IMF, Problem Set 3

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Q1

0.1 RAFAFP

The household's problem in Country A is:

$$\max_{\{C_{A,T,t},C_{A,O,t},l_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \Big(\log(c_{A,t}) + \phi \log(1 - l_t) \Big) \tag{1}$$

subject to:

$$\begin{aligned} P_{O,t}c_{A,O,t} + P_{T,t}c_{A,T,t} =& W_t l_t + \Pi_t + E_t(n_{A,t} - \frac{n_{A,t+1}}{R_t^{\$}}) \\ n_{A,t} =& 0 \\ c_{A,Ot}, c_{A,T,t} \geq& \, 0 \\ l_t \in& (0,1) \end{aligned}$$

Similarly, the household's problem in Country B is:

$$\max_{\{C_{B,T,t},C_{B,O,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \log(c_{B,t}) \tag{2}$$

subject to:

$$\begin{aligned} P_{O,t}c^{\$}_{B,O,t} + P^{\$}_{T,t}c_{B,T,t} =& y_{O,t} + (n_{B,t} - \frac{n_{B,t+1}}{R_t^{\$}}) \\ n_{B,t} =& 0 \\ c_{B,O,t}, c_{B,T,t} \geq& \, 0 \end{aligned}$$

where for each household, consumption is aggregated as:

$$c_{j,t} = \left[s_T c_{j,T,t}^{\frac{\eta-1}{\eta}} + (1-s_T) c_{j,O,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad j \in \{A, B\}$$

Moreover, it is assumed that the law of one price holds for both oil and tradeable goods, such that:

$$P_{T,t} = E_t P_{T,t}^{\$} = P_{T,t}^{\$}$$
$$P_{O,t} = E_t P_{O,t}^{\$} = 1$$

since $E_t = 1$ due to the assumption of fixed exchange rate and $P_{O,t} = 1$ due to normalisation.

The households' first order conditions consist of their oil-tradeable Euler equation:

$$(1-s_T) c_{J,O,t}^{-\frac{1}{\eta}} = \frac{s_T c_{J,T,t}^{-\frac{1}{\eta}}}{P_{T,t}}, \quad j \in \{A, B\} \tag{3}$$

the household's labour supply decision in Country A:

$$\frac{(1-s_T) c_{A,O,t}^{-\frac{1}{\eta}}}{s_T c_{A,T,t}^{1-\frac{1}{\eta}} + (1-s_T) c_{A,O,t}^{1-\frac{1}{\eta}}} W_t = \frac{\psi}{1-l_t} \tag{4}$$

and the budget constraints

$$P_{O,t} c_{A,O,t} + P_{T,t} c_{A,T,t} = W_t l_t + \Pi_t \tag{5}$$

$$P_{O,t} c_{B,O,t}^{\$} + P_{T,t}^{\$} c_{B,T,t} = y_{O,t} \tag{6}$$

Next, the monopolistically competitive firm's problem with flexible price is:

$$\max_{l_{it}} P_{i,t} y_{i,t} - W_t l_{i,t} \tag{7}$$

subject to:

$$
\begin{aligned}
y_{i,t} =& l_{i,t}^{1-\alpha} \\
P_{i,t} =& P_{T,t}\left(\frac{y_{i,t}}{y_{T,t}}\right)^{-\theta}
\end{aligned}
$$

The first order condition is:

$$P_{T,t}(1-\theta)(1-\alpha)l_{i,t}^{(1-\theta)(1-\alpha)-1} = y_{T,t}^{-\theta}W_t \tag{8}$$

Finally, define the oil endowment in Country B as an AR(1) process, such that:

$$y_{O,t} = \gamma + \rho y_{O,t-1} + \epsilon_{O,t} \tag{9}$$

I can now define an equilibrium. An equilibrium in this economy consists of sequences of quantities $\{c_{A,O,t}, c_{A,T,t}, c_{B,O,t}, c_{B,T,t}, l_t, y_{T,t}, y_{O,t}, \Pi_t\}_{t=0}^{\infty}$ and prices $\{P_{T,t}, P_{O,t}, P_{T,t}^{\$}, P_{O,t}^{\$}, W_t, E_t\}_{t=0}^{\infty}$ such that the FOCs 3 to 9 hold and market-clearing is satisfied on the tradeable goods market:

$$c_{A,T,t} + c_{B,T,t} = y_{T,t} \tag{10}$$

the oil market:

$$c_{A,O,t} + c_{B,O,t} = y_{O,t} \tag{11}$$

and the labour market:

$$l_t = \int_0^1 l_{i,t}\, di \tag{12}$$

0.2 RANBFP

The problem is similar to the RAFAFP economy, except households in Country A and B are no longer in financial autarky. Therefore, the households' problems are now:

$$\max_{\{C_{A,T,t},C_{A,O,t},l_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \Big(\log(c_{A,t}) + \phi \log(1 - l_t) \Big) \tag{13}$$

subject to:

$$\begin{aligned} P_{O,t}c_{A,O,t} + P_{T,t}c_{A,T,t} =& W_t l_t + \Pi_t + E_t(n_{A,t} - \frac{n_{A,t+1}}{R_t^{\$}}) \\ c_{A,Ot}, c_{A,T,t} \geq& 0 \\ l_t \in& (0,1) \end{aligned}$$

and:

$$\max_{\{C_{B,T,t},C_{B,O,t}\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta^t \log(c_{B,t}) \tag{14}$$

subject to:

$$\begin{aligned} P_{O,t}c^{\$}_{B,O,t} + P^{\$}_{T,t}c_{B,T,t} =& y_{O,t} + (n_{B,t} - \frac{n_{B,t+1}}{R_t^{\$}}) \\ c_{B,O,t}, c_{B,T,t} \geq& 0 \end{aligned}$$

where $n_{A,t}, n_{B,t} \in (-\infty, \infty)$. The FOCs are identical to RAFAFP with the addition of the intertemporal Euler equations:

$$\frac{c_{J,O,t}^{-\frac{1}{\eta}}}{s_T c_{J,T,t}^{1-\frac{1}{\eta}} + (1-s_T)c_{J,O,t}^{1-\frac{1}{\eta}}} = \beta R_t^{\$} \frac{c_{J,O,t+1}^{-\frac{1}{\eta}}}{s_T c_{J,T,t+1}^{1-\frac{1}{\eta}} + (1-s_T)c_{J,O,t+1}^{1-\frac{1}{\eta}}}, \quad j \in \{A, B\} \tag{15}$$

The equilibrium is now defined as follows. An equilibrium in this economy consists of sequences of quantities $\{c_{A,O,t}, c_{A,T,t}, c_{B,O,t}, c_{B,T,t}, l_t, y_{T,t}, y_{O,t}, \Pi_t, n_{A,t}, n_{B,t}\}_{t=0}^{\infty}$ and prices $\{P_{T,t}, P_{O,t}, P^{\$}_{T,t}, P^{\$}_{O,t}, W_t, E_t, R_t^{\$}\}_{t=0}^{\infty}$ such that the FOCs (3) to (9), (15) hold and market-clearing conditions (10) to (12) are satisfied.

0.3 TANBFP

In the TANBFP economy, there is a mass of χ Ricardian and $(1-\chi)$ hand-to-mouth (HTM) households in country A. Ricardian households' problem is defined as in equations (1) and HTM households' problem is defined as in equations (13). Ricardian households' FOCs are characterised by:

$$(1-s_T)c_{AR,O,t}^{-\frac{1}{\eta}} = \frac{s_T c_{AR,T,t}^{-\frac{1}{\eta}}}{P_{T,t}} \tag{16}$$

$$\frac{c_{AR,O,t}^{-\frac{1}{\eta}}}{s_T c_{AR,T,t}^{1-\frac{1}{\eta}} + (1-s_T)c_{AR,O,t}^{1-\frac{1}{\eta}}} = \beta R_t^{\$} \frac{c_{AR,O,t+1}^{-\frac{1}{\eta}}}{s_T c_{AR,T,t+1}^{1-\frac{1}{\eta}} + (1-s_T)c_{AR,O,t+1}^{1-\frac{1}{\eta}}}, \quad j \in \{A, B\} \tag{17}$$

$$P_{O,t}c_{AR,O,t} + P_{T,t}c_{AR,T,t} = W_t l_{Rt} + \Pi_t + E_t(n_{AR,t} - \frac{n_{AR,t+1}}{R_t^{\$}}) \tag{18}$$

and HTM households' FOCs by:

$$(1-s_T)c_{AH,O,t}^{-\frac{1}{\eta}} = \frac{s_T c_{AH,T,t}^{-\frac{1}{\eta}}}{P_{T,t}} \tag{19}$$

$$\frac{(1-s_T)c_{AH,O,t}^{-\frac{1}{\eta}}}{s_T c_{AH,T,t}^{1-\frac{1}{\eta}} + (1-s_T)c_{AH,O,t}^{1-\frac{1}{\eta}}} W_t = \frac{\psi}{1-l_t} \tag{20}$$

$$P_{O,t}c_{AH,O,t} + P_{T,t}c_{AH,T,t} = W_t l_{Ht} + \Pi_t \tag{21}$$

0.4 TANBNR FER

In the TANBNR fixed exchange rate economy, the firm's FOC becomes:

$$\begin{aligned} W_t = (1-\theta)(1-\alpha)P_{T,t}\frac{l_{i,t}^{(1-\theta)(1-\alpha)-1}}{y_{T,t}^{-\theta}} - \phi\left[\frac{P_{T,t}}{P_{T,t-1}}\frac{l_{i,t}^{-\theta(1-\alpha)}}{y_{T,t}^{-\theta}}\left(\frac{y_{i,t-1}}{y_{T,t-1}}\right)^{\theta} - 1\right]... \\ P_{T,t}Y_{T,t}(-\theta)(1-\alpha)\left[\frac{P_{T,t}}{P_{T,t-1}}\frac{l_{i,t}^{-\theta(1-\alpha)}}{y_{T,t}^{-\theta}}\left(\frac{y_{i,t-1}}{y_{T,t-1}}\right)^{\theta}\right] \end{aligned} \tag{22}$$

0.5 TANBNR PIT

The TANBNR price inflation targeting economy is identical to the TANBNR FER economy, except E_t is no longer fixed and the monetary authority in Country A fixes the price of the tradeable goods, such that $P_{T,t} = P_{T,t-1}$. The oil-tradeable Euler equation of households in Country B becomes:

$$\frac{(1-s_T)c_{B,O,t}^{-\frac{1}{\eta}}}{E_t} = \frac{s_T c_{B,T,t}^{-\frac{1}{\eta}}}{P_{T,t}} \tag{23}$$

The Euler equation for Ricardian households is:

$$\frac{c_{AR,O,t}^{-\frac{1}{\eta}}}{s_T c_{AR,T,t}^{1-\frac{1}{\eta}} + (1-s_T)c_{AR,O,t}^{1-\frac{1}{\eta}}} = \beta R_t^{\$} \frac{E_t}{E_{t+1}} \frac{c_{AR,O,t+1}^{-\frac{1}{\eta}}}{s_T c_{AR,T,t+1}^{1-\frac{1}{\eta}} + (1-s_T)c_{AR,O,t+1}^{1-\frac{1}{\eta}}} \tag{24}$$

and labour supply decision for both households is:

$$\frac{(1-s_T)c_{J,O,t}^{-\frac{1}{\eta}}}{s_T c_{J,T,t}^{1-\frac{1}{\eta}} + (1-s_T)c_{J,O,t}^{1-\frac{1}{\eta}}} \frac{W_t}{E_t} = \frac{\psi}{1-l_t}, \quad J \in \{AH, AR\} \tag{25}$$

0.6 TANBFPNH

The TANBFPNH economy is identical to the TANBFP economy (i.e. no nominal rigidity) except s_T, the weight given to the tradeable goods in the CES aggregator is allowed to vary between types of households, such that preferences are non-homothetic.

Q2

The model is calibrated such that steady-state nominal output of Country A, $P_T^* y_T^*$, equals the nominal GDP of the EU in 2022, which was at 16.75 trillion euros. Moreover, average labour supply, l^*, is targeted to reflect the average work hour in the EU of 37.5 hours per week, resulting in a target value of 0.22. Finally, the model is calibrated to obtain steady-state oil endowment that is equal to the annual GDP of Saudi Arabia in 2022 denominated in euro, since I assume a fixed exchange rate between Country A and B throughout most models and the price of oil is the numeraire. This yields a target of 1 trillion euros for y_O^*.

For the parameters, $\alpha = 0.3$ and $\beta = 0.99$ were chosen to reflect standard values in the macroeconomic literature. The elasticity of labour supply was set to $\psi = 1.5$ following Blundell et al. (2000). The elasticity of substitution between the tradeable good and oil was set at a low value such that $\eta = 0.4$ such that tradeable goods and oil have low levels of substitutability in the consumption basket. The proportion of Ricardian households, χ, was set at 0.8 to reflect the proportion of households that are not credit-constrained in the EU according to the HFCS survey data. I assumed a highly persistent oil endowment process, such that $\rho = 0.9$. Finally, the weight given to the tradeable goods, s_T, as well as the elasticity of substitution between the varieties of tradeables, θ, and the intercept of the AR(1) process for oil endowment γ, were calibrated to attain the target moments described above.

Table 1: Targeted values

	Benchmark	RANBFP	TANBFP	TANBNR FER	TANBNR PIT	TANBFPNH
$P_T Y_T$	16.75	19.9	16.7	13.3	16.75	23.0
l_t	0.22	0.22	0.26	0.23	0.27	0.19
Y_O	1.0	1.0	1.0	1.0	1.0	1.0

Table 2: Calibrated values

	Benchmark	RANBFP	TANBFP	TANBNR FER	TANBNR PIT	TANBFPNH
α	0.3	0.3	0.3	0.3	0.3	0.3
β	0.99	0.99	0.99	0.99	0.99	0.99
ψ	1.5	1.5	1.5	1.5	1.5	1.5
ϕ				10	10	
η	0.4	0.4	0.4	0.4	0.4	0.4
s_T	0.8	0.8	0.8	0.8	0.8	0.8
$s_{AR,T}$						0.81
$s_{AH,T}$						0.75
$s_{B,T}$						0.8
θ	1.0	1.0	1.0	1.0	1.0	1.0
ρ	0.9	0.9	0.9	0.9	0.9	0.9
γ	0.1	0.1	0.1	0.1	0.1	0.1
χ	0.8	0.8	0.8	0.8	0.8	0.8

Q3

The price index in all models is calculated from the CES aggregator, such that:

$$P_{j,t} = \left[s_T P_{j,T,t}^{\frac{\eta-1}{\eta}} + (1 - s_T) P_{j,O,t}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}}, \quad j \in \{A, B\} \tag{26}$$

Therefore, it follows that the price level is identical in Country A and B for all models, except TANBFPNH.

