A Dynamic Model for Macroprudential and Monetary Policy Analysis

Dimitrios P. Tsomocos

St. Edmund Hall and Saïd Business School, University of Oxford.

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1DISCLAIMER: The views expressed here are my own and do not necessarily represent those of the St. Edmund Hall, U. of Oxford or the Saïd Business School, nor the Central Bank of Chile or its Board. Based on "A Financial Stability Analysis for the Chilean Economy" (Kazakova, Martinez, Peiris, Tsomocos, 2019).
Financial Stability and Policy Responses

- There is a long standing debate whether monetary policy should target only price stability, or also other macroeconomic variables.
- The experience of the global financial crisis has shown that price stability targets alone are insufficient for macroeconomic stability.
- This has focused the debate on financial stability as being an additional target of monetary policy.
- Indeed, the price stability target of the 1980s-2007 period was insufficient to prevent the macroeconomic fluctuations of 2007 onwards.
- Should central banks employ additional policy tools to address financial stability or just augment the monetary policy toolkit?
## Price vs financial stability

<table>
<thead>
<tr>
<th>Concept</th>
<th>Price Stability</th>
<th>Financial Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement</td>
<td>Yes, subject to technical queries</td>
<td>Hardly/except by absence</td>
</tr>
<tr>
<td>Instrument for control</td>
<td>Yes, subject to lags</td>
<td>Limited/difficult to use</td>
</tr>
<tr>
<td>Accountable</td>
<td>Yes</td>
<td>Hardly</td>
</tr>
<tr>
<td>Forecasting structure</td>
<td>Central tendency and distribution</td>
<td>Tails of distribution</td>
</tr>
<tr>
<td>Forecasting procedure</td>
<td>Standard</td>
<td>Simulations or stress tests</td>
</tr>
<tr>
<td>Administrative procedure</td>
<td>Simple</td>
<td>Difficult</td>
</tr>
</tbody>
</table>
Default and financial stability

"Default is to macro-economics what sin is to theology: regrettable but central and essential".

Charles Goodhart

Default is costly
- To both, creditor and debtor (via punishment).
- To market (negative externality worsened by adverse selection)
- Assets may not be traded!

When markets are incomplete
- Provides extra insurance (spanning) opportunities to creditors.
- Allows debtor to customize his own insurance opportunities.
- Agents can be on both sides of the market (pooling).

Financial (in)stability definition (Goodhart et al. (2004, 2005, 2006), Aspachs et al. (2007))

An economic regime is said to be financially unstable if, inter alia, a "number" (but not necessarily all) of households, firms, and banks defaults (i.e. liquidity crisis) without necessarily becoming bankrupt and the aggregate profitability of the banking sector decreases significantly (i.e. banking crisis).
On Modeling Default

- Default as a (General) Equilibrium phenomenon
  - incomplete markets
  - money
  = FINANCIAL FRAGILITY

- Regulation affects default, insurance (spanning), and financial trade
  ⇒ Welfare depends on regulatory intervention.
On Modeling Default

- Default is a decision (variable) or bad luck

- Continuous/non-pecuniary penalties (Dubey, Geanakoplos and Shubik, 2005)
  
  or

  Cost reflected in margins (collateral)
An intermediate level of default penalties can make everyone better-off
Shubik & Wilson, 1977 (Journal of Economics)
Dubey, Geanakoplos & Shubik, 2005 (Econometrica)
Default modelling: continuous

Effect of penalties (Shubik & Tsomocos (Journal of Economics, 1992))

<table>
<thead>
<tr>
<th></th>
<th>$k &lt; k^*$</th>
<th>$k = k^*$</th>
<th>$k &gt; k^*$</th>
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<tbody>
<tr>
<td>$\lambda &lt; \lambda^*$</td>
<td>Default/deflation $r &gt; 0$</td>
<td>Default/Price shift $r &gt; 0$</td>
<td>Possible default/inflation $r \geq 0$</td>
</tr>
<tr>
<td>$\lambda = \lambda^*$</td>
<td>Default/deflation $r &gt; 0$</td>
<td>No default $r = 0$</td>
<td>No default/inflation $r = 0$</td>
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<tr>
<td>$\lambda &gt; \lambda^*$</td>
<td>Possible default/inflation $r \geq 0$</td>
<td>No default/Potential inflation $r = 0$</td>
<td>No default/Deflation or inflation $r = 0$</td>
</tr>
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</table>
Model characteristics

Model Features
- General equilibrium model of an exchange economy with money and banks
- Incomplete markets (limited participation)
- Heterogeneous investors/consumers and banks
- Liquidity constraints
- Endogenous default

Implications
- Equilibrium is compatible with default
- Equilibrium is constrained Pareto inefficient (policy matters!)
- Nominal changes affect both prices and quantities (money is non-neutral)
- The Central Bank controls the overall liquidity of the economy and such liquidity, as well as
  Endogenous default risk, determines the interest rates
Chilean case study: the paper in a nutshell

“A Financial Stability Analysis for the Chilean Economy”
(Kazakova, Martínez, Peiris, Tsomocos, 2019).

