Financial Conditions, Commodity Prices and Monetary Policy in an small open economy with banking intermediation

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Preliminary Work

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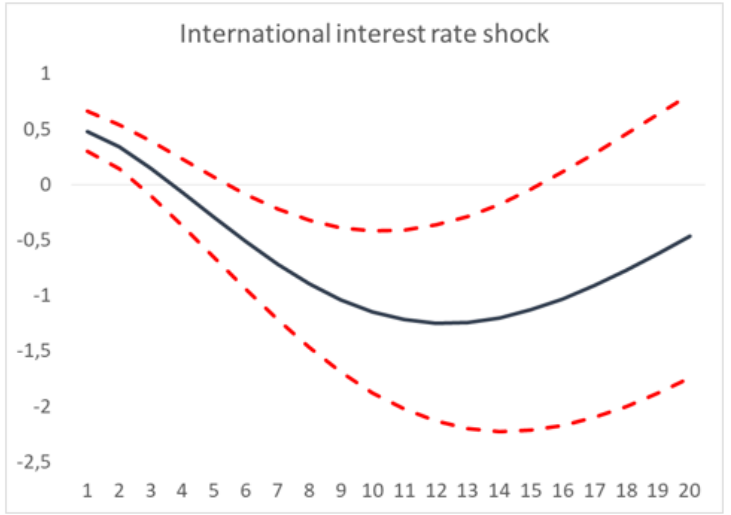
Some motivation

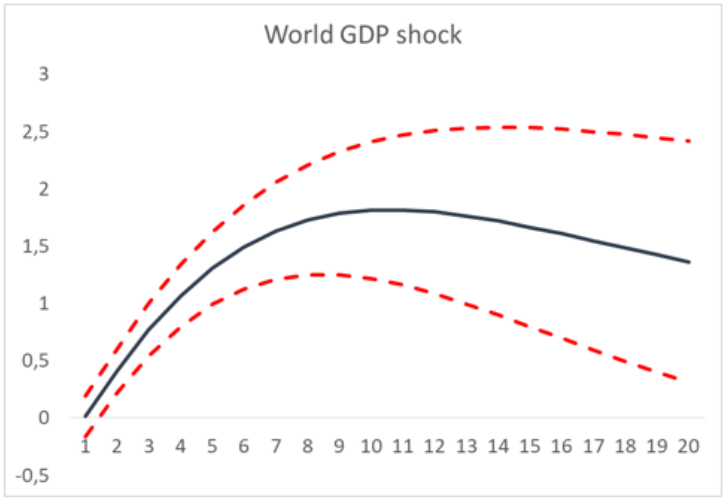
- The *IT* regime in Peru has a particular design with multiple instruments:
- Conventional tool:
  - Policy rate: Implemented via a monetary policy rule as a function of deviations of inflation w.r.t target and output gap.
- Non conventional tools aimed to take explicit account of the risks brought by **financial dollarization:**
  - Exchange rate interventions: Smooth exchange rate fluctuations/volatility
  - Foreign reserve accumulation: Precautionary motive due to possible sudden stops or capital reversals
  - Reserve requirements: Foreign currency

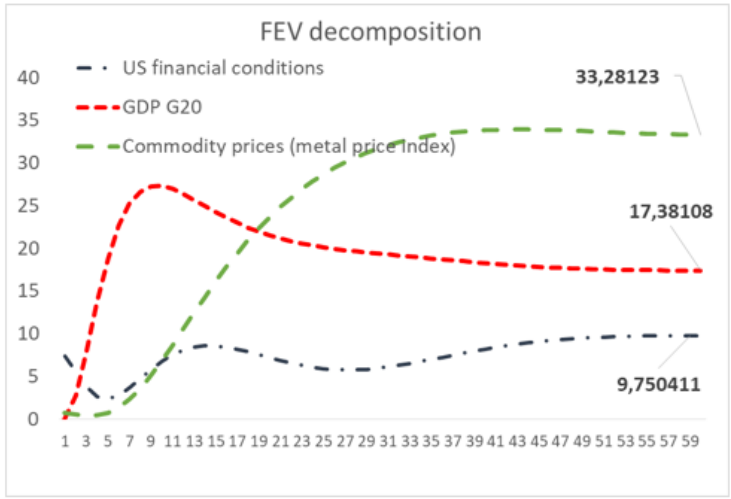
Some motivation

- We need a framework to evaluate this multiplicity of monetary policy instruments:
  - Optimality of the strategy (responses) being used at the BCRP.
  - Quantify the impact of each instrument in a general equilibrium setting.
  - Recently BCRP have implemented a dedollarization program using reserve requirements.
- Study de transmission of commodity prices through credit conditions in the banking system.
- Study the transmission of the global financial cycle: Financial shocks, QE, low interest rates...

Transmission of foreign shocks through credit are important







This presentation

- A first pass to a model economy for a *commodity exporter SOE* where the balance sheet of banks matter.
  - The SOE is integrated to world financial markets.
  - Banks obtain funds in two currencies:
    - Deposits from domestic households
    - Credit lines from abroad.
  - A separated commodity sector is included
- The model is based on Aoki, Benigno and Kiyotaki (2016) "*Monetary and financial policies in emerging markets*", which follows Gertler and Karadi (2011) and Gertler and Kiyotaki (2011) for modelling financial intermediation (banking) sector.

Model

- **Agents:**
  - Households
  - Firms: Final, intermediate, capital and commodity good producers.
  - Banks
  - Government: "Fiscal.ªnd monetary authorities
  - External sector.

Model: Main assumptions

- Banks exists due to an agency problem (moral hazard):
  - Banks may abscond with funds away from investment in order to consume personally.
  - Agency problem limit bank's ability to raise funds.
- Intermediate good producers issue equity in order to buy/rent capital and produce.
- Households and banks fund intermediate good producers by buying equity (ownership of capital).
  - Households face an extra cost of investing in equity.