0.7 RAFAFP

Given a 10 percent negative shock to oil endowment, the price level in Country A and B increases due to the increase in the price of oil relative to the price of the tradeable goods. Since the price of tradeable goods relative to oil decreases while output stays constant, consumption in Country A decreases. Country B on the other hand, experiences an increase in consumption due to the increase in the price of oil. In fact, because of the low substitutability of oil and tradeables, the price effect dominates over the volume effect and Country B is able to consume more. This transfer of consumption from Country A to Country B is reflected by an increase in net export for Country A.

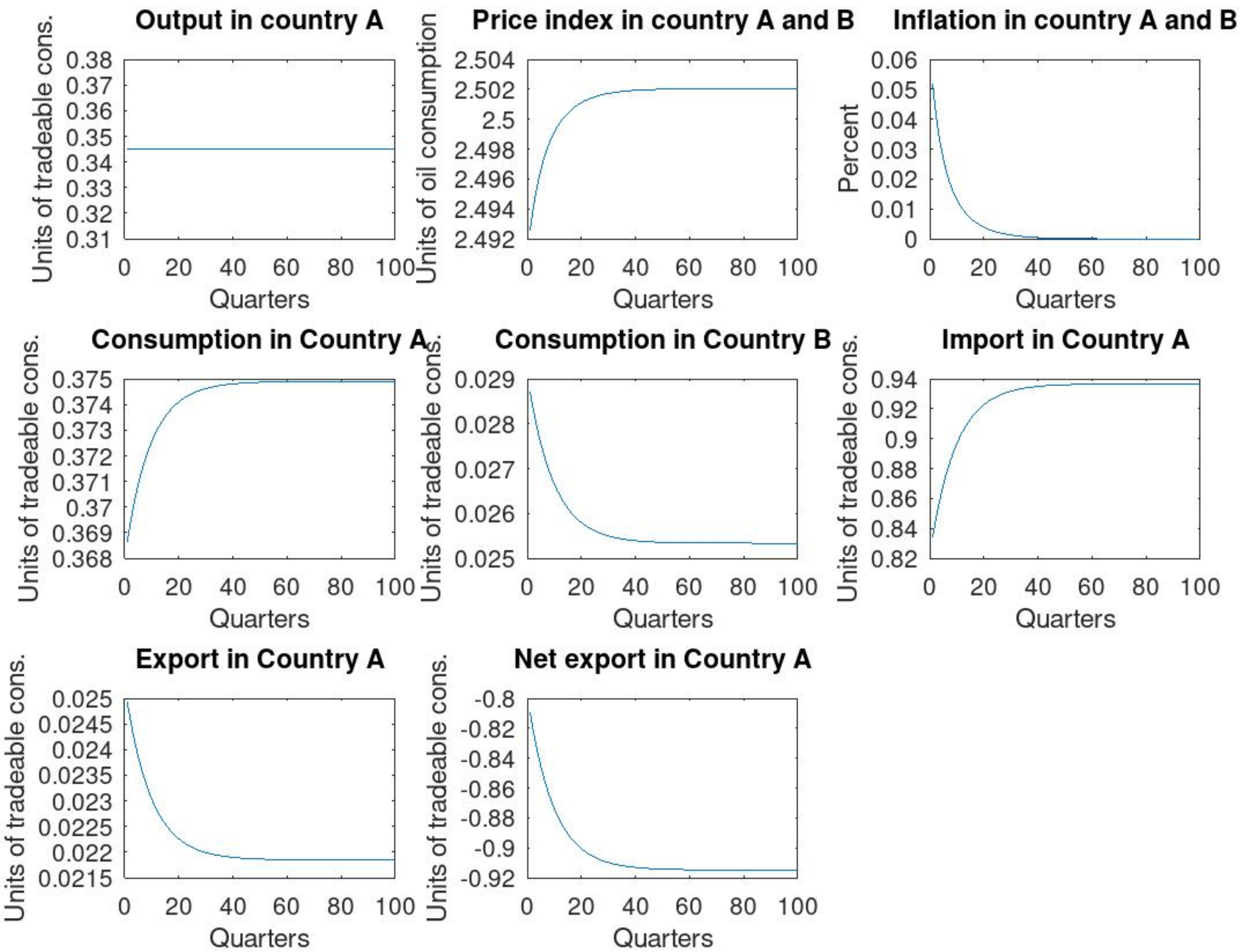

Figure 1: IRFs for RAFAFP

0.8 RANBFP

By opening financial markets, Country A borrows from Country B to smooth consumption. As a result, the shock to consumption in Country A should be less significant than in the RAFAFP model and as a result, the shock to all other variables should be damped compared to RAFAFP (which is indeed the case when we observe inflation).

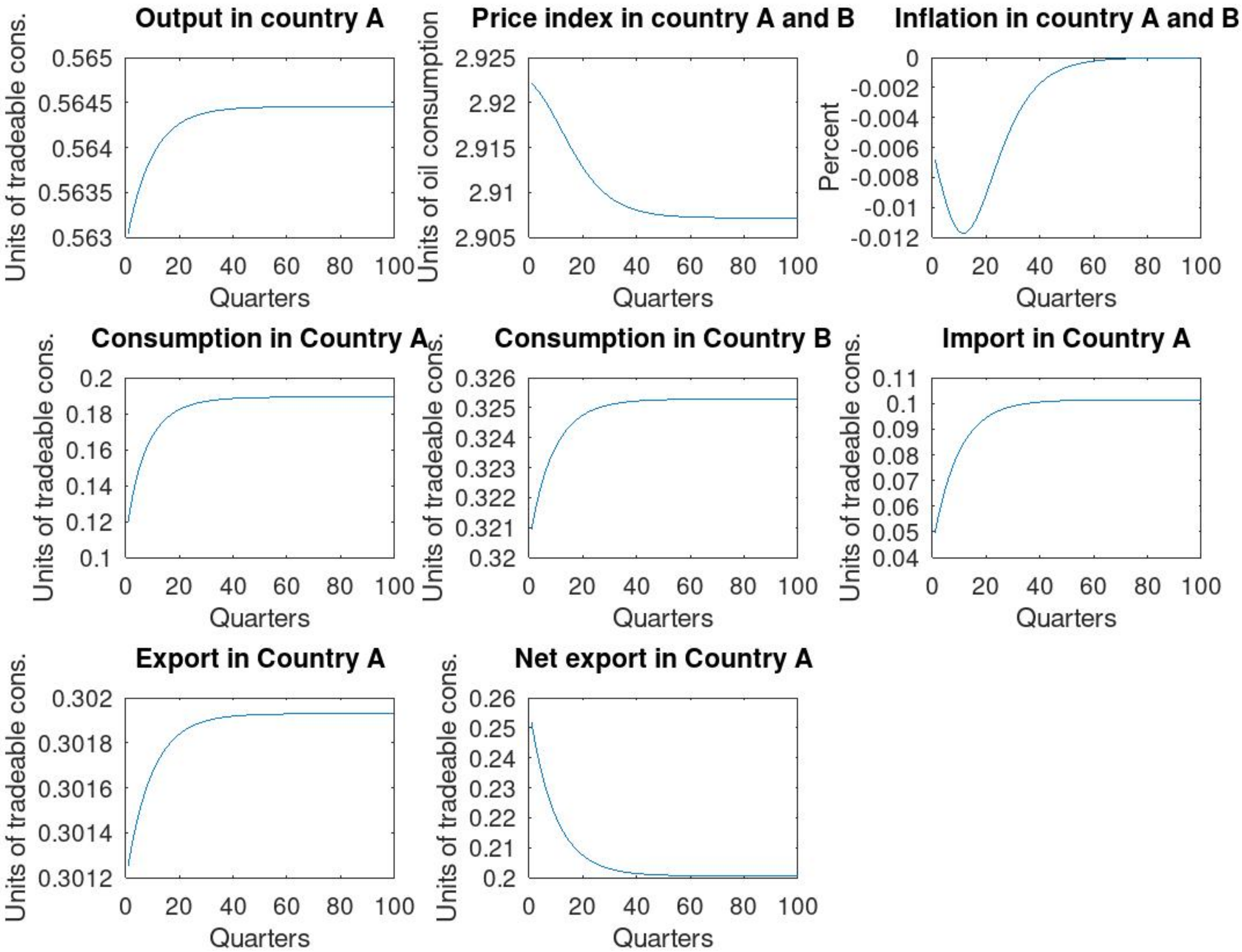

Figure 2: IRFs for RANBFP

0.9 TANBFP

Under TANBFP, I obtain an intermediary outcome between the RAFAFP and RANBFP models in terms of magnitude of the shock, since some of the shock is dampened by the share of Ricardian households.

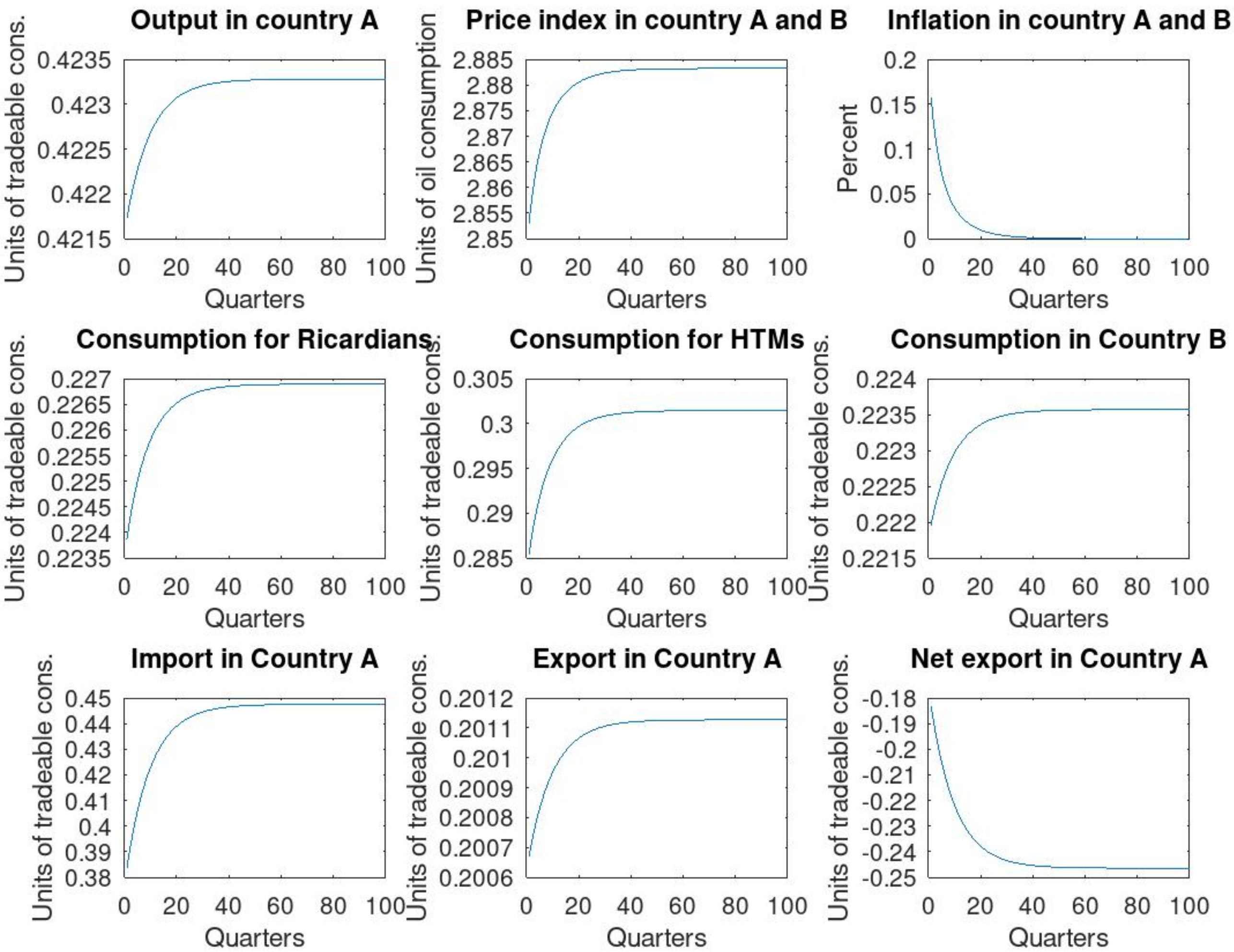

Figure 3: IRFs for TANBFP

0.10 TANBNR FER

The shock is more persistent when nominal rigidity is introduced compared to RAFAFP, as price take more time to adjust to their equilibrium level.

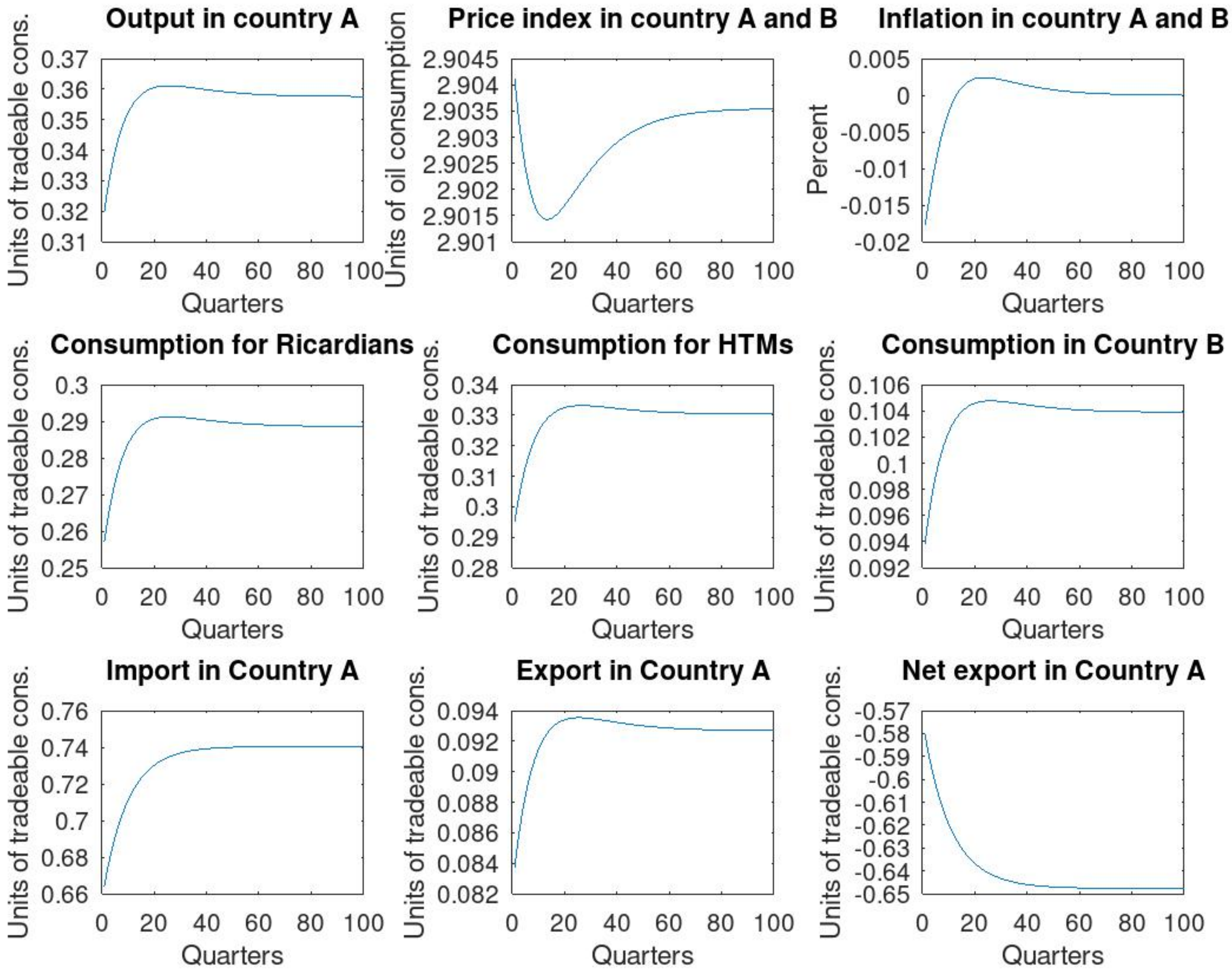

Figure 4: IRFs for TANBNR FER

0.11 TANBNR PIT

In theory, the effects of the foreign shock should be dampened by the exchange ratein Country A, which we do not observe in the IRFs.