The question:
What is the impact of - real and nominal - shocks to financial stability of SOE commodity exporters? What is the role of the banking system IO structure?

What we do:
- We estimate a small open economy model that allows us to study financial stability for Chile.
- The model incorporates banking system heterogeneity in a reduced fashion and reflects SOEs’ banking industry IO structure in the Chilean context.
- We find evidence of the interplay of real and financial economies, and the effect of banking sector heterogeneity.
- We conduct monetary-macroprudential policy experiments.
Financial (In)Stability in Chile

- Chile has experienced three relevant episodes in the last 40 years with different degrees of relevance and policy/regulatory environments.
- The current situation is the result of convergence to an open economy with safer banking system. Chile has inflation targeting with free floating exchange rate, which acts as a natural stabilizer of international shocks.
- However, there is still dependence of copper prices that may feedback to the financial sector directly or indirectly.

<table>
<thead>
<tr>
<th>Period</th>
<th>Characteristics</th>
<th>Context</th>
</tr>
</thead>
</table>
Motivation

Commodity price shocks’ role

- In particular, recent periods of fragility seem related to commodity price fluctuations...

**Figure:** Financial Fragility and Economic Activity (percentage)

Source: Own elaboration. Grey areas based on Martínez et al. (2018).
**The role of bank heterogeneity**

![Graph](image.png)

Source: Own elaboration. Grey areas based on Martínez et al. (2018).
Focus of Analysis

Our paper concerns macroprudential regulation/monitoring in fragility times with macroeconomic shocks being amplified due to the presence of pecuniary externalities. The two sources of the externalities are:

- Cost of default
- Collateral constraints dependent on market valuation of capital

Banking sector features:

- Big and small banks
- Perfect competition
- Ex post heterogeneity manifested in idiosyncratic shocks experienced by small banks
Model structure

- New-Keynesian DSGE model with nominal rigidities.
- Considers a commodity exporter Small Open Economy.
- Assume that all goods are tradable and there are no barriers to trade.
- There is households, firms, external sector, Central Bank, Regulator and Government.
- Heterogenous 2-period lived Firms with idiosyncratic risk and default.
- Heterogenous 2-period lived banks, and capital requirements.
- Hence, there is default - for secured and collateralized loans - and capital requirements.
- Consider further bank heterogeneity in the form of systemic and small banks.

Implication

Endogenous (strategic) default allows modeling risk taking behavior by firms, and justifies prudential regulation of banks and monetary policy.
Flow of funds

- **Copper Producers**
  - Copper Profits
  - Domestic Profits
  - Undepreciated capital
  - Final capital

- **Wholesale Producers**
  - Loans
  - Interest

- **Intermediate Producers**
  - Wholesale goods
  - Wages
  - Profits

- **Saver Households**
  - Profits
  - Deposits

- **Big banks**
  - Bond

- **Small banks**
  - Profits

- **The Government**
  - Bonds

- **The CB**
  - Banking Sector

- **Rest of the world**
  - Copper

- **DP Consumption goods**
  - DP Government Consumption

- **Foreign-priced goods**
Formulation: firms (ex ante)

OLG structure

- Two period lived firms
- Secured vs unsecured borrowing
- \( t=0 \): Firms issue non-state-contingent nominal unsecured debt(credit) to banks.
- \( t=1 \): Firms liquidate assets, and pay dividends net of renegotiation costs depending on their default decisions and the business cycle fluctuations.

\[
p^K_t K_{t+1} + T^w = \mu^w_{t+1} + e^{w,\text{total}}_t,
\]

where \( \mu^w_{t+1} = \mu^{w,s}_{t+1} + \mu^{w,u}_{t+1} \) and \( e^{w,\text{total}}_t = e^w_t + (1 - \tau)p^K_t K^w_t \)

\[
\mathbb{E}(1 + r^w_{t+1})\mu^w_{t+1} \leq \text{coll}(1 - \tau)K^w_{t+1} \mathbb{E} p^K_{t+1}
\]
Model

Formulation: firms (ex post)

- ‘Lucky’ vs ‘unlucky’ firms: probability