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
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.
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
  - Quadratic 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 $\xi$ of total assets from the household as start-up funds.
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 endogenous 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:

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

- **Savings**: 
  - \( D_t \): Hold real deposits with banks (short term, riskless bond) denominated in domestic currency \((D_t = \frac{D^n_t}{P_t})\).
  - \( K^h_t \): Hold equity issued by intermediate good producers.

- Households can fund firms directly by holding equity but at an extra management cost: \( \chi \left( K^h_t \right) = \frac{\chi}{2} \left( K^h_t \right)^2 \).
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
  \[C_t + Q_t K_t^h + \chi \left( K_t^h \right) + D_t = w_t L_t + \Pi_t + (Z_t + \lambda Q_t) K_{t-1}^h + R_t D_{t-1}\]
  where
  - \(Q_t\): Equity price in terms of goods.
  - \(\lambda Q_t\): 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.
    - \( \epsilon_t \): 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**

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

s.t

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

- **FOCs yield:**

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

- **Log-linealizing around \( \pi = 1 \) yields standard NKPC:**

\[
\hat{\pi}_t = \frac{\eta - 1}{\kappa} \hat{m}_t^C + \beta E_t \hat{\pi}_{t+1}
\]
Capital good producers

- Capital accumulation is
  \[ K_t = I_t + \lambda K_{t-1} \]
  where \( \lambda = 1 - \delta \)

- Adjustment cost of investment:
  \[ \left[ 1 + \Phi \left( \frac{I_t}{l} \right) \right] l_t \]
  where
  \[ \Phi \left( \frac{I_t}{l} \right) = \frac{\kappa l}{2} \left( \frac{I_t}{l} - 1 \right)^2 \]

- Per period profits are given by
  \[ \Pi^K_t = Q_t l_t - \left[ 1 + \Phi \left( \frac{I_t}{l} \right) \right] l_t \]
Capital good producers

- Optimization problem

\[
\max_l Q_t l_t - \left[ 1 + \Phi \left( \frac{l_t}{l} \right) \right] l_t
\]

- FOC yields:

\[
Q_t = 1 + \Phi \left( \frac{l_t}{l} \right) + \frac{l_t}{l} \Phi' \left( \frac{l_t}{l} \right)
\]
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 \( \chi \) 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 \( \chi \).

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:
  \[ Y_t^s = A^s (K_t^s)^{1-\eta_s} \]

- Capital accumulation:
  \[ K_t^s = I_t^s + \lambda^s K_{t-1}^s \]

- Adjustment costs of investment:
  \[ \left[ 1 + \Phi \left( \frac{I_t^s}{I_s^s} \right) \right] I_t^s \]

- Current profits:
  \[ \Pi_t^C = P_t^s Y_t^s - \left[ 1 + \Phi \left( \frac{I_t^s}{I_s^s} \right) \right] I_t^s \]
Commodity good producers

- Problem of the firm is
  \[
  \max_{\{K_t^s, l_t^s\}} \sum_{t=0}^{\infty} \Delta_{t,t+1} \left( P_t^s A^s (K_t^s)^{1-\eta_s} - \left[ 1 + \Phi \left( \frac{l_t^s}{l_s} \right) \right] l_t^s \right)
  \]

- s.t
  \[
  K_t^s = l_t^s + \lambda^s K_{t-1}^s
  \]

- FOC’s:
  \[
  Q_t^s = 1 + \Phi \left( \frac{l_t^s}{l_s} \right) + \Phi' \left( \frac{l_t^s}{l_s} \right) \frac{l_t^s}{l_s}
  \]
  \[
  (1 - \eta_s) P_t^s A^s (K_t^s)^{-\eta_s} + E_t \Delta_{t,t+1} Q_{t+1}^s \lambda^s = Q_t^s
  \]
Banks

- Each bank manager "survives until 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 receive a fraction $\xi$ 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 (intermediate good producers) by buying **equity** (ownership capital or **capital holdings**): $k^b_t$
Banks

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

\[ Q_t k^b_t = n_t + d_t + \epsilon_t d^*_t \]

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

\[ n_t = (Z_t + \lambda Q_t) k^b_{t-1} - R_t d_{t-1} - \epsilon_t R^*_t d^*_{t-1} \]

where

- \( Z_t + \lambda Q_t \): Gross real return on equity.
  - \( Z_t \): Dividend.
  - \( \lambda Q_t \): Equity value net of depreciation.