Model: Main assumptions

- Intermediate good producers face nominal price rigidities *a la* Rotemberg
  - Cuadratic costs of price adjustment
- Capital good producers sell investment goods to households and banks
  - Face adjustment costs of investment.
- There is no financial frictions for bank lending (between banks and firms).
- Commodity good producers export all production and do not need external funding for investment.
  - Capital is specific to this sector.
  - Face adjustment costs of investment.

Households

- The representative household has two types of members:
- *Workers* : Supply labor and return their earnings (wages) to the household.
- *Bankers* : Manages a financial intermediary (a bank) and transfer earnings (net worth) to the household when retiring. The latter occurs with probability $1 - \sigma$.
- Perfect consumption insurance within the family: keep the tractability of an almost representative agent framework.
- Population size is normalized to one.
  - Retired bankers are replaced by an equal number of workers who become new bankers.
  - New bankers receive a fraction ξ of total assets from the household as start-up funds.

Households

- It is optimal for a banker to retain earnings until they exit the industry (become workers).
- This is true due to the fact that bankers face an **agency problem** that leads to an edogenous capital constraint.
- Bankers that exit pay out their retained earnings (accumulated net worth)as dividends to their respective household.
- Household provide its new bankers with a small amount of start up funds

Households

- *Preferences* over family consumption and labor supply:

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \ln \left(C_t - \frac{\zeta_0}{1+\zeta} L_t^{1+\zeta} \right)$$

- *Savings* :
  - D_t : Hold real deposits with banks (short term, riskless bond) denominated in domestic currency ($D_t = \frac{D_t^n}{P_t}$).
  - K_t^h : Hold equity issued by intermediate good producers.
- Households can fund firms directly by holding equity but at an extra management cost: $\chi\left(K_t^h\right) = \frac{\chi}{2}\left(K_t^h\right)^2$.

Households

- Household problem is

$$\max E_0 \sum_{t=0}^{\infty} \beta^t \ln \left(C_t - \frac{\zeta_0}{1+\zeta} L_t^{1+\zeta} \right)$$

- *Budget constraint*

$$C_t + Q_t K_t^h + \chi\left(K_t^h\right) + D_t = w_t L_t + \Pi_t + \left(Z_t + \lambda Q_t\right) K_{t-1}^h + R_t D_{t-1}$$

where

  - Q_t : Equity price in terms of goods.
  - λQ_t : Equity value net of depreciation. $\lambda = 1 - \delta$.
  - Z_t : Dividends paid by firms to equity holders.
  - $\chi\left(K_t^h\right) = \frac{\chi}{2}\left(K_t^h\right)^2$: Extra management cost for workers when buying equity directly from firms. Banks do not face it.
  - The rate of return of holding equity:

$$R_{t+1}^K = \frac{Z_{t+1} + \lambda Q_{t+1}}{Q_t}$$

Intermediate good producers

- Technology:

$$y_{it} = A_t \left(\frac{k_{it}}{\alpha_K}\right)^{\alpha_K} \left(\frac{m_{it}}{\alpha_M}\right)^{\alpha_M} \left(\frac{l_{it}}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M}$$

where

- k_{it} : Capital.
- m_{it} : Imported materials.
- l_{it} : Labor.

Intermediate good producers

- **Stage 1: Cost minimization problem yields**
  - Total cost

$$TC(Z_t, \epsilon_t, w_t) = \frac{w_t^{1-\alpha_K-\alpha_M} Z_t^{\alpha_K} \epsilon_t^{\alpha_M}}{A_t} y_{it}$$

  - Marginal cost

$$MC(Z_t, \epsilon_t, w_t) = \frac{w_t^{1-\alpha_K-\alpha_M} Z_t^{\alpha_K} \epsilon_t^{\alpha_M}}{A_t}$$

- Where
  - Z_t : Rental price of capital.
  - ϵ_t : Real exchange rate (price of M is normalized to 1).
  - w_t : Real wage.

Intermediate good producers

- **Stage 2: Price setting subject to adjustment costs**

$$\max_{p_{it}} E_0 \sum_{t=0}^{\infty} \Lambda_{0,t} \left[\left(\frac{p_{it}}{P_t} - m_t^C \right) y_{it} - \frac{\kappa}{2} \left(\frac{p_{it}}{p_{it-1}} - 1 \right)^2 Y_t^F \right]$$

s.t

$$y_{it} = \left(\frac{p_{it}}{P_t} \right)^{-\eta} Y_t^F$$

- FOCs yield:

$$(\pi_t - 1)\pi_t = \frac{1}{\kappa} \left(1 - \eta + \eta m_t^C \right) + E_t \Lambda_{t,t+1} (\pi_{t+1} - 1) \pi_{t+1} \frac{Y_{t+1}^F}{Y_t^F}$$

  - Log-linealizing around $\pi = 1$ yields standard NKPC:

$$\widehat{\pi}_t = \frac{\eta - 1}{\kappa} \widehat{m}_t^C + \beta E_t \widehat{\pi}_{t+1}$$

Capital good producers

- Capital accumulation is

$$K_t = I_t + \lambda K_{t-1}$$

where $\lambda = 1 - \delta$

- Adjustment cost of investment:

$$\left[1 + \Phi\left(\frac{I_t}{I}\right)\right] I_t$$

where

$$\Phi\left(\frac{I_t}{I}\right) = \frac{\kappa_I}{2}\left(\frac{I_t}{I} - 1\right)^2$$