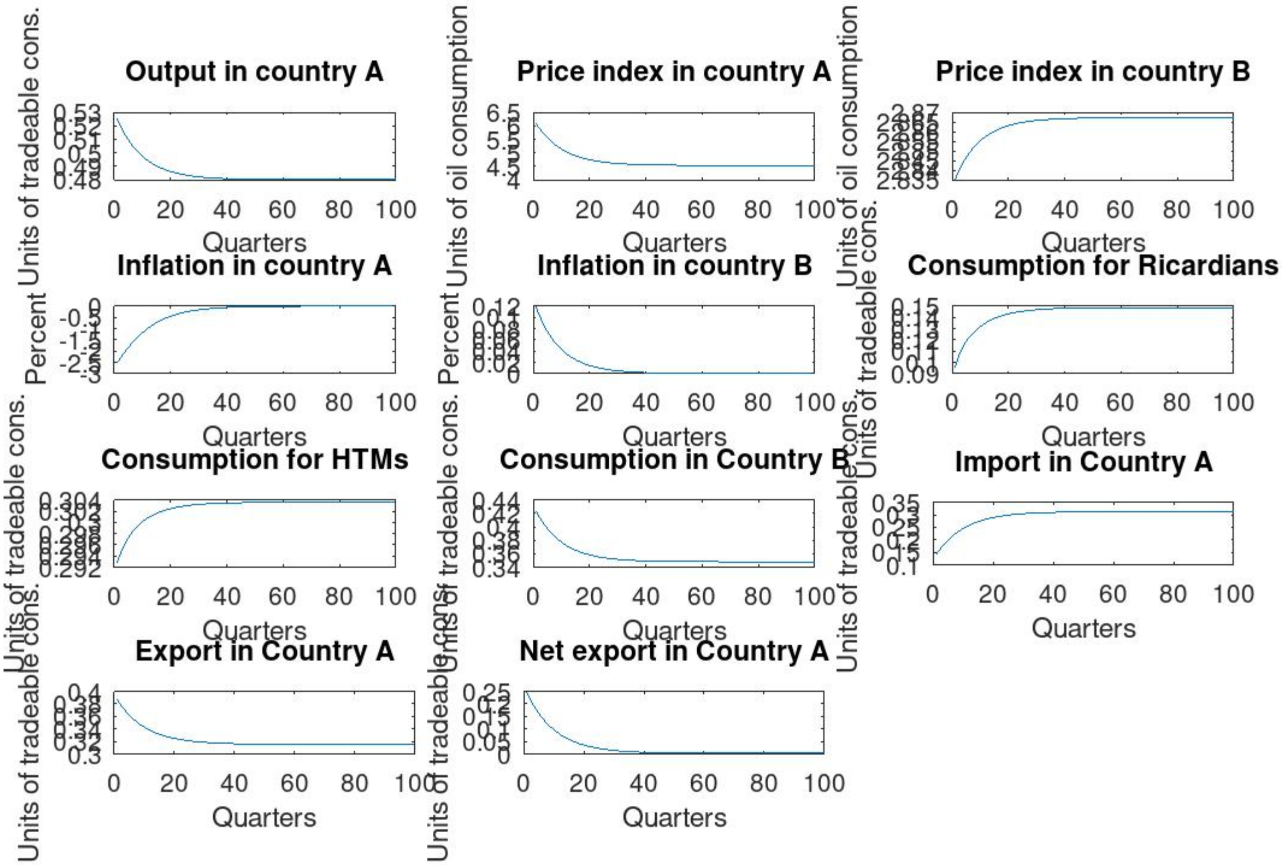

Figure 5: IRFs for TANBNR PIT

0.12 TANBFPNH

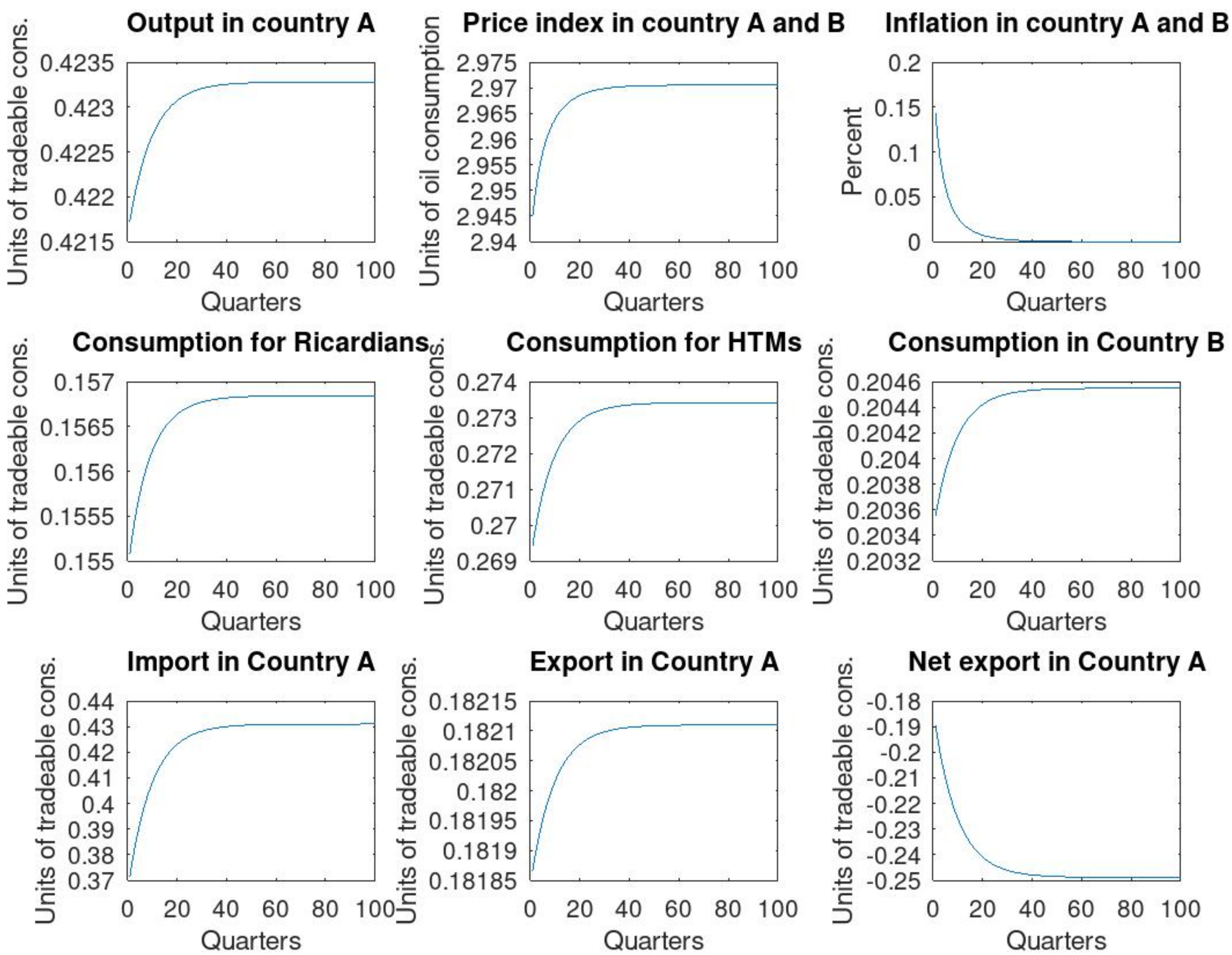

Figure 6: IRFs for TANBFPNH

Appendix A: Main File

```
%----------------------------------------------------------------------
%
% Title: International Macro-Finance Problem Set 4, main file
% Author: ---
% Date: 10/01/2024
% Description: Main file for the final problem set
%
%----------------------------------------------------------------------


%----------------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%----------------------------------------------------------------------

close all;
clear all;


%----------------------------------------------------------------------
% 1. Load parameters
%----------------------------------------------------------------------

parameters;
save parameters par;


%----------------------------------------------------------------------
% 1. Run models
%----------------------------------------------------------------------

dynare rafafp;
dynare ranbfp;
dynare tanbfp;
dynare tanbnr_fer;
dynare tanbnr_pit;
dynare tanbfpnh;


%----------------------------------------------------------------------
% 2. Load results
%----------------------------------------------------------------------


rafafp_results = load("rafafp_results.mat");

RAFAFP.c_aoss = rafafp_results.oo_.steady_state(1);
RAFAFP.c_boss = rafafp_results.oo_.steady_state(2);
RAFAFP.c_atss = rafafp_results.oo_.steady_state(3);
RAFAFP.c_btss = rafafp_results.oo_.steady_state(4);
RAFAFP.lss = rafafp_results.oo_.steady_state(5);
RAFAFP.y_tss = rafafp_results.oo_.steady_state(6);
RAFAFP.y_oss = rafafp_results.oo_.steady_state(7);
RAFAFP.p_tss = rafafp_results.oo_.steady_state(8);
RAFAFP.wss = rafafp_results.oo_.steady_state(9);
RAFAFP.piss = rafafp_results.oo_.steady_state(10);

RAFAFP.c_ao = rafafp_results.oo_.irfs.c_ao_err_yo;
RAFAFP.c_at = rafafp_results.oo_.irfs.c_at_err_yo;
RAFAFP.c_bo = rafafp_results.oo_.irfs.c_bo_err_yo;
RAFAFP.c_bt = rafafp_results.oo_.irfs.c_bt_err_yo;
RAFAFP.l    = rafafp_results.oo_.irfs.l_err_yo;
RAFAFP.p_t  = rafafp_results.oo_.irfs.p_t_err_yo;
RAFAFP.pi   = rafafp_results.oo_.irfs.pi_err_yo;
RAFAFP.w    = rafafp_results.oo_.irfs.w_err_yo;
RAFAFP.y_o  = rafafp_results.oo_.irfs.y_o_err_yo;
RAFAFP.y_t  = rafafp_results.oo_.irfs.y_t_err_yo;

psi = rafafp_results.M_.params(2);
RAFAFP.eta = rafafp_results.M_.params(3);
RAFAFP.s_t = rafafp_results.M_.params(4);
```

```
ranbfp_results = load("ranbfp_results.mat");

RANBFP.c_aoss = ranbfp_results.oo_.steady_state(1);
RANBFP.c_boss = ranbfp_results.oo_.steady_state(2);
RANBFP.c_atss = ranbfp_results.oo_.steady_state(3);
RANBFP.c_btss = ranbfp_results.oo_.steady_state(4);
RANBFP.lss = ranbfp_results.oo_.steady_state(5);
RANBFP.y_tss = ranbfp_results.oo_.steady_state(6);
RANBFP.y_oss = ranbfp_results.oo_.steady_state(7);
RANBFP.p_tss = ranbfp_results.oo_.steady_state(8);
RANBFP.wss = ranbfp_results.oo_.steady_state(9);
RANBFP.piss = ranbfp_results.oo_.steady_state(10);
RANBFP.n_ass = ranbfp_results.oo_.steady_state(11);
RANBFP.n_bss = ranbfp_results.oo_.steady_state(12);
RANBFP.r_starss = ranbfp_results.oo_.steady_state(13);

RANBFP.c_ao = ranbfp_results.oo_.irfs.c_ao_err_yo;
RANBFP.c_at = ranbfp_results.oo_.irfs.c_at_err_yo;
RANBFP.c_bo = ranbfp_results.oo_.irfs.c_bo_err_yo;
RANBFP.c_bt = ranbfp_results.oo_.irfs.c_bt_err_yo;
RANBFP.l    = ranbfp_results.oo_.irfs.l_err_yo;
RANBFP.p_t  = ranbfp_results.oo_.irfs.p_t_err_yo;
RANBFP.pi   = ranbfp_results.oo_.irfs.pi_err_yo;
RANBFP.w    = ranbfp_results.oo_.irfs.w_err_yo;
RANBFP.y_o  = ranbfp_results.oo_.irfs.y_o_err_yo;
RANBFP.y_t  = ranbfp_results.oo_.irfs.y_t_err_yo;

beta = ranbfp_results.M_.params(2);
RANBFP.eta = ranbfp_results.M_.params(4);
RANBFP.s_t = ranbfp_results.M_.params(5);


tanbfp_results = load("tanbfp_results.mat");

TANBFP.c_ahoss = ranbfp_results.oo_.steady_state(1);
TANBFP.c_aross = tanbfp_results.oo_.steady_state(2);
TANBFP.c_boss = tanbfp_results.oo_.steady_state(3);
TANBFP.c_ahtss = tanbfp_results.oo_.steady_state(4);
TANBFP.c_artss = tanbfp_results.oo_.steady_state(5);
TANBFP.c_btss = tanbfp_results.oo_.steady_state(6);
TANBFP.l_hss = tanbfp_results.oo_.steady_state(7);
TANBFP.l_rss = tanbfp_results.oo_.steady_state(8);
TANBFP.lss = tanbfp_results.oo_.steady_state(9);
TANBFP.y_tss = tanbfp_results.oo_.steady_state(10);
TANBFP.y_oss = tanbfp_results.oo_.steady_state(11);
TANBFP.p_tss = tanbfp_results.oo_.steady_state(12);
TANBFP.wss = tanbfp_results.oo_.steady_state(13);
TANBFP.piss = tanbfp_results.oo_.steady_state(14);
TANBFP.n_ass = tanbfp_results.oo_.steady_state(15);
TANBFP.n_bss = tanbfp_results.oo_.steady_state(16);
TANBFP.rstarss = tanbfp_results.oo_.steady_state(17);
TANBFP.pirss = tanbfp_results.oo_.steady_state(18);
TANBFP.pihss = tanbfp_results.oo_.steady_state(19);

TANBFP.c_aro = tanbfp_results.oo_.irfs.c_aro_err_yo;
TANBFP.c_art = tanbfp_results.oo_.irfs.c_art_err_yo;
TANBFP.c_aho = tanbfp_results.oo_.irfs.c_aho_err_yo;
TANBFP.c_aht = tanbfp_results.oo_.irfs.c_aht_err_yo;
TANBFP.c_bo  = tanbfp_results.oo_.irfs.c_bo_err_yo;
TANBFP.c_bt  = tanbfp_results.oo_.irfs.c_bt_err_yo;
TANBFP.l_r   = tanbfp_results.oo_.irfs.l_r_err_yo;
TANBFP.l_h   = tanbfp_results.oo_.irfs.l_h_err_yo;
TANBFP.l   = tanbfp_results.oo_.irfs.l_err_yo;
TANBFP.p_t   = tanbfp_results.oo_.irfs.p_t_err_yo;
TANBFP.pi    = tanbfp_results.oo_.irfs.pi_err_yo;
TANBFP.w     = tanbfp_results.oo_.irfs.w_err_yo;
TANBFP.y_o   = tanbfp_results.oo_.irfs.y_o_err_yo;
TANBFP.y_t   = tanbfp_results.oo_.irfs.y_t_err_yo;

TANBFP.eta = tanbfp_results.M_.params(4);
TANBFP.s_t = tanbfp_results.M_.params(5);
chi = tanbfp_results.M_.params(9);
```

```
tanbnr_fer_results = load("tanbnr_fer_results.mat");

TANBNR_FER.c_ahoss = tanbnr_fer_results.oo_.steady_state(1);
TANBNR_FER.c_aross = tanbnr_fer_results.oo_.steady_state(2);
TANBNR_FER.c_boss = tanbnr_fer_results.oo_.steady_state(3);
TANBNR_FER.c_ahtss = tanbnr_fer_results.oo_.steady_state(4);
TANBNR_FER.c_artss = tanbnr_fer_results.oo_.steady_state(5);
TANBNR_FER.c_btss = tanbnr_fer_results.oo_.steady_state(6);
TANBNR_FER.l_hss = tanbnr_fer_results.oo_.steady_state(7);
TANBNR_FER.l_rss = tanbnr_fer_results.oo_.steady_state(8);
TANBNR_FER.lss = tanbnr_fer_results.oo_.steady_state(9);
TANBNR_FER.y_tss = tanbnr_fer_results.oo_.steady_state(10);
