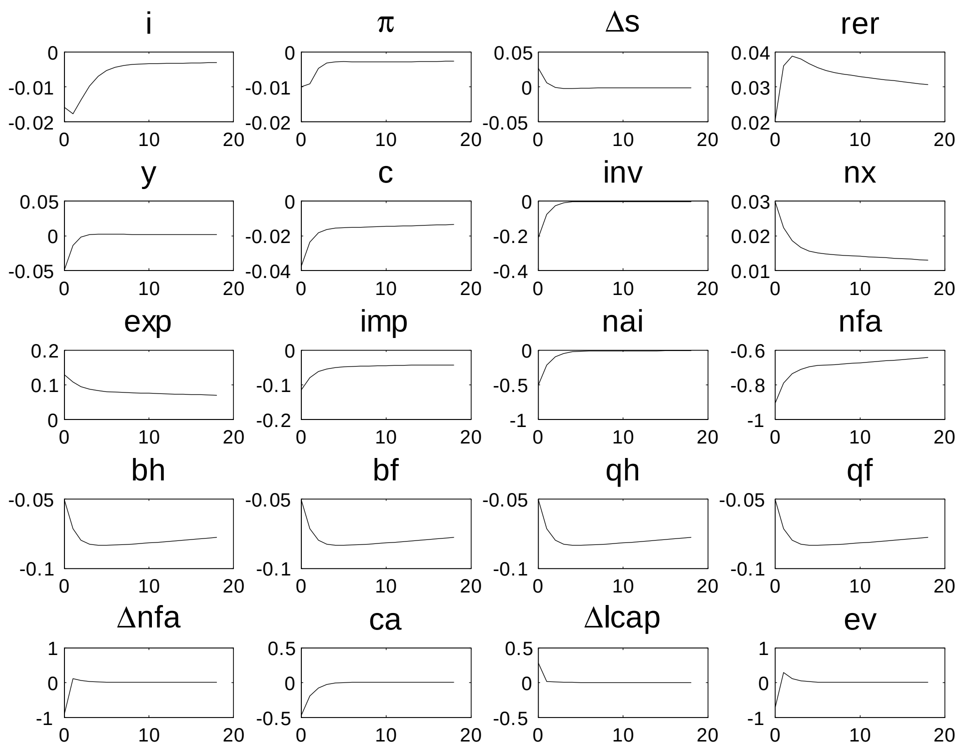

Figure A9: Difference "Higher goods market integration, Higher GFA and Lower Costs" to "Baseline"

Impulse responses are reported in percentage point deviations from the steady state. Here the differences in the responses between the "Higher goods market integration, Higher GFA and Lower Costs" and the "Baseline" sceanrios are reported.

Appendix B: Technical Appendix of the Model

This technical appendix derives the theoretical model in more detail. Section 1 outlines the derivation of the optimality conditions of households and firms. Section 2 outlines the aggregation of the optimality conditions. Section 3 lists the market clearing conditions. Section 4 restates the behavior of the monetary authorities. Section 5 derives the steady state. Section 6 log-linearizes the system, and the last section derives some additional variables of interest.

B.1 Optimality Conditions

B.1.1 Optimal allocation of expenditures

The optimization problem with regards to the optimal allocation of consumption involves three stages. The first stage is the optimal allocation of consumption across the brands of the three different sub-baskets, i.e. the minimization of the costs of purchasing a given aggregate traded or nontraded goods index. For example, for the Home traded goods basket, a representative Home household j faces the following optimization problem:

$$\min_{C_{HTt}(j,i)} \int_0^{\alpha\gamma} P_{HTt}(i) C_{HTt}(j,i) di$$

$$s.t. \left[\left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \int_0^{\alpha\gamma} \left(C_{HTt}(j,i)\right)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}} = \bar{C}_{HTt}(j)$$

The FOC with respect to $C_{HTt}(j,i)$ is:

$$\begin{aligned} -P_{HTt}(i) &= \lambda \left[\frac{\theta}{\theta-1} \left[\left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \int_0^{\alpha\gamma} \left(C_{HTt}(j,i)\right)^{\frac{\theta-1}{\theta}} di \right]^{\frac{\theta}{\theta-1}-1} \right] \\ & \left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \left(\frac{\theta-1}{\theta}\right) \left(C_{HTt}(j,i)\right)^{\frac{\theta-1}{\theta}-1} \end{aligned}$$

Multiplying both sides by $C_{HTt}(j,i)$ and integrating over $\int_0^{\alpha\gamma} ...di$:

$$P_{HTt} = -\lambda$$

Combining:

$$P_{HTt}(i) = P_{HTt} \left[\left[\left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \int_0^{\alpha\gamma} \left(C_{HTt}(j,i)\right)^{\frac{\theta-1}{\theta}} di \right]^{\frac{1}{\theta-1}} \right] \left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \left(C_{HTt}(j,i)\right)^{-\frac{1}{\theta}}$$

Replacing the Home traded goods consumption basket:

$$C_{HTt}(j,i) = \left(\frac{1}{\alpha\gamma}\right)\left(\frac{P_{HTt}(i)}{P_{HTt}}\right)^{-\theta} C_{HTt}(j)$$

Aggregating over all Home households:

$$\begin{aligned}
\int_0^{\alpha} C_{HTt}(j,i)dj &= \int_0^{\alpha} \left(\frac{1}{\alpha\gamma}\right)\left(\frac{P_{HTt}(i)}{P_{HTt}}\right)^{-\theta} C_{HTt}(j)dj \\
C_{HTt}(i) &= \left(\frac{1}{\alpha\gamma}\right)\left(\frac{P_{HTt}(i)}{P_{HTt}}\right)^{-\theta} C_{HTt}
\end{aligned}$$

where the aggregate consumption of good i and the aggregate Home traded consumption basket are defined as:

$$C_{HTt}(i) \equiv \int_0^{\alpha} C_{HTt}(j,i)dj$$

$$C_{HTt} = \int_0^{\alpha} C_{HTt}(j)dj$$

The Home traded goods price index can be computed by plugging this aggregate optimality condition into the definition of the Home traded goods consumption basket:

$$C_{HTt} = \left[\left(\frac{1}{\alpha\gamma}\right)^{\frac{1}{\theta}} \int_0^{\alpha\gamma} \left(C_{HTt}(i)\right)^{\frac{\theta-1}{\theta}} di\right]^{\frac{\theta}{\theta-1}}$$

yielding:

$$P_{HTt} = \left[\left(\frac{1}{\alpha\gamma}\right) \int_0^{\alpha\gamma} P_{HTt}(i)^{1-\theta} di\right]^{\frac{1}{1-\theta}}$$

By analogous optimization problems one can derive the optimal consumption allocations and price indices for the Foreign traded goods basket and the Home nontraded goods basket:

$$C_{FTt}(j,i) = \left(\frac{1}{(1-\alpha)\gamma}\right)\left(\frac{P_{FTt}(i)}{P_{FTt}}\right)^{-\theta} C_{FTt}(j)$$

$$C_{Nt}(j,i) = \left(\frac{1}{\alpha\,(1-\gamma)}\right)\left(\frac{P_{Nt}(i)}{P_{Nt}}\right)^{-\theta} C_{Nt}(j)$$

and

$$P_{FTt} \equiv \left[\left(\frac{1}{(1-\alpha)\gamma}\right) \int_{\alpha\gamma}^{\gamma} \left(P_{FTt}(i)\right)^{1-\theta} di\right]^{\frac{1}{1-\theta}}$$

$$P_{Nt} \equiv \left[\left(\frac{1}{\alpha\,(1-\gamma)}\right) \int_{\gamma}^{1} \left(P_{Nt}(i)\right)^{1-\theta} di\right]^{\frac{1}{1-\theta}}$$

The second stage is the optimal allocation of consumption between the Home and Foreign traded goods baskets for a given aggregate traded goods basket, i.e. the minimization of the costs of purchasing a given traded goods basket. A representative Home household j faces the following optimization problem:

$$\min_{C_{HTt},C_{FTt}} \left[P_{HTt}C_{HTt}(j) + P_{FTt}C_{FTt}(j)\right]$$
$$s.t. \ \left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}} = \bar{C}_{Tt}(j)$$

The FOC with respect to $C_{HTt}(j)$ is:

$$\begin{aligned} -P_{HTt} &= \lambda \left[\left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}-1}\right] \\ &\quad \left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}-1}\right] \end{aligned}$$

Multiplying by $C_{HTt}(j)$:

$$\begin{aligned} P_{HTt}C_{HTt}(j) &= -\lambda \left[\left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}-1}\right] \\ &\quad \left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}}\right] \end{aligned}$$

The FOC with respect to $C_{FTt}(j)$ is:

$$\begin{aligned} -P_{FTt} &= \lambda \left[\left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}-1}\right] \\ &\quad \left[(1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}-1}\right] \end{aligned}$$

Multiplying by $C_{FTt}(j)$:

$$\begin{aligned} P_{FTt}C_{FTt}(j) &= -\lambda \left[\left[\alpha^{\frac{1}{\phi}} \left(C_{HTt}(j)\right)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}-1}\right] \\ &\quad \left[(1-\alpha)^{\frac{1}{\phi}} \left(C_{FTt}(j)\right)^{\frac{\phi-1}{\phi}}\right] \end{aligned}$$

Adding the two FOCs:

$$P_{Tt} = -\lambda$$

Combining:

$$C_{HTt}(j) = \alpha \left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}(j)$$

and similarly for the foreign traded goods basket:

$$C_{FTt}(j) = (1-\alpha)\left(\frac{P_{FTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}(j)$$

Aggregating these optimality conditions over all Home households yields for the aggregate Home traded goods consumption in the Home economy:

$$\int_0^{\alpha} C_{HTt}(j)dj = \int_0^{\alpha} (1-\alpha)\left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}(j)dj$$

$$C_{HTt} = (1-\alpha)\left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}$$

and similarly for the aggregate Foreign traded goods consumption in the Home economy:

$$C_{HTt} = (1-\alpha)\left(\frac{P_{FTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}$$

The traded goods price index can be computed by plugging this aggregate optimality conditions into the definition of the traded goods consumption basket:

$$C_{Tt} = \left[\alpha^{\frac{1}{\phi}}\left(\alpha\left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}\right)^{\frac{\phi-1}{\phi}} + (1-\alpha)^{\frac{1}{\phi}}\left((1-\alpha)\left(\frac{P_{FTt}}{P_{Tt}}\right)^{-\phi} C_{Tt}\right)^{\frac{\phi-1}{\phi}}\right]^{\frac{\phi}{\phi-1}}$$

$$P_{Tt} = \left[\alpha P_{HTt}^{1-\phi} + (1-\alpha) P_{FTt}^{1-\phi}\right]^{\frac{1}{1-\phi}}$$

The third stage is the optimal allocation of expenditures between traded and non-traded goods for a given overall consumption basket, i.e. the minimization of the costs for purchasing a given overall aggregate consumption basket. A representative Home household j faces the following optimization problem:

$$\min_{C_{Tt}(j), C_{Nt}(j)} \left[P_{Tt}C_{Tt}(j) + P_{Nt}C_{Nt}(j)\right]$$

$$s.t. \left[\gamma^{\frac{1}{\omega}} (C_{Tt}(j))^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} (C_{Nt}(j))^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}} = \bar{C}_t(j)$$

The FOC with respect to $C_{Tt}(j)$ is:

$$\begin{aligned} -P_{Tt} \quad = \quad & \lambda\left[\left[\gamma^{\frac{1}{\omega}} (C_{Tt}(j))^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} (C_{Nt}(j))^{\frac{\omega-1}{\omega}}\right]^{\frac{\omega}{\omega-1}-1}\right] \\ & \left[\gamma^{\frac{1}{\omega}} (C_{Tt}(j))^{\frac{\omega-1}{\omega}-1}\right] \end{aligned}$$

Multiplying by $C_{Tt}(j)$:

$$P_{Tt}C_{Tt}(j) = -\lambda \left[\left[\gamma^{\frac{1}{\omega}} \left(C_{Tt}(j)\right)^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} \left(C_{Nt}(j)\right)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}-1} \right] \left[\gamma^{\frac{1}{\omega}} \left(C_{Tt}(j)\right)^{\frac{\omega-1}{\omega}} \right]$$

The FOC with respect to $C_{Nt}(j)$ is:

$$-P_{Nt} = \lambda \left[\left[\gamma^{\frac{1}{\omega}} \left(C_{Tt}(j)\right)^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} \left(C_{Nt}(j)\right)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}-1} \right] \left[(1-\gamma)^{\frac{1}{\omega}} \left(C_{Nt}(j)\right)^{\frac{\omega-1}{\omega}-1} \right]$$

Multiplying by $C_{Nt}(j)$:

$$P_{Nt}C_{Nt} = -\lambda \left[\left[\gamma^{\frac{1}{\omega}} \left(C_{Tt}(j)\right)^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} \left(C_{Nt}(j)\right)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}-1} \right] \left[(1-\gamma)^{\frac{1}{\omega}} \left(C_{Nt}(j)\right)^{\frac{\omega-1}{\omega}} \right]$$

Adding the two FOCs:

$$P_t = -\lambda$$

Combining:

$$C_{Tt}(j) = \gamma \left(\frac{P_{Tt}}{P_t}\right)^{-\omega} C_t(j)$$

An analogous condition holds for the nontraded goods basket:

$$C_{Nt}(j) = (1-\gamma) \left(\frac{P_{Nt}}{P_t}\right)^{-\omega} C_t(j)$$

Aggregating these optimality conditions over all Home consumers:

$$\int_0^{\alpha} C_{Tt}(j)dj = \int_0^{\alpha} \gamma \left(\frac{P_{Tt}}{P_t}\right)^{-\omega} C_t(j)dj$$

$$C_{Tt} = \gamma \left(\frac{P_{Tt}}{P_t}\right)^{-\omega} C_t$$

$$C_{Nt} = (1-\gamma) \left(\frac{P_{Nt}}{P_t}\right)^{-\omega} C_t$$

Plugging these aggregate optimality conditions into the definition of the overall aggregate consumption basket:

$$C_t = \left[\gamma^{\frac{1}{\omega}} C_{Tt}^{\frac{\omega-1}{\omega}} + (1-\gamma)^{\frac{1}{\omega}} C_{Nt}^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}}$$

yields:

$$P_t = \left[\gamma P_{Tt}^{1-\omega} + (1-\gamma) P_{Nt}^{1-\omega} \right]^{\frac{1}{1-\omega}}$$

Combining the optimality conditions of these three stages yields:

$$C_{HTt}(j,i)=\left(\frac{P_{HTt}(i)}{P_{HTt}}\right)^{-\theta}\left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{-\omega}C_t(j)$$

$$C_{FTt}(j,i)=\left(\frac{P_{FTt}(i)}{P_{FTt}}\right)^{-\theta}\left(\frac{P_{FTt}}{P_{Tt}}\right)^{-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{-\omega}C_t(j)$$

$$C_{Nt}(j,i)=\frac{1}{\alpha}\left(\frac{P_{Nt}(i)}{P_{Nt}}\right)^{-\theta}\left(\frac{P_{Nt}}{P_t}\right)^{-\omega}C_t(j)$$

and as derived above the following aggregate price indices:

$$P_{HTt}=\left[\left(\frac{1}{\alpha\gamma}\right)\int_0^{\alpha\gamma}P_{HTt}(i)^{1-\theta}di\right]^{\frac{1}{1-\theta}} \tag{B.1}$$

$$P_{FTt}\equiv\left[\left(\frac{1}{(1-\alpha)\gamma}\right)\int_{\alpha\gamma}^{\gamma}\left(P_{FTt}(i)\right)^{1-\theta}di\right]^{\frac{1}{1-\theta}} \tag{B.2}$$

$$P_{Nt}\equiv\left[\left(\frac{1}{\alpha\left(1-\gamma\right)}\right)\int_{\gamma}^{1}\left(P_{Nt}(i)\right)^{1-\theta}di\right]^{\frac{1}{1-\theta}} \tag{B.3}$$

$$P_{Tt}=\left[\alpha P_{HTt}^{1-\phi}+\left(1-\alpha\right)P_{FTt}^{1-\phi}\right]^{\frac{1}{1-\phi}} \tag{B.4}$$

$$P_t=\left[\gamma P_{Tt}^{1-\omega}+(1-\gamma)P_{Nt}^{1-\omega}\right]^{\frac{1}{1-\omega}} \tag{B.5}$$