- Per period profits are given by

$$\Pi_t^K = Q_t I_t - \left[1 + \Phi\left(\frac{I_t}{I}\right)\right] I_t$$

Capital good producers

- Optimization problem

$$\max_{I} Q_t I_t - \left[1 + \Phi\left(\frac{I_t}{I}\right)\right] I_t$$

- FOC yields:

$$Q_t = 1 + \Phi\left(\frac{I_t}{I}\right) + \frac{I_t}{I}\Phi'\left(\frac{I_t}{I}\right)$$

Commodity good producers

- There is a representative firm in the commodity sector that produces an homogenous good.
- The entire production is exported: Foreign demand is perfectly elastic.
- As in Fornero, Markus and Yany (2014): A fraction χ of the assets of this firm is owned by the government and the remaining fraction is owned by foreign investors.
- The revenue or profits is shared accordingly to χ .
- Uses **specific capital** as the only input:
  - Investment in this sector uses home produced final goods.
- Commodity producer **does not need external funding** for capital accumulation.
- But it is also subject to investment **adjustment costs**.

Commodity good producers

- Technology:

$$Y_t^s = A^s \left(K_t^s\right)^{1-\eta_s}$$

- Capital accumulation:

$$K_t^s = I_t^s + \lambda^s K_{t-1}^s$$

- Adjustment costs of investment:

$$\left[1 + \Phi\left(\frac{I_t^s}{I^s}\right)\right] I_t^s$$

- Current profits:

$$\Pi_t^C = P_t^s Y_t^s - \left[1 + \Phi\left(\frac{I_t^s}{I^s}\right)\right] I_t^s$$

Commodity good producers

- Problem of the firm is

$$\max_{\{K_t^s, I_t^s\}} \sum_{t=0}^{\infty} \Delta_{t,t+1} \left(P_t^s A^s \left(K_t^s\right)^{1-\eta_s} - \left[1 + \Phi\left(\frac{I_t^s}{I^s}\right)\right] I_t^s \right)$$

s.t

$$K_t^s = I_t^s + \lambda^s K_{t-1}^s$$

- FOC's:

$$Q_t^s = 1 + \Phi\left(\frac{I_t^s}{I^s}\right) + \Phi'\left(\frac{I_t^s}{I^s}\right)\frac{I_t^s}{I^s}$$

$$\left(1 - \eta_s\right) P_t^s A^s \left(K_t^s\right)^{-\eta_s} + E_t \Delta_{t,t+1} Q_{t+1}^s \lambda^s = Q_t^s$$

Banks

- Each bank manager "surviveüntil she retires with probability $1 - \sigma$.
- Retired bankers bring back the net worth as dividend.
- Retired bankers are replaced by an equal number of workers who become new bankers
- New bankers receibe a fraction ξ of total assets from the households as start-up funds.
- **Bank funding:**
  - Issue deposits to households: d_t
  - Borrow from foreigners. d_t^*
  - Use own net worth: n_t
- **Uses/allocation of bank funding:**
  - Lend funds to non-financial firms (intermdiate good producers) by buying **equity** (ownership capital or **capital holdings**): k_t^b

Banks

- **Flow of funds** constraint (**Balance sheet**) is:

$$Q_t k_t^b = n_t + d_t + \epsilon_t d_t^*$$

- **Net worth accumulation:** Difference between the return on assets and the cost of liabilities (accumulated through retained earnings)

$$n_t = \underbrace{(Z_t + \lambda Q_t)\, k_{t-1}^b}_{\text{return on assets}} \underbrace{- R_t d_{t-1} - \epsilon_t R_{t-1}^* d_{t-1}^*}_{\text{cost of liabilities}}$$

where

  - $Z_t + \lambda Q_t$: Gross real return on equity.
    - Z_t : Dividend.
    - λQ_t : Equity value net of depreciation.
  - R_t : The gross real interest rate on home deposits.
  - R_t^* : The gross real interest rate on foreing deposits.

Banks

- The objective of the bank is to maximize the expected present value of future net worth (divends to be paid to the household when the banker retired)

$$V_t = E_t \sum_{j=1}^{\infty} \Lambda_{t,t+j} \sigma^{j-1} (1-\sigma) n_{t+j}$$

where n_{t+j} are the dividends that the bank delivers to the household when its manager retires at date $t+j$ with probability $\sigma^{j-1}(1-\sigma)$.

Banks: Agency problem

- After rising funds and buy equity at the begining of the period t, the banker decides wether to **operate honestly** or **divert assets** for personal use.
  - **Operating honestly** means holding capital until payoffs are realized in the next perdio and then meet the obligations to creditors.
  - To **divert assets** means to channel funds away from investment in order to consume personally.
- **Assumption:** Banker's ability to deviert assets depend on the sources and the use of funds.
  - Specifically, the banker can divert a fraction $\Theta(x_t)$ of assets:

$$\Theta(x_t) = \theta\left(1 + \frac{\gamma}{2}x_t^2\right)$$

where x_t is the fraction of assets financed by foreing borrowing and it is given by

$$x_t = \frac{\epsilon_t d_t^*}{Q_t k_t^b}$$

Banks: Agency problem

- The banker decision reduces to compare the value of a bank V_t wich measures the present discounted value of future payouts from operating honestly, with the gain from diverting the funds.
- Rational creditors will not supply funds to the banker if the banker has an incentive to cheat.
- **Incentive constraint**: Any financial contract between the bank and its creditors must satisfy the following incentive constraint

$$V_t \geq \Theta\left(x_t\right) Q_t k_t^b$$

or

$$V_t = E_t \sum_{j=1}^{\infty} \Lambda_{t,t+j} \sigma^{j-1} \left(1-\sigma\right) n_{t+j} \geq \Theta\left(x_{t+j}\right) Q_{t+j} k_{t+j}^b$$

- Notice that the above is an **intertemporal incentive constraint or forward looking constraint**.

