Capital Flows and Bank Risk-Taking

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October 31, 2018
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Introduction

- 1998 Peruvian sudden stop: After 1998Q3, there is a gradual reduction of the ST NFL to GDP ratio and an almost immediate increase of the morosity ratio of the banking system. The morosity ratio jumped from 6.4 to 10.3 in three quarters.

- I provide a framework to understand the dynamics of the excessive bank risk-taking after an unanticipated sudden stop.

- I simulate the 1998 Peruvian sudden stop.

Figure 1: Morosity rate of the Peruvian banking system (%)

Source: SBS.
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- The limited liability + deposit insurance ⇒ Inefficiently high level of loans.

- The intertemporal effect amplifies the inefficiency.
  - The fact that banks have limited liability and deposit insurance not only in the present but also in the future creates incentive to increases even by more the inefficient overvaluation of the marginal benefits of the loans.
  - The default probability of banks is 6 times its value when abstracting from this intertemporal effect.

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- **Infinity time period small open economy model.**

- Domestic households (HHs), banks, foreign investors government. HHs own banks.

- Each period households decide how much to consume and save (only through deposits on banks).

- Banks receive deposits from HHs and foreign investors, and make risky investments.

- **Assumptions:**
  - Banks face limited liability.
  - Domestic and foreign deposits are insured by the government.
  - Banks have an exogenous binding foreign borrowing limit.
  - An exogenous law of motion of the bank equity.
  - Agents are risk-neutral.
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Domestic Households

- Utility of HHs at time \( t \),

\[
W_t = \mathbb{E}_t \left\{ \sum_{i=0}^{\infty} \beta^i C_{t+i} \right\},
\]

\( \beta \) is the HHs discount factor, \( C_t \) is the consumption level at period \( t \).

- The budget constraint at time \( t \) is,

\[
C_t + D_t = \omega^H + \bar{R}_t^{D} D_{t-1} + \Pi_t + T_t,
\]

- \( \omega^H \): fixed exogenous income,
- \( D_t \): one-period deposits held in the bank by domestic households (domestic deposits),
- \( \bar{R}_t^{D} \): gross return agreed at time \( t \) for the domestic deposits held from \( t \) to \( t+1 \),
- \( \Pi_t \): banks’ dividends, \( T_t \): lump sum government taxes.

- Since I assume deposit insurance domestic depositors will also always receive the agreed gross return.

- HHs maximize (1) subject to (2). The first order condition for \( D_t \) requires,

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1 = \beta \bar{R}_t^{D}.
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$$C_t + D_t = \omega^H + \bar{R}_t D_{t-1} + \Pi_t + T_t, \quad (2)$$

  - $\omega^H$: fixed exogenous income,
  - $D_t$: one-period deposits held in the bank by domestic households (domestic deposits),
  - $\bar{R}_t$: gross return agreed at time $t$ for the domestic deposits held from $t$ to $t+1$,
  - $\Pi_t$: banks’ dividends. $T_t$: lump sum government taxes.

- Since I assume deposit insurance domestic depositors will also always receive the agreed gross return.

- HHs maximize (1) subject to (2). The first order condition for $D_t$ requires,

$$1 = \beta \bar{R}_t^D.$$
Domestic Households

- Utility of HHs at time $t$,
  \[ W_t = \mathbb{E}_t \left\{ \sum_{i=0}^{\infty} \beta^i C_{t+i} \right\}, \]  
  \[ (1) \]
  - $\beta$ is the HHs discount factor, $C_t$ is the consumption level at period $t$.
- The budget constraint at time $t$ is,
  \[ C_t + D_t = \omega^H + R_t^D D_{t-1} + \Pi_t + T_t, \]  
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Banks

- The balance sheet equation,

\[ K_t = D_t + D_t^F + N_t, \]

  - \( N_t \): Equity at time \( t \).
  - \( D_t^F \): Short-term deposits held by foreign investors (foreign deposits).

- Banks intermediate \( K_t \) of capital in period \( t \).

- There is a payoff of \( Z_{t+1} K_t^\alpha \) in period \( t+1 \) plus the leftover capital.

- \( Z_{t+1} \) is the capital productivity for banks and follows a log-normal AR(1) process.

- The exogenous foreign borrowing limit:

\[ D_t^F \leq \phi_t. \]

- It says that foreign depositors have less ability to force banks to honor their obligations.