- \( R_t \): The gross real interest rate on home deposits.
- \( R^*_t \): The gross real interest rate on foreign deposits.
The objective of the bank is to maximize the expected present value of future net worth (dividends 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 \( \sigma^{j-1} (1 - \sigma) \).
After raising funds and buy equity at the beginning of the period \( t \), the banker decides whether to operate honestly or divert assets for personal use.

- **Operating honestly** means holding capital until payoffs are realized in the next period 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 divert 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 foreign 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 $V_t$ which 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

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

or

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

- 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.
- \( \mu^*_{d,t} = E_t \Omega_{t+1} \left( R_{t+1} - \frac{\epsilon_{t+1}}{\epsilon_t} R^* \right) \): Cost advantage of home deposit over foreign debt.
- \( \chi_t = \frac{\epsilon_t d^*_t}{Q_t k^b_t} = G(\frac{\mu_{d,t}}{\mu_t}) \): 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:**
  \[ K_t = K^h_t + K^b_t \]

- **Aggregate production function:**
  \[ Y^F_t = A_t \left( \frac{K_{t-1}}{\alpha_K} \right)^{\alpha_K} \left( \frac{M_t}{\alpha_M} \right)^{\alpha_M} \left( \frac{L_t}{1 - \alpha_K - \alpha_M} \right)^{1 - \alpha_K - \alpha_M} \]
  with
  \[ Y^F_t = \left( \int_0^1 y_{it}^{\eta-1} \; di \right)^{\frac{\eta}{\eta-1}} \]
Balance of payment (Foreign debt position):

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

Economy resource constraint (GDP):

\[
Y_t = C_t + (E_{Xt} + E_{Xt}^S) + \left( 1 + \Phi \left( \frac{l_t}{l^s} \right) \right) l_t + \left( 1 + \Phi \left( \frac{l_{t}^S}{l_{s}^s} \right) \right) l_{t}^s \\
+ \chi \left( K_t^h \right) + \frac{\kappa}{2} (\pi_t - 1)^2 Y_t^F
\]

where

\[
Y_t = Y_t^F + P_t^s Y_t^s
\]
**Monetary policy:** Taylor rule

\[
\frac{R_t}{R} = \left( \frac{R_{t-1}}{R} \right)^{\rho_i} (\pi_t - 1)^{\omega} (1 - \rho_i) \exp \left( \xi_t \right)
\]
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 periodo 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 brought by new bankers: $\xi = 3,03 \times 10^{-5}$
  - Cost parameter of household direct funding to firms: $\kappa = 0,0012$
Baseline parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Source/Target</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Banks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divertable proportion of assets</td>
<td>$\theta = 0.5140$</td>
<td>Peru’s Bank Leverage</td>
</tr>
<tr>
<td>Home bias in funding</td>
<td>$\gamma = 10$</td>
<td>Peru’s debt to assets ratio (Banks)</td>
</tr>
<tr>
<td>Survival probability</td>
<td>$\sigma = 0.93$</td>
<td>Aoki, Benigno and Kiyotaki (2016)</td>
</tr>
<tr>
<td>Fraction of total assets brought by new banks</td>
<td>$\xi = 3.03 \times 10^{-5}$</td>
<td>Bank’s interest spread =2%</td>
</tr>
<tr>
<td><strong>Households</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discount rate</td>
<td>$\beta = 0.985$</td>
<td>Domestic interest rate</td>
</tr>
<tr>
<td>Inverse Frisch elasticity</td>
<td>$\zeta = 0.2$</td>
<td>Aoki, Benigno and Kiyotaki (2016)</td>
</tr>
<tr>
<td>Inverse of labor supply capacity</td>
<td>$\zeta_0 = 7.12$</td>
<td>Return on capital</td>
</tr>
<tr>
<td>Cost parameter of direct finance</td>
<td>$\kappa = 0.0012$</td>
<td>share of capital financed by banks</td>
</tr>
<tr>
<td><strong>Non-commodity producers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost share of capital</td>
<td>$\alpha_K = 0.3$</td>
<td>Standard for DSGE SOE model</td>
</tr>
<tr>
<td>Cost share of imported intermediated goods</td>
<td>$\alpha_M = 0.21$</td>
<td>Capital-output ratio</td>
</tr>
<tr>
<td>Depreciation rate</td>
<td>$\lambda = 0.98$</td>
<td>Standard for DSGE SOE model</td>
</tr>
<tr>
<td>Elasticity of demand</td>
<td>$\eta = 8$</td>
<td>Standard for DSGE SOE model</td>
</tr>
<tr>
<td>Fraction of non-adjusters</td>
<td>$\omega = 0.75$</td>
<td>Aoki, Benigno and Kiyotaki (2016)</td>
</tr>
<tr>
<td>Adjustment cost parameter</td>
<td>$\kappa_I = 0.2$</td>
<td>ratio volatility investment-output</td>
</tr>
<tr>
<td>Price elasticity of export demand</td>
<td>$\varphi = 2$</td>
<td>Standard for DSGE SOE model</td>
</tr>
<tr>
<td><strong>Commodity producers</strong></td>
<td></td>
<td></td>
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<tr>
<td>Cost share of capital</td>
<td>$\alpha_C = 0.21$</td>
<td>Peru’s commodity export share</td>
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<tr>
<td>Depreciation rate</td>
<td>$\lambda_C = 0.98$</td>
<td>Standard for DSGE SOE model</td>
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<tr>
<td>Adjustment cost parameter</td>
<td>$\kappa_C = 0.2$</td>
<td>ratio volatility investment-output</td>
</tr>
<tr>
<td>Domestic ownership of commodity firms</td>
<td>$\kappa_C = 0.6$</td>
<td>Garcia-Cicco etal. (2017)</td>
</tr>
</tbody>
</table>
### Baseline steady state (Annual)