TANBNR_FER.y_oss = tanbnr_fer_results.oo_.steady_state(11);
TANBNR_FER.p_tss = tanbnr_fer_results.oo_.steady_state(12);
TANBNR_FER.wss = tanbnr_fer_results.oo_.steady_state(13);
TANBNR_FER.piss = tanbnr_fer_results.oo_.steady_state(14);
TANBNR_FER.n_ass = tanbnr_fer_results.oo_.steady_state(15);
TANBNR_FER.n_bss = tanbnr_fer_results.oo_.steady_state(16);
TANBNR_FER.r_starss = tanbnr_fer_results.oo_.steady_state(17);
TANBNR_FER.pirss = tanbnr_fer_results.oo_.steady_state(18);
TANBNR_FER.pihss = tanbnr_fer_results.oo_.steady_state(19);

TANBNR_FER.c_aro = tanbnr_fer_results.oo_.irfs.c_aro_err_yo;
TANBNR_FER.c_art = tanbnr_fer_results.oo_.irfs.c_art_err_yo;
TANBNR_FER.c_aho = tanbnr_fer_results.oo_.irfs.c_aho_err_yo;
TANBNR_FER.c_aht = tanbnr_fer_results.oo_.irfs.c_aht_err_yo;
TANBNR_FER.c_bo  = tanbnr_fer_results.oo_.irfs.c_bo_err_yo;
TANBNR_FER.c_bt  = tanbnr_fer_results.oo_.irfs.c_bt_err_yo;
TANBNR_FER.l_r   = tanbnr_fer_results.oo_.irfs.l_r_err_yo;
TANBNR_FER.l_h   = tanbnr_fer_results.oo_.irfs.l_h_err_yo;
TANBNR_FER.l   = tanbnr_fer_results.oo_.irfs.l_err_yo;
TANBNR_FER.p_t   = tanbnr_fer_results.oo_.irfs.p_t_err_yo;
TANBNR_FER.pi    = tanbnr_fer_results.oo_.irfs.pi_err_yo;
TANBNR_FER.w     = tanbnr_fer_results.oo_.irfs.w_err_yo;
TANBNR_FER.y_o   = tanbnr_fer_results.oo_.irfs.y_o_err_yo;
TANBNR_FER.y_t   = tanbnr_fer_results.oo_.irfs.y_t_err_yo;

TANBNR_FER.eta = tanbnr_fer_results.M_.params(5);
TANBNR_FER.s_t = tanbnr_fer_results.M_.params(6);


tanbnr_pit_results = load("tanbnr_pit_results.mat");

TANBNR_PIT.c_ahoss = tanbnr_pit_results.oo_.steady_state(1);
TANBNR_PIT.c_aross = tanbnr_pit_results.oo_.steady_state(2);
TANBNR_PIT.c_boss = tanbnr_pit_results.oo_.steady_state(3);
TANBNR_PIT.c_ahtss = tanbnr_pit_results.oo_.steady_state(4);
TANBNR_PIT.c_artss = tanbnr_pit_results.oo_.steady_state(5);
TANBNR_PIT.c_btss = tanbnr_pit_results.oo_.steady_state(6);
TANBNR_PIT.l_hss = tanbnr_pit_results.oo_.steady_state(7);
TANBNR_PIT.l_rss = tanbnr_pit_results.oo_.steady_state(8);
TANBNR_PIT.lss = tanbnr_pit_results.oo_.steady_state(9);
TANBNR_PIT.y_tss = tanbnr_pit_results.oo_.steady_state(10);
TANBNR_PIT.y_oss = tanbnr_pit_results.oo_.steady_state(11);
TANBNR_PIT.p_tss = tanbnr_pit_results.oo_.steady_state(12);
TANBNR_PIT.ess = tanbnr_pit_results.oo_.steady_state(13);
TANBNR_PIT.wss = tanbnr_pit_results.oo_.steady_state(14);
TANBNR_PIT.piss = tanbnr_pit_results.oo_.steady_state(15);
TANBNR_PIT.n_ass = tanbnr_pit_results.oo_.steady_state(16);
TANBNR_PIT.n_bss = tanbnr_pit_results.oo_.steady_state(17);
TANBNR_PIT.r_starss = tanbnr_pit_results.oo_.steady_state(18);
TANBNR_PIT.pirss = tanbnr_pit_results.oo_.steady_state(19);
TANBNR_PIT.pihss = tanbnr_pit_results.oo_.steady_state(20);

TANBNR_PIT.c_aro = tanbnr_pit_results.oo_.irfs.c_aro_err_yo;
TANBNR_PIT.c_art = tanbnr_pit_results.oo_.irfs.c_art_err_yo;
TANBNR_PIT.c_aho = tanbnr_pit_results.oo_.irfs.c_aho_err_yo;
TANBNR_PIT.c_aht = tanbnr_pit_results.oo_.irfs.c_aht_err_yo;
TANBNR_PIT.c_bo  = tanbnr_pit_results.oo_.irfs.c_bo_err_yo;
TANBNR_PIT.c_bt  = tanbnr_pit_results.oo_.irfs.c_bt_err_yo;
TANBNR_PIT.l_r   = tanbnr_pit_results.oo_.irfs.l_r_err_yo;
TANBNR_PIT.l_h   = tanbnr_pit_results.oo_.irfs.l_h_err_yo;
TANBNR_PIT.l   = tanbnr_pit_results.oo_.irfs.l_err_yo;
TANBNR_PIT.p_t   = tanbnr_pit_results.oo_.irfs.p_t_err_yo;
```

```
TANBNR_PIT.e     = tanbnr_pit_results.oo_.irfs.e_err_yo;
TANBNR_PIT.pi    = tanbnr_pit_results.oo_.irfs.pi_err_yo;
TANBNR_PIT.w     = tanbnr_pit_results.oo_.irfs.w_err_yo;
TANBNR_PIT.y_o   = tanbnr_pit_results.oo_.irfs.y_o_err_yo;
TANBNR_PIT.y_t   = tanbnr_pit_results.oo_.irfs.y_t_err_yo;

TANBNR_PIT.eta = tanbnr_pit_results.M_.params(5);
TANBNR_PIT.s_t = tanbnr_pit_results.M_.params(6);


tanbfpnh_results = load("tanbfpnh_results.mat");

TANBFPNH.c_ahoss = tanbfpnh_results.oo_.steady_state(1);
TANBFPNH.c_aross = tanbfpnh_results.oo_.steady_state(2);
TANBFPNH.c_boss = tanbfpnh_results.oo_.steady_state(3);
TANBFPNH.c_ahtss = tanbfpnh_results.oo_.steady_state(4);
TANBFPNH.c_artss = tanbfpnh_results.oo_.steady_state(5);
TANBFPNH.c_btss = tanbfpnh_results.oo_.steady_state(6);
TANBFPNH.l_hss = tanbfpnh_results.oo_.steady_state(7);
TANBFPNH.l_rss = tanbfpnh_results.oo_.steady_state(8);
TANBFPNH.lss = tanbfpnh_results.oo_.steady_state(9);
TANBFPNH.y_tss = tanbfpnh_results.oo_.steady_state(10);
TANBFPNH.y_oss = tanbfpnh_results.oo_.steady_state(11);
TANBFPNH.p_tss = tanbfpnh_results.oo_.steady_state(12);
TANBFPNH.wss = tanbfpnh_results.oo_.steady_state(13);
TANBFPNH.piss = tanbfpnh_results.oo_.steady_state(14);
TANBFPNH.n_ass = tanbfpnh_results.oo_.steady_state(15);
TANBFPNH.n_bss = tanbfpnh_results.oo_.steady_state(16);
TANBFPNH.rstarss = tanbfpnh_results.oo_.steady_state(17);
TANBFPNH.pirss = tanbfpnh_results.oo_.steady_state(18);
TANBFPNH.pihss = tanbfpnh_results.oo_.steady_state(19);

TANBFPNH.c_aro = tanbfpnh_results.oo_.irfs.c_aro_err_yo;
TANBFPNH.c_art = tanbfpnh_results.oo_.irfs.c_art_err_yo;
TANBFPNH.c_aho = tanbfpnh_results.oo_.irfs.c_aho_err_yo;
TANBFPNH.c_aht = tanbfpnh_results.oo_.irfs.c_aht_err_yo;
TANBFPNH.c_bo  = tanbfpnh_results.oo_.irfs.c_bo_err_yo;
TANBFPNH.c_bt  = tanbfpnh_results.oo_.irfs.c_bt_err_yo;
TANBFPNH.l_r   = tanbfpnh_results.oo_.irfs.l_r_err_yo;
TANBFPNH.l_h   = tanbfpnh_results.oo_.irfs.l_h_err_yo;
TANBFPNH.l   = tanbfpnh_results.oo_.irfs.l_err_yo;
TANBFPNH.p_t   = tanbfpnh_results.oo_.irfs.p_t_err_yo;
TANBFPNH.pi    = tanbfpnh_results.oo_.irfs.pi_err_yo;
TANBFPNH.w     = tanbfpnh_results.oo_.irfs.w_err_yo;
TANBFPNH.y_o   = tanbfpnh_results.oo_.irfs.y_o_err_yo;
TANBFPNH.y_t   = tanbfpnh_results.oo_.irfs.y_t_err_yo;

TANBFPNH.eta = tanbfpnh_results.M_.params(4);
TANBFPNH.s_art = tanbfpnh_results.M_.params(5);
TANBFPNH.s_aht = tanbfpnh_results.M_.params(6);
TANBFPNH.s_bt = tanbfpnh_results.M_.params(7);

TANBFPNH.s_t = chi * TANBFPNH.s_art + (1 - chi) * TANBFPNH.s_aht;


%--------------------------------------------------------------
% 4. Function definition
%--------------------------------------------------------------

% CES aggregator:

function cons = ces_agg(c_t, c_o, eta, s_t)

  cons = (s_t * c_t.^(1 - 1 / eta) +
                    (1 - s_t) * c_o.^(1 - 1 / eta)).^(eta / (eta - 1));

endfunction



%--------------------------------------------------------------
% 3. Create key variables
%--------------------------------------------------------------