Banks

- Solution of the bank problem yields:
  - $\mu_t = E_t\Omega_{t+1}\left(\frac{Z_{t+1}+\lambda Q_{t+1}}{Q_t} - R_{t+1}\right)$: Excess return of capital over home deposits.
  - $\mu^*_{d,t} = E_t\Omega_{t+1}\left(R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t}R^*_t\right)$: Cost advantage of home deposit over foreign debt.
  - $x_t = \frac{\epsilon_t d^*_t}{Q_t k^b_t} = G(\frac{\mu_{d,t}}{\mu_t})$: Increasing function
  - $\phi_t = \frac{Q_t k^b_t}{n_t} = F(\theta, \mu_t, \mu_{d,t})$: Decreasing, increasing, increasing
- Together with the following definitions:
  - $\psi_t = \frac{V_t}{n_t}$: Tobin's Q for a bank
  - $\phi_t = \frac{Q_t k^b_t}{n_t}$: Leverage ratio

Aggregation and market equilibrium

- **Equity market:**

$$K_t = K_t^h + K_t^b$$

- **Aggregate production function:**

$$Y_t^F = A_t \left(\frac{K_{t-1}}{\alpha_K}\right)^{\alpha_K} \left(\frac{M_t}{\alpha_M}\right)^{\alpha_M} \left(\frac{L_t}{1-\alpha_K-\alpha_M}\right)^{1-\alpha_K-\alpha_M}$$

with

$$Y_t^F = \left(\int_0^1 y_{it}^{\frac{\eta-1}{\eta}} di\right)^{\frac{\eta}{\eta-1}}$$

Aggregation and market equilibrium

- **Balance of payment (Foreign debt position):**

$$\left(D_t^* - R_{t-1}^* D_{t-1}^*\right) = -\left(\frac{1}{\epsilon_t}\left(E_{Xt} + E_{Xt}^s\right) - M_t\right) + \left(1 - \chi^s\right)\frac{1}{\epsilon_t}\Pi_t^C$$

- **Economy resource constraint (GDP):**

$$\begin{aligned} Y_t &= C_t + \left(E_{Xt} + E_{Xt}^s\right) + \left(1 + \Phi\left(\frac{I_t}{I}\right)\right) I_t + \left(1 + \Phi\left(\frac{I_t^s}{I^s}\right)\right) I_t^s \\ &\quad + \chi\left(K_t^h\right) + \frac{\kappa}{2}\left(\pi_t - 1\right)^2 Y_t^F \end{aligned}$$

where

$$Y_t = Y_t^F + P_t^s Y_t^s$$

Aggregation and market equilibrium

- **Monetary policy:** Taylor rule

$$\frac{R_t}{R} = \left(\frac{R_{t-1}}{R}\right)^{\rho_i} (\pi_t - 1)^{\omega_\pi (1-\rho_i)} \exp\left(\xi_t^i\right)$$

Calibration: Steady state targets for the banking sector of the model

- Peru's debt to assets ratio: 8
  - Adeudados con el exterior de sociedades de depositos/activos de sociedades de depositos. Promedio de periodo de inflation targeting.
- Share of capital financed by banks: 0,2
  - Financiamiento bancario/financiamiento ampliado del sector privado no financiero. promedio período del inflation targeting.
- Peru's interest rate spread: Target of 2 percent.
- Parameters consistent with banking targets:
  - Divertable proportion of assets: $\theta = 0{,}5140$
  - Home bias in funding: $\gamma = 10$
  - Fraction of total assets brougth by new bankers: $\xi = 3{,}03 \times 10^{-5}$
  - Cost parameter of household direct funding to firms: $\varkappa = 0{,}0012$