B.1.2 Optimal intertemporal allocation

Maximizing the utility function subject to the budget constraint with respect to $C_t(j)$, $Q_{Ht+1}(j)$, $Q_{Ft+1}(j)$, $B_{Ht+1}(j)$, and $B_{Ft+1}(j)$ yields the following FOCs:

$$C_t(j):\left(C_t(j)\right)^{-\sigma}-\lambda_t P_t=0$$

$$Q_{Ht+1}(j):-\lambda_t\left(P_{Qt}+\gamma_{Q_H}P_{Qt}\frac{\left(Q_{Ht+1}(j)-Q_{Ht}(j)\right)}{Y_t}\right)$$
$$-\beta\lambda_{t+1}\left(\begin{array}{c}\gamma_{Q_H}P_{Qt+1}\frac{\left(Q_{Ht+2}(j)-Q_{Ht+1}(j)\right)}{Y_{t+1}}(-1)+\psi_{Q_H}P_{Qt+1}\frac{\left(Q_{Ht+1}(j)-\bar{Q}_H(j)\right)}{Y_{t+1}}\\-\left(P_{Qt+1}+\left(\frac{V_{t+1}}{\bar{Q}}\right)\right)\end{array}\right)=0$$

$$Q_{Ft+1}(j): -\lambda_t \left(S_t P^*_{Qt} + \gamma_{_{Q_F}} S_t P^*_{Qt} \frac{(Q_{Ft+1}(j) - Q_{Ft}(j))}{Y^*_t} \right)$$

$$-\beta\lambda_{t+1} \left(\begin{array}{c} \gamma_{_{Q_F}} S_{t+1} P^*_{Qt+1} \frac{(Q_{Ft+2}(j) - Q_{Ft+1}(j))}{Y^*_{t+1}} (-1) + \psi_{Q_F} S_{t+1} P^*_{Qt+1} \frac{\left(Q_{Ft+1}(j) - \bar{Q}_F(j)\right)}{Y^*_{t+1}} \\ -\left(S_{t+1} \left(P^*_{Qt+1} + \left(\frac{V^*_{t+1}}{\bar{Q}^*} \right) \right) \right) \end{array} \right) = 0$$

$$B_{Ht+1}(j): -\lambda_t \left(1 + \gamma_{_{B_H}} \frac{(B_{Ht+1}(j) - B_{Ht}(j))}{P_t Y_t} \right)$$

$$-\beta\lambda_{t+1} \left(\begin{array}{c} \gamma_{_{B_H}} \frac{(B_{Ht+2}(j) - B_{Ht+1}(j))}{P_{t+1} Y_{t+1}} (-1) + \psi_{B_H} \frac{\left(B_{Ht+1}(j) - \bar{B}_H(j)\right)}{P_{t+1} Y_{t+1}} \\ -(1 + i_{t+1}) \end{array} \right) = 0$$

$$B_{Ft+1}(j): -\lambda_t \left(S_t + \gamma_{_{B_F}} S_t \frac{(B_{Ft+1}(j) - B_{Ft}(j))}{P^*_t Y^*_t} \right)$$

$$-\beta\lambda_{t+1} \left(\begin{array}{c} \gamma_{_{B_F}} S_{t+1} \frac{(B_{Ft+2}(j) - B_{Ft+1}(j))}{P^*_{t+1} Y^*_{t+1}} (-1) + \psi_{_{B_F}} S_{t+1} \frac{\left(B_{Ft+1}(j) - \bar{B}_F(j)\right)}{P^*_{t+1} Y^*_{t+1}} \\ -S_{t+1}(1 + i^*_{t+1}) \end{array} \right) = 0$$

Combining these equations yields the following Euler equations (for Home bond holdings, Home equity shares, Foreign bond holdings, and Foreign equity shares, respectively):

$$\left(P_{Qt} + \gamma_{_{Q_H}} P_{Qt} \frac{(Q_{Ht+1}(j) - Q_{Ht}(j))}{Y_t} \right) \tag{B.6}$$

$$= D_{t,t+1}(j) \left(\begin{array}{c} \gamma_{_{Q_H}} P_{Qt+1} \frac{(Q_{Ht+2}(j) - Q_{Ht+1}(j))}{Y_{t+1}} - \psi_{Q_H} P_{Qt+1} \frac{\left(Q_{Ht+1}(j) - \bar{Q}_H(j)\right)}{Y_{t+1}} \\ + \left(P_{Qt+1} + \left(\frac{V_{t+1}}{\bar{Q}} \right) \right) \end{array} \right)$$

where

$$D_{t,t+1}(j) = \beta \left(\frac{(C_{t+1}(j))}{(C_t(j))} \right)^{-\sigma} \frac{P_t}{P_{t+1}}$$

$$\left(S_t P^*_{Qt} + \gamma_{_{Q_F}} S_t P^*_{Qt} \frac{(Q_{Ft+1}(j) - Q_{Ft}(j))}{Y^*_t} \right) \tag{B.7}$$

$$= D_{t,t+1}(j) \left(\begin{array}{c} \gamma_{_{Q_F}} S_{t+1} P^*_{Qt+1} \frac{(Q_{Ft+2}(j) - Q_{Ft+1}(j))}{Y^*_{t+1}} (-1) + \psi_{Q_F} S_{t+1} P^*_{Qt+1} \frac{\left(Q_{Ft+1}(j) - \bar{Q}_F(j)\right)}{Y^*_{t+1}} \\ -\left(S_{t+1} \left(P^*_{Qt+1} + \left(\frac{V^*_{t+1}}{\bar{Q}^*} \right) \right) \right) \end{array} \right)$$

$$\left(1+\gamma_{_{B_H}}\frac{(B_{Ht+1}(j)-B_{Ht}(j))}{P_tY_t}\right) \tag{B.8}$$
$$= \quad D_{t,t+1}(j)\left(\begin{array}{c}\gamma_{_{B_H}}\frac{(B_{Ht+2}(j)-B_{Ht+1}(j))}{P_{t+1}Y_{t+1}}-\psi_{B_H}\frac{\left(B_{Ht+1}(j)-\bar{B}_H(j)\right)}{P_{t+1}Y_{t+1}}\\ +(1+i_{t+1})\end{array}\right)$$

$$\left(S_t+\gamma_{_{B_F}}S_t\frac{(B_{Ft+1}(j)-B_{Ft}(j))}{P_t^*Y_t^*}\right) \tag{B.9}$$
$$= D_{t,t+1}(j)\left(\begin{array}{c}\gamma_{_{B_F}}S_{t+1}\frac{(B_{Ft+2}(j)-B_{Ft+1}(j))}{P_{t+1}^*Y_{t+1}^*}-\psi_{_{B_F}}S_{t+1}\frac{\left(B_{Ft+1}(j)-\bar{B}_F(j)\right)}{P_{t+1}^*Y_{t+1}^*}\\ +S_{t+1}(1+i_{t+1}^*)\end{array}\right)$$

B.1.3 Optimal wage setting

Maximizing the utility function subject to the budget constraint with respect to $W_t^{Opt}(j)$ and taking into account the aggregate wage and employment indices and firms' labour input demand schedules that each household faces (derived below in the section on firms):

$$W_t=\left[\int_0^n W_t(j)^{1-\eta}dj\right]^{\frac{1}{1-\eta}}$$

$$N_{t+k}\equiv\int_0^{\alpha\gamma+n(1-\gamma)}N(i)di$$

$$N_{t+k|t}(j)=\left(\frac{W_t^{Opt}(j)}{W_{t+k}}\right)^{-\eta}N_{t+k}$$

yields:

$$E_t\sum_{k=0}^{\infty}(\beta\theta_W)^k\left[\begin{array}{c}U_{N_{t+k|t}(j)}N_{t+k}\left(\frac{1}{W_{t+k}}\right)^{-\eta}(-\eta)\,W_t^{Opt}(j)^{-\eta-1}\\ +\lambda_{t+k}\left[\begin{array}{c}\left(\left(\frac{W_t^{Opt}(j)}{W_{t+k}}\right)^{-\eta}N_{t+k}\right)\\ +W_t^{Opt}(j)N_{t+k}\left(\frac{1}{W_{t+k}}\right)^{-\eta}(-\eta)\,W_t^{Opt}(j)^{-\eta-1}\end{array}\right]\end{array}\right]=0$$

Plugging this condition into the FOC with respect to $C_{t+k|t}(j)$ from the intertemporal optimization problem above yields:

$$E_t \sum_{k=0}^{\infty} (\beta\theta_W)^k \left[\begin{array}{c} U_{N_{t+k|t}(j)} N_{t+k} \left(\frac{1}{W_{t+k}}\right)^{-\eta} (-\eta) W_t^{Opt}(j)^{-\eta-1} \\ + \frac{U_{C_{t+k|t}(j)}}{P_{t+k}} \left[\begin{array}{c} \left(\left(\frac{W_t^{Opt}(j)}{W_{t+k}}\right)^{-\eta} N_{t+k} \right) \\ + W_t^{Opt}(j) N_{t+k} \left(\frac{1}{W_{t+k}}\right)^{-\eta} (-\eta) W_t^{Opt}(j)^{-\eta-1} \end{array} \right] \end{array} \right] = 0$$

or

$$E_t \sum_{k=0}^{\infty} (\beta\theta_W)^k \left[N_{t+k|t}(j) U_{C_{t+k|t}(j)} \left[\frac{W_t^{Opt}(j)}{P_{t+k}} - \mu_W MRS_{t+k|t}(j) \right] \right] = 0$$

where $\mu_W \equiv \left(\frac{\eta}{\eta-1}\right)$ and $MRS_{t+k|t}(j) = -\frac{U_{N_{t+k|t}(j)}}{U_{C_{t+k|t}(j)}}$, or

$$E_t \sum_{k=0}^{\infty} (\beta\theta_W)^k \left[N_{t+k|t}(j) \left(C_{t+k|t}(j)\right)^{-\sigma} \left[\frac{W_t^{Opt}(j)}{P_{t+k}} - \mu_W \frac{\kappa \left(N_{t+k|t}(j)\right)^{\varphi}}{\left(C_{t+k|t}(j)\right)^{-\sigma}} \right] \right] = 0 \qquad \text{(B.10)}$$

where $C_{t+k|t}(j)$ and $N_{t+k|t}(j)$ denote consumption and labor supply in period $t+k$ of a household that last reset its wage in period t.

B.1.4 Optimal investment

An installment firm solves the following optimization problem:

$$\begin{aligned} & \max_{K_{t+1}(I)} E_t \sum_{k=0}^{\infty} D_{t,t+k}(I) \left[P_{t+k} r_{t+k}^k K_{t+k.}(I) - P_{t+k} I_{t+k.}(I) \right] \\ & s.t. \\ K_{t+k+1} \quad = \quad & (1-\delta) K_{t+k} + I_{t+k} - \frac{\xi}{2} \frac{\left(K_{t+k+1}(I) - K_{t+k}(I)\right)^2}{K_{t+k}(I)} \end{aligned}$$

i.e. that we assume that an installment firm I's discount factor reflects the intertemporal marginal rate of substitution of a representative Home household j.

Optimization with respect to $K_{t+1}(I)$ leads to the following FOC:

$$\begin{array}{c} -D_{t,t} P_t \left(1 + \xi \frac{(K_{t+1}(I) - K_t(I))}{K_t(I)}\right) \\ + E_t \left\{ D_{t,t+1} P_{t+1} \left[\begin{array}{c} r_{t+1}^k + (1-\delta) \\ -\frac{\xi}{2} \left(\frac{-2(K_{t+2}(I) - K_{t+1}(I)) K_{t+1} - (K_{t+2}(I) - K_{t+1}(I))^2}{(K_{t+1}(I))^2} \right) \end{array} \right] \right\} = 0 \end{array}$$

Replacing the discount factors and rearranging:

$$\left(1+\xi\frac{(K_{t+1}(I)-K_t(I))}{K_t(I)}\right) \tag{B.11}$$
$$=\beta E_t\left\{\left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma}\left[(1-\delta)+r^k_{t+1}+\frac{\xi}{2}\left(\frac{K_{t+1}(I)^2-K_{t+1}(I)^2}{(K_{t+1}(I))^2}\right)\right]\right\}$$

The profits of Installment firms are assumed to be rebated to households as lump-sum transfers, T_I. The per capita lump-sum transfer T_I^j is:

$$T_I^j=\frac{1}{\alpha}\int_0^\alpha V_t(j)dj=\frac{1}{\alpha}\int_0^\alpha\Big(P_t r_t^k K_{t.}(j)-P_t I_{t.}(j)\Big)\,dj=\Big[P_t r_t^k K_{t.}-P_t I_{t.}\Big]$$

B.1.5 Cost minimization with respect to differentiated labor

Let $W_t(j)$ denote nominal wage for type-j labor effective in period t for all $j\in[0,n]$. The cost minimization problem of a representative Home firm i with respect to differentiated labor services for a given level of the aggregate labor index is:

$$\min_{N_t(i,j)}\int_0^\alpha W_t(j)N_t(i,j)dj$$
$$s.t.\ \left[\int_0^\alpha N_t(i,j)^{\frac{\eta-1}{\eta}}dj\right]^{\frac{\eta}{\eta-1}}=\bar{N}_t(i)$$

The optimality condition is:

$$N_t(i,j)=\left(\frac{W_t(j)}{W_t}\right)^{-\eta}N_t(i)$$

The wage index can be computed by plugging this optimality condition into the definition of the labor index:

$$N_t(i)=\left[\int_0^\alpha N_t(i,j)^{\frac{\eta-1}{\eta}}dj\right]^{\frac{\eta}{\eta-1}}$$

yielding:

$$W_t=\left[\int_0^\alpha W_t(j)^{1-\eta}dj\right]^{\frac{1}{1-\eta}}$$

B.1.6 Optimal aggregate input demand

A Home firm i chooses its aggregate factor inputs $N_t(i)$ and $K_t(i)$ in order to solve the following cost minimization problem:

$$\min_{N_t(i),K_t(i)} \left[W_t N_t(i) + P_t.r_t^k K_t(i)\right]$$
$$s.t.\ A_t \left(K_t(i)\right)^{1-\mu} \left(N_t(i)\right)^{\mu} = \bar{Y}_t(i)$$

The optimal factor demands can be written as:

$$N_t(i) = \frac{\mu}{(1-\mu)} \frac{P_t.r_t^k}{W_t} K_t(i) \text{ and } K_t(i) = \frac{(1-\mu)}{\mu} \frac{W_t}{P_t.r_t^k} N_t(i)$$

Substituting these into the production function:

$$Y_t(i) = A_t \left(K_t(i)\right)^{1-\mu} \left(N_t(i)\right)^{\mu}$$

yields:

$$N_t(i) = \left(\frac{\mu}{(1-\mu)} \frac{P_t.r_t^k}{W_t}\right)^{1-\mu} \frac{Y_t(i)}{A_t} \text{ and } K_t(i) = \left(\frac{(1-\mu)}{\mu} \frac{W_t}{P_t.r_t^k}\right)^{\mu} \frac{Y_t(i)}{A_t}$$