```

```
% output in country A

RAFAFP.output = RAFAFP.y_t + RAFAFP.y_tss;
RANBFP.output = RANBFP.y_t + RANBFP.y_tss;
TANBFP.output = TANBFP.y_t + TANBFP.y_tss;
TANBNR_FER.output = TANBNR_FER.y_t + TANBNR_FER.y_tss;
TANBNR_PIT.output = TANBNR_PIT.y_t + TANBNR_PIT.y_tss;
TANBFPNH.output = TANBFPNH.y_t + TANBFPNH.y_tss;


% price levels

% re-express eveything as levels
RAFAFP.p_t = RAFAFP.p_t + RAFAFP.p_tss;
RAFAFP.p_o = 1;

% create a price index
RAFAFP.price = ces_agg(RAFAFP.p_t, RAFAFP.p_o, RAFAFP.eta, RAFAFP.s_t);


RANBFP.p_t = RANBFP.p_t + RANBFP.p_tss;
RANBFP.p_o = 1;

RANBFP.price = ces_agg(RANBFP.p_t, RANBFP.p_o, RANBFP.eta, RANBFP.s_t);


TANBFP.p_t = TANBFP.p_t + TANBFP.p_tss;
TANBFP.p_o = 1;

TANBFP.price = ces_agg(TANBFP.p_t, TANBFP.p_o, TANBFP.eta, TANBFP.s_t);


TANBNR_FER.p_t = TANBNR_FER.p_t + TANBNR_FER.p_tss;
TANBNR_FER.p_o = 1;

TANBNR_FER.price = ces_agg(TANBNR_FER.p_t, TANBNR_FER.p_o, TANBNR_FER.eta, TANBNR_FER.s_t);


TANBNR_PIT.p_at = TANBNR_PIT.p_tss;
TANBNR_PIT.p_ao = TANBNR_PIT.e + TANBNR_PIT.ess;

TANBNR_PIT.price_a = ces_agg(TANBNR_PIT.p_at, TANBNR_PIT.p_ao, TANBNR_PIT.eta, TANBNR_PIT.s_t);


TANBNR_PIT.p_bt = TANBNR_PIT.p_tss ./ (TANBNR_PIT.e + TANBNR_PIT.ess);
TANBNR_PIT.p_bo = 1;

TANBNR_PIT.price_b = ces_agg(TANBNR_PIT.p_bt, TANBNR_PIT.p_bo, TANBNR_PIT.eta, TANBNR_PIT.s_t);


TANBFPNH.p_t = TANBFPNH.p_t + TANBFPNH.p_tss;
TANBFPNH.p_o = 1;

TANBFPNH.price = ces_agg(TANBFPNH.p_t, TANBFPNH.p_o, TANBFPNH.eta, TANBFPNH.s_t);



% Inflation
RAFAFP.infl = diff(RAFAFP.price) ./ RAFAFP.price(1:(end-1)) * 100;
RANBFP.infl = diff(RANBFP.price) ./ RANBFP.price(1:(end-1)) * 100;
TANBFP.infl = diff(TANBFP.price) ./ TANBFP.price(1:(end-1)) * 100;
TANBNR_FER.infl = diff(TANBNR_FER.price) ./ TANBNR_FER.price(1:(end-1)) * 100;
TANBNR_PIT.infl_a = diff(TANBNR_PIT.price_a) ./ TANBNR_PIT.price_a(1:(end-1)) * 100;
TANBNR_PIT.infl_b = diff(TANBNR_PIT.price_b) ./ TANBNR_PIT.price_b(1:(end-1)) * 100;
TANBFPNH.infl = diff(TANBFPNH.price) ./ TANBFPNH.price(1:(end-1)) * 100;


% consumption

% re-express eveything as levels
RAFAFP.c_at = RAFAFP.c_at + RAFAFP.c_atss;
RAFAFP.c_ao = RAFAFP.c_ao + RAFAFP.c_aoss;
RAFAFP.c_bt = RAFAFP.c_bt + RAFAFP.c_btss;
RAFAFP.c_bo = RAFAFP.c_bo + RAFAFP.c_boss;
```

```
% rule out negative consumption
RAFAFP.c_at = max(RAFAFP.c_at, eps);
RAFAFP.c_ao = max(RAFAFP.c_ao, eps);
RAFAFP.c_bt = max(RAFAFP.c_bt, eps);
RAFAFP.c_bo = max(RAFAFP.c_bo, eps);

% compute consumption basket
RAFAFP.c_a = ces_agg(RAFAFP.c_at, RAFAFP.c_ao, RAFAFP.eta, RAFAFP.s_t);
RAFAFP.c_b = ces_agg(RAFAFP.c_bt, RAFAFP.c_bo, RAFAFP.eta, RAFAFP.s_t);


RANBFP.c_at = RANBFP.c_at + RANBFP.c_atss;
RANBFP.c_ao = RANBFP.c_ao + RANBFP.c_aoss;
RANBFP.c_bt = RANBFP.c_bt + RANBFP.c_btss;
RANBFP.c_bo = RANBFP.c_bo + RANBFP.c_boss;

RANBFP.c_at = max(RANBFP.c_at, eps);
RANBFP.c_ao = max(RANBFP.c_ao, eps);
RANBFP.c_bt = max(RANBFP.c_bt, eps);
RANBFP.c_bo = max(RANBFP.c_bo, eps);

RANBFP.c_a = ces_agg(RANBFP.c_at, RANBFP.c_ao, RANBFP.eta, RANBFP.s_t);
RANBFP.c_b = ces_agg(RANBFP.c_bt, RANBFP.c_bo, RANBFP.eta, RANBFP.s_t);


TANBFP.c_art = TANBFP.c_art + TANBFP.c_artss;
TANBFP.c_aro = TANBFP.c_aro + TANBFP.c_aross;
TANBFP.c_aht = TANBFP.c_aht + TANBFP.c_ahtss;
TANBFP.c_aho = TANBFP.c_aho + TANBFP.c_ahoss;
TANBFP.c_bt = TANBFP.c_bt + TANBFP.c_btss;
TANBFP.c_bo = TANBFP.c_bo + TANBFP.c_boss;

TANBFP.c_art = max(TANBFP.c_art, eps);
TANBFP.c_aro = max(TANBFP.c_aro, eps);
TANBFP.c_aht = max(TANBFP.c_aht, eps);
TANBFP.c_aho = max(TANBFP.c_aho, eps);
TANBFP.c_bt = max(TANBFP.c_bt, eps);
TANBFP.c_bo = max(TANBFP.c_bo, eps);

TANBFP.c_ar = ces_agg(TANBFP.c_art, TANBFP.c_aro, TANBFP.eta, TANBFP.s_t);
TANBFP.c_ah = ces_agg(TANBFP.c_aht, TANBFP.c_aho, TANBFP.eta, TANBFP.s_t);
TANBFP.c_b = ces_agg(TANBFP.c_bt, TANBFP.c_bo, TANBFP.eta, TANBFP.s_t);


TANBNR_FER.c_art = TANBNR_FER.c_art + TANBNR_FER.c_artss;
TANBNR_FER.c_aro = TANBNR_FER.c_aro + TANBNR_FER.c_aross;
TANBNR_FER.c_aht = TANBNR_FER.c_aht + TANBNR_FER.c_ahtss;
TANBNR_FER.c_aho = TANBNR_FER.c_aho + TANBNR_FER.c_ahoss;
TANBNR_FER.c_bt = TANBNR_FER.c_bt + TANBNR_FER.c_btss;
TANBNR_FER.c_bo = TANBNR_FER.c_bo + TANBNR_FER.c_boss;

TANBNR_FER.c_art = max(TANBNR_FER.c_art, eps);
TANBNR_FER.c_aro = max(TANBNR_FER.c_aro, eps);
TANBNR_FER.c_aht = max(TANBNR_FER.c_aht, eps);
TANBNR_FER.c_aho = max(TANBNR_FER.c_aho, eps);
TANBNR_FER.c_bt = max(TANBNR_FER.c_bt, eps);
TANBNR_FER.c_bo = max(TANBNR_FER.c_bo, eps);

TANBNR_FER.c_ar = ces_agg(TANBNR_FER.c_art, TANBNR_FER.c_aro, TANBNR_FER.eta, TANBNR_FER.s_t);
TANBNR_FER.c_ah = ces_agg(TANBNR_FER.c_aht, TANBNR_FER.c_aho, TANBNR_FER.eta, TANBNR_FER.s_t);
TANBNR_FER.c_b = ces_agg(TANBNR_FER.c_bt, TANBNR_FER.c_bo, TANBNR_FER.eta, TANBNR_FER.s_t);


TANBNR_PIT.c_art = TANBNR_PIT.c_art + TANBNR_PIT.c_artss;
TANBNR_PIT.c_aro = TANBNR_PIT.c_aro + TANBNR_PIT.c_aross;
TANBNR_PIT.c_aht = TANBNR_PIT.c_aht + TANBNR_PIT.c_ahtss;
TANBNR_PIT.c_aho = TANBNR_PIT.c_aho + TANBNR_PIT.c_ahoss;
TANBNR_PIT.c_bt = TANBNR_PIT.c_bt + TANBNR_PIT.c_btss;
TANBNR_PIT.c_bo = TANBNR_PIT.c_bo + TANBNR_PIT.c_boss;

TANBNR_PIT.c_art = max(TANBNR_PIT.c_art, eps);
TANBNR_PIT.c_aro = max(TANBNR_PIT.c_aro, eps);
TANBNR_PIT.c_aht = max(TANBNR_PIT.c_aht, eps);
```

```
TANBNR_PIT.c_aho = max(TANBNR_PIT.c_aho, eps);
TANBNR_PIT.c_bt = max(TANBNR_PIT.c_bt, eps);
TANBNR_PIT.c_bo = max(TANBNR_PIT.c_bo, eps);

TANBNR_PIT.c_ar = ces_agg(TANBNR_PIT.c_art, TANBNR_PIT.c_aro, TANBNR_PIT.eta, TANBNR_PIT.s_t);
TANBNR_PIT.c_ah = ces_agg(TANBNR_PIT.c_aht, TANBNR_PIT.c_aho, TANBNR_PIT.eta, TANBNR_PIT.s_t);
TANBNR_PIT.c_b = ces_agg(TANBNR_PIT.c_bt, TANBNR_PIT.c_bo, TANBNR_PIT.eta, TANBNR_PIT.s_t);


TANBFPNH.c_art = TANBFPNH.c_art + TANBFPNH.c_artss;
TANBFPNH.c_aro = TANBFPNH.c_aro + TANBFPNH.c_aross;
TANBFPNH.c_aht = TANBFPNH.c_aht + TANBFPNH.c_ahtss;
TANBFPNH.c_aho = TANBFPNH.c_aho + TANBFPNH.c_ahoss;
TANBFPNH.c_bt = TANBFPNH.c_bt + TANBFPNH.c_btss;
TANBFPNH.c_bo = TANBFPNH.c_bo + TANBFPNH.c_boss;

TANBFPNH.c_art = max(TANBFPNH.c_art, eps);
TANBFPNH.c_aro = max(TANBFPNH.c_aro, eps);
TANBFPNH.c_aht = max(TANBFPNH.c_aht, eps);
TANBFPNH.c_aho = max(TANBFPNH.c_aho, eps);
TANBFPNH.c_bt = max(TANBFPNH.c_bt, eps);
TANBFPNH.c_bo = max(TANBFPNH.c_bo, eps);

TANBFPNH.c_ar = ces_agg(TANBFPNH.c_art, TANBFPNH.c_aro, TANBFPNH.eta, TANBFPNH.s_art);
TANBFPNH.c_ah = ces_agg(TANBFPNH.c_aht, TANBFPNH.c_aho, TANBFPNH.eta, TANBFPNH.s_aht);
TANBFPNH.c_b = ces_agg(TANBFPNH.c_bt, TANBFPNH.c_bo, TANBFPNH.eta, TANBFPNH.s_bt);



% labour supply

RAFAFP.l = RAFAFP.l + RAFAFP.lss;

RANBFP.l = RANBFP.l + RANBFP.lss;

TANBFP.l = TANBFP.l + TANBFP.lss;
TANBFP.l_r = TANBFP.l_r + TANBFP.l_rss;
TANBFP.l_h = TANBFP.l_h + TANBFP.l_hss;

TANBNR_FER.l = TANBNR_FER.l + TANBNR_FER.lss;
TANBNR_FER.l_r = TANBNR_FER.l_r + TANBNR_FER.l_rss;
TANBNR_FER.l_h = TANBNR_FER.l_h + TANBNR_FER.l_hss;

TANBNR_PIT.l = TANBNR_PIT.l + TANBNR_PIT.lss;
TANBNR_PIT.l_r = TANBNR_PIT.l_r + TANBNR_PIT.l_rss;
TANBNR_PIT.l_h = TANBNR_PIT.l_h + TANBNR_PIT.l_hss;

TANBFPNH.l = TANBFPNH.l + TANBFPNH.lss;
TANBFPNH.l_r = TANBFPNH.l_r + TANBFPNH.l_rss;
TANBFPNH.l_h = TANBFPNH.l_h + TANBFPNH.l_hss;


% discount vector
betas = zeros(1, 100);

for t = 1:length(betas)

  betas(1, t) = beta^(t - 1);

endfor



% welfare

RAFAFP.utility_a = log(RAFAFP.c_a) + psi * log(1 - RAFAFP.l);
RAFAFP.welfare_a = betas * RAFAFP.utility_a.';

RAFAFP.utility_b = log(RAFAFP.c_b);
RAFAFP.welfare_b = betas * RAFAFP.utility_b.';


RANBFP.utility_a = log(RANBFP.c_a) + psi * log(1 - RANBFP.l);
RANBFP.welfare_a = betas * RANBFP.utility_a.';
```

```
RANBFP.utility_b = log(RANBFP.c_b);
RANBFP.welfare_b = betas * RANBFP.utility_b.';


TANBFP.utility_ar = log(TANBFP.c_ar) + psi * log(1 - TANBFP.l_r);
TANBFP.welfare_ar = betas * TANBFP.utility_ar.';

TANBFP.utility_ah = log(TANBFP.c_ah) + psi * log(1 - TANBFP.l_h);
TANBFP.welfare_ah = betas * TANBFP.utility_ah.';

TANBFP.utility_b = log(TANBFP.c_b);
TANBFP.welfare_b = betas * TANBFP.utility_b.';


TANBNR_FER.utility_ar = log(TANBNR_FER.c_ar) + psi * log(1 - TANBNR_FER.l_r);
TANBNR_FER.welfare_ar = betas * TANBNR_FER.utility_ar.';

TANBNR_FER.utility_ah = log(TANBNR_FER.c_ah) + psi * log(1 - TANBNR_FER.l_h);
TANBNR_FER.welfare_ah = betas * TANBNR_FER.utility_ah.';

TANBNR_FER.utility_b = log(TANBNR_FER.c_b);
TANBNR_FER.welfare_b = betas * TANBNR_FER.utility_b.';


TANBNR_PIT.utility_ar = log(TANBNR_PIT.c_ar) + psi * log(1 - TANBNR_PIT.l_r);
TANBNR_PIT.welfare_ar = betas * TANBNR_PIT.utility_ar.';

TANBNR_PIT.utility_ah = log(TANBNR_PIT.c_ah) + psi * log(1 - TANBNR_PIT.l_h);
TANBNR_PIT.welfare_ah = betas * TANBNR_PIT.utility_ah.';

TANBNR_PIT.utility_b = log(TANBNR_PIT.c_b);
TANBNR_PIT.welfare_b = betas * TANBNR_PIT.utility_b.';


TANBFPNH.utility_ar = log(TANBFPNH.c_ar) + psi * log(1 - TANBFPNH.l_r);
TANBFPNH.welfare_ar = betas * TANBFPNH.utility_ar.';

TANBFPNH.utility_ah = log(TANBFPNH.c_ah) + psi * log(1 - TANBFPNH.l_h);
TANBFPNH.welfare_ah = betas * TANBFPNH.utility_ah.';

TANBFPNH.utility_b = log(TANBFPNH.c_b);
TANBFPNH.welfare_b = betas * TANBFPNH.utility_b.';



% import/export, trade balance in country A:
RAFAFP.import = RAFAFP.c_ao;
RAFAFP.export = RAFAFP.c_bt;
RAFAFP.nex = RAFAFP.export - RAFAFP.import;


RANBFP.import = RANBFP.c_ao;
RANBFP.export = RANBFP.c_bt;
RANBFP.nex = RANBFP.export - RANBFP.import;


TANBFP.import = chi * TANBFP.c_aro + (1 - chi) * TANBFP.c_aho;
TANBFP.export = TANBFP.c_bt;
TANBFP.nex = TANBFP.export - TANBFP.import;


TANBNR_FER.import = chi * TANBNR_FER.c_aro + (1 - chi) * TANBNR_FER.c_aho;
TANBNR_FER.export = TANBNR_FER.c_bt;
TANBNR_FER.nex = TANBNR_FER.export - TANBNR_FER.import;


TANBNR_PIT.import = chi * TANBNR_PIT.c_aro + (1 - chi) * TANBNR_PIT.c_aho;
TANBNR_PIT.export = TANBNR_PIT.c_bt;
TANBNR_PIT.nex = TANBNR_PIT.export - TANBNR_PIT.import;


TANBFPNH.import = chi * TANBFPNH.c_aro + (1 - chi) * TANBFPNH.c_aho;
TANBFPNH.export = TANBFPNH.c_bt;
```

```
TANBFPNH.nex = TANBFPNH.export - TANBFPNH.import;


%-----------------------------------------------------------------------
% 4. Plot IRFs
%-----------------------------------------------------------------------

% RAFAFP

subplot(3, 3, 1);
plot(1:100, RAFAFP.output, 1:100);
title('Output in country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 2);
plot(1:100, RAFAFP.price, 1:100, RAFAFP.p_tss);
title('Price index in country A and B');
xlabel('Quarters');
ylabel('Units of oil consumption');
subplot(3, 3, 3);
plot(1:99, RAFAFP.infl);
title('Inflation in country A and B');
xlabel('Quarters');
ylabel('Percent');
subplot(3, 3, 4);
plot(1:100, RAFAFP.c_a);
title('Consumption in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 5);
plot(1:100, RAFAFP.c_b);
title('Consumption in Country B');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 6);
plot(1:100, RAFAFP.import);
title('Import in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 7);
plot(1:100, RAFAFP.export);
title('Export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 8);
plot(1:100, RAFAFP.nex);
title('Net export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');

saveas(gcf, 'rafafp.jpg');


% RANBFP

subplot(3, 3, 1);
plot(1:100, RANBFP.output);
title('Output in country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 2);
plot(1:100, RANBFP.price);
title('Price index in country A and B');
xlabel('Quarters');
ylabel('Units of oil consumption');
subplot(3, 3, 3);
plot(1:99, RANBFP.infl);
title('Inflation in country A and B');
xlabel('Quarters');
ylabel('Percent');
subplot(3, 3, 4);
plot(1:100, RANBFP.c_a);
title('Consumption in Country A');
xlabel('Quarters');
```

```
ylabel('Units of tradeable cons.');
subplot(3, 3, 5);
plot(1:100, RANBFP.c_b);
title('Consumption in Country B');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 6);
plot(1:100, RANBFP.import);
title('Import in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 7);
plot(1:100, RANBFP.export);
title('Export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 8);
plot(1:100, RANBFP.nex);
title('Net export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');

saveas(gcf, 'ranbfp.jpg');


% TANBFP

subplot(3, 3, 1);
plot(1:100, TANBFP.output);
title('Output in country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 2);
plot(1:100, TANBFP.price);
title('Price index in country A and B');
xlabel('Quarters');
ylabel('Units of oil consumption');
subplot(3, 3, 3);
plot(1:99, TANBFP.infl);
title('Inflation in country A and B');
xlabel('Quarters');
ylabel('Percent');
subplot(3, 3, 4);
plot(1:100, TANBFP.c_ar);
title('Consumption for Ricardians');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 5);
plot(1:100, TANBFP.c_ah);
title('Consumption for HTMs');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 6);
plot(1:100, TANBFP.c_b);
title('Consumption in Country B');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 7);
plot(1:100, TANBFP.import);
title('Import in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 8);
plot(1:100, TANBFP.export);
title('Export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 9);
plot(1:100, TANBFP.nex);
title('Net export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');

saveas(gcf, 'tanbfp.jpg');
```

```
% TANBNR_FER

subplot(3, 3, 1);
plot(1:100, TANBNR_FER.output);
title('Output in country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 2);
plot(1:100, TANBNR_FER.price);
title('Price index in country A and B');
xlabel('Quarters');
ylabel('Units of oil consumption');
subplot(3, 3, 3);
plot(1:99, TANBNR_FER.infl);
title('Inflation in country A and B');
xlabel('Quarters');
ylabel('Percent');
subplot(3, 3, 4);
plot(1:100, TANBNR_FER.c_ar);
title('Consumption for Ricardians');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 5);
plot(1:100, TANBNR_FER.c_ah);
title('Consumption for HTMs');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 6);
plot(1:100, TANBNR_FER.c_b);
title('Consumption in Country B');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 7);
plot(1:100, TANBNR_FER.import);
title('Import in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 8);
plot(1:100, TANBNR_FER.export);
title('Export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 9);
plot(1:100, TANBNR_FER.nex);
title('Net export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');

saveas(gcf, 'tanbnr_fer.jpg');



% TANBNR_PIT

subplot(5, 3, 1);
plot(1:100, TANBNR_PIT.output);
title('Output in country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(5, 3, 2);
plot(1:100, TANBNR_PIT.price_a);
title('Price index in country A');
xlabel('Quarters');
ylabel('Units of oil consumption');
subplot(5, 3, 3);
plot(1:100, TANBNR_PIT.price_b);
title('Price index in country B');
xlabel('Quarters');
ylabel('Units of oil consumption');
```

```
subplot(5, 3, 4);
plot(1:99, TANBNR_PIT.infl_a);
title('Inflation in country A');
xlabel('Quarters');
ylabel('Percent');
subplot(5, 3, 5);
plot(1:99, TANBNR_PIT.infl_b);
title('Inflation in country B');
xlabel('Quarters');
ylabel('Percent');
subplot(5, 3, 6);
plot(1:100, TANBNR_PIT.c_ar);
title('Consumption for Ricardians');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(5, 3, 7);
plot(1:100, TANBNR_PIT.c_ah);
title('Consumption for HTMs');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(5, 3, 8);
plot(1:100, TANBNR_PIT.c_b);
title('Consumption in Country B');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(5, 3, 9);
plot(1:100, TANBNR_PIT.import);
title('Import in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(5, 3, 10);
plot(1:100, TANBNR_PIT.export);
title('Export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(5, 3, 11);
plot(1:100, TANBNR_PIT.nex);
title('Net export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');

saveas(gcf, 'tanbnr_pit.jpg');



% TANBFPNH

subplot(3, 3, 1);
plot(1:100, TANBFP.output);
title('Output in country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 2);
plot(1:100, TANBFPNH.price);
title('Price index in country A and B');
xlabel('Quarters');
ylabel('Units of oil consumption');
subplot(3, 3, 3);
plot(1:99, TANBFPNH.infl);
title('Inflation in country A and B');
xlabel('Quarters');
ylabel('Percent');
subplot(3, 3, 4);
plot(1:100, TANBFPNH.c_ar);
title('Consumption for Ricardians');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 5);
plot(1:100, TANBFPNH.c_ah);
title('Consumption for HTMs');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 6);
plot(1:100, TANBFPNH.c_b);
```

```
title('Consumption in Country B');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 7);
plot(1:100, TANBFPNH.import);
title('Import in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 8);
plot(1:100, TANBFPNH.export);
title('Export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');
subplot(3, 3, 9);
plot(1:100, TANBFPNH.nex);
title('Net export in Country A');
xlabel('Quarters');
ylabel('Units of tradeable cons.');

saveas(gcf, 'tanbfpnh.jpg');
```