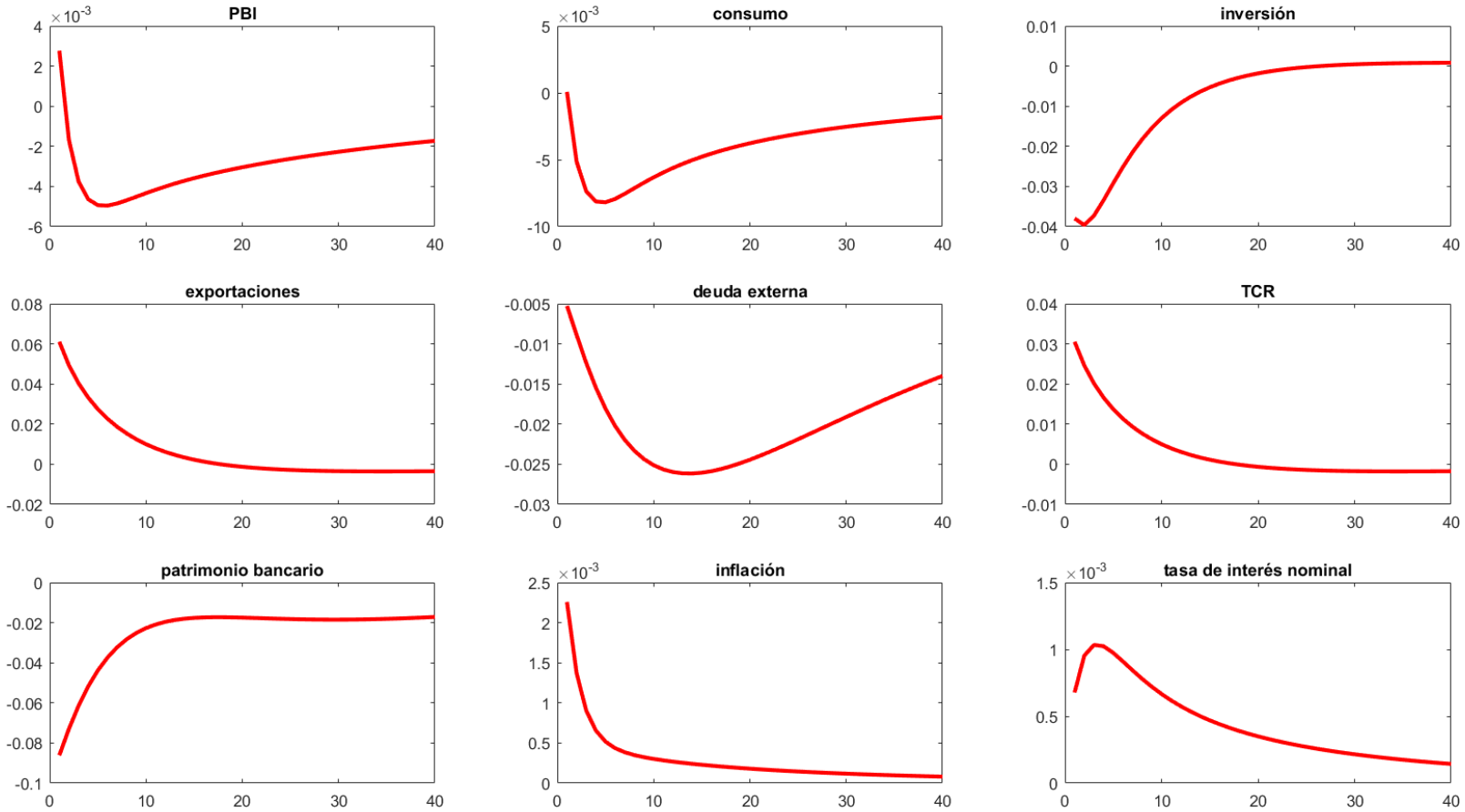
Baseline parameters

Parameter	Value	Source/Target
Banks		
Divertable proportion of assets	$\theta = 0{,}5140$	Peru's Bank Leverage
Home bias in funding	$\gamma = 10$	Peru's debt to assets ratio (Banks)
Survival probability	$\sigma = 0{,}93$	Aoki, Benigno and Kiyotaki (2016)
Fraction of total assets brought by new banks	$\xi = 3{,}03 \times 10^{-5}$	Bank's interest spread =2 %
Households		
Discount rate	$\beta = 0{,}985$	Domestic interest rate
Inverse Frisch elasticity	$\zeta = 0{,}2$	Aoki, Benigno and Kiyotaki (2016)
Inverse of labor supply capacity	$\zeta_0 = 7{,}12$	Return on capital
Cost parameter of direct finance	$\varkappa = 0{,}0012$	share of capital financed by banks
Non-commodity producers		
Cost share of capital	$\alpha_K = 0{,}3$	Standard for DSGE SOE model
Cost share of imported intermediated goods	$\alpha_M = 0{,}21$	Capital-output ratio
Depreciation rate	$\lambda = 0{,}98$	Standard for DSGE SOE model
Elasticity of demand	$\eta = 8$	Standard for DSGE SOE model
Fraction of non-adjusters	$\omega = 0{,}75$	Aoki, Benigno and Kiyotaki (2016)
Adjustment cost parameter	$\kappa_I = 0{,}2$	ratio volatility investment-output
Price elasticity of export demand	$\varphi = 2$	Standard for DSGE SOE model
Commodity producers		
Cost share of capital	$\alpha_C = 0{,}21$	Peru's commodity export share
Depreciation rate	$\lambda_C = 0{,}98$	Standard for DSGE SOE model
Adjustment cost parameter	$\kappa_C = 0{,}2$	ratio volatility investment-output
Domestic ownership of commodity firms	$\varkappa_C = 0{,}6$	Garcia-Cicco etal. (2017)

Baseline steady state (Annual)

Steady State	Value	Description
Q	1	Price of capital
π	1	inflation rate
R^*	1,02	foreign interest rate
R	1,06	deposit interest rate
R^K	1,08	rate of return on capital for bank
ϕ	8	bank leverage multiple
x	0,20	foreign debt-to-bank asset ratio
$\frac{K}{GDP}$	1,8692	capital-output ratio
$\frac{K^b}{K}$	0,8	share of capital financed by banks
$\frac{\epsilon D^*}{Y-\epsilon M}$	0,32	Foreign debt to GDP ratio
$\frac{E_X^C}{E_X+E_X^C}$	0,7	commodity exports share of total exports
$\frac{I^C}{I}$	0,15	commodity investment share of total investment