- The net operating income of the banks is,

\[ NOI_{t+1} = (1 - \delta)K_t + Z_{t+1} K_t^\alpha - \bar{R}_t^D D_t - \bar{R}_t^F D_t^F - N_t, \]

  - \( \bar{R}_t^F \): gross return of foreign deposits.
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- The NPV of future dividends \( (d_t) \) of bank is,

\[
V_t = \mathbb{E}_t \left\{ \sum_{i=0}^{\infty} \beta^i d_{t+i} \right\}.
\]

- Banks default at \( t+1 \) if the revenues are not enough to cover the agreed obligations, i.e. banks default if,

\[
(1 - \delta)K_t + Z_{t+1}K_t^\alpha \leq \bar{R}_D^D D_t + \bar{R}_F^F \phi_t, \quad \text{or} \quad NOI_{t+1} + N_t < 0.
\]

- I assume:
  - There are not default costs.
  - There are not equity injections.
  - Banks continue operating but with zero equity.

- Hence, if banks default,

\[
d_{t+1} = 0, \quad \text{and} \quad N_{t+1} = 0.
\]

- When banks do not default, they allocate a fraction \( 0 < \gamma < 1 \) of, \( NOI_{t+1} + N_t \), as dividends.

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  \[ d_{t+1} = \gamma [\text{NOI}_{t+1} + N_t]^+, \]
  \[ N_{t+1} = (1 - \gamma) [\text{NOI}_{t+1} + N_t]^+. \]

  which is the law of motion of equity.

- I define \( e^{z_{t+1}}: \)
  \[ (1 - \delta)K_t + Z_{t+1}^* K_t^{\alpha} = \bar{R}_D D_t + \bar{R}_F D_t^F. \]

  where \( Z_{t+1}^* = \exp(\mu_z(1 - \rho_z) + \rho_z \log(Z_t) + e^{z_{t+1}}). \)

- If \( e^z_{t+1} < e^{z_{t+1}}^*, \) banks default. The default probability is,
  \[ p_t = F(e^{z_{t+1}}^*). \]

- Dividends can be rewritten as,
  \[ d_t = \frac{\gamma}{1 - \gamma} N_t. \]

- Banks seek to maximize \( V_t \) subject to balance sheet the law of motion of equity.
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\[ N_{t+1} = (1 - \gamma) [NOI_{t+1} + N_t]^+ . \]
which is the law of motion of equity.

I define \( e_{t+1}^{z,*} : \)
\[ (1 - \delta)K_t + Z_{t+1}^* K_t^\alpha = \bar{R}^D D_t + \bar{R}^F D_t^F. \]

where \( Z_{t+1}^* = \exp(\mu_z (1 - \rho_z) + \rho_z \log(Z_t) + e_{t+1}^{z,*}) . \)

If \( e_{t+1}^z < e_{t+1}^{z,*} , \) banks default. The default probability is,
\[ p_t = F(e_{t+1}^{z,*}) . \]

Dividends can be rewritten as,
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The Lagrangian equation is:

\[ L_t = \mathbb{E}_t \left\{ \sum_{i=t}^{\infty} \beta^{i-t} \left( \gamma \frac{N_i}{1 - \gamma} + \lambda_i \left[ (1 - \delta)K_{i-1} + Z_iK_{i-1}^\alpha - \bar{R}_{i-1}^D D_{i-1} - \bar{R}_{i-1}^F \phi_{i-1} \right]^+ (1 - \gamma) - N_i \right) \right\} , \]

where \( \lambda_t \) is the LM associated with the law of motion of equity.

\( \lambda_t \): Shadow value of bank equity. Rewriting \( L_t \),

\[ L_t = \frac{\gamma}{1 - \gamma} N_t + \lambda_t \left[ [NOI_t + N_{t-1}]^+ (1 - \gamma) - N_t \right] + \mathbb{E}_t \left\{ \frac{\gamma \beta}{1 - \gamma} N_{t+1} \right\} + \beta \int_{e^{z^*}_{i+1}}^{+\infty} \lambda_{t+1} [NOI_{t+1} + N_t] (1 - \gamma) dF(e^{z^*}_{i+1}) - \mathbb{E}_t \{ \lambda_{t+1} N_{t+1} \} + \mathbb{E}_t \{ L_{t+2} \} . \]