Appendix A2: Parameter File

```

%--------------------------------------------------------------------------
%
% Title: International Macro-Finance Problem Set 4, parameter file
% Author: ---
% Date: 10/01/2024
% Description: Parameter file for the final problem set
%
%--------------------------------------------------------------------------


%--------------------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%--------------------------------------------------------------------------

close all;
clear all;

%--------------------------------------------------------------------------
% 1. Defining parameters
%--------------------------------------------------------------------------


% key moments to target:
% y_o = 12.1 * 365 * 90 * 10^(-6) = .4 Saudi oil production in 2022, tn euro
% c_ao  = .46 EU import of oil from Saudi Arabia in 2022, tn euro
% l = .22; average weekly work hours in the EU (37.5 / (24 * 7))
% y_t * p_t = 16.75 EU GDP in 2022, tn USD

% this implies:
% y_t = l^(1 - alpha) = .35 with alpha = .3
% p_t = 16.75 / .35 = 47.86


par.alpha = .3; % income share of capital
par.beta  = .99;
par.psi = 1.5; % elasticity of labour supply, normally between 1 and 2 (see Blundell et al. 2000)
par.phi = 10; % strength of the nominal rigidity
par.eta = .4; % elasticity of substitution between the tradeable good and oil
par.s_t = .75; % home bias towards tradeable in both countries
par.s_art = .78; %  home bias towards tradeable for ricardians
par.s_aht = .9; % home bias towards tradeable for htms
par.s_bt  = .8; % home bias towards tradeable in country b
par.theta = .4; % elasticity of substitution between goods in the tradeable sector
par.rho = .9; % persistence of shock
par.gamma = .1; % mean oil endowment of country b (y_bbar = gamma / (1 - rho))
par.chi = .8; % proportion of ricardian HHs in country a
```

Appendix B: RAFAFP mod file

```

%-------------------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ----
% Date: 25/12/2023
% Description: Representative agent, financial autarky, flexible prices
%
%-------------------------------------------------------------------------


%-------------------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%-------------------------------------------------------------------------

close all;

%-------------------------------------------------------------------------
% 1. Defining variables
%-------------------------------------------------------------------------

var c_ao c_bo c_at c_bt l y_t y_o p_t w pi;

varexo err_yo;


%-------------------------------------------------------------------------
% 2. Calibration
%-------------------------------------------------------------------------

parameters alpha psi eta s_t theta rho gamma;

load parameters;

set_param_value('alpha'   ,par.alpha);
set_param_value('psi'     ,par.psi);
set_param_value('eta'     ,par.eta);
set_param_value('s_t'     ,par.s_t);
set_param_value('theta'   ,par.theta);
set_param_value('rho'     ,par.rho);
set_param_value('gamma'   ,par.gamma);


%-------------------------------------------------------------------------
% 3. Model
%-------------------------------------------------------------------------


model;

% consumption allocation between oil and tradeable in country a
(1 - s_t) * c_ao^(-1 / eta) - s_t * c_at^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
(1 - s_t) * c_bo^(-1 / eta) - s_t * c_bt^(-1 / eta) / p_t;

% HH's labour supply decision in country a
psi - (1 - s_t) * c_ao^(-1 / eta) / (s_t * c_at^(1 - 1 / eta) +
                      (1 - s_t) * c_ao^(1 - 1 / eta)) *
                                w * (1 - l);

% HH's budget constraint in country a
p_t * c_at + c_ao - w * l - pi;

% HH's budget constraint in country b
c_bo + p_t * c_bt  - y_o;

% firm's FOC
(1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta - w;

% firm's profit
p_t * l^(1 - alpha) - w * l - pi;
```

```
% tradeable goods market-clearing condition
y_t - c_at - c_bt;

% oil market-clearing condition
y_o - c_ao - c_bo;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

end;


%----------------------------------------------------------------------
% 4. Steady state
%----------------------------------------------------------------------


initval;

l = .22;
c_ao = .46;
y_t = l^(1 - alpha);
p_t = 16.75 / y_t;
c_at = s_t^eta * c_ao / (p_t^eta * (1 - s_t)^eta);
c_bt = y_t - c_at;
y_o = gamma / (1 - rho);
c_bo = y_o - c_ao;
w = (1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta;
pi = p_t * l^(1 - alpha) - w * l;

end;

steady(maxit = 1000, solve_algo = 1);


%----------------------------------------------------------------------
% 5. Impulse response function
%----------------------------------------------------------------------


shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1, irf=100, irf_plot_threshold=0) c_ao
                              c_bo c_at c_bt l y_t y_o p_t w pi;
```

Appendix C: RANBFP mod file

```

%----------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ---
% Date: 25/12/2023
% Description: Representative agent, nominal bond, flexible prices
%
%----------------------------------------------------------------


%----------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%----------------------------------------------------------------

close all;

%----------------------------------------------------------------
% 1. Defining variables
%----------------------------------------------------------------

var c_ao c_bo c_at c_bt l y_t y_o p_t w pi n_a n_b r_star;

varexo err_yo;


%----------------------------------------------------------------
% 2. Calibration
%----------------------------------------------------------------

parameters alpha beta psi eta s_t theta rho gamma;

load parameters;

set_param_value('alpha'   ,par.alpha);
set_param_value('beta'   ,par.beta);
set_param_value('psi'     ,par.psi);
set_param_value('eta'     ,par.eta);
set_param_value('s_t'     ,par.s_t);
set_param_value('theta'   ,par.theta);
set_param_value('rho'     ,par.rho);
set_param_value('gamma'   ,par.gamma);

s_t = .8;
theta = .65;


%----------------------------------------------------------------
% 3. Model
%----------------------------------------------------------------


model;

% consumption allocation between oil and tradeable in country a
(1 - s_t) * c_ao^(-1 / eta) - s_t * c_at^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
(1 - s_t) * c_bo^(-1 / eta) - s_t * c_bt^(-1 / eta) / p_t;

% Euler equation in country a
c_ao^(-1 / eta) / (s_t * c_at^(1 - 1 / eta) +
     (1 - s_t) * c_ao^(1 - 1 / eta))
         - beta * r_star *
                  c_ao(+1)^(-1 / eta) / (s_t * c_at(+1)^(1 - 1 / eta) +
                             (1 - s_t) * c_ao(+1)^(1 - 1 / eta));

% Euler equation in country b
c_bo^(-1 / eta) / (s_t * c_bt^(1 - 1 / eta) +
     (1 - s_t) * c_bo^(1 - 1 / eta)) -
         beta * r_star *
                  c_bo(+1)^(-1 / eta) / (s_t * c_bt(+1)^(1 - 1 / eta) +
                             (1 - s_t) * c_bo(+1)^(1 - 1 / eta));
```

```
% HH's labour supply decision in country a
psi - (1 - s_t) * c_ao^(-1 / eta) / (s_t * c_at^(1 - 1 / eta) +
                      (1 - s_t) * c_ao^(1 - 1 / eta)) *
                                w * (1 - l);

% HH's budget constraint in country a
p_t * c_at + c_ao - w * l - pi - (n_a(-1) - n_a / r_star);

% HH's budget constraint in country b
c_bo + p_t * c_bt  - y_o - (n_b(-1) - n_b / r_star);

% firm's FOC
(1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta - w;

% firm's profit
p_t * l^(1 - alpha) - w * l - pi;

% tradeable goods market-clearing condition
y_t - c_at - c_bt;

% oil market-clearing condition
y_o - c_ao - c_bo;

% bond market clearing condition
n_a + n_b;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

end;


%------------------------------------------------------------------
% 4. Steady state
%------------------------------------------------------------------


initval;

l = .22;
c_ao = .46;
y_t = l^(1 - alpha); % from production function
p_t = 16.75 / y_t; % from target GDP in country a
c_at = s_t^eta * c_ao / (p_t^eta * (1 - s_t)^eta); % from tradeable-oil tradeoff
c_bt = y_t - c_at; % from tradeable MC
y_o = gamma / (1 - rho); % from oil stochastic process
c_bo = y_o - c_ao; % from oil MC
w = (1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta; % from firm's FOC
pi = p_t * l^(1 - alpha) - w * l; % from firm's profit
r_star = 1 / beta; % from SS Euler
n_a = r_star / (r_star - 1) * (p_t * c_at + c_ao - w * l - pi); % from the BC
n_b = - n_a; % from bond MC

end;

steady(maxit = 1000);


%------------------------------------------------------------------
% 5. Impulse response function
%------------------------------------------------------------------

initval;

c_ao = 0.425983;
c_bo = 0.174017;
c_at = 0.318506;
c_bt = 0.130112;
l = 0.318186;
y_t = 0.448618;
y_o = 0.6;
```

```
p_t = 30.8469;
w = 4.56664;
pi = 12.3854;
n_a = -358.757;
n_b = 358.757;
r_star = 1.0101;


end;

endval;

n_a = -358.757;
n_b = 358.757;

end;


shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1,  irf=100, irf_plot_threshold=0) c_ao
                               c_bo c_at c_bt l y_t y_o p_t w pi r_star
                               n_a n_b;

model_diagnostics;
```