response to 1 % foreign interest shock



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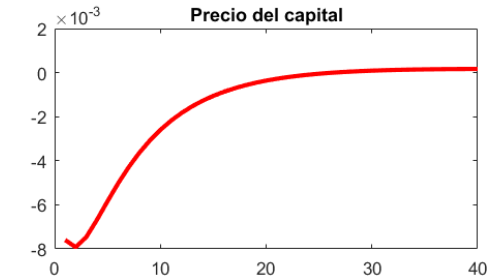
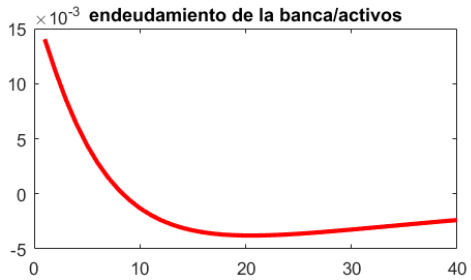
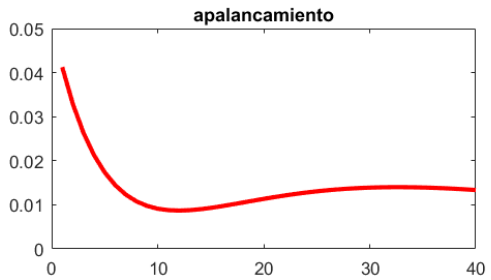
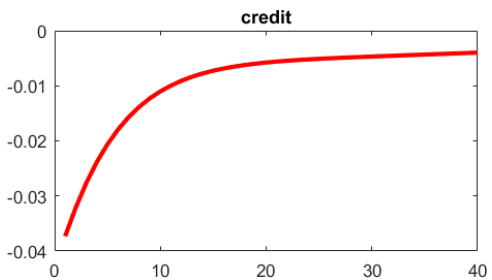
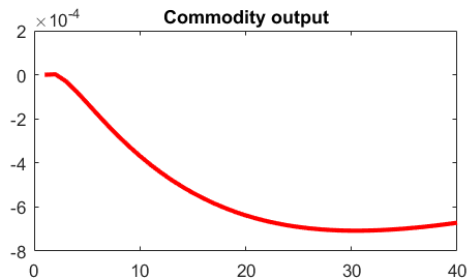
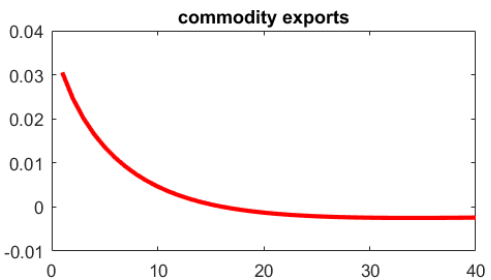