The FOC for \( D_t \) yields:

\[
\beta \int_{e^{z^*}_{i+1}}^{+\infty} \lambda_{t+1} \left( 1 - \delta + Z_{t+1} \alpha K_{t+1}^\alpha - \bar{R}_{t+1}^D \right) (1 - \gamma) dF(e^{z^*}_{t+1}) + \\
\beta \lambda_{t+1} \left( (1 - \delta)K_t + Z_{t+1}K_t^\alpha - \bar{R}_{t+1}^D D_t - \bar{R}_{t+1}^F \phi_t \right) (1 - \gamma) f(e^{z^*}_{t+1}) \bigg|_{e^{z^*}_{i+1}=e^{z^*}_{i+1}} \frac{\partial e^{z^*}_{t+1}}{\partial D_t} = 0.
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\[ \beta \int_{\tilde{z},*}^{+\infty} \lambda_{t+1} \left[ NOI_{t+1} + N_t \right] (1 - \gamma) dF(e_{t+1}^\tilde{z}) - \mathbb{E}_t \left\{ \lambda_{t+1}N_{t+1} \right\} + \mathbb{E}_t \{ L_{t+2} \}. \]

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Banks

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- The FOC for $N_t$ yields,

$$\gamma \frac{1}{1 - \gamma} - \lambda_{t+1} + \beta \int_{e_{t+1}^z}^{+\infty} \lambda_{t+1} (1 - \delta + Z_{t+1} \alpha K_t^{\alpha-1}) (1 - \gamma) dF(e_{t+1}^z) = 0.$$ 

- The shadow value of equity, $\lambda_{t+1}$, affects the marginal (net) benefits of the loans.
- $\lambda_{t+1}$ captures the intertemporal effects.
- If $\lambda_{t+1}$ is independent of $e_{t+1}^z$: two-period model.
- Market clearing condition:

$$C_t = \omega^H + (1 - \delta) K_{t-1} + Z_t K_{t-1} - K_t + \phi_t - \bar{R}_t^F \phi_{t-1},$$

- $NFL_t = \phi_t$.
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$$\beta \int_{e_t^{z_1}}^{+\infty} \lambda_{t+1} (1 - \delta + Z_{t+1} \alpha K_t^{\alpha-1} - \bar{R}_t) (1 - \gamma) dF(e_{t+1}^{z}) = 0.$$ 

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Jorge Pozo
Domestic Social Planner

- The social planner aims to maximize the welfare of the domestic economy: Utility of HHs, $W_t$.

- The planner chooses $K_t$, by maximizing $W_t$ subject to,

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- Socially efficient level of loans,

  $$ K_t = \left( \frac{\mathbb{E}_t\{Z_{t+1}\} \alpha}{1/\beta - (1 - \delta)} \right)^{\frac{1}{1-\alpha}}, $$

  where,

  $$ \mathbb{E}_t\{Z_{t+1}\} = \exp(\mu_z(1 - \rho_z) + \rho_z \log(Z_t) + 0.5\sigma_z^2). $$

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$$K_t = \left( \frac{\mathbb{E}_t \{ Z_{t+1} \} \alpha}{1/\beta - (1 - \delta)} \right)^{\frac{1}{1-\alpha}},$$

where,

$$\mathbb{E}_t \{ Z_{t+1} \} = \exp(\mu_z(1 - \rho) + \rho_z \log(Z_t) + 0.5\sigma_z^2).$$

$K_t$ is independent of $\gamma$.
The social planner aims to maximize the welfare of the domestic economy: Utility of HHs, $W_t$.

The planner chooses $K_t$, by maximizing $W_t$ subject to,

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Domestic Social Planner

The social planner aims to maximize the welfare of the domestic economy: Utility of HHs, $W_t$.

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$$C_t = \omega^H + (1 - \delta)K_{t-1} + Z_t K_{t-1}^\alpha - K_t + \phi_t - \bar{R}_t^F \phi_{t-1},$$

Socially efficient level of loans,

$$K_t = \left( \frac{\mathbb{E}_t\{Z_{t+1}\} \alpha}{1/\beta - (1 - \delta)} \right)^{\frac{1}{1-\alpha}},$$

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Comparing the SP and CE equilibriums

- Is capital inefficiently high under limited liability (as in the two period version)?

The socially efficient level of loans is,

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In the competitive equilibrium (LL + DI) loans are,

$$K_t^{CE} = \left( \frac{\mathbb{E}_t\{Z_{t+1} \lambda_{t+1} | e_{t+1}^z \geq e_{t+1}^{z,*}\} \alpha}{\mathbb{E}_t\{\lambda_{t+1} | e_{t+1}^z \geq e_{t+1}^{z,*}\}} \right)^{\frac{1}{1-\alpha}} \frac{1/\beta - (1 - \delta)}{1-\alpha},$$

- SP: Planner equilibrium. CE: Competitive equilibrium.