Substituting the rewritten optimal factor demands in the total cost function yields:

$$\begin{aligned} TC_t(i) &= W_t N_t(i) + P_t.r_t^k K_t(i) \\ &= W_t \left(\frac{\mu}{(1-\mu)} \frac{P_t.r_t^k}{W_t}\right)^{1-\mu} \frac{Y_t(i)}{A_t} + P_t.r_t^k \left(\frac{(1-\mu)}{\mu} \frac{W_t}{P_t.r_t^k}\right)^{\mu} \frac{Y_t(i)}{A_t} \\ &= \left[\frac{1}{(1-\mu)^{1-\mu}\mu^{\mu}}\right] (W_t)^{\mu} \left(P_t.r_t^k\right)^{1-\mu} \frac{Y_t(i)}{A_t} \end{aligned}$$

The marginal costs can then be derived as:

$$MC_t = \frac{\delta TC_t(i)}{\delta Y_t(i)} = \frac{(W_t)^{\mu} \left(P_t.r_t^k\right)^{1-\mu}}{(1-\mu)^{1-\mu}\mu^{\mu} A_t} \tag{B.12}$$

Given these marginal costs the optimal factor demands can be written as

$$N_t(i) = \mu MC_t \frac{Y_t(i)}{W_t} \tag{B.13}$$

$$K_t(i) = (1-\mu)\, MC_t \frac{Y_t(i)}{P_t.r_t^k} \tag{B.14}$$

B.1.7 Optimal price setting

Traded goods sector

A representative firm in the Home traded goods sector sets prices $\left\{P_{HTt+k}^{Opt}(i), P_{HTt+k}^{Opt*}(i)\right\}_{k=0}^{\infty}$ that maximize its expected discounted future profits while these prices remain effective. Formally, it solves the following problem for the domestic market:

$$\max_{P_{HTt}^{Opt}(i)} \sum_{k=0}^{\infty} \theta_P^k E_t \left\{ \begin{array}{c} D_{t,t+k}(j) \\ \left(\begin{array}{c} \left(P_{HTt}^{Opt}(i) - MC_{t+k|t}\right) Y_{HTt+k|t} \\ + \left(P_{HTt}^{Opt*}(i) S_{t+k}^{1-\tau} - MC_{t+k|t}\right) Y_{HTt+k|t}^{*} \end{array} \right) \end{array} \right\}$$

where $D_{t,t+k}(j) = \beta^k \left(\frac{(C_{t+k}(j))}{(C_t(j))}\right)^{-\sigma} \frac{P_t}{P_{t+k}}$

i.e. that it is assumed that a representative Home firm's discount factor represents the intertemporal marginal rate of substitution of a representative Home household j,

and where MC_t denotes the (nominal) marginal cost function

subject to the respective demand schedules of the Home and Foreign households and installment firms, respectively:

$$Y_{HTt+k|t}(i) = \int_0^{\alpha} \left[\begin{array}{c} \left(\frac{P_{HTt}(i)}{P_{HTt+k}}\right)^{-\theta} \left(\frac{P_{HTt+k}}{P_{Tt+k}}\right)^{-\phi} \left(\frac{P_{Tt+k}}{P_{t+k}}\right)^{-\omega} (C_{t+k}(j)) \\ + \left(\frac{P_{HTt}(i)}{P_{HTt+k}}\right)^{-\theta} \left(\frac{P_{HTt+k}}{P_{Tt+k}}\right)^{-\phi} \left(\frac{P_{Tt+k}}{P_{t+k}}\right)^{-\omega} (I(j)) \end{array} \right] dj$$

or aggregated:

$$Y_{HTt+k|t}(i) = \left(\frac{P_{HTt}^{Opt}(i)}{P_{HTt+k}}\right)^{-\theta} \left(\frac{P_{HTt+k}}{P_{Tt+k}}\right)^{-\phi} \left(\frac{P_{Tt+k}}{P_{t+k}}\right)^{-\omega} (C_{t+k} + I_{t+k}) \tag{B.15}$$

and

$$Y_{HTt+k|t}^{*}(i) = \int_{\alpha}^{1} \left[\begin{array}{c} \left(\frac{P_{HTt}^{*}(i)}{P_{HTt+k}^{*}}\right)^{-\theta} \left(\frac{P_{HTt+k}^{*}}{P_{Tt+k}^{*}}\right)^{-\phi} \left(\frac{P_{Tt+k}^{*}}{P_{t+k}^{*}}\right)^{-\omega} (C_{t+k}^{*}(j)) \\ + \left(\frac{P_{HTt}^{*}(i)}{P_{HTt+k}^{*}}\right)^{-\theta} \left(\frac{P_{HTt+k}^{*}}{P_{Tt+k}^{*}}\right)^{-\phi} \left(\frac{P_{Tt+k}^{*}}{P_{t+k}^{*}}\right)^{-\omega} (I_{t+k}^{*}(j)) \end{array} \right] dj$$

or aggregated:

$$Y_{HTt+k|t}^{*}(i) = \left(\frac{P_{HTt}^{Opt*}(i) S_{t+k}^{-\tau}}{P_{HTt+k}^{*}}\right)^{-\theta} \left(\frac{P_{HTt+k}^{*}}{P_{Tt+k}^{*}}\right)^{-\phi} \left(\frac{P_{Tt+k}^{*}}{P_{t+k}^{*}}\right)^{-\omega} (C_{t+k}^{*} + I_{t+k}^{*}) \tag{B.16}$$

The FOC with respect to $P_{HTt}^{Opt}(i)$ is:

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{D_{t,t+k}(j)\left(\begin{array}{c} P_{HTt}^{Opt}(i)\frac{\delta Y_{HTt+k|t}(i)}{\delta P_{HTt}^{Opt}(i)}+Y_{HTt+k|t}(i) \\ -MC_{t+k}\frac{\delta Y_{HTt+k|t}(i)}{\delta P_{HTt}^{Opt}(i)} \end{array}\right)\right\}=0$$

Using the fact that:

$$\frac{\delta Y_{HTt+k|t}(i)}{\delta P_{HTt}^{Opt}(i)}=-\theta Y_{HTt+k|t}(i)\left(\frac{1}{P_{HTt}^{Opt}(i)}\right)$$

one can rewrite as:

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{D_{t,t+k}(j)\left(\begin{array}{c} -\theta Y_{HTt+k|t}(i)+Y_{HTt+k|t}(i) \\ +MC_{t+k}\theta Y_{HTt+k|t}(i)\left(\frac{1}{P_{HTt}^{Opt}(i)}\right) \end{array}\right)\right\}=0$$

or

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{D_{t,t+k}(j)Y_{HTt+k|t}(i)\left(P_{HTt}^{Opt}(i)-\mu_P MC_{t+k}\right)\right\}=0 \tag{B.17}$$

where $\mu_P=\frac{\theta}{\theta-1}$

Analogously a representative firm in the Home traded goods sector solves the following problem for the other countries:

$$\max_{P_{HTt}^{Opt*}(i)}\sum_{k=0}^{\infty}\theta_P^k E_t\left\{\begin{array}{c} D_{t,t+k}(j) \\ \left(\begin{array}{c}\left(P_{HTt}^{Opt}(i)-MC_{t+k|t}\right)Y_{HTt+k|t} \\ +\left(P_{HTt}^{Opt*}(i)S_{t+k}^{1-\tau}-MC_{t+k|t}\right)Y_{HTt+k|t}^{*}\end{array}\right)\end{array}\right\}$$

The optimality condition is:

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{D_{t,t+k}(j)Y_{HTt+k|t}^{*}(i)\left(S_{t+k}^{1-\tau}P_{HTt}^{Opt*}(i)-\mu_P MC_{t+k}\right)\right\}=0 \tag{B.18}$$

Nontraded goods sector

A representative firm in the Home nontraded goods sector sets a price $P_{NTt}(i)$ that maximizes its expected discounted future profits while that price remains effective. Formally, it solves the following problem:

$$\max_{P_{Nt}^{Opt}(i)}\sum_{k=0}^{\infty}\theta_P^k E_t\left\{D_{t,t+k}\left(\left(P_{Nt}^{Opt}(i)-MC_{t+k}\right)Y_{Nt+k|t}(i)\right)\right\}$$

subject to the demand schedules:

$$Y_{Nt+k|t}(i) = \int_0^\alpha \left[\begin{array}{c} \frac{1}{\alpha}\left(\frac{P_{Nt}(i)}{P_{Nt}}\right)^{-\theta}\left(\frac{P_{Nt}}{P_t}\right)^{-\omega} C_{t+k}(j) \\ +\frac{1}{\alpha}\left(\frac{P_{Nt}(i)}{P_{Nt}}\right)^{-\theta}\left(\frac{P_{Nt}}{P_t}\right)^{-\omega} I_{t+k}(j) \end{array} \right] dj$$

or aggregated:

$$Y_{Nt+k|t}(i) = \left(\frac{P_{Nt}^{Opt}(i)}{P_{Nt}}\right)^{-\theta}\left(\frac{P_{Nt}}{P_t}\right)^{-\omega}(C_{t+k}+I_{t+k}) \tag{B.19}$$

The optimality condition can be written as:

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{D_{t,t+k}Y_{Nt+k|t}(i)\left(P_{Nt}^{Opt}(i)-\mu_P MC_{t+k}\right)\right\}=0 \tag{B.20}$$

B.1.8 Monetary policies

The monetary policy rule of the Home central bank is defined as:

$$1+i_t = (1+i_{t-1})^\rho\left(\left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi}(Y_t)^{\phi_y}\right)^{(1-\rho)} R_t \tag{B.21}$$

where ρ captures the degree of interest-rate smoothing, R_t represents a time-varying,exogenous factor that may, for example, represent changes in the inflation target.

Analogously, the monetary policy rule of the Foreign central bank is defined as:

$$1+i_t^* = (1+i_t^*)^{\rho^*}\left(\left(\frac{P_t^*}{P_{t-1}^*}\right)^{\phi_\pi^*}(Y_t^*)^{\phi_y^*}\right)^{(1-\rho^*)} \tag{B.22}$$

B.2 Aggregation

As all households and firms are symmetric equations (B.4) to (B.20) can be rewritten in aggregate terms by replacing every variable indexed by j, i, or I with the aggregate, e.g. for consumption: $\int_0^\alpha C_t(j)dj = \alpha C_t^j \equiv C_t$.

By taking into account wage stickiness the wage index $W_t = \left[\int_0^\alpha W_t(j)^{1-\eta}dj\right]^{\frac{1}{1-\eta}}$ can be aggregated to:

$$W_t = \left(\theta_W W_{t-1}^{1-\eta} + (1-\theta_W)\left(W_t^{Opt}\right)^{1-\eta}\right)^{\frac{1}{1-\eta}} \tag{B.23}$$

Similarly, by taking into account price stickiness equations (B.1) to (B.3) can be aggregated to:

$$P_{HTt} = \left(\theta_P\left(P_{HTt-1}\right)^{1-\theta} + (1-\theta_P)\left(P_{HTt}^{Opt}\right)^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{B.24}$$

$$P_{Nt} \equiv \left(\theta_P P_{Nt-1}^{1-\theta} + (1-\theta_P)\left(P_{Nt}^{Opt}\right)^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{B.25}$$

and

$$P_{FTt} \equiv S_t P_{FTt}^{AVG} \tag{B.26}$$

where

$$P_{FTt}^{AVG} = \left(\theta_P \left(P_{FTt-1}^{AVG}\right)^{1-\theta} + (1-\theta_P)\left(P_{FTt}^{OPT}\right)^{1-\theta}\right)^{\frac{1}{1-\theta}} \tag{B.27}$$

and

$$P_{FTt}^{OPT} = S_t^{\tau-1} P_{FTt}^{Opt} \tag{B.28}$$

Total aggregate demand in the Home economy can be written as:

$$Y_t = \frac{1}{P_t}\left(\alpha\gamma\left(P_{HTt} \cdot Y_{HTt}^{Avg} + P_{HTt}^{AVG*} \cdot Y_{HTt}^{Avg*}\right) + \alpha(1-\gamma)\left(P_{Nt} \cdot Y_{Nt}^{Avg}\right)\right) \tag{B.29}$$

where

$$\begin{aligned} Y_{HTt}^{Avg} &= \left(\frac{\left(\theta_P \left(P_{HTt-1}\right)^{1-\theta} + (1-\theta_P)\left(P_{HTt}^{Opt}\right)^{1-\theta}\right)^{\frac{1}{1-\theta}}}{P_{HTt}}\right)^{-\theta} \\ &\quad \left(\frac{P_{HTt}}{P_{Tt}}\right)^{-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{-\omega}(C_t + I_t) \end{aligned}$$

$$\begin{aligned} Y_{HTt}^{Avg*} &= \left(\frac{\left(\left(\theta_P \left(P_{HTt-1}^{AVG*}\right)^{1-\theta} + (1-\theta_P)\left(P_{HTt}^{OPT*}\right)^{1-\theta}\right)^{\frac{1}{1-\theta}}\right) S^{-1}}{P_{HTt}^*}\right)^{-\theta} \\ &\quad \left(\frac{P_{HTt}^*}{P_{Tt}^*}\right)^{-\phi}\left(\frac{P_{Tt}^*}{P_t^*}\right)^{-\omega}(C_t^* + I_t^*) \\ &= \left(\frac{P_{HTt}^{AVG*} S^{-1}}{P_{HTt}^*}\right)^{-\theta}\left(\frac{P_{HTt}^*}{P_{Tt}^*}\right)^{-\phi}\left(\frac{P_{Tt}^*}{P_t^*}\right)^{-\omega}(C_t^* + I_t^*) \end{aligned}$$

$$Y_{Nt}^{Avg} = \left(\frac{\left(\theta_P P_{Nt-1}^{1-\theta} + (1-\theta_P) \left(P_{Nt}^{Opt} \right)^{1-\theta} \right)^{\frac{1}{1-\theta}}}{P_{Nt}} \right)^{-\theta} \frac{1}{\alpha} \left(\frac{P_{Nt}}{P_t} \right)^{-\omega} (C_t + I_t)$$

Equity shares in a given country are assumed to be claims on profits and represent a balanced portfolio across all firms of both the traded and nontraded goods sector in that country. The per period profits of a firm in the traded goods sector which can reset its price in period t is:

$$\underbrace{V_{HTt}(i)}_{\text{for all } i \notin \theta_P} = P_{HTt}^{Opt}(i) Y_{HTt}(i) + S_t^{1-\tau} P_{HTt}^{Opt*}(i) Y_{HTt}^*(i) - \left[W_t N_t(i) + P_{t.} r_t^k K_t(i) \right]$$

The profits of a firm in the traded goods sector that cannot reset its price is:

$$\underbrace{V_{HTt}(i)}_{\text{for all } i \epsilon \theta_P} = P_{HTt-1}(i) Y_{HTt}(i) + P_{HTt-1}^{AVG*}(i) Y_{HTt}^*(i) - \left[W_t N_t(i) + P_{t.} r_t^k K_t(i) \right]$$

where

$$P_{HTt}^{AVG*} = \left(\theta_P \left(P_{HTt-1}^{AVG*} \right)^{1-\theta} + (1-\theta_P) \left(P_{HTt}^{OPT*} \right)^{1-\theta} \right)^{\frac{1}{1-\theta}}$$

The total aggregate profits in the Home economy are:

$$V_t = \int_0^{\alpha\gamma} \left[\underbrace{V_{HTt}(i)}_{\text{for all } i \notin \theta_P} + \underbrace{V_{HTt}(i)}_{\text{for all } i \epsilon \theta_P} \right] di + \int_{\alpha\gamma}^{\alpha\gamma + \alpha(1-\gamma)} \left[\underbrace{V_{Nt}(i)}_{\text{for all } i \notin \theta_P} + \underbrace{V_{Nt}(i)}_{\text{for all } i \epsilon \theta_P} \right] di$$