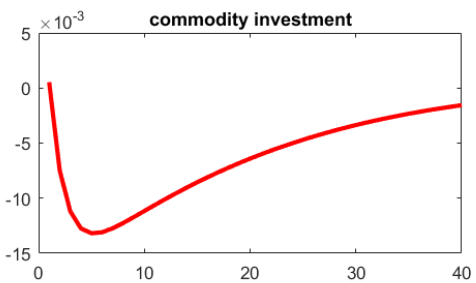




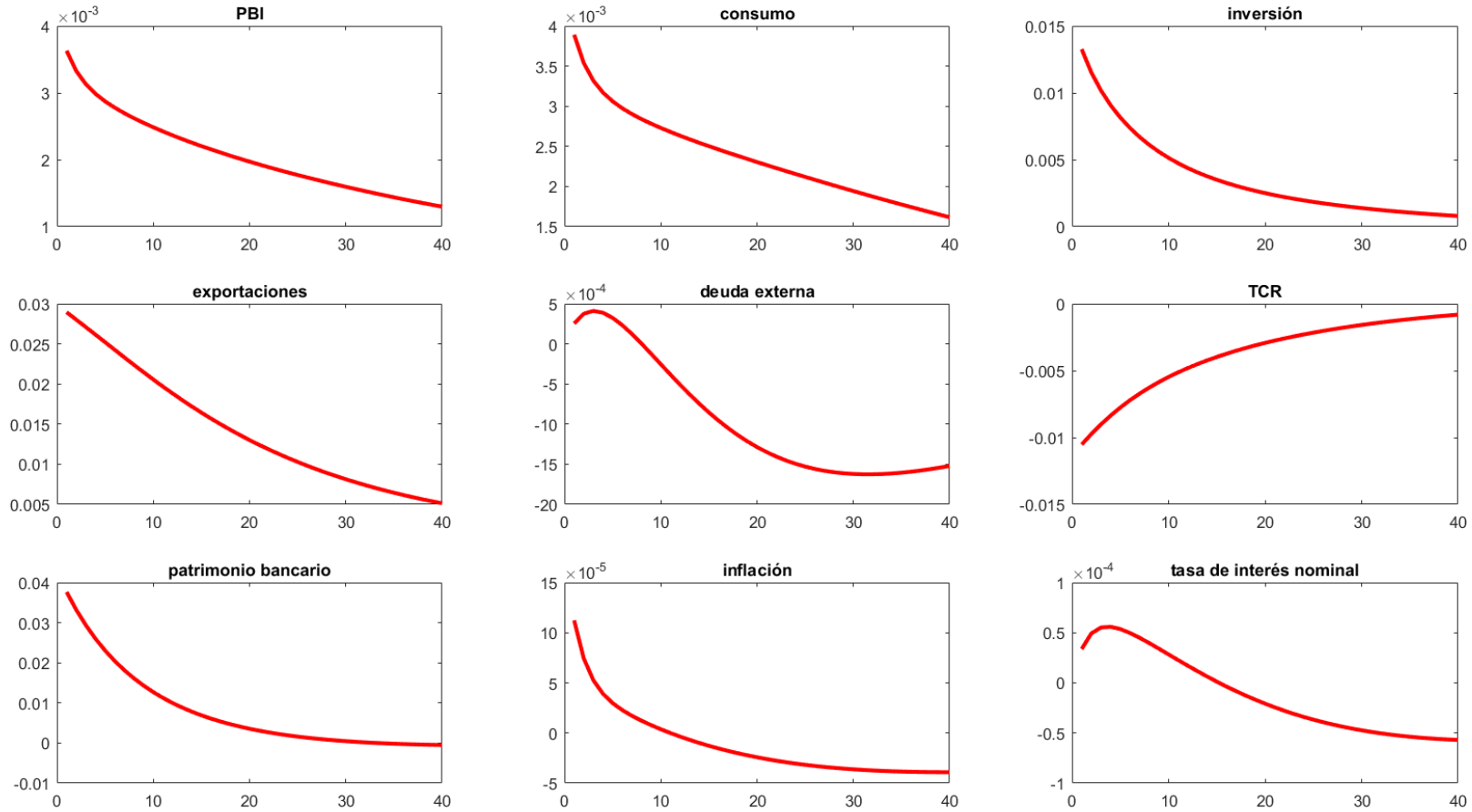








response to 1 % foreign output shock



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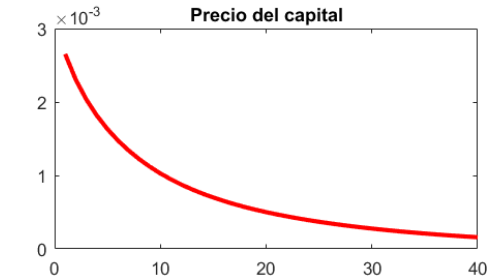
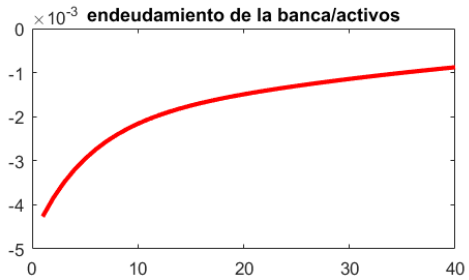
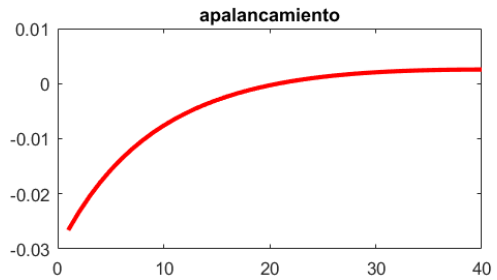
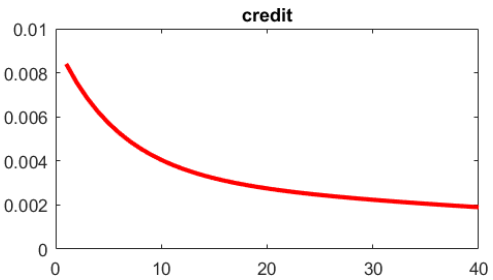
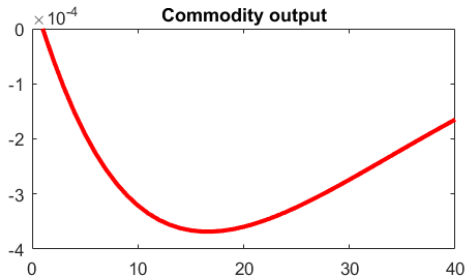
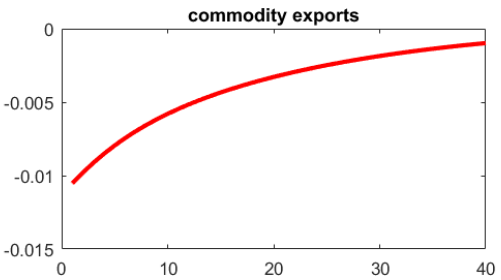