Rewriting $K_t^{CE}$:

$$K_t^{CE} = \left( \frac{\mathbb{E}_t\{Z_{t+1} \lambda_{t+1} | e_{t+1}^z \geq e_{t+1}^{z,*}\} \alpha}{\mathbb{E}_t\{\lambda_{t+1} | e_{t+1}^z \geq e_{t+1}^{z,*}\}} \right)^{\frac{1}{1-\alpha}} \frac{1/\beta - (1 - \delta)}{1-\alpha}.$$
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- In the competitive equilibrium (LL + DI) loans are,

\[ K_t^{CE} = \left( \frac{\frac{\mathbb{E}_t\{Z_{t+1}\lambda_{t+1}| e_{t+1}^{z,r} \geq e_{t+1}^{z,r}\} \alpha}{\mathbb{E}_t\{\lambda_{t+1}| e_{t+1}^{z,r} \geq e_{t+1}^{z,r}\} - 1/\beta - (1 - \delta)}}{1/\beta - (1 - \delta)} \right)^{\frac{1}{1-\alpha}}, \]

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Comparing the SP and CE equilibriums

- By definition $\mathbb{E}_t\{Z_{t+1} e_{t+1} \geq e_{t+1}^*\} \geq \mathbb{E}_t\{Z_{t+1}\}$. From the FOCs of $D_t$ and $N_t$,
  
  $$\lambda_t = \int_{e_{t+1}^*}^{+\infty} \lambda_{t+1} dF(e_{t+1}^*)(1 - \gamma) + \frac{\gamma}{1 - \gamma}.$$ 

- $\lambda_{t+1}$ is not independent of $e_{t+1}^*$. Numerical results: $\text{Cov}_t\{Z_{t+1} \lambda_{t+1} e_{t+1} \geq e_{t+1}^*\} > 0$, then $K_t^{CE} > K_t^{SP}$.

- The lower the productivity shock, $e_t^*$, the higher likelihood that banks default at $t + 1$ and thus the lower the probability that an exogenous unit of bank’s equity at $t$ increases bank’s capacity to accumulate equity at $t + 1$.

- In an infinity time period model the excess bank risk-taking is amplified:
  
  - Since banks have limited liability and deposit insurance not only in the present but also in the future, they inefficiently overestimate even by more the marginal benefits of loans.

- The excess marginal benefits of loans, $\theta_t$, is found in:
  
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### Table 1: Parameters

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
<th>Source / Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discount factor</td>
<td>$\beta$</td>
<td>0.986 Gross domestic rate = 1.060 (annual)</td>
</tr>
<tr>
<td>Gross foreign interest rate</td>
<td>$R^F$</td>
<td>1.003 Gross foreign rate = 1.0124 (annual)</td>
</tr>
<tr>
<td>Capital’s shares in output</td>
<td>$\alpha$</td>
<td>0.330 Standard value</td>
</tr>
<tr>
<td>Capital depreciation ratio</td>
<td>$\delta$</td>
<td>0.120 Bank Leverage ratio</td>
</tr>
<tr>
<td>Dividend policy</td>
<td>$\gamma$</td>
<td>0.540 Short-term dynamics of $p_t$</td>
</tr>
<tr>
<td>Foreign borrowing limit</td>
<td>$\phi$</td>
<td>2.066 NFL to GDP ratio</td>
</tr>
<tr>
<td>Government Expenses</td>
<td>$G$</td>
<td>0.975 Bank Credit to GDP ratio</td>
</tr>
<tr>
<td>Households’ exogenous income</td>
<td>$\omega^H$</td>
<td>3.906 Consumption to GDP ratio</td>
</tr>
<tr>
<td>Mean of log $Z_1$</td>
<td>$\mu_z$</td>
<td>0.000 Normalized</td>
</tr>
<tr>
<td>Std. Dev. of the productivity shock</td>
<td>$\sigma_{e^Z}$</td>
<td>0.952 Default Probability= 3% (annual)</td>
</tr>
<tr>
<td>Persistence of the shock</td>
<td>$\rho_z$</td>
<td>0.850 Standard value</td>
</tr>
</tbody>
</table>