Similarly, the aggregate profits in the Foreign country are:

$$\begin{aligned} V_t^* &= \int_{\alpha\gamma + \alpha(1-\gamma)}^{\alpha\gamma + \alpha(1-\gamma) + (1-\alpha)\gamma} \left[\underbrace{V_{FTt}^*(i)}_{\text{for all } i \notin \theta_P} + \underbrace{V_{FTt}^*(i)}_{\text{for all } i \epsilon \theta_P} \right] di \\ &+ \int_{\alpha\gamma + \alpha(1-\gamma) + (1-\alpha)\gamma}^{1} \left[\underbrace{V_{Nt}^*(i)}_{\text{for all } i \notin \theta_P} di + \underbrace{V_{Nt}^*(i)}_{\text{for all } i \epsilon \theta_P} \right] di \end{aligned}$$

which can be rewritten as:

$$\begin{aligned} V_t &= \alpha\gamma \left(P_{HTt} \cdot Y_{HTt}^{Avg} + P_{HTt}^{AVG*} \cdot Y_{HTt}^{Avg*} \right) + \alpha(1-\gamma) \left(P_{Nt} \cdot Y_{Nt}^{Avg} \right) \\ &- \left[W_t N_t + P_{t.} r_t^k K_t \right] \end{aligned} \tag{B.30}$$

where

$$N_t = N_{HTt} + N_{Nt} \tag{B.31}$$

$$K_t = K_{HTt} + K_{Nt} \tag{B.32}$$

The rewritten aggregate profits in the Foreign country are:

$$\begin{aligned} V_t^* \quad = \quad & (1-\alpha)\,\gamma\left(P_{FTt}^* Y_{FTt}^{Avg*} + P_{FTt}^{AVG} Y_{FTt}^{Avg}\right) + (1-\alpha)\,(1-\gamma)\left(P_{Nt}^* Y_{Nt}^{Avg*}\right) \\ & -\left(W_t^* N_t^* + P_{t.}^* r_t^{k*} K_t^*\right) \end{aligned} \tag{B.33}$$

B.3 Market clearing conditions

Bonds are assumed to be in zero net supply, hence:

$$B_{Ht} = -B_{Ht}^* \tag{B.34}$$

and

$$B_{Ft} = -B_{Ft}^* \tag{B.35}$$

The aggregate equity supplies are fixed and given by $\bar{Q}$ and $\bar{Q}^*$:

$$\bar{Q} = Q_{Ht} + Q_{Ht}^* \tag{B.36}$$

$$\bar{Q}^* = Q_{Ft}^* + Q_{Ft} \tag{B.37}$$

Goods market clearing conditions imply that the aggregate supplies in the different sectors (taken account of in the derivation of the optimal factor demands above) are equal to the following aggregate demands (in the Home traded goods, the Foreign traded goods, and the two nontraded goods sectors, respectively):

$$Y_{HTt} \equiv \alpha\gamma\left(Y_{HTt}^{Avg} + Y_{HTt}^{Avg*}\right) \tag{B.38}$$

$$Y_{FTt}^* = (1-\alpha)\,\gamma\left(Y_{FTt}^{Avg*} + Y_{FTt}^{Avg}\right) \tag{B.39}$$

$$Y_{Nt} = \alpha(1-\gamma) P_{Nt} Y_{Nt}^{Avg} \tag{B.40}$$

$$Y_{Nt}^* = (1-\alpha)\,(1-\gamma)\,P_{Nt}^* Y_{Nt}^{Avg*} \tag{B.41}$$

B.4 Steady state

The model is defined by equations (B.1) to (B.41) together with, where relevant, the analogous equations for the Foreign country. The model is linearized around a steady state where the net foreign asset position of both countries and inflation are zero. To ensure a stationary steady state all nominal Home and Foreign variables are scaled by the Home and Foreign CPIs, respectively, and the CPIs and the nominal exchange rate are expressed in first differences.

The steady state discount factor for the period t,t+k is $\bar{D}_{t,t+k} = \beta^k \left(\frac{(\bar{C})}{(\bar{C})}\right)^{-\sigma} \frac{\bar{P}}{\bar{P}} = \beta^k$. The steady state interest rates can be derived from the Euler equation on Home bond holdings

$$\bar{\imath} = \frac{1-\beta}{\beta} \tag{B.42}$$

The steady state rental rate of capital can be derived from the investment condition

$$\bar{r}^k = \left(\frac{1-\beta}{\beta}\right) + \delta \tag{B.43}$$

From the optimal goods price equations the following steady state relation can be derived: $\frac{\bar{P}_{HT}^{Opt}}{\bar{P}} = \frac{\bar{P}_{N}^{Opt}}{\bar{P}} = \mu_P \frac{\overline{MC}}{\bar{P}}$. From the aggregate goods price relations one can derive $\frac{\bar{P}_N}{\bar{P}} = \frac{\bar{P}_N^{Opt}}{\bar{P}} = \frac{\bar{P}_{HT}}{\bar{P}} = \frac{\bar{P}_{HT}^{Opt}}{\bar{P}} = \mu_P \frac{\overline{MC}}{\bar{P}}$. Solving for marginal costs yields:

$$\frac{\overline{MC}}{\bar{P}} = \frac{\frac{\bar{P}_{HT}}{\bar{P}}}{\mu_P} \tag{B.44}$$

The steady state Home producers PPI in the Foreign country is $\frac{\bar{P}_{HT}^{Avg*}}{\bar{P}} = \frac{\bar{P}_{HT}^{Opt*}}{\bar{P}} = \mu_P \frac{\overline{MC}}{\bar{P}}$. The Foreign consumers' price index of the Home traded good is $\frac{\bar{P}_{HT}^*}{\bar{P}^*} = \frac{1}{\overline{RER}} \mu_P \frac{\overline{MC}}{\bar{P}}$. The analogous condition in the Home country is therefore:

$$\frac{\bar{P}_{FT}}{\bar{P}} = \overline{RER} \mu_P \frac{\overline{MC}^*}{\bar{P}^*} \tag{B.45}$$

The relative traded goods index can be derived from the definition of the CPI:[32]

$$\frac{\bar{P}_T}{\bar{P}} = \left[\frac{1-(1-\gamma)\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{1-\omega}}{\gamma}\right]^{\frac{1}{1-\omega}} \tag{B.46}$$

The relative traded goods price of the imported good can be derived from the definition of the traded goods price index $\frac{\bar{P}_{FT}}{\bar{P}} = \left[\frac{\left(\frac{\bar{P}_T}{\bar{P}}\right)^{1-\phi} - \alpha\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{1-\phi}}{(1-\alpha)}\right]^{\frac{1}{1-\phi}}$. Solving for the price of

[32] The analogous condition in the Foreign country is $\frac{\bar{P}_T^*}{\bar{P}^*} = \left[\frac{1-(1-\gamma)\left(\frac{\bar{P}_{FT}^*}{\bar{P}^*}\right)^{1-\omega}}{\gamma}\right]^{\frac{1}{1-\omega}}$.

home traded goods yields:

$$\frac{\bar{P}_{HT}}{\bar{P}} = \left[\frac{\left(\frac{\bar{P}_T}{\bar{P}}\right)^{1-\phi} - (1-\alpha)\left(\frac{\bar{P}_{FT}}{\bar{P}}\right)^{1-\phi}}{\alpha} \right]^{\frac{1}{1-\phi}} \tag{B.47}$$

The definition of marginal costs $\frac{\overline{MC}}{\bar{P}} = \frac{\left(\frac{\bar{W}}{\bar{P}}\right)^{\mu}\left(\bar{r}^k\right)^{1-\mu}}{(1-\mu)^{1-\mu}\mu^{\mu}}$ can be solved for real wages as follows:

$$\frac{\bar{W}}{\bar{P}} = \left(\frac{\frac{\overline{MC}}{\bar{P}}(1-\mu)^{1-\mu}\mu^{\mu}}{\left(\bar{r}^k\right)^{1-\mu}} \right)^{\frac{1}{\mu}} \tag{B.48}$$

Optimal wage setting $\frac{\bar{W}}{\bar{P}} = \frac{\bar{W}^{Opt}}{\bar{P}} = \mu_W \frac{\kappa \bar{N}^{\varphi}}{\bar{C}^{-\sigma}}$, where $\bar{N} = \bar{N}_{HT} + \bar{N}_N$, can be solved for labor demand as follows:

$$\bar{N}_N = \left(\frac{\frac{\bar{W}}{\bar{P}}\left(\bar{C}\right)^{-\sigma}}{\kappa \mu_W} \right)^{\frac{1}{\varphi}} - \bar{N}_{HT} \tag{B.49}$$

From the capital accumulation equation one can derive:

$$\bar{I} = \delta \bar{K} \tag{B.50}$$

where $\bar{K} = \bar{K}_{HT} + \bar{K}_N$ and $\bar{Y} = \bar{Y}_{HT} + \bar{Y}_N$.

Factor market clearing conditions in the traded goods sector are:

$$\bar{N}_{HT} = \frac{\mu \overline{\overline{\frac{MC}{P}}}}{\frac{\bar{W}}{\bar{P}}} \alpha\gamma \left(\bar{Y}_{HT}^{Avg} + \bar{Y}_{HT}^{Avg*}\right) \tag{B.51}$$

and

$$\bar{K}_{HT} = \frac{(1-\mu)}{\bar{r}^k}\frac{\overline{MC}}{\bar{P}} \alpha\gamma \left(\bar{Y}_{HT}^{Avg} + \bar{Y}_{HT}^{Avg*}\right) \tag{B.52}$$

Similar conditions in the nontraded goods sector, i.e. $\bar{Y}_N = (1-\gamma)\bar{Y}_N^{Avg}$, yield

$$\bar{K}_N = \frac{(1-\mu)}{\bar{r}^k}\frac{\overline{MC}}{\bar{P}}(1-\gamma)\bar{Y}_N^{Avg} \tag{B.53}$$

and

$$\bar{Y}_N^{Avg} = \frac{\bar{N}_N \frac{\bar{W}}{\bar{P}}}{(1-\gamma)\mu \overline{\overline{\frac{MC}{P}}}} \tag{B.54}$$

where

$$\bar{Y}_{HT}^{Avg} = \left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}\left(\bar{C} + \delta\left(\bar{K}_{HT} + \bar{K}_N\right)\right) \tag{B.55}$$

$$\bar{Y}_{FT}^{Avg} = \left(\frac{\bar{P}_{FT}}{\bar{P}}\right)^{-\phi} \left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega} \left(\bar{C} + \delta\left(\bar{K}_{HT} + \bar{K}_N\right)\right) \tag{B.56}$$

$$\bar{C} = \frac{\bar{Y}_N^{Avg}}{\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{-\omega}} - \delta\left(\bar{K}_{HT} + \bar{K}_N\right) \tag{B.57}$$

The budget constraint:

$$\begin{aligned} & \bar{P}\bar{C} + \bar{P}_Q\bar{Q}_H + \bar{S}\bar{P}_Q^*\bar{Q}_F + \bar{B}_H + \bar{S}\bar{B}_F \\ \approx\ & \bar{W}\bar{N} + \left(\bar{P}_Q + \left(\frac{\bar{V}}{\bar{Q}}\right)\right)\bar{Q}_H + \bar{S}\left(\bar{P}_Q^* + \left(\frac{\bar{V}^*}{\bar{Q}^*}\right)\right)\bar{Q}_F + (1+\bar{\imath})\bar{B}_H + \bar{S}(1+\bar{\imath}^*)\bar{B}_F + \bar{P}\bar{r}^k\bar{K} - \bar{P}\bar{I} \end{aligned}$$

can be solved for the real exchange rate as follows:

$$\overline{RER} = \frac{\frac{1}{\alpha\gamma}\bar{C} - \frac{\bar{P}_{HT}}{\bar{P}}\bar{Y}_{HT}^{Avg} - \frac{1}{\alpha\gamma}\frac{\bar{P}_{HT}}{\bar{P}}(1-\gamma)\bar{Y}_N^{Avg} + \frac{1}{\alpha\gamma}\delta\left(\bar{K}_{HT} + \bar{K}_N\right)}{\frac{\bar{P}_{HT}^*}{\bar{P}^*}\bar{Y}_{HT}^{Avg*}} \tag{B.58}$$

With the interest rate and the rental rate of capital defined exogenously (equations B.42 and B.43), a system of 27 equations (equations B.44 and B.57 together with the analogous equations for the foreign country and equation B.58) in the following 27 unknowns can be derived:

$$\frac{\bar{P}_{HT}}{\bar{P}}, \frac{\bar{P}_{FT}^*}{\bar{P}^*}, \frac{\bar{P}_T}{\bar{P}}, \frac{\bar{P}_T^*}{\bar{P}^*}, \frac{\bar{P}_{FT}}{\bar{P}_T}, \frac{\bar{P}_{HT}^*}{\bar{P}_T^*}, \overline{RER}, \frac{\bar{W}}{\bar{P}}, \frac{\bar{W}^*}{\bar{P}^*}, \frac{\overline{MC}}{\bar{P}}, \frac{\overline{MC}^*}{\bar{P}^*}, \bar{C}, \bar{C}^*,$$

$$\bar{N}_{HT}, \bar{N}_{FT}^*, \bar{N}_N, \bar{N}_N^*, \bar{K}_{HT}, \bar{K}_{FT}^*, \bar{K}_N, \bar{K}_N^*, \bar{Y}_{HT}^{Avg}, \bar{Y}_{FT}^{Avg*}, \bar{Y}_{HT}^{Avg*}, \bar{Y}_{FT}^{Avg}, \bar{Y}_N^{Avg}, \bar{Y}_N^{Avg*}$$

This system is solved numerically. Given the solution of the system, aggregate factors, $\bar{N}$ and $\bar{K}$, aggregate outputs, $\bar{Y}_{HT}, \bar{Y}_{FT}, \bar{Y}_N, \bar{Y}$, and real profits, $\frac{\bar{V}}{\bar{P}}$ can be defined recursively.[33],[34]

Note that the calibration of the asset holdings has to satisfy the net foreign asset condition:

$$\bar{S}\bar{P}_Q^*\bar{Q}_F - \bar{P}_Q\bar{Q}_H^* + \bar{S}\bar{B}_F - \bar{B}_H^* = 0$$

[33] The steady state aggregate profits in real terms are $\frac{\bar{V}}{\bar{P}} = \alpha\gamma\left(\bar{P}_{HT}^{Avg}\bar{Y}_{HT}^{Avg} + P_{HT}^{AVG*}Y_{HT}^{AVG*}\right) + \alpha(1-\gamma)\bar{Y}_N^{Avg} - \left[\frac{\bar{W}}{\bar{P}}\bar{N} + \bar{r}^k\bar{K}\right]$. Steady state Home equity prices in real terms can be derived from the Euler equation on Home equity holdings: $\frac{\bar{P}_Q}{\bar{P}} = \frac{\beta}{(1-\beta)}\left(\frac{\frac{\bar{V}}{\bar{P}}}{\bar{Q}}\right)$. The total stock market capitalization can be written as: $\frac{\bar{P}_Q\bar{Q}}{\bar{P}\bar{Y}} = \frac{\beta}{(1-\beta)}\left(\frac{\frac{\bar{V}}{\bar{P}}}{\bar{Y}}\right)$.