<table>
<thead>
<tr>
<th>Steady State</th>
<th>Value</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>$Q$</td>
<td>1</td>
<td>Price of capital</td>
</tr>
<tr>
<td>$\pi$</td>
<td>1</td>
<td>inflation rate</td>
</tr>
<tr>
<td>$R^*$</td>
<td>1,02</td>
<td>foreign interest rate</td>
</tr>
<tr>
<td>$R$</td>
<td>1,06</td>
<td>deposit interest rate</td>
</tr>
<tr>
<td>$R^K$</td>
<td>1,08</td>
<td>rate of return on capital for bank</td>
</tr>
<tr>
<td>$\phi$</td>
<td>8</td>
<td>bank leverage multiple</td>
</tr>
<tr>
<td>$\times$</td>
<td>0,20</td>
<td>foreign debt-to-bank asset ratio</td>
</tr>
<tr>
<td>$K/GDP$</td>
<td>1,8692</td>
<td>capital-output ratio</td>
</tr>
<tr>
<td>$K^b/K$</td>
<td>0,8</td>
<td>share of capital financed by banks</td>
</tr>
<tr>
<td>$\epsilon D^*$</td>
<td>0,32</td>
<td>Foreign debt to GDP ratio</td>
</tr>
<tr>
<td>$Y-\epsilon M$</td>
<td>0,7</td>
<td>commodity exports share of total exports</td>
</tr>
<tr>
<td>$I^c/X$</td>
<td>0,15</td>
<td>commodity investment share of total investment</td>
</tr>
</tbody>
</table>
response to 1% foreign interest shock

- PBI
- consumo
- inversión
- exportaciones
- deuda externa
- TCR
- patrimonio bancario
- inflación
- tasa de interés nominal
response to 1% foreign interest shock
response to 1% foreign output shock
response to 1% foreign output shock
response to 1% commodity price shock
response to 1% commodity price shock
**Further extensions**

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

\[
C_t + Q_t K_t^h + \chi (K_t^h) + D_t + D^*_t
\]

\[
= w_t L_t + \Pi_t + (Z_t + \lambda Q_t) K_{t-1}^h + R_t D_{t-1} + \epsilon_t R_t^* D_{t-1}^*
\]

- **Banks**
  - Possibility that banks may lend funds to firms 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 extensions

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

\[ Q_t k_t^b + \epsilon_t Q_t^d k_t^d + q_t^d b_t = n_t + d_t + \epsilon_t d_t^* \]

\[ V_t \geq \Theta (x_t) (Q_t k_t^b + \Delta \ast (Q_t^d k_t^d + q_t^d b_t)) \]

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