Each period represents a quarter.
### Table 2: Stochastic Steady State

<table>
<thead>
<tr>
<th>Description</th>
<th>Variables</th>
<th>(1)</th>
<th>(2)</th>
<th>(3) (\dagger)</th>
<th>(4) CE-ULL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank leverage ratio</td>
<td>(K_{ss}/N_{ss})</td>
<td>-</td>
<td>9.53</td>
<td>9.14</td>
<td>9.07</td>
</tr>
<tr>
<td>NFL to GDP ratio (%)</td>
<td>(\phi/(4.GDP_{ss})) (%)</td>
<td>7.57</td>
<td>7.54</td>
<td>7.56</td>
<td>7.57</td>
</tr>
<tr>
<td>Bank credit to GDP ratio (%)</td>
<td>(K_{ss}/(4.GDP_{ss})) (%)</td>
<td>27.49</td>
<td>28.38</td>
<td>27.63</td>
<td>27.49</td>
</tr>
<tr>
<td>Consumption to GDP ratio (%)</td>
<td>(C_{ss}/GDP_{ss}) (%)</td>
<td>72.44</td>
<td>72.07</td>
<td>72.39</td>
<td>72.44</td>
</tr>
<tr>
<td>NFL to credit ratio (%)</td>
<td>(\phi/K_{ss}) (%)</td>
<td>27.51</td>
<td>26.56</td>
<td>27.37</td>
<td>27.51</td>
</tr>
<tr>
<td>Bank default probability (%)</td>
<td>(p_{ss}) (%)</td>
<td>-</td>
<td>0.74</td>
<td>0.37</td>
<td>0.32</td>
</tr>
<tr>
<td>Excess marginal benefits (%)</td>
<td>(\theta_{ss}) (%)</td>
<td>-</td>
<td>0.31</td>
<td>0.05</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(K_{ss}^{CE}/K_{ss}^{SP} - 1) (%)</td>
<td>-</td>
<td>3.58</td>
<td>0.54</td>
<td>-</td>
</tr>
</tbody>
</table>

\(CE^{\dagger}\): Competitive equilibrium abstracting from the intertemporal channel, i.e. assuming \(\lambda_t\) is independent of \(e_{t}^{\gamma}\).

\(CE – ULL\): Competitive equilibrium under unlimited liability. NFL = Net foreign liabilities=\(\phi\). NFL to GDP ratio = \(\phi/GDP_{ss}\). \(GPD_{ss} = G + Y_{ss}\). \(Y_{ss} = \omega^{H} + Z_{ss}K_{ss}^{\alpha}\). 
1998 Sudden Stop Simulation

- The economy starts from its stochastic steady state at time $t = 0$.
- The sudden stop simulation: A 87% reduction of ST NFL, $\phi$.
- This is in order to capture a reduction of the ST NFL to GDP ratio from 7.5% to 1%.
- The adjustment of the borrowing limit is gradual,
  \[
  \log(\phi_t) = \rho_\phi \log(\phi_{t-1}) + (1 - \rho_\phi) \log(\phi_{\text{new}}),
  \]
  for $t \geq 1$.
- The initial fall in the foreign borrowing limit happening in $t = 1$ is not anticipated by agents.
- From the period 1 on, agents correctly anticipate the path of $\phi_t$.
- I set $\rho_\phi = 0.92$ in order to match the dynamics of the ST NFL to GDP ratio.
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- The economy starts from its stochastic steady state at time $t = 0$.

- The sudden stop simulation: A 87% reduction of ST NFL, $\phi$.

- This is in order to capture a reduction of the ST NFL to GDP ratio from 7.5% to 1%.

- The adjustment of the borrowing limit is gradual,

$$
\log(\phi_t) = \rho_\phi \log(\phi_{t-1}) + (1 - \rho_\phi) \log(\phi_{new}),
$$

for $t \geq 1$.

- The initial fall in the foreign borrowing limit happening in $t = 1$ is not anticipated by agents.

- From the period 1 on, agents correctly anticipate the path of $\phi_t$.

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Figure 2: ST NFL to GDP (%)

1998 Sudden Stop Simulation

\[ C_t \]

\[ K_t \]

\[ N_t \]

\[ K_t/N_t \]

\[ p_t(\%) \]

\[ \theta_t(\%) \]

\[ NFL_t/GDP_t(\%) \]

\[ CA_t/GDP_t(\%) \]

\[ \phi_t \]

\[ CE^\dagger \]: Competitive equilibrium when abstracting from the intertemporal channel.
1998 Sudden Stop Simulation

- **In the long-term:**
  - The (quarterly) default probability moves from 0.7% to 1.8%.
  - The relative excess loans moves from 3.6% to 6.2%.
  - The excess marginal benefits increases from 0.31% to 0.52%.

- **In the short-term:**
  - The default probability of banks becomes 1.3 times its initial value.
  - The relative excess loans becomes 1.5 times its initial value.
  - The excess marginal benefits of loans becomes 1.5 times its initial value.
  - These account for the 23%, 63% and 64% of their long-term movements.

- This is in line with the behavior of the morosity ratio.

- When abstracting from the intertemporal effect, the short-term responses are (1.1, 1.1 and 1.1 respectively) and those account for the 8.5%, 6.8% and 6.5% of their long-term movements.
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*Future research*: Optimal policies. Risk-averse agents.
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