[34] Note that in a symmetric steady state where $\alpha = 0.5$ all prices in the Home and Foreign country are equal and $\bar{S} = 1$ the following variables (or ratios) can derived analytically: $\frac{\overline{MC}}{\bar{P}} = \frac{1}{\mu_P}$ (where $\mu_P = \frac{\theta}{\theta-1}$), $\frac{\bar{K}}{\bar{Y}} = \frac{(1-\mu)}{\left(\frac{1-\beta}{\beta}\right)+\delta}\frac{1}{\mu_P}$, $\frac{\bar{N}}{\bar{Y}} = \left(\frac{(1-\mu)}{\left(\frac{1-\beta}{\beta}\right)+\delta}\frac{1}{\mu_P}\right)^{\frac{\mu-1}{\mu}}$, $\frac{\bar{W}}{\bar{P}} = \frac{\mu\frac{1}{\mu_P}}{\left(\frac{(1-\mu)}{\left(\frac{1-\beta}{\beta}\right)+\delta}\frac{1}{\mu_P}\right)^{\frac{\mu-1}{\mu}}}$, $\frac{\bar{C}}{\bar{Y}} = 1 - \delta\left(\frac{(1-\mu)}{\left(\frac{1-\beta}{\beta}\right)+\delta}\frac{1}{\mu_P}\right)$

which can be reexpressed in real terms as: $\overline{RER}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\frac{\bar{Y}^*}{\bar{Y}} - \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H^*}{\bar{Y}} + \overline{RER}\frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\frac{\bar{Y}^*}{\bar{Y}} - \frac{\bar{B}_H^*}{\bar{P}\bar{Y}} = 0$, as well as the market clearing conditions, i.e. $\frac{\bar{B}_H}{\bar{P}\bar{Y}} = -\frac{\bar{B}_H^*}{\bar{P}\bar{Y}}$ and $\frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H}{\bar{Y}} = \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}}{\bar{Y}} - \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H^*}{\bar{Y}}$, and $\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F^*}{\bar{Y}^*} = \frac{\bar{P}_Q^*\bar{Q}^*}{\bar{P}^*\bar{Y}^*} - \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}$. Thus, if $\frac{\bar{P}_Q\bar{Q}_F}{\bar{P}\bar{Y}}$, $\frac{\bar{P}_Q\bar{Q}_H^*}{\bar{P}\bar{Y}}$ and $\frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}$ are calibrated the following asset holdings are residually determined as

$$\frac{\bar{B}_H^*}{\bar{P}\bar{Y}} = \overline{RER}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\frac{\bar{Y}^*}{\bar{Y}} - \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H^*}{\bar{Y}} + \overline{RER}\frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\frac{\bar{Y}^*}{\bar{Y}}$$

$$\frac{\bar{B}_H}{\bar{P}\bar{Y}} = -\frac{\bar{B}_H^*}{\bar{P}\bar{Y}}$$

$$\frac{\bar{B}_F^*}{\bar{P}^*\bar{Y}^*} = -\frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}$$

$$\frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H}{\bar{Y}} = \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}}{\bar{Y}} - \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H^*}{\bar{Y}}$$

$$\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F^*}{\bar{Y}^*} = \frac{\bar{P}_Q^*\bar{Q}^*}{\bar{P}^*\bar{Y}^*} - \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}$$

B.5 Linearized model

The model is solved by linearizing the stationary versions of equations (B.1) to (B.41) together with, where relevant, the analogous equations for the Foreign country around the symmetric steady state outlined above. The variables of the linearized system are expressed in percentage (or log-) deviations from the steady state.[35]

Stationarizing and linearizing equations (B.1) to (B.41) and the relevant Foreign equations yields a system of 52 equations (equations B.59 to B.110 below) in 52 unknown variables: $\hat{p}_{Qt}$, $\hat{p}^*_{Qt}$,$\hat{q}_{Ft}$, $\hat{q}^*_{Ht}, \hat{c}_t$, $\hat{c}^*_t, \hat{b}_{Ft}$, $\hat{b}^*_{Ht}, \widehat{rer}_t, \hat{w}_t$, $\hat{w}^*_t, \hat{I}_t$, $\hat{I}^*_t, \hat{k}_t,$, $\hat{k}^*_t, \hat{p}_{HTt}$, $\hat{p}^*_{FTt}, \hat{\pi}_t$, $\Pi^*, \hat{p}^*_{HTt}$, $\hat{p}_{FTt}, \hat{p}_{Tt}$, $\hat{p}^*_{Tt}, \widehat{\Delta s}_t, \widehat{mc}_t$, $\widehat{mc}^*_t, \hat{n}_{Nt}$, $\hat{n}^*_{Nt}, \hat{n}_{HTt}$, $\hat{n}^*_{FTt}, \hat{r}^k_t$, $\hat{r}^{k*}_t, \hat{k}_{HTt}$, $\hat{k}^*_{FTt}, \hat{v}_t$, $\hat{v}^*_t, \hat{n}_t$, $\hat{n}^*_t, \hat{k}_{Nt}$, $\hat{k}^*_{Nt}, \hat{y}_t$, $\hat{y}^*_t, \hat{b}_{Ht}$, $\hat{b}^*_{Ft}, \hat{q}_{Ht}$, $\hat{q}^*_{Ft}, \hat{y}_{HTt}$, $\hat{y}^*_{FTt}, \hat{y}_{Nt}$, $\hat{y}^*_{Nt}, \hat{i}_t$, $\hat{i}^*_t$. The following paragraphs list the whole system with all non-linearized and linearized equations.

[35] Thus, for a variable x: $\hat{x} \equiv \frac{X-\bar{X}}{\bar{X}} \equiv \frac{dX}{\bar{X}} \approx \ln X - \ln \bar{X}$. All prices and wages are expressed in relation to the CPI, e.g. $\hat{p}_{Qt} \equiv \frac{\frac{P_{Qt}}{P_t} - \frac{\bar{P}_Q}{\bar{P}}}{\frac{\bar{P}_Q}{\bar{P}}} \equiv \frac{d\frac{P_{Qt}}{P_t}}{\frac{\bar{P}_Q}{\bar{P}}} \approx \ln\left(\frac{P_{Qt}}{P_t}\right) - \ln\left(\frac{\bar{P}_Q}{\bar{P}}\right)$. Asset holdings are expressed in relation to real GDP, e.g. $\hat{Q}_{Ht} \equiv \frac{Q_{Ht}-\bar{Q}_H}{\bar{Y}} \equiv \frac{dQ_{Ht}}{\bar{Y}}$. Inflation is defined as $\Pi_t \equiv \frac{P_t}{P_{t-1}}$and $\hat{\pi}_t \approx \ln\left(\frac{P_t}{P_{t-1}}\right)$.

Aggregate Euler equations

The linearized version of:

$$
\begin{aligned}
&\left(\frac{P_{Qt}}{P_t}+\frac{\gamma_{Q_H}\bar{P}_Q}{\bar{Y}P_t}\left(Q_{Ht+1}-Q_{Ht}\right)\right)\\
&=\beta\left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+1}}\left(\begin{array}{c}\frac{\gamma_{Q_H}\bar{P}_Q}{\bar{Y}P_t}\left(Q_{Ht+2}-Q_{Ht+1}\right)-\frac{\gamma_{Q_H}\bar{P}_Q}{\bar{Y}P_t}\left(Q_{Ht+1}-\bar{Q}_H\right)\\+\left(\frac{P_{Qt+1}}{P_{t+1}}\frac{P_{t+1}}{P_t}+\left(\frac{\frac{V_{t+1}}{P_{t+1}}\frac{P_{t+1}}{P_t}}{\bar{Q}}\right)\right)\end{array}\right)
\end{aligned}
$$

is:

$$
\begin{aligned}
&\gamma_{Q_H}\left(\hat{Q}_{Ht+1}-\hat{Q}_{Ht}\right)\\
&=\sigma\left(\hat{c}_t-E_t\left\{\hat{c}_{t+1}\right\}\right)+\beta\left(\begin{array}{c}\gamma_{Q_H}\left(E_t\left\{\hat{Q}_{Ht+2}\right\}-\hat{Q}_{Ht+1}\right)\\-\psi_{Q_H}\hat{Q}_{Ht+1}+E_t\left\{\hat{p}_{Qt+1}\right\}\end{array}\right)\\
&+(1-\beta)E_t\left\{\hat{v}_{t+1}\right\}-\hat{p}_{Qt}
\end{aligned}
\tag{B.59}
$$

The linearized version of:

$$
\begin{aligned}
&\left(\frac{P^*_{Qt}}{P^*_t}+\frac{\gamma_{Q^F}\bar{S}\bar{P}^*_Q}{\bar{Y}^*P^*_tS_t}\left(Q_{Ft+1}-Q_{Ft}\right)\right)\\
&=\beta\left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+1}}\left(\begin{array}{c}\frac{\gamma_{Q_F}\bar{S}\bar{P}^*_Q}{\bar{Y}^*P^*_tS_t}\left(Q_{Ft+2}-Q_{Ft+1}\right)-\frac{\psi_{Q_H}\bar{S}\bar{P}^*_Q}{\bar{Y}^*P^*_tS_t}\left(Q_{Ft+1}-\bar{Q}_F\right)\\+\left(\frac{S_{t+1}}{S_t}\left(\frac{P^*_{Qt+1}}{P^*_{t+1}}\frac{P^*_{t+1}}{P^*_t}+\left(\frac{\frac{V^*_{t+1}}{P^*_{t+1}}\frac{P^*_{t+1}}{P^*_t}}{\bar{Q}^*}\right)\right)\right)\end{array}\right)
\end{aligned}
$$

is:

$$
\begin{aligned}
&\gamma_{Q^F}\left(\hat{Q}_{Ft+1}-\hat{Q}_{Ft}\right)\\
&=\sigma\left(\hat{c}_t-E_t\left\{\hat{c}_{t+1}\right\}\right)-E_t\left\{\hat{\pi}_{t+1}\right\}\\
&+\beta\left(\gamma_{Q_F}\left(E_t\left\{\hat{Q}_{Ft+2}\right\}-\hat{Q}_{Ft+1}\right)-\psi_{Q_H}\left(\hat{Q}_{Ft+1}\right)+E_t\left\{\hat{p}^*_{Qt+1}\right\}\right)\\
&+E_t\left\{\hat{\pi}^*_{t+1}\right\}+E_t\left\{\widehat{\Delta s}_{t+1}\right\}+(1-\beta)E_t\left\{\hat{v}^*_{t+1}\right\}-\hat{p}^*_{Qt}
\end{aligned}
\tag{B.60}
$$

The linearized version of:

$$
\begin{aligned}
& \left(1+\frac{\gamma_{B_H}\bar{P}}{\bar{Y}}\left(\frac{B_{Ht+1}}{P_t}-\frac{B_{Ht}}{P_t}\right)\frac{1}{P_t}\right) \\
= \quad & E_t\left\{\beta\left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+1}}\left(\begin{array}{c}\frac{\gamma_{B_H}\bar{P}}{\bar{Y}}\left(\frac{B_{Ht+2}}{P_{t+1}}-\frac{B_{Ht+1}}{P_{t+1}}\right)\left(\frac{1}{P_{t+1}}\right)-\frac{\psi_{B_H}\bar{P}}{\bar{Y}}\left(\frac{B_{Ht+1}}{P_{t+1}}-\frac{\bar{B}_H}{\bar{P}}\right)\frac{1}{P_{t+1}} \\ +(1+i_{t+1})\end{array}\right)\right\}
\end{aligned}
$$

is:

$$
\begin{gathered}
\gamma_{B_H}\left(E_t\left\{\hat{b}_{Ht+1}\right\}-\hat{b}_{Ht}\right) \\
=\sigma\left(\hat{c}_t-E_t\left\{\hat{c}_{t+1}\right\}\right)-E_t\left\{\hat{\pi}_{t+1}\right\}+\beta\left(\begin{array}{c}\gamma_{B_H}E_t\left\{\hat{b}_{Ht+2}-\hat{b}_{Ht+1}\right\} \\ -\psi_{B_H}E_t\left\{\hat{b}_{Ht+1}\right\}\end{array}\right) \\
+E_t\left\{\hat{\imath}_{t+1}\right\}
\end{gathered} \tag{B.61}
$$

The linearized version of:

$$
\begin{gathered}
\left(1+\frac{\gamma_{B_F}\bar{P}^*\bar{S}}{\bar{Y}^*S_t}\left(\frac{B_{Ft+1}}{P_t^*}-\frac{B_{Ft}}{P_t}\right)\frac{1}{P_t^*}\right) \\
=E_t\left\{\beta\left(\frac{(C_{t+1})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+1}}\left(\begin{array}{c}\frac{\gamma_{B_F}\bar{P}^*\bar{S}}{\bar{Y}^*S_t}\left(\frac{B_{Ft+2}}{P_{t+1}^*}-\frac{B_{Ft+1}}{P_{t+1}^*}\right)\left(\frac{1}{P_{t+1}^*}\right) \\ -\frac{\gamma_{B_F}\bar{P}^*\bar{S}}{\bar{Y}^*S_t}\left(\frac{B_{Ft+1}}{P_{t+1}^*}-\frac{\bar{B}_F}{\bar{P}^*}\right)\frac{1}{P_{t+1}^*} \\ +\frac{S_{t+1}}{S_t}(1+i_t^*)\end{array}\right)\right\}
\end{gathered}
$$

is:

$$
\begin{gathered}
\gamma_{B_F}\left(E_t\left\{\hat{b}_{Ft+1}\right\}-\hat{b}_{Ft}\right) \\
=\sigma\left(\hat{c}_t-E_t\left\{\hat{c}_{t+1}\right\}\right)-E_t\left\{\hat{\pi}_{t+1}\right\}+\beta\left(\begin{array}{c}\gamma_{B_F}E_t\left\{\hat{b}_{Ft+2}-\hat{b}_{Ft+1}\right\} \\ -\psi_{B_F}E_t\left\{\hat{b}_{Ft+1}\right\}\end{array}\right) \\
+E_t\left\{\widehat{\Delta s}_{t+1}\right\}+E_t\left\{\hat{\imath}_{t+1}^*\right\}
\end{gathered} \tag{B.62}
$$