Appendix D: TANBFP mod file

```

%--------------------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ---
% Date: 25/12/2023
% Description: Two agent, nominal bond, flexible prices
%
%--------------------------------------------------------------------------


%--------------------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%--------------------------------------------------------------------------

close all;

%--------------------------------------------------------------------------
% 1. Defining variables
%--------------------------------------------------------------------------

var c_aho c_aro c_bo c_aht c_art c_bt l_h l_r l y_t y_o p_t w pi
          n_a n_b r_star pi_r pi_h;

varexo err_yo;


%--------------------------------------------------------------------------
% 2. Calibration
%--------------------------------------------------------------------------

parameters alpha beta psi eta s_t theta rho gamma chi;
load parameters;

set_param_value('alpha'    ,par.alpha);
set_param_value('beta'     ,par.beta);
set_param_value('psi'      ,par.psi);
set_param_value('eta'      ,par.eta);
set_param_value('s_t'    ,par.s_t);
set_param_value('theta'    ,par.theta);
set_param_value('rho'      ,par.rho);
set_param_value('gamma'    ,par.gamma);
set_param_value('chi'      ,par.chi);

s_t = .8;
theta = .5;



%--------------------------------------------------------------------------
% 3. Model
%--------------------------------------------------------------------------


model;

% consumption allocation between oil and tradeable for htm HHs in country a
(1 - s_t) * c_aho^(-1 / eta) - s_t * c_aht^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable for ricardian HHs in country a
(1 - s_t) * c_aro^(-1 / eta) - s_t * c_art^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
(1 - s_t) * c_bo^(-1 / eta) - s_t * c_bt^(-1 / eta) / p_t;

% Euler equation for ricardian HHs in country a
c_aro^(-1 / eta) / (s_t * c_art^(1 - 1 / eta) +
     (1 - s_t) * c_aro^(1 - 1 / eta)) -
          beta * r_star *
                 c_aro(+1)^(-1 / eta) / (s_t * c_art(+1)^(1 - 1 / eta) +
                          (1 - s_t) * c_aro(+1)^(1 - 1 / eta));

% Euler equation in country b
```

```
c_bo^(-1 / eta) / (s_t * c_bt^(1 - 1 / eta) +
     (1 - s_t) * c_bo^(1 - 1 / eta)) -
       beta * r_star *
                  c_bo(+1)^(-1 / eta) / (s_t * c_bt(+1)^(1 - 1 / eta) +
                             (1 - s_t) * c_bo(+1)^(1 - 1 / eta));

% labour supply decision for htm HHs in country a
psi - (1 - s_t) * c_aho^(-1 / eta) / (s_t * c_aht^(1 - 1 / eta) +
                      (1 - s_t) * c_aho^(1 - 1 / eta)) *
                                w * (1 - l_h);

% labour supply decision for ricardian HHs in country a
psi - (1 - s_t) * c_aro^(-1 / eta) / (s_t * c_art^(1 - 1 / eta) +
                      (1 - s_t) * c_aro^(1 - 1 / eta)) *
                                w * (1 - l_r);

% htm's budget constraint in country a
p_t * c_aht + c_aho - w * l_h - pi_h;

% ricardian's budget constraint in country a
p_t * c_art + c_aro - w * l_r - pi_r - (n_a(-1) - n_a / r_star);

% HH's budget constraint in country b
c_bo + p_t * c_bt  - y_o - (n_b(-1) - n_b / r_star);

% firm's FOC
(1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta - w;

% firm's profit
p_t * l^(1 - alpha) - w * l - pi;

% profit distribution
chi * pi_r + (1 - chi) * pi_h - pi;

% fix ricardian's profit
pi_r - pi;

% tradeable goods market-clearing condition
y_t - (1 - chi) * c_aht - chi * c_art - c_bt;

% oil market-clearing condition
y_o - (1 - chi) * c_aho - chi * c_aro - c_bo;

% labour market-clearing condition
chi * l_r + (1 - chi) * l_h - l;

% bond market clearing condition
chi * n_a + n_b;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

end;


%-----------------------------------------------------------------
% 4. Steady state
%-----------------------------------------------------------------


initval;

l_r = .22;
l_h = .22;
c_aro = .46;
c_aho = .46;
l = chi * l_r + (1 - chi) * l_h;
y_t = l^(1 - alpha); % from production function
p_t = 16.75 / y_t; % from target GDP in country a
c_art = s_t^eta * c_aro / (p_t^eta * (1 - s_t)^eta); % from tradeable-oil tradeoff
c_aht = s_t^eta * c_aho / (p_t^eta * (1 - s_t)^eta);
c_bt = y_t - chi * c_art - (1 - chi) * c_aht; % from tradeable MC
y_o = gamma / (1 - rho); % from oil stochastic process
```

```
c_bo = y_o - chi * c_aro - (1 - chi) * c_aho; % from oil MC
w = (1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta; % from firm's FOC
pi = p_t * l^(1 - alpha) - w * l; % from firm's profit
pi_r = pi;
pi_h = (pi - chi * pi_r) / (1 - chi);
r_star = 1 / beta; % from SS Euler
n_a = r_star / (r_star - 1) * (p_t * c_art + c_aro - w * l - pi_r); % from the BC
n_b = - chi * n_a; % from bond MC

end;

steady(maxit = 1000, solve_algo = 3);



%--------------------------------------------------------------
% 5. Impulse response function
%--------------------------------------------------------------


shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1, irf=100, irf_plot_threshold=0)
                      c_aho c_aro c_bo c_aht c_art c_bt l_h
                             l_r l y_t y_o p_t w pi n_a n_b r_star;
```

Appendix E: TANBFP mod file

```

%--------------------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ---
% Date: 25/12/2023
% Description: Two agent, nominal bond, flexible prices
%
%--------------------------------------------------------------------------


%--------------------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%--------------------------------------------------------------------------

close all;

%--------------------------------------------------------------------------
% 1. Defining variables
%--------------------------------------------------------------------------

var c_aho c_aro c_bo c_aht c_art c_bt l_h l_r l y_t y_o p_t w pi
          n_a n_b r_star pi_r pi_h;

varexo err_yo;


%--------------------------------------------------------------------------
% 2. Calibration
%--------------------------------------------------------------------------

parameters alpha beta psi eta s_t theta rho gamma chi;
load parameters;

set_param_value('alpha'   ,par.alpha);
set_param_value('beta'    ,par.beta);
set_param_value('psi'     ,par.psi);
set_param_value('eta'     ,par.eta);
set_param_value('s_t'   ,par.s_t);
set_param_value('theta'   ,par.theta);
set_param_value('rho'     ,par.rho);
set_param_value('gamma'   ,par.gamma);
set_param_value('chi'     ,par.chi);

s_t = .8;
theta = .5;



%--------------------------------------------------------------------------
% 3. Model
%--------------------------------------------------------------------------


model;

% consumption allocation between oil and tradeable for htm HHs in country a
(1 - s_t) * c_aho^(-1 / eta) - s_t * c_aht^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable for ricardian HHs in country a
(1 - s_t) * c_aro^(-1 / eta) - s_t * c_art^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
(1 - s_t) * c_bo^(-1 / eta) - s_t * c_bt^(-1 / eta) / p_t;

% Euler equation for ricardian HHs in country a
c_aro^(-1 / eta) / (s_t * c_art^(1 - 1 / eta) +
     (1 - s_t) * c_aro^(1 - 1 / eta)) -
          beta * r_star *
               c_aro(+1)^(-1 / eta) / (s_t * c_art(+1)^(1 - 1 / eta) +
                         (1 - s_t) * c_aro(+1)^(1 - 1 / eta));

% Euler equation in country b
```

```
c_bo^(-1 / eta) / (s_t * c_bt^(1 - 1 / eta) +
     (1 - s_t) * c_bo^(1 - 1 / eta)) -
       beta * r_star *
                  c_bo(+1)^(-1 / eta) / (s_t * c_bt(+1)^(1 - 1 / eta) +
                              (1 - s_t) * c_bo(+1)^(1 - 1 / eta));

% labour supply decision for htm HHs in country a
psi - (1 - s_t) * c_aho^(-1 / eta) / (s_t * c_aht^(1 - 1 / eta) +
                        (1 - s_t) * c_aho^(1 - 1 / eta)) *
                                   w * (1 - l_h);

% labour supply decision for ricardian HHs in country a
psi - (1 - s_t) * c_aro^(-1 / eta) / (s_t * c_art^(1 - 1 / eta) +
                        (1 - s_t) * c_aro^(1 - 1 / eta)) *
                                   w * (1 - l_r);

% htm's budget constraint in country a
p_t * c_aht + c_aho - w * l_h - pi_h;

% ricardian's budget constraint in country a
p_t * c_art + c_aro - w * l_r - pi_r - (n_a(-1) - n_a / r_star);

% HH's budget constraint in country b
c_bo + p_t * c_bt  - y_o - (n_b(-1) - n_b / r_star);

% firm's FOC
(1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta - w;

% firm's profit
p_t * l^(1 - alpha) - w * l - pi;

% profit distribution
chi * pi_r + (1 - chi) * pi_h - pi;

% fix ricardian's profit
pi_r - pi;

% tradeable goods market-clearing condition
y_t - (1 - chi) * c_aht - chi * c_art - c_bt;

% oil market-clearing condition
y_o - (1 - chi) * c_aho - chi * c_aro - c_bo;

% labour market-clearing condition
chi * l_r + (1 - chi) * l_h - l;

% bond market clearing condition
chi * n_a + n_b;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

end;


%-----------------------------------------------------------------
% 4. Steady state
%-----------------------------------------------------------------


initval;

l_r = .22;
l_h = .22;
c_aro = .46;
c_aho = .46;
l = chi * l_r + (1 - chi) * l_h;
y_t = l^(1 - alpha); % from production function
p_t = 16.75 / y_t; % from target GDP in country a
c_art = s_t^eta * c_aro / (p_t^eta * (1 - s_t)^eta); % from tradeable-oil tradeoff
c_aht = s_t^eta * c_aho / (p_t^eta * (1 - s_t)^eta);
c_bt = y_t - chi * c_art - (1 - chi) * c_aht; % from tradeable MC
y_o = gamma / (1 - rho); % from oil stochastic process
```

```
c_bo = y_o - chi * c_aro - (1 - chi) * c_aho; % from oil MC
w = (1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta; % from firm's FOC
pi = p_t * l^(1 - alpha) - w * l; % from firm's profit
pi_r = pi;
pi_h = (pi - chi * pi_r) / (1 - chi);
r_star = 1 / beta; % from SS Euler
n_a = r_star / (r_star - 1) * (p_t * c_art + c_aro - w * l - pi_r); % from the BC
n_b = - chi * n_a; % from bond MC

end;

steady(maxit = 1000, solve_algo = 3);



%-----------------------------------------------------------------
% 5. Impulse response function
%-----------------------------------------------------------------


shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1, irf=100, irf_plot_threshold=0)
                       c_aho c_aro c_bo c_aht c_art c_bt l_h
                              l_r l y_t y_o p_t w pi n_a n_b r_star;
```

Appendix F: TANBNR FER mod file

```

%----------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ---
% Date: 25/12/2023
% Description: Two agent, nominal bond, nominal rigidities, fixed exchange rate
%
%----------------------------------------------------------------


%----------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%----------------------------------------------------------------

close all;

%----------------------------------------------------------------
% 1. Defining variables
%----------------------------------------------------------------

var c_aho c_aro c_bo c_aht c_art c_bt l_h l_r l y_t y_o p_t w pi
          n_a n_b r_star pi_r pi_h;

varexo err_yo;


%----------------------------------------------------------------
% 2. Calibration
%----------------------------------------------------------------

parameters alpha beta psi phi eta s_t theta rho gamma chi;

load parameters;

set_param_value('alpha'   ,par.alpha);
set_param_value('beta'    ,par.beta);
set_param_value('psi'     ,par.psi);
set_param_value('phi'     ,par.phi);
set_param_value('eta'     ,par.eta);
set_param_value('s_t'   ,par.s_t);
set_param_value('theta'   ,par.theta);
set_param_value('rho'     ,par.rho);
set_param_value('gamma'   ,par.gamma);
set_param_value('chi'     ,par.chi);

s_t = .8;
theta = .5;


%----------------------------------------------------------------
% 3. Model
%----------------------------------------------------------------


model;

% consumption allocation between oil and tradeable for htm HHs in country a
(1 - s_t) * c_aho^(-1 / eta) - s_t * c_aht^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable for ricardian HHs in country a
(1 - s_t) * c_aro^(-1 / eta) - s_t * c_art^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
(1 - s_t) * c_bo^(-1 / eta) - s_t * c_bt^(-1 / eta) / p_t;

% Euler equation for ricardian HHs in country a
c_aro^(-1 / eta) / (s_t * c_art^(1 - 1 / eta) +
     (1 - s_t) * c_aro^(1 - 1 / eta)) -
          beta * r_star *
                c_aro(+1)^(-1 / eta) / (s_t * c_art(+1)^(1 - 1 / eta) +
                          (1 - s_t) * c_aro(+1)^(1 - 1 / eta));