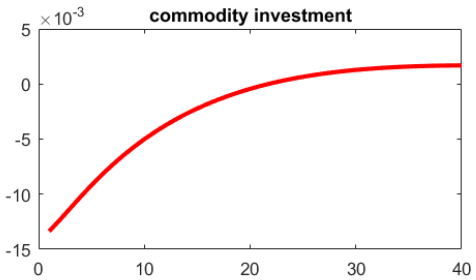




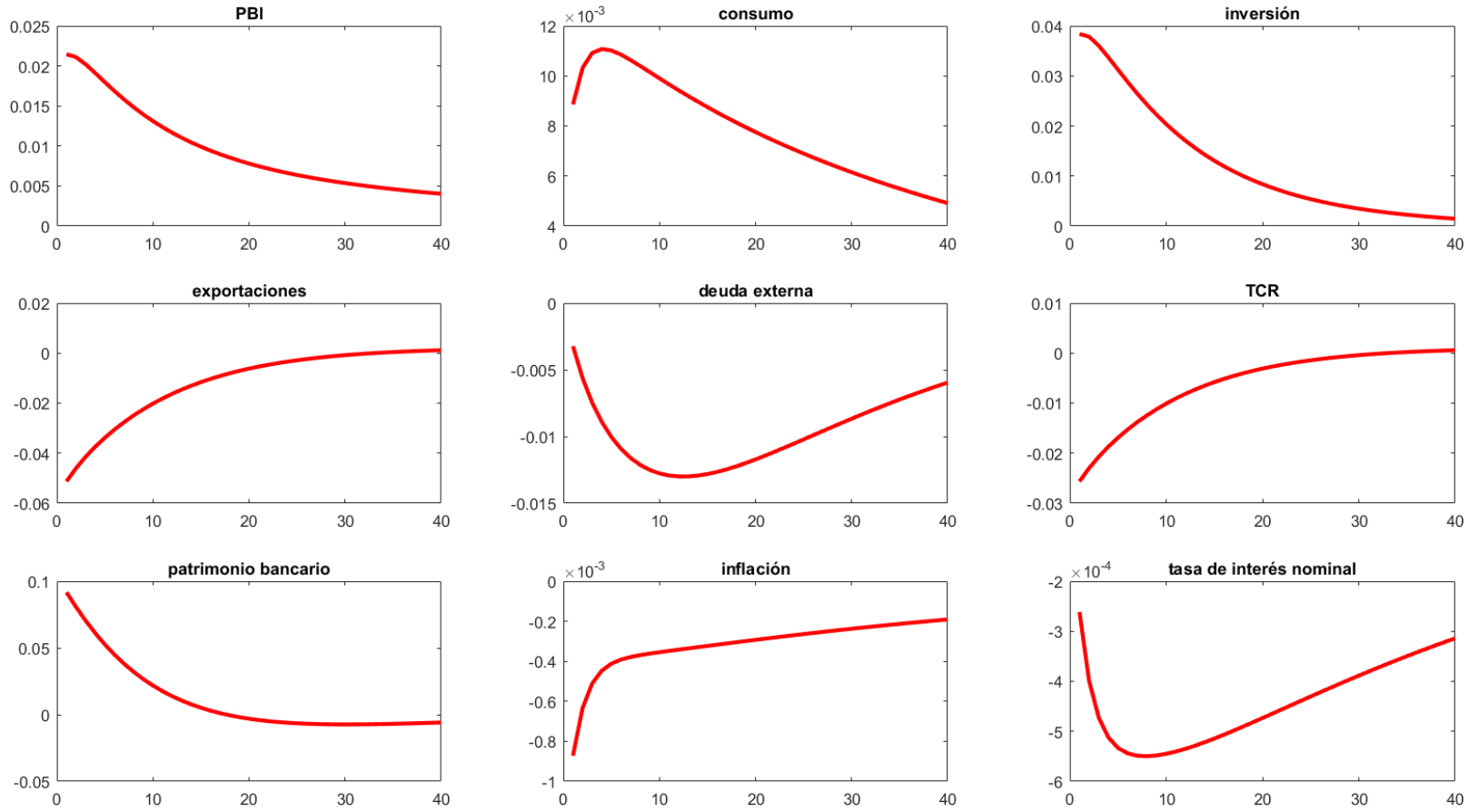




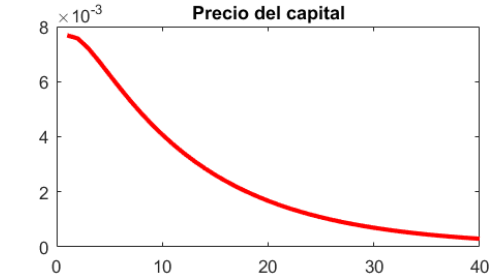


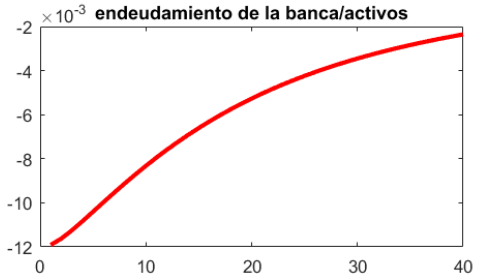


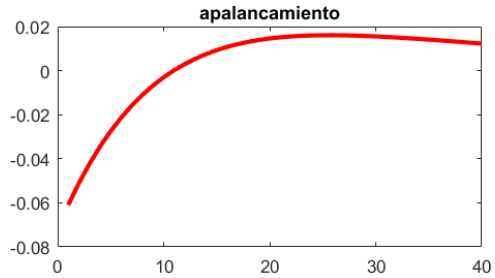
response to 1 % commodity price shock

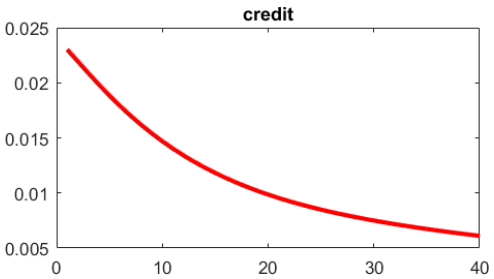


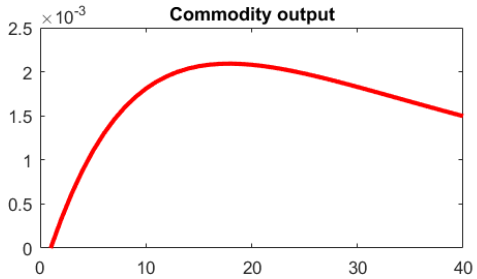
response to 1 % commodity price shock

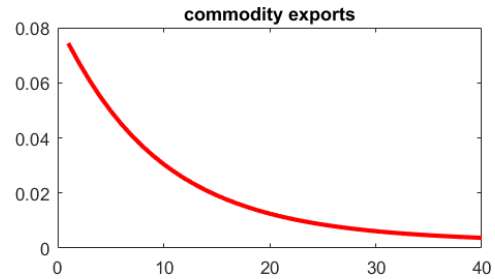


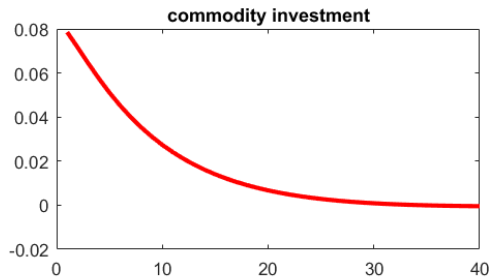












Further extentions

- **Households**
  - Posibility that households may save in foreign currency (in dollars).

$$\begin{aligned} & C_t + Q_t K_t^h + \chi\left(K_t^h\right) + D_t + D_t^* \\ = \quad & w_t L_t + \Pi_t + \left(Z_t + \lambda Q_t\right) K_{t-1}^h + R_t D_{t-1} + \epsilon_t R_t^* D_{t-1}^* \end{aligned}$$

- **Banks**
  - Posibility that banks may lend funds to fimrs in foreign currency:

$$Q_t k_t^b + \epsilon_t Q_t^d k_t^d = n_t + d_t + \epsilon_t d_t^*$$

  - In this framework means that firms issue equity in terms of a foreign good.

Further extentions

- **Exchange rate interventions:**
- $\mu^*_{d,t} = E_t \Omega_{t+1} \left(R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t} R^*_t \right)$:

$$Q_t k^b_t + \epsilon_t Q^d_t k^d_t + q^d_t b_t = n_t + d_t + \epsilon_t d^*_t$$

$$V_t \geq \Theta(x_t) \left(Q_t k^b_t + \Delta * \left(Q^d_t k^d_t + q^d_t b_t \right) \right.$$

- **Reserve requirements** in domestic currency and dollars.
- Active/productive **fiscal policy** related to the commodity sector.