The analogous Foreign Euler equations in linearized terms are:

$$
\begin{gathered}
\gamma_{Q_H}^*\left(\hat{Q}_{Ht+1}^*-\hat{Q}_{Ht}^*\right) \\
=\sigma\left(\hat{c}_t^*-E_t\left\{\hat{c}_{t+1}^*\right\}\right)-E_t\left\{\hat{\pi}_{t+1}^*\right\} \\
+\beta\left(\gamma_{Q_H}^*\left(E_t\left\{\hat{Q}_{Ht+2}^*\right\}-\hat{Q}_{Ht+1}^*\right)-\psi_{Q_H^*}\left(\hat{Q}_{Ht+1}^*\right)+E_t\left\{\hat{p}_{Qt+1}\right\}\right) \\
+E_t\left\{\hat{\pi}_{t+1}\right\}-E_t\left\{\widehat{\Delta s}_{t+1}\right\}+(1-\beta)E_t\left\{\hat{v}_{t+1}\right\}-\hat{p}_{Qt}
\end{gathered} \tag{B.63}
$$

$$
\begin{aligned}
&\gamma^*_{Q_F}\left(\hat{Q}^*_{Ft+1}-\hat{Q}^*_{Ft}\right) \\
&= \sigma\left(\hat{c}^*_t - E_t\left\{\hat{c}^*_{t+1}\right\}\right) + \beta\left(\begin{array}{c} \gamma^*_{Q_F}\left(E_t\left\{\hat{Q}^*_{Ft+2}\right\}-\hat{Q}^*_{Ft+1}\right) \\ -\psi^*_{Q_F}\hat{Q}^*_{Ft+1}+E_t\left\{\hat{p}^*_{Qt+1}\right\} \end{array}\right) \\
&+ (1-\beta)\,E_t\left\{\hat{v}^*_{t+1}\right\} - \hat{p}^*_{Qt}
\end{aligned} \tag{B.64}
$$

$$
\begin{aligned}
&\gamma_{B^*_H}\left(E_t\left\{\hat{b}^*_{Ht+1}\right\}-\hat{b}^*_{Ht}\right) \\
&= \sigma\left(\hat{c}^*_t - E_t\left\{\hat{c}^*_{t+1}\right\}\right) - E_t\left\{\hat{\pi}^*_{t+1}\right\} + \beta\left(\begin{array}{c} \gamma_{B^*_H} E_t\left\{\hat{b}^*_{Ht+2}-\hat{b}^*_{Ht+1}\right\} \\ -\psi_{B^*_H} E_t\left\{\hat{b}^*_{Ht+1}\right\} \end{array}\right) \\
&- E_t\left\{\widehat{\Delta s}_{t+1}\right\} + E_t\left\{\hat{\imath}_{t+1}\right\}
\end{aligned} \tag{B.65}
$$

$$
\begin{aligned}
&\gamma^*_{B_F}\left(E_t\left\{\hat{b}^*_{Ft+1}\right\}-\hat{b}^*_{Ft}\right) \\
&= \sigma\left(\hat{c}^*_t - E_t\left\{\hat{c}^*_{t+1}\right\}\right) - E_t\left\{\hat{\pi}^*_{t+1}\right\} + \beta\left(\begin{array}{c} \gamma^*_{B_F} E_t\left\{\hat{b}^*_{Ft+2}-\hat{b}^*_{Ft+1}\right\} \\ -\psi^*_{B_F} E_t\left\{\hat{b}^*_{Ft+1}\right\} \end{array}\right) \\
&+ E_t\left\{\hat{\imath}^*_{t+1}\right\}
\end{aligned} \tag{B.66}
$$

Aggregate Home consumer's budget constraint

The linearized version of:

$$
\begin{aligned}
& C_t \\
& +\frac{P_{Qt}}{P_t} Q_{Ht+1} + \frac{\gamma_{Q_H}}{2} \frac{\bar{P}_Q \left(Q_{Ht+1} - Q_{Ht}\right)^2}{P_t \bar{Y}} + \frac{\psi_{Q_H}}{2} \frac{\bar{P}_Q \left(Q_{Ht} - \bar{Q}_H\right)^2}{P_t \bar{Y}} \\
& +\frac{S_t P_t^*}{P_t} \frac{P_{Qt}^*}{P_t^*} Q_{Ft+1} + \frac{\gamma_{Q_F}}{2} \frac{\bar{S}\bar{P}_Q^* \left(Q_{Ft+1} - Q_{Ft}\right)^2}{P_t \bar{Y}} + \frac{\psi_{Q_F}}{2} \frac{\bar{S}\bar{P}_Q^* \left(Q_{Ft} - \bar{Q}_F\right)^2}{P_t \bar{Y}} \\
& +\frac{B_{Ht+1}}{P_t} + \frac{\gamma_{B_H}}{2} \frac{\bar{P} \left(\frac{B_{Ht+1}}{P_t} - \frac{B_{Ht}}{P_t}\right)^2}{P_t \bar{Y}} + \frac{\psi_{B_H}}{2} \frac{\bar{P} \left(\frac{B_{Ht}}{P_t} - \frac{\bar{B}_H}{\bar{P}}\right)^2}{P_t \bar{Y}} \\
& +\frac{S_t P_t^*}{P_t} \frac{B_{Ft+1}}{P_t^*} + \frac{\gamma_{B_F}}{2} \frac{\bar{S}\bar{P}^* \left(\frac{B_{Ft+1}}{P_t^*} - \frac{B_{Ft}}{P_t^*}\right)^2}{P_t \bar{Y}} + \frac{\psi_{B_F}}{2} \frac{\bar{S}\bar{P}^* \left(\frac{B_{Ft}}{P_t^*} - \frac{\bar{B}_F}{\bar{P}^*}\right)^2}{P_t \bar{Y}} \\
= \; & \frac{W_t}{P_t} N_t + \left(\frac{P_{Qt}}{P_t} + \left(\frac{\frac{V_t}{P_t}}{\bar{Q}}\right)\right) Q_{Ht} + \frac{S_t P_t^*}{P_t} \left(\frac{P_{Qt}^*}{P_t^*} + \left(\frac{\frac{V_t^*}{P_t^*}}{\bar{Q}^*}\right)\right) Q_{Ft} \\
& +(1+i_t)\frac{B_{Ht}}{P_t} + \frac{S_t P_t^*}{P_t}(1+i_t^*)\frac{B_{Ft}}{P_t^*} + \left[r_t^k K_{t.} - I_{t.}\right] + T_{\gamma t}
\end{aligned}
$$

is:

$$
\begin{aligned}
& \bar{C}\hat{c}_t \\
& +\frac{\bar{P}_Q}{\bar{P}} \frac{\bar{Q}_H}{\bar{Y}} \bar{Y} \hat{p}_{Qt} + \frac{\bar{P}_Q}{\bar{P}} \bar{Y} \hat{q}_{Ht+1} \\
& +\frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \frac{\bar{Q}_F}{\bar{Y}^*} \bar{Y}^* \widehat{rer}_t + \frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \frac{\bar{Q}_F}{\bar{Y}^*} \bar{Y}^* \hat{p}_{Qt}^* + \frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \bar{Y}^* \hat{Q}_{Ft+1} \\
& +\bar{Y}\hat{b}_{Ht+1} + \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*} \bar{Y}^* \frac{\overline{SP^*}}{P} \widehat{rer}_t + \frac{\overline{SP^*}}{P} \bar{Y}^* \hat{b}_{Ft+1} \\
= \; & \frac{\bar{W}}{\bar{P}} \bar{N}\hat{w}_t + \frac{\bar{W}}{\bar{P}} \bar{N}\hat{n}_t + \frac{\bar{P}_Q}{\bar{P}} \frac{\bar{Q}_H}{\bar{Y}} \bar{Y} \hat{p}_{Qt} + \left(\frac{(1-\beta)}{\beta}\right) \frac{\bar{P}_Q}{\bar{P}} \frac{\bar{Q}_H}{\bar{Y}} \bar{Y} \hat{v}_t + \frac{1}{\beta} \frac{\bar{P}_Q}{\bar{P}} \bar{Y} \hat{Q}_{Ht} \\
& +\frac{1}{\beta} \frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \frac{\bar{Q}_F}{\bar{Y}^*} \bar{Y}^* \widehat{rer}_t + \frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \frac{\bar{Q}_F}{\bar{Y}^*} \bar{Y}^* \hat{p}_{Qt}^* \\
& +\left(\frac{(1-\beta)}{\beta}\right) \frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \frac{\bar{Q}_F}{\bar{Y}^*} \bar{Y}^* \hat{v}_t^* + \frac{1}{\beta} \frac{\overline{SP^*}}{P} \frac{\bar{P}_Q^*}{\bar{P}^*} \bar{Y}^* \hat{Q}_{Ft} \\
& +\frac{1}{\beta} \frac{\bar{B}_H}{\bar{P}\bar{Y}} \bar{Y}\hat{\imath}_t + \frac{1}{\beta} \bar{Y}\hat{b}_{Ht} + \frac{1}{\beta} \frac{\overline{SP^*}}{P} \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*} \bar{Y}^* \widehat{rer}_t + \frac{1}{\beta} \frac{\overline{SP^*}}{P} \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*} \bar{Y}^* \hat{\imath}_t^* + \frac{1}{\beta} \frac{\overline{SP^*}}{P} \bar{Y}^* \hat{b}_{Ft} \\
& +\bar{r}^k \bar{K} \hat{r}_t^k + \bar{r}^k \bar{K} \hat{k}_t - \bar{I}\hat{I}_{t.}
\end{aligned}
\tag{B.67}
$$

Wage dynamics

Equations:

$$E_t \sum_{k=0}^{\infty} (\beta\theta_W)^k \left[N_{t+k|t}(j) \left(C_{t+k|t}(j)\right)^{-\sigma} \left[\frac{W_t^{Opt}}{P_{t+k}} - \mu_W \frac{\kappa \left(N_{t+k|t}(j)\right)^{\varphi}}{\left(C_{t+k|t}(j)\right)^{-\sigma}} \right] \right] = 0$$

and:

$$\left(\frac{W_t}{P_t}\right)^{1-\eta} = \left(\theta_W \left(\frac{W_{t-1}}{P_{t-1}} \frac{1}{\frac{P_t}{P_{t-1}}} \right)^{1-\eta} + (1-\theta_W) \left(\frac{W_t^{Opt}}{P_t} \right)^{1-\eta} \right)$$

can be linearized and combined to:

$$\begin{aligned} \hat{w}_t \approx\ & \left(\frac{\theta_W}{1+\beta(\theta_W)^2} \right) \hat{w}_{t-1} - \left(\frac{\theta_W}{1+\beta(\theta_W)^2} \right) \hat{\pi}_t \\ & + \left(\frac{\beta\theta_W}{1+\beta(\theta_W)^2} \right) E_t \{ \hat{w}_{t+1} + \hat{\pi}_{t+1} \} + \frac{(1-\theta_W)(1-\beta\theta_W)}{1+\beta(\theta_W)^2} \{ \varphi \hat{n}_t + \sigma \hat{c}_t \} \end{aligned} \tag{B.68}$$

$$\begin{aligned} \hat{w}_t^* \approx\ & \left(\frac{\theta_W}{1+\beta(\theta_W)^2} \right) \hat{w}_{t-1}^* - \left(\frac{\theta_W}{1+\beta(\theta_W)^2} \right) \hat{\pi}_t^* \\ & + \left(\frac{\beta\theta_W}{1+\beta(\theta_W)^2} \right) E_t \left\{ \hat{w}_{t+1}^* + \hat{\pi}_{t+1}^* \right\} + \frac{(1-\theta_W)(1-\beta\theta_W)}{1+\beta(\theta_W)^2} \{ \varphi \hat{n}_t^* + \sigma \hat{c}_t^* \} \end{aligned} \tag{B.69}$$

Capital accumulation

The linearized version of:

$$K_{t+1} = (1-\delta)K_t + I_t - \frac{\xi}{2} \frac{(K_{t+1} - K_t)^2}{K_t}$$

is:

$$\hat{k}_{t+1} \approx (1-\delta)\,\hat{k}_t + \delta \hat{I}_t \tag{B.70}$$

and, analogously:

$$\hat{k}_{t+1}^* \approx (1-\delta)\,\hat{k}_t^* + \delta \hat{I}_t^* \tag{B.71}$$

Optimal investment

The linearized version of:

$$\begin{aligned} & \left(1 + \xi \frac{(K_{t+1} - K_t)}{K_t} \right) \\ = \beta E_t & \left\{ \left(\frac{(C_{t+1})}{(C_t)} \right)^{-\sigma} \left[(1-\delta) + r_{t+1}^k + \frac{\xi}{2} \left(\frac{K_{t+2}^2 - K_{t+1}^2}{K_{t+1}^2} \right) \right] \right\} \end{aligned}$$

is:

$$\xi\left(\hat{k}_{t+1}-\hat{k}_t\right)\approx E_t\left\{\sigma\left(\hat{c}_t-\hat{c}_{t+1}\right)+\beta\bar{r}^k\hat{r}^k_{t+1}+\beta\xi\left(\hat{k}_{t+2}-\hat{k}_{t+1}\right)\right\} \tag{B.72}$$

and, analogously:

$$\xi\left(\hat{k}^*_{t+1}-\hat{k}^*_t\right)\approx E_t\left\{\sigma\left(\hat{c}^*_t-\hat{c}^*_{t+1}\right)+\beta\bar{r}^k\hat{r}^{k*}_{t+1}+\beta\xi\left(\hat{k}^*_{t+2}-\hat{k}^*_{t+1}\right)\right\} \tag{B.73}$$

Price dynamics

Combining the linearized version of:

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{\beta^k\left(\frac{(C_{t+k})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+k}}Y_{HTt+k|t}\left(\frac{P^{Opt}_{HTt}}{P_t}-\mu_P\frac{MC_{t+k}}{P_{t+k}}\frac{P_{t+k}}{P_t}\right)\right\}=0$$

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{\begin{array}{c}\beta^k\left(\frac{(C_{t+k})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+k}}Y^*_{HTt+k|t}\\ \left(\left(\frac{S_{t-1}}{S_t}\right)^{1-\tau}\left(\frac{S_t^{1-\tau}P^{Opt*}_{HTt}}{P_t}\right)-\mu_P\left(\frac{S_{t+k}}{S_{t-1}}\right)^{\tau-1}\frac{MC_{t+k}}{P_{t+k}}\frac{P_{t+k}}{P_t})\right)\end{array}\right\}=0$$

$$\sum_{k=0}^{\infty}\theta_P^k E_t\left\{\beta^k\left(\frac{(C_{t+k})}{(C_t)}\right)^{-\sigma}\frac{P_t}{P_{t+k}}Y_{Nt+k|t}\left(\frac{P^{Opt}_{Nt}}{P_t}-\mu_P\frac{MC_{t+k}}{P_{t+k}}\frac{P_{t+k}}{P_t})\right)\right\}=0$$

$$\left(\frac{P_{HTt}}{P_t}\right)^{1-\theta}=\left(\theta_P\left(\frac{P_{HTt-1}}{P_{t-1}}\frac{1}{\frac{P_t}{P_{t-1}}}\right)^{1-\theta}+(1-\theta_P)\left(\frac{P^{Opt}_{HTt}}{P_t}\right)^{1-\theta}\right)$$

$$\left(\frac{P^{AVG*}_{HTt}}{P_t}\right)^{1-\theta}=\left(\theta_P\left(\frac{P^{AVG*}_{HTt}}{P_{t-1}}\frac{1}{\frac{P_t}{P_{t-1}}}\right)^{1-\theta}+(1-\theta_P)\left(\frac{S_t^{1-\tau}P^{Opt*}_{HTt}}{P_t}\right)^{1-\theta}\right)$$

$$\frac{P^*_{HTt}}{P^*_t}=\left(\frac{1}{\frac{S_tP^*_t}{P_t}}\right)\frac{P^{AVG*}_{HTt}}{P_t}$$

$$\left(\frac{P_{Nt}}{P_t}\right)^{1-\theta}=\left(\theta_P\left(\frac{P_{Nt-1}}{P_{t-1}}\frac{1}{\frac{P_t}{P_{t-1}}}\right)^{1-\theta}+(1-\theta_P)\left(\frac{P^{Opt}_{Nt}}{P_t}\right)^{1-\theta}\right)$$

$$\left(\frac{P_{Tt}}{P_t}\right)^{1-\phi}=\left[\alpha\left(\frac{P_{HTt}}{P_t}\right)^{1-\phi}+(1-\alpha)\left(\frac{P_{FTt}}{P_t}\right)^{1-\phi}\right]$$

$$1=\left[\gamma\left(\frac{P_{Tt}}{P_t}\right)^{1-\omega}+(1-\gamma)\left(\frac{P_{Nt}}{P_t}\right)^{1-\omega}\right]$$

and the analogous Foreign equations yields a system of the following eight price equations:[36]

[36] Note that the domestic traded goods price and the nontraded goods price are equivalent. Thus, the nontraded goods price will bedropped in the final system