```

```
% Euler equation in country b
c_bo^(-1 / eta) / (s_t * c_bt^(1 - 1 / eta) +
     (1 - s_t) * c_bo^(1 - 1 / eta)) -
       beta * r_star *
                 c_bo(+1)^(-1 / eta) / (s_t * c_bt(+1)^(1 - 1 / eta) +
                          (1 - s_t) * c_bo(+1)^(1 - 1 / eta));

% labour supply decision for htm HHs in country a
psi - (1 - s_t) * c_aho^(-1 / eta) / (s_t * c_aht^(1 - 1 / eta) +
                      (1 - s_t) * c_aho^(1 - 1 / eta)) *
                               w * (1 - l_h);

% labour supply decision for ricardian HHs in country a
psi - (1 - s_t) * c_aro^(-1 / eta) / (s_t * c_art^(1 - 1 / eta) +
                      (1 - s_t) * c_aro^(1 - 1 / eta)) *
                               w * (1 - l_r);

% htm's budget constraint in country a
p_t * c_aht + c_aho - w * l_h - pi_h;

% ricardian's budget constraint in country a
p_t * c_art + c_aro - w * l_r - pi_r - (n_a(-1) - n_a / r_star);

% HH's budget constraint in country b
c_bo + p_t * c_bt  - y_o - (n_b(-1) - n_b / r_star);

% firm's FOC
p_t * (1 - theta) * (1 - alpha) * l^((1 - theta) * (1 - alpha) - 1) * y_t^theta -
          w - phi * (p_t * y_t^theta * l(-1)^(theta * (1 - alpha)) /
                (p_t(-1) * l^(theta * (1 - alpha)) * y_t(-1)^theta) - 1) *
                          p_t * y_t * (-theta) * (1 - alpha) * p_t * y_t^theta *
                                l(-1)^(theta * (1 - alpha)) / (p_t(-1) *
                                      l^(theta * (1 - alpha) + 1) * y_t(-1)^theta);

% firm's profit
p_t * l^(1 - alpha) - w * l - phi / 2 * (p_t / p_t(-1) - 1)^2 * p_t * y_t - pi;

% profit distribution
chi * pi_r + (1 - chi) * pi_h - pi;

% impose profit for ricardians
pi_r - pi;

% tradeable goods market-clearing condition
y_t - (1 - chi) * c_aht - chi * c_art - c_bt;

% oil market-clearing condition
y_o - (1 - chi) * c_aho - chi * c_aro - c_bo;

% labour market-clearing condition
chi * l_r + (1 - chi) * l_h - l;

% bond market clearing condition
chi * n_a + n_b;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

end;


%-----------------------------------------------------------------
% 4. Steady state
%-----------------------------------------------------------------


initval;

l_r = .22;
l_h = .22;
c_aro = .46;
c_aho = .46;
l = chi * l_r + (1 - chi) * l_h;
y_t = l^(1 - alpha); % from production function
```

```
p_t = 16.75 / y_t; % from target GDP in country a
c_art = s_t^eta * c_aro / (p_t^eta * (1 - s_t)^eta); % from tradeable-oil tradeoff
c_aht = s_t^eta * c_aho / (p_t^eta * (1 - s_t)^eta);
c_bt = y_t - chi * c_art - (1 - chi) * c_aht; % from tradeable MC
y_o = gamma / (1 - rho); % from oil stochastic process
c_bo = y_o - chi * c_aro - (1 - chi) * c_aho; % from oil MC
w = (1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta; % from firm's FOC at SS
pi = p_t * l^(1 - alpha) - w * l; % from firm's profit at SS
pi_r = pi;
pi_h = (pi - chi * pi_r) / (1 - chi);
r_star = 1 / beta; % from SS Euler
n_a = r_star / (r_star - 1) * (p_t * c_art + c_aro - w * l - pi_r); % from the BC
n_b = - n_a; % from bond MC

end;

steady(maxit = 1000, solve_algo = 3);




%------------------------------------------------------------
% 5. Impulse response function
%------------------------------------------------------------

shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1, irf=100, irf_plot_threshold=0)
                      c_aho c_aro c_bo c_aht c_art c_bt l_h
                             l_r l y_t y_o p_t w pi n_a n_b r_star;

model_diagnostics;
```

Appendix G: TANBNR PIT mod file

```
%----------------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ---
% Date: 25/12/2023
% Description: Two agent, nominal bond, nominal rigidities,
%                    price inflation targeting
%
%----------------------------------------------------------------------


%----------------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%----------------------------------------------------------------------

close all;

%----------------------------------------------------------------------
% 1. Defining variables
%----------------------------------------------------------------------

var c_aho c_aro c_bo c_aht c_art c_bt l_h l_r l y_t y_o p_t
        e w pi n_a n_b r_star pi_r pi_h;

varexo err_yo;


%----------------------------------------------------------------------
% 2. Calibration
%----------------------------------------------------------------------

parameters alpha beta psi phi eta s_t theta rho gamma chi;

load parameters;

set_param_value('alpha'   ,par.alpha);
set_param_value('beta'    ,par.beta);
set_param_value('psi'     ,par.psi);
set_param_value('phi'     ,par.phi);
set_param_value('eta'     ,par.eta);
set_param_value('s_t'   ,par.s_t);
set_param_value('theta'   ,par.theta);
set_param_value('rho'     ,par.rho);
set_param_value('gamma'   ,par.gamma);
set_param_value('chi'     ,par.chi);


s_t = .8;
theta = .562;


%----------------------------------------------------------------------
% 3. Model
%----------------------------------------------------------------------


model;

% consumption allocation between oil and tradeable for htm HHs in country a
(1 - s_t) * c_aho^(-1 / eta) / e - s_t * c_aht^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable for ricardian HHs in country a
(1 - s_t) * c_aro^(-1 / eta) / e - s_t * c_art^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
% here, p_tstar = p_t / e by LOOP
(1 - s_t) * c_bo^(-1 / eta) - s_t * c_bt^(-1 / eta) / (p_t / e);

% Euler equation for ricardian HHs in country a
c_aro^(-1 / eta) / ((s_t * c_art^(1 - 1 / eta) +
     (1 - s_t) * c_aro^(1 - 1 / eta)) * e) -
        beta * r_star *
```

```
            c_aro(+1)^(-1 / eta) / ((s_t * c_art(+1)^(1 - 1 / eta) +
                 (1 - s_t) * c_aro(+1)^(1 - 1 / eta)) * e(+1));

% Euler equation in country b
c_bo^(-1 / eta) / (s_t * c_bt^(1 - 1 / eta) +
     (1 - s_t) * c_bo^(1 - 1 / eta)) -
       beta * r_star *
                 c_bo(+1)^(-1 / eta) / (s_t * c_bt(+1)^(1 - 1 / eta) +
                           (1 - s_t) * c_bo(+1)^(1 - 1 / eta));

% labour supply decision for htm HHs in country a
psi - (1 - s_t) * c_aho^(-1 / eta) / ((s_t * c_aht^(1 - 1 / eta) +
                 (1 - s_t) * c_aho^(1 - 1 / eta)) * e) *
                           w * (1 - l_h);

% labour supply decision for ricardian HHs in country a
psi - (1 - s_t) * c_aro^(-1 / eta) / ((s_t * c_art^(1 - 1 / eta) +
                 (1 - s_t) * c_aro^(1 - 1 / eta)) * e) *
                           w * (1 - l_r);

% htm's budget constraint in country a
p_t * c_aht + e * c_aho - w * l_h - pi_h;

% ricardian's budget constraint in country a
p_t * c_art + e * c_aro - w * l_r - pi_r - e * (n_a(-1) - n_a / r_star);

% HH's budget constraint in country b
c_bo + (p_t / e) * c_bt  - y_o - (n_b(-1) - n_b / r_star);

% firm's FOC
p_t * (1 - theta) * (1 - alpha) * l^((1 - theta) * (1 - alpha) - 1) * y_t^theta -
          w - phi * (p_t * y_t^theta * l(-1)^(theta * (1 - alpha)) /
                (p_t(-1) * l^(theta * (1 - alpha)) * y_t(-1)^theta) - 1) *
                          p_t * y_t * (-theta) * (1 - alpha) * p_t * y_t^theta *
                                l(-1)^(theta * (1 - alpha)) / (p_t(-1) *
                                      l^(theta * (1 - alpha) + 1) * y_t(-1)^theta);

% firm's profit
p_t * l^(1 - alpha) - w * l - pi;

% profit distribution
chi * pi_r + (1 - chi) * pi_h - pi;

% impose profit for ricardians
pi_r - pi;

% tradeable goods market-clearing condition
y_t - (1 - chi) * c_aht - chi * c_art - c_bt;

% oil market-clearing condition
y_o - (1 - chi) * c_aho - chi * c_aro - c_bo;

% labour market-clearing condition
chi * l_r + (1 - chi) * l_h - l;

% bond market clearing condition
chi * n_a + n_b;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

% monetary policy rule
p_t - p_t(-1);

end;


%----------------------------------------------------------------
% 4. Steady state
%----------------------------------------------------------------


initval;

```

```
l_r = .22;
l_h = .22;
c_aro = .46;
c_aho = .46;
e = 1;
l = chi * l_r + (1 - chi) * l_h;
y_t = l^(1 - alpha); % from production function
p_t = 16.75 / y_t; % from target GDP in country a
c_art = s_t^eta * e^eta * c_aro / (p_t^eta * (1 - s_t)^eta); % from tradeable-oil tradeoff
c_aht = s_t^eta * e^eta * c_aho / (p_t^eta * (1 - s_t)^eta);
c_bt = y_t - chi * c_art - (1 - chi) * c_aht; % from tradeable MC
y_o = gamma / (1 - rho); % from oil stochastic process
c_bo = y_o - chi * c_aro - (1 - chi) * c_aho; % from oil MC
w = (1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta; % from firm's FOC at SS
pi = p_t * l^(1 - alpha) - w * l; % from firm's profit at SS
pi_r = pi;
pi_h = (pi - chi * pi_r) / (1 - chi);
r_star = 1 / beta; % from SS Euler
n_a = r_star / ((r_star - 1) * e) * (p_t * c_art + e * c_aro - w * l - pi_r); % from the BC
n_b = - n_a; % from bond MC


end;

steady(maxit = 1000);




%--------------------------------------------------------------
% 5. Impulse response function
%--------------------------------------------------------------

shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1, irf=100, solve_algo = 3, irf_plot_threshold=0)
                      c_aho c_aro c_bo c_aht c_art c_bt l_h
                             l_r l y_t y_o p_t e w pi n_a n_b r_star;


model_diagnostics;
```

Appendix H: TANBFPNH mod file

```

%----------------------------------------------------------------
%
% Title: International Macro-Finance Final Assignment, model file
% Author: ---
% Date: 25/12/2023
% Description: Two agent, nominal bond, flexible prices,
%                                       non-homothetic prefences
%
%----------------------------------------------------------------


%----------------------------------------------------------------
% 0. Housekeeping (close all graphic windows)
%----------------------------------------------------------------

close all;

%----------------------------------------------------------------
% 1. Defining variables
%----------------------------------------------------------------

var c_aho c_aro c_bo c_aht c_art c_bt l_h l_r l y_t y_o p_t w pi
          n_a n_b r_star pi_r pi_h;

varexo err_yo;


%----------------------------------------------------------------
% 2. Calibration
%----------------------------------------------------------------

parameters alpha beta psi eta s_art s_aht s_bt theta rho gamma chi;
load parameters;

set_param_value('alpha'    ,par.alpha);
set_param_value('beta'     ,par.beta);
set_param_value('psi'      ,par.psi);
set_param_value('eta'      ,par.eta);
set_param_value('theta'    ,par.theta);
set_param_value('rho'      ,par.rho);
set_param_value('gamma'    ,par.gamma);
set_param_value('chi'      ,par.chi);

chi = .7;
s_t = .8;
s_aht = .75; % home bias towards tradeable for htms
s_art = (s_t - (1 - chi) * s_aht) / chi; %  home bias towards tradeable for ricardians
s_bt  = s_t; % home bias towards tradeable in country b
theta = .68;


%----------------------------------------------------------------
% 3. Model
%----------------------------------------------------------------


model;

% consumption allocation between oil and tradeable for htm HHs in country a
(1 - s_aht) * c_aho^(-1 / eta) - s_aht * c_aht^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable for ricardian HHs in country a
(1 - s_art) * c_aro^(-1 / eta) - s_art * c_art^(-1 / eta) / p_t;

% consumption allocation between oil and tradeable in country b
(1 - s_bt) * c_bo^(-1 / eta) - s_bt * c_bt^(-1 / eta) / p_t;

% Euler equation for ricardian HHs in country a
c_aro^(-1 / eta) / (s_art * c_art^(1 - 1 / eta) +
     (1 - s_art) * c_aro^(1 - 1 / eta)) -
          beta * r_star *
                c_aro(+1)^(-1 / eta) / (s_art * c_art(+1)^(1 - 1 / eta) +
```

```
                            (1 - s_art) * c_aro(+1)^(1 - 1 / eta));

% Euler equation in country b
c_bo^(-1 / eta) / (s_bt * c_bt^(1 - 1 / eta) +
     (1 - s_bt) * c_bo^(1 - 1 / eta)) -
       beta * r_star *
                  c_bo(+1)^(-1 / eta) / (s_bt * c_bt(+1)^(1 - 1 / eta) +
                            (1 - s_bt) * c_bo(+1)^(1 - 1 / eta));

% labour supply decision for htm HHs in country a
psi - (1 - s_aht) * c_aho^(-1 / eta) / (s_aht * c_aht^(1 - 1 / eta) +
                       (1 - s_aht) * c_aho^(1 - 1 / eta)) *
                                 w * (1 - l_h);

% labour supply decision for ricardian HHs in country a
psi - (1 - s_art) * c_aro^(-1 / eta) / (s_art * c_art^(1 - 1 / eta) +
                       (1 - s_art) * c_aro^(1 - 1 / eta)) *
                                 w * (1 - l_r);

% htm's budget constraint in country a
p_t * c_aht + c_aho - w * l_h - pi_h;

% ricardian's budget constraint in country a
p_t * c_art + c_aro - w * l_r - pi_r - (n_a(-1) - n_a / r_star);

% HH's budget constraint in country b
c_bo + p_t * c_bt  - y_o - (n_b(-1) - n_b / r_star);

% firm's FOC
(1 - theta) * (1 - alpha) * p_t *
          l^((1 - theta) * (1 - alpha) - 1) * y_t^theta - w;

% firm's profit
p_t * l^(1 - alpha) - w * l - pi;

% profit distribution
chi * pi_r + (1 - chi) * pi_h - pi;

% impose profit for ricardians
pi_r - pi;

% tradeable goods market-clearing condition
y_t - (1 - chi) * c_aht - chi * c_art - c_bt;

% oil market-clearing condition
y_o - (1 - chi) * c_aho - chi * c_aro - c_bo;

% labour market-clearing condition
chi * l_r + (1 - chi) * l_h - l;

% bond market clearing condition
chi * n_a + n_b;

% oil endowment, stochastic process
gamma + rho * y_o(-1) - err_yo - y_o;

end;


%----------------------------------------------------------------------
% 4. Steady state
%----------------------------------------------------------------------


initval;

l_r = .22;
l_h = .22;
c_aro = .46;
c_aho = .46;
l = chi * l_r + (1 - chi) * l_h;
y_t = l^(1 - alpha); % from production function
p_t = 16.75 / y_t; % from target GDP in country a
c_art = s_art^eta * c_aro / (p_t^eta * (1 - s_art)^eta); % from tradeable-oil tradeoff
```

```
c_aht = s_aht^eta * c_aho / (p_t^eta * (1 - s_aht)^eta);
c_bt = y_t - chi * c_art - (1 - chi) * c_aht; % from tradeable MC
y_o = gamma / (1 - rho); % from oil stochastic process
c_bo = y_o - chi * c_aro - (1 - chi) * c_aho; % from oil MC
w = (1 - theta) * (1 - alpha) * p_t *
        l^((1 - theta) * (1 - alpha) - 1) * y_t^theta; % from firm's FOC
pi = p_t * l^(1 - alpha) - w * l; % from firm's profit
pi_r = pi;
pi_h = (pi - chi * pi_r) / (1 - chi);
r_star = 1 / beta; % from SS Euler
n_a = r_star / (r_star - 1) * (p_t * c_art + c_aro - w * l - pi_r); % from the BC
n_b = - n_a; % from bond MC

end;

steady(maxit = 1000, solve_algo = 3);



%----------------------------------------------------------------
% 5. Impulse response function
%----------------------------------------------------------------


shocks;

var err_yo;
stderr .1;

end;


stoch_simul(order=1, irf=100, irf_plot_threshold=0)
                    c_aho c_aro c_bo c_aht c_art c_bt l_h
                          l_r l y_t y_o p_t w pi n_a n_b r_star;


model_diagnostics;
```