Domestic traded goods price index

$$\begin{aligned}\hat{p}_{HTt} \quad &\approx \quad \left(\frac{\theta_P}{1+\beta\left(\theta_P\right)^2}\right)\hat{p}_{HTt-1}-\left(\frac{\theta_P}{1+\beta\left(\theta_P\right)^2}\right)\hat{\pi}_t \\ &+\beta\left(\frac{\theta_P}{1+\beta\left(\theta_P\right)^2}\right)E_t\left\{\hat{p}_{HTt+1}+\hat{\pi}_{t+1}\right\}+\frac{\left(1-\theta_P\right)\left(1-\theta_P\beta\right)}{\left(1+\beta\left(\theta_P\right)^2\right)}\widehat{mc}_t\end{aligned} \tag{B.74}$$

$$\begin{aligned}\hat{p}^*_{FTt} \quad &\approx \quad \left(\frac{\theta_P}{1+\beta\left(\theta_P\right)^2}\right)\hat{p}^*_{FTt-1}-\left(\frac{\theta_P}{1+\beta\left(\theta_P\right)^2}\right)\hat{\pi}^*_t \\ &+\beta\left(\frac{\theta_P}{1+\beta\left(\theta_P\right)^2}\right)E_t\left\{\hat{p}^*_{FTt+1}+\hat{\pi}^*_{t+1}\right\}+\frac{\left(1-\theta_P\right)\left(1-\theta_P\beta\right)}{\left(1+\beta\left(\theta_P\right)^2\right)}\widehat{mc}^*_t\end{aligned} \tag{B.75}$$

Domestic traded goods price index in the other country

The domestic traded goods price index in the other country can be solved for inflation:

$$\begin{aligned}&\hat{\pi}_t \approx \widehat{p^*_{HTt-1}}+\widehat{rer}_{t-1}-\left(\frac{1+\beta\left(\theta_P\right)^2}{\theta_P}\right)\left(\widehat{p^*_{HTt}}+\widehat{rer}_t\right) \\ &+\beta E_t\left\{\widehat{p^*_{HTt+1}}+\widehat{rer}_{t+1}-\left(1-\theta_P\right)\left(1-\tau\right)\widehat{\Delta s}_{t+1}+\hat{\pi}_{t+1}\right\} \\ &+\frac{\left(1-\theta_P\right)\left(1-\theta_P\beta\right)}{\theta_P}\widehat{mc}_t\end{aligned} \tag{B.76}$$

$$\begin{aligned}&\hat{\pi}^*_t \approx \widehat{p_{FTt-1}}-\widehat{rer}_{t-1}-\left(\frac{1+\beta\left(\theta_P\right)^2}{\theta_P}\right)\left(\widehat{p_{FTt}}-\widehat{rer}_t\right) \\ &+\beta E_t\left\{\widehat{p_{FTt+1}}-\widehat{rer}_{t+1}+\left(1-\theta_P\right)\left(1-\tau\right)\widehat{\Delta s}_{t+1}+\hat{\pi}^*_{t+1}\right\} \\ &+\frac{\left(1-\theta_P\right)\left(1-\theta_P\beta\right)}{\theta_P}\widehat{mc}^*_t\end{aligned} \tag{B.77}$$

Traded goods price index

The traded goods price index can be solved for the other country's traded goods price index:

$$\hat{p}_{FTt} \approx \frac{1}{\left(1-\alpha\right)\left(\frac{\bar{P}_{FT}}{\bar{P}}\frac{1}{\left(\frac{\bar{P}_T}{\bar{P}}\right)}\right)^{1-\phi}}\hat{p}_{Tt}-\frac{\alpha\left(\frac{\bar{P}_{HT}}{\bar{P}}\frac{1}{\left(\frac{\bar{P}_T}{\bar{P}}\right)}\right)^{1-\phi}}{\left(1-\alpha\right)\left(\frac{\bar{P}_{FT}}{\bar{P}}\frac{1}{\left(\frac{\bar{P}_T}{\bar{P}}\right)}\right)^{1-\phi}}\hat{p}_{HTt} \tag{B.78}$$

$$\hat{p}^*_{HTt} \approx \frac{1}{\alpha\left(\frac{\bar{P}^*_{HT}}{\bar{P}^*}\frac{1}{\left(\frac{\bar{P}^*_T}{\bar{P}^*}\right)}\right)^{1-\phi}}\hat{p}^*_{Tt} - \frac{(1-\alpha)\left(\frac{\bar{P}^*_{FT}}{\bar{P}^*}\frac{1}{\left(\frac{\bar{P}^*_T}{\bar{P}^*}\right)}\right)^{1-\phi}}{\alpha\left(\frac{\bar{P}^*_{HT}}{\bar{P}^*}\frac{1}{\left(\frac{\bar{P}^*_T}{\bar{P}^*}\right)}\right)^{1-\phi}}\hat{p}^*_{FTt} \tag{B.79}$$

Consumer price index

The consumer price index can be solved for the traded goods price index:

$$\hat{p}_{Tt} \approx \frac{(\gamma-1)}{\gamma}\left(\frac{\frac{\bar{P}_{HT}}{\bar{P}}}{\frac{\bar{P}_T}{\bar{P}}}\right)^{1-\omega}\hat{p}_{HTt} \tag{B.80}$$

$$\hat{p}^*_{Tt} \approx \frac{(\gamma-1)}{\gamma}\left(\frac{\frac{\bar{P}^*_{FT}}{\bar{P}^*}}{\frac{\bar{P}^*_T}{\bar{P}^*}}\right)^{1-\omega}\hat{p}^*_{FTt} \tag{B.81}$$

Change in nominal exchange rate

The linearized version of a rewritten definition of the change in the nominal exchange rate:

$$\frac{S_t}{S_{t-1}} = \left(\frac{S_t P^*_t}{P_t}\right)\left(\frac{P_{t-1}}{S_{t-1}P^*_{t-1}}\right)\left(\frac{P_t}{P_{t-1}}\right)\left(\frac{P^*_{t-1}}{P^*_t}\right)$$

yields:

$$\widehat{\Delta s}_t \approx \widehat{rer}_t - \widehat{rer}_{t-1} + \hat{\pi}_t - \hat{\pi}^*_t \tag{B.82}$$

Marginal costs

The linearized version of:

$$\frac{MC_t}{P_t} = \frac{\left(\frac{W_t}{P_t}\right)^{\mu}\left(r^k_t\right)^{1-\mu}}{(1-\mu)^{1-\mu}\mu^{\mu}A_t}$$

is:

$$\widehat{mc}_t = \mu\hat{w}_t + (1-\mu)\,\hat{r}^k_t - \hat{a}_t \tag{B.83}$$

and, analogously:

$$\widehat{mc}^*_t = \mu\hat{w}^*_t + (1-\mu)\,\hat{r}^{k*}_t - \hat{a}^*_t \tag{B.84}$$

Labor market clearing

The linearized version of:

$$N_{HTt} = \frac{\mu \frac{MC_t}{P_t}}{\frac{W_t}{P_t}} Y_{HTt}$$

$$N_{Nt} = \frac{\mu \frac{MC_t}{P_t}}{\frac{W_t}{P_t}} Y_{Nt}$$

is:

$$\hat{n}_{Nt} \approx (\widehat{mc}_t + \hat{y}_{Nt} - \hat{w}_t) \tag{B.85}$$

and, analogously:

$$\hat{n}^*_{Nt} \approx (\widehat{mc}^*_t + \hat{y}^*_{Nt} - \hat{w}^*_t) \tag{B.86}$$

as well as:

$$\hat{n}_{HTt} \approx (\widehat{mc}_t + \hat{y}_{HTt} - \hat{w}_t) \tag{B.87}$$

and

$$\hat{n}^*_{FTt} \approx (\widehat{mc}^*_t + \hat{y}^*_{FTt} - \hat{w}^*_t) \tag{B.88}$$

Capital market clearing

The linearized version of:

$$K_{HTt} = \frac{(1-\mu)}{r^k_t} \frac{MC_t}{P_t} Y_{HTt}$$

$$K_{Nt} = \frac{(1-\mu)}{r^k_t} \frac{MC_t}{P_t} Y_{Nt}$$

is:

$$\hat{k}_{Nt} \approx \left(\widehat{mc}_t + \hat{y}_{Nt} - \hat{r}^k_t\right) \tag{B.89}$$

and, analogously:

$$\hat{k}^*_{Nt} \approx \left(\widehat{mc}^*_t + \hat{y}^*_{Nt} - \hat{r}^{k*}_t\right) \tag{B.90}$$

as well as:

$$\hat{k}_{HTt} \approx \left(\widehat{mc}_t + \hat{y}_{HTt} - \hat{r}^k_t\right) \tag{B.91}$$

and:

$$\hat{k}^*_{FTt} \approx \left(\widehat{mc}^*_t + \hat{y}^*_{FTt} - \hat{r}^{k*}_t\right) \tag{B.92}$$

Aggregate labor

The linearized version of:

$$N_t = N_{HTt} + N_{Nt}$$

is:

$$\hat{n}_t \approx \frac{\bar{N}_{HT}}{\bar{N}}\hat{n}_{HTt} + \frac{\bar{N}_N}{\bar{N}}\hat{n}_{Nt} \tag{B.93}$$

and, analogously:

$$\hat{n}_t^* \approx \frac{\bar{N}_{HT}^*}{\bar{N}^*}\hat{n}_{FTt}^* + \frac{\bar{N}_N^*}{\bar{N}^*}\hat{n}_{Nt}^* \tag{B.94}$$

Aggregate capital

The linearized version of:

$$K_t = K_{HTt} + K_{Nt}$$

is:

$$\hat{k}_t \approx \frac{\bar{K}_{HT}}{\bar{K}}\hat{k}_{HTt} + \frac{\bar{K}_N}{\bar{K}}\hat{k}_{Nt} \tag{B.95}$$

and, analogously:

$$\hat{k}_t^* \approx \frac{\bar{K}_{FT}^*}{\bar{K}^*}\hat{k}_{FTt}^* + \frac{\bar{K}_N^*}{\bar{K}^*}\hat{k}_{Nt}^* \tag{B.96}$$

Aggregate output

The linearized version of:

$$\begin{aligned} Y_t &= \alpha\gamma \begin{pmatrix} \left(\frac{P_{HTt}}{P_t}\right)^{1-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{\phi-\omega}(C_t+I_t) \\ +\left(\frac{S_tP_t^*}{P_t}\right)\left(\frac{P_{HTt}^*}{P_t^*}\right)^{1-\phi}\left(\frac{P_{Tt}^*}{P_t^*}\right)^{\phi-\omega}(C_t^*+I_t^*) \end{pmatrix} \\ &\quad +(1-\gamma)\left(\left(\frac{P_{Nt}}{P_t}\right)^{1-\omega}(C_t+I_t)\right) \end{aligned}$$

is:

$$\begin{aligned} \hat{y}_t &\approx \left(\alpha\gamma\left(\begin{array}{c} \frac{\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{1-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\bar{Y}} \\ \begin{pmatrix} (1-\phi)\hat{p}_{HTt}+(\phi-\omega)\,\hat{p}_{Tt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t+\frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \end{pmatrix} \\ +\frac{\left(\frac{\overline{SP^*}}{\bar{P}}\right)\left(\frac{\bar{P}_{HT}^*}{\bar{P}^*}\right)^{1-\phi}\left(\frac{\bar{P}_T^*}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\bar{Y}} \\ \begin{pmatrix} \widehat{rer}_t+(1-\phi)\hat{p}_{HTt}^*+(\phi-\omega)\,\hat{p}_{Tt}^* \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^*+\frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^* \end{pmatrix} \end{array}\right)\right) \\ &\quad +\left(\left((1-\gamma)\frac{\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{1-\omega}(\bar{C}+\bar{I})}{\bar{Y}}\right)\left((1-\omega)\,\hat{p}_{HTt}+\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t+\frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t\right)\right) \end{aligned} \tag{B.97}$$

and, analogously:

$$\hat{y}_t^* \approx \left((1-\alpha)\gamma \left(\begin{array}{c} \frac{\left(\frac{\bar{P}_{FT}^*}{\bar{P}^*}\right)^{1-\phi}\left(\frac{\bar{P}_T^*}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\bar{Y}^*} \\ \left(\begin{array}{c} (1-\phi)\,\hat{p}_{FTt}^* + (\phi-\omega)\,\hat{p}_{Tt}^* \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^* \end{array} \right) \\ +\frac{\left(\frac{\bar{SP}^*}{\bar{P}}\right)^{-1}\left(\frac{\bar{P}_{FT}}{\bar{P}}\right)^{1-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\bar{Y}^*} \\ \left(\begin{array}{c} -\widehat{rer}_t + (1-\phi)\,\hat{p}_{FTt} + (\phi-\omega)\,\hat{p}_{Tt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \end{array} \right) \end{array} \right) \right) \tag{B.98}$$

$$+ \left(\left((1-\gamma)\frac{\left(\frac{\bar{P}_{FT}^*}{\bar{P}^*}\right)^{1-\omega}(\bar{C}^*+\bar{I}^*)}{\bar{Y}^*} \right) \left((1-\omega)\,\hat{p}_{FTt}^* + \frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^* \right) \right)$$

Aggregate profits

The linearized version of:

$$\frac{V_t}{P_t} = \alpha\gamma \left(\begin{array}{c} \left(\frac{P_{HTt}}{P_t}\right)^{1-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{\phi-\omega}(C_t+I_t) \\ +\frac{S_t P_t^*}{P_t}\left(\frac{P_{HTt}^*}{P_t^*}\right)^{1-\phi}\left(\frac{P_{Tt}^*}{P_t^*}\right)^{\phi-\omega}(C_t^*+I_t^*) \end{array} \right)$$
$$+(1-\gamma)\left(\left(\frac{P_{Nt}}{P_t}\right)^{1-\omega}(C_t+I_t) \right) - \left[\frac{W_t}{P_t}N_t + r_t^k K_t \right]$$

is:

$$\hat{v}_t = \alpha\gamma \left(\begin{array}{c} \frac{\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{1-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\frac{\bar{V}}{\bar{P}}} \left(\begin{array}{c} (1-\phi)\,\hat{p}_{HTt} + (\phi-\omega)\,\hat{p}_{Tt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \end{array} \right) \\ +\frac{\left(\frac{\bar{SP}^*}{\bar{P}}\right)\left(\frac{\bar{P}_{HT}^*}{\bar{P}^*}\right)^{1-\phi}\left(\frac{\bar{P}_T^*}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\frac{\bar{V}}{\bar{P}}} \\ \left(\begin{array}{c} \widehat{rer}_t + (1-\phi)\,\hat{p}_{HTt}^* + (\phi-\omega)\,\hat{p}_{Tt}^* \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^* \end{array} \right) \end{array} \right) \tag{B.99}$$
$$+(1-\gamma)\frac{\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{1-\omega}(\bar{C}+\bar{I})}{\frac{\bar{V}}{\bar{P}}} \left(\begin{array}{c} (1-\omega)\,\hat{p}_{HTt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \end{array} \right)$$
$$-\frac{\frac{\bar{W}}{\bar{P}}\bar{N}}{\frac{\bar{V}}{\bar{P}}}(\hat{w}_t + \hat{n}_t) - \frac{\bar{r}^k\bar{K}}{\frac{\bar{V}}{\bar{P}}}\left(\hat{r}_t^k + \hat{k}_t\right)$$

and, analogously:

$$\hat{v}_t^* = (1-\alpha)\gamma \left(\begin{array}{c} \frac{\left(\frac{\bar{P}_{FT}^*}{\bar{P}^*}\right)^{1-\phi}\left(\frac{\bar{P}_T^*}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\frac{\bar{V}^*}{\bar{P}^*}} \left(\begin{array}{c} (1-\phi)\,\hat{p}_{FTt}^* + (\phi-\omega)\,\hat{p}_{Tt}^* \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^* \end{array} \right) \\ +\frac{\left(\frac{1}{\frac{\bar{SP}^*}{\bar{P}}}\right)\left(\frac{\bar{P}_{FT}}{\bar{P}}\right)^{1-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\frac{\bar{V}^*}{\bar{P}^*}} \\ \left(-\widehat{rer}_t + (1-\phi)\,\hat{p}_{FTt} + (\phi-\omega)\,\hat{p}_{Tt} + \frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t\right) \end{array} \right) \tag{B.100}$$

$$+(1-\gamma)\frac{\left(\frac{\bar{P}_{FT}^*}{\bar{P}^*}\right)^{1-\omega}(\bar{C}^*+\bar{I}^*)}{\frac{\bar{V}^*}{\bar{P}^*}}\left((1-\omega)\,\hat{p}_{FTt}^* + \frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^*\right)$$

$$-\frac{\frac{\bar{W}^*}{\bar{P}^*}\bar{N}^*}{\frac{\bar{V}^*}{\bar{P}^*}}\left(\hat{w}_t^* + \hat{n}_t^*\right) - \frac{\bar{r}^{k*}\bar{K}^*}{\frac{\bar{V}^*}{\bar{P}^*}}\left(\hat{r}_t^{k*} + \hat{k}_t^*\right)$$

Asset market clearings

The linearized versions of:

$$\frac{B_{Ht}}{P_t\bar{Y}} = -\frac{B_{Ht}^*}{P_t\bar{Y}}$$

$$B_{Ft} = -B_{Ft}^*$$

$$\bar{Q} = Q_{Ht} + Q_{Ht}^*$$
$$\bar{Q}^* = Q_{Ft}^* + Q_{Ft}$$

are:

$$\hat{b}_{Ht} = -\hat{b}_{Ht}^* \tag{B.101}$$

$$\hat{b}_{Ft} = -\hat{b}_{Ft}^* \tag{B.102}$$

$$\hat{q}_{Ht} \approx -\hat{q}_{Ht}^* \tag{B.103}$$

$$\hat{q}_{Ft} \approx -\hat{q}_{Ft}^* \tag{B.104}$$

Goods market clearings

The linearized versions of:

$$Y_{HTt} = \alpha\gamma \left(\begin{array}{c} \left(\frac{P_{HTt}}{P_t}\right)^{-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{\phi-\omega}(C_t+I_t) \\ +\left(\frac{P_{HTt}^*}{P_t^*}\right)^{-\phi}\left(\frac{P_{Tt}^*}{P_t^*}\right)^{\phi-\omega}(C_t^*+I_t^*) \end{array} \right)$$

$$Y^*_{FT} = (1-\alpha)\gamma \begin{pmatrix} \left(\frac{P_{FTt}}{P_t}\right)^{-\phi}\left(\frac{P_{Tt}}{P_t}\right)^{\phi-\omega}(C_t+I_t) \\ +\left(\frac{P^*_{FTt}}{P^*_t}\right)^{-\phi}\left(\frac{P^*_{Tt}}{P^*_t}\right)^{\phi-\omega}(C^*_t+I^*_t) \end{pmatrix}$$

$$Y_{Nt} = \alpha(1-\gamma)\left(\frac{1}{\alpha}\left(\frac{P_{Nt}}{P_t}\right)^{-\omega}(C_t+I_t)\right)$$

are:

$$\begin{aligned} &\hat{y}_{HTt} \\ = \quad &\alpha\gamma \begin{pmatrix} \frac{\left(\frac{\bar{P}_{HT}}{\bar{P}}\right)^{-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\bar{Y}_{HT}} \begin{pmatrix} (-\phi)\,\hat{p}_{HTt} + (\phi-\omega)\,\hat{p}_{Tt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \end{pmatrix} \\ +\frac{\left(\frac{\bar{P}^*_{HT}}{\bar{P}^*}\right)^{-\phi}\left(\frac{\bar{P}^*_T}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\bar{Y}_{HT}} \begin{pmatrix} (-\phi)\,\hat{p}^*_{HTt} + (\phi-\omega)\,\hat{p}^*_{Tt} \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}^*_t + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}^*_t \end{pmatrix} \end{pmatrix} \end{aligned} \tag{B.105}$$

$$\begin{aligned} &\hat{y}^*_{FTt} \\ = \quad &(1-\alpha)\gamma \begin{pmatrix} \frac{\left(\frac{\bar{P}^*_{FT}}{\bar{P}^*}\right)^{-\phi}\left(\frac{\bar{P}^*_T}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\bar{Y}^*_{FT}} \begin{pmatrix} (-\phi)\,\hat{p}^*_{FTt} + (\phi-\omega)\,\hat{p}^*_{Tt} \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}^*_t + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}^*_t \end{pmatrix} \\ +\frac{\left(\frac{\bar{P}_{FT}}{\bar{P}}\right)^{-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\bar{Y}^*_{FT}} \begin{pmatrix} (-\phi)\,\hat{p}_{FTt} + (\phi-\omega)\,\hat{p}_{Tt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \end{pmatrix} \end{pmatrix} \end{aligned} \tag{B.106}$$

$$\hat{y}_{Nt} \approx (-\omega)\,\hat{p}_{HTt} + \frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t \tag{B.107}$$

and, analogously:

$$\hat{y}^*_{Nt} \approx (-\omega)\,\hat{p}^*_{FTt} + \frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}^*_t + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}^*_t \tag{B.108}$$

Taylor rules

The linearized versions of:

$$1+i_t = (1+i_{t-1})^{\rho}\left(\left(\frac{P_t}{P_{t-1}}\right)^{\phi_\pi}(Y_t)^{\phi_y}\right)^{(1-\rho)} R_t$$

$$1+i^*_t = (1+i^*_t)^{\rho^*}\left(\left(\frac{P^*_t}{P^*_{t-1}}\right)^{\phi^*_\pi}(Y^*_t)^{\phi^*_y}\right)^{(1-\rho^*)}$$

are:

$$\hat{\imath}_t \approx \rho\hat{\imath}_{t-1} + (1-\rho)\left(\phi_\pi\hat{\pi}_t + \phi_y\hat{y}_t\right) + \hat{r}_t \tag{B.109}$$

$$\hat{\imath}_t^* \approx \rho^* \hat{\imath}_{t-1}^* + (1-\rho^*)\,\phi_\pi^* \hat{\pi}_t^* + \phi_y^* \hat{y}_t^* \tag{B.110}$$

B.6 Additional variables

The current account is defined as:

$$\begin{aligned} CA_t &= B_{Ht+1} - B_{Ht} + S_t\left(B_{Ft+1} - B_{Ft}\right) \\ &\quad + P_{Qt}\left(Q_{Ht+1} - Q_{Ht}\right) + S_t P_{Qt}^*\left(Q_{Ft+1} - Q_{Ft}\right) \end{aligned}$$

Using the asset market clearing conditions the current account can also be written as the sum of the trade balance and net asset income:

$$\begin{aligned} CA_t = &\underbrace{S_t i_t^* B_{Ft} - i_t B_{Ht}^* + S_t\left(\frac{V_t^*}{\bar{Q}^*}\right) Q_{Ft} - \left(\frac{V_t}{\bar{Q}}\right) Q_{Ht}^*}_{\text{Net asset income}} \\ &+\underbrace{\underbrace{V_t + W_t N_t + P_t r_t^k K_{t.}}_{P_t Y_t} - P_t I_{t.} - P_t C_t}_{\text{Trade balance}} \end{aligned}$$

The net foreign asset position of the Home country (at the end of period t) is:

$$NFA_{t+1} = S_t B_{Ft+1} - B_{Ht+1}^* + S_t P_{Qt}^* Q_{Ft+1} - P_{Qt} Q_{Ht+1}^*$$

The dynamics in the net foreign asset position are:

$$\begin{aligned} NFA_{t+1} - NFA_t &= S_t B_{Ft+1} - B_{Ht+1}^* + S_t P_{Qt}^* Q_{Ft+1} - P_{Qt} Q_{Ht+1}^* \\ &\quad - \left[S_{t-1} B_{Ft} - B_{Ht}^* + S_{t-1} P_{Qt-1}^* Q_{Ft} - P_{Qt-1} Q_{Ht}^*\right] \end{aligned}$$

Using the asset market clearing conditions this can also be written as the sum of the current account, changes in local currency asset prices, and exchange rate valuation effects:

$$\begin{aligned} NFA_{t+1} - NFA_t &= CA_t \\ &\quad - \underbrace{\left(P_{Qt} - P_{Qt-1}\right) Q_{Ht}^* + \left(P_{Qt}^* - P_{Qt-1}^*\right) S_{t-1} Q_{Ft}}_{\text{Changes in local currency asset prices}} \\ &\quad + \underbrace{\left(S_t - S_{t-1}\right) B_{Ft} + \left(S_t - S_{t-1}\right) P_{Qt}^* Q_{Ft}}_{\text{Exchange rate valuation}} \end{aligned}$$

If the linearized version of the current account, the net foreign asset positions and their subcomponents are defined in terms of a stationary variable such as output, i.e. $\widehat{ca}_t \equiv \frac{d\frac{CA_t}{P_t}}{\bar{Y}}$, $\widehat{nai}_t \approx \frac{d\frac{NAI_t}{P_t}}{\bar{Y}}$, $\widehat{tb}_t \approx \frac{d\frac{TB_t}{P_t}}{\bar{Y}}$, $\widehat{nfa}_{t+1} \approx \frac{d\left(\frac{NFA_{t+1}}{P_t}\right)}{\bar{Y}}$, $\widehat{\Delta nfa}_{t+1} \approx \frac{d\left(\frac{NFA_{t+1}}{P_t} - \frac{NFA_{t-1}}{P_{t-1}}\right)}{\bar{Y}}$, $\widehat{clcap}_t \equiv$

$\frac{d\frac{CLCAP_t}{P_t}}{\bar{Y}}$, and $\widehat{ev}_t \equiv \frac{d\frac{EV_t}{P_t}}{\bar{Y}}$, then they can be derived as:

$$\begin{aligned}\widehat{ca}_t &\approx \hat{b}_{Ht+1} - \hat{b}_{Ht} + \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\left(\hat{b}_{Ft+1} - \hat{b}_{Ft}\right) \\ &\quad + \frac{\bar{P}_Q}{\bar{P}}\left(\hat{Q}_{Ht+1} - \hat{Q}_{Ht}\right) + \frac{\bar{P}_Q^*}{\bar{P}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\left(\hat{Q}_{Ft+1} - \hat{Q}_{Ft}\right)\end{aligned}$$

and

$$\widehat{nai}_t \approx \widehat{ca}_t - \widehat{tb}_t$$

where[37]

$$\begin{aligned}\widehat{tb}_t &= \alpha\gamma\left(\begin{array}{c}\frac{\left(\frac{\overline{SP^*}}{P}\right)\left(\frac{\bar{P}_{HT}^*}{\bar{P}^*}\right)^{1-\phi}\left(\frac{\bar{P}_T^*}{\bar{P}^*}\right)^{\phi-\omega}(\bar{C}^*+\bar{I}^*)}{\bar{Y}} \\ \left(\begin{array}{c}\widehat{rer}_t + (1-\phi)\hat{p}_{HTt}^* + (\phi-\omega)\,\hat{p}_{Tt}^* \\ +\frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^*\end{array}\right)\end{array}\right) \\ &\quad -(1-\alpha)\gamma\left(\begin{array}{c}\frac{\left(\frac{\overline{SP^*}}{P}\right)^{-1}\left(\frac{\bar{P}_{FT}}{\bar{P}}\right)^{1-\phi}\left(\frac{\bar{P}_T}{\bar{P}}\right)^{\phi-\omega}(\bar{C}+\bar{I})}{\bar{Y}} \\ \left(\begin{array}{c}-\widehat{rer}_t + (1-\phi)\,\hat{p}_{FTt} + (\phi-\omega)\,\hat{p}_{Tt} \\ +\frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}_t\end{array}\right)\end{array}\right)\end{aligned}$$

and

$$\begin{aligned}\widehat{nfa}_{t+1} &\approx \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{rer}_t + \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{b}_{Ft+1} - \hat{b}_{Ht+1}^* \\ &\quad + \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{rer}_t + \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{p}_{Qt}^* + \frac{\bar{P}_Q^*}{\bar{P}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{Q}_{Ft+1} \\ &\quad - \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}_H^*}{\bar{Y}}\hat{p}_{Qt} - \frac{\bar{P}_Q}{\bar{P}}\hat{Q}_{Ht+1}^*\end{aligned}$$

and

$$\Delta\widehat{nfa}_{t+1} \approx \widehat{nfa}_{t+1} - \widehat{nfa}_t$$

[37] Note that the log-linearized version of real exports in terms of Home currency is $\widehat{exp}_t = \widehat{rer}_t + (1-\phi)\,\hat{p}_{HTt}^* + (\phi-\omega)\,\hat{p}_{Tt}^* + \frac{\bar{C}^*}{(\bar{C}^*+\bar{I}^*)}\hat{c}_t^* + \frac{\bar{I}^*}{(\bar{C}^*+\bar{I}^*)}\hat{I}_t^*$, while the log-linearized version of real imports in terms of Home currency is $\widehat{imp}_t = (1-\phi)\,\hat{p}_{FTt} + (\phi-\omega)\,\hat{p}_{Tt} + \frac{\bar{C}}{(\bar{C}+\bar{I})}\hat{c}_t + \frac{\bar{I}}{(\bar{C}+\bar{I})}\hat{I}$.

or

$$
\begin{aligned}
\widehat{\Delta nf}a_{t+1} \;\approx\;& \underbrace{\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{b}_{Ft+1} - \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{b}_{Ft} + \hat{b}_{Ht+1} - \hat{b}_{Ht}}_{\text{CA...}} \\
&+\underbrace{\frac{\bar{P}_Q^*}{\bar{P}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{Q}_{Ft+1} - \frac{\bar{P}_Q^*}{\bar{P}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\hat{Q}_{Ft} - \frac{\bar{P}_Q}{\bar{P}}\hat{Q}^*_{Ht+1} + \frac{\bar{P}_Q}{\bar{P}}\hat{Q}^*_{Ht}}_{\text{...CA}} \\
&+\underbrace{\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\left(\widehat{\Delta s}_t - \widehat{\pi}_t + \widehat{\pi}^*_t\right) + \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\widehat{\Delta s}_t}_{\text{EV}} \\
&+\underbrace{\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\widehat{rer}_t - \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\widehat{rer}_{t-1} - \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\widehat{\Delta s}_t}_{\Delta\text{LCAP...}} \\
&+\underbrace{\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\hat{p}^*_{Qt} - \overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\hat{p}^*_{Qt-1} - \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}^*_H}{\bar{Y}}\hat{p}_{Qt} + \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}^*_H}{\bar{Y}}\hat{p}_{Qt-1}}_{\text{...}\Delta\text{LCAP}}
\end{aligned}
$$

where

$$
\begin{aligned}
\widehat{clcap}_t \;\approx\;& -\frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}^*_H}{\bar{Y}}\hat{p}_{Qt} + \frac{\bar{P}_Q}{\bar{P}}\frac{\bar{Q}^*_H}{\bar{Y}}\hat{p}_{Qt-1} \\
&+\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{p^*_{Q_t}} - \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{\Delta s}_t + \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{rer}_t \\
&-\frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{rer}_{t-1} - \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{p^*_{Q_{t-1}}}
\end{aligned}
$$

and

$$
\widehat{ev}_t \approx \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{\Delta s}_t - \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{\pi}_t + \frac{\bar{B}_F}{\bar{P}^*\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{\pi}^*_t + \frac{\bar{P}_Q^*}{\bar{P}^*}\frac{\bar{Q}_F}{\bar{Y}^*}\overline{RER}\frac{\bar{Y}^*}{\bar{Y}}\widehat{\Delta s}_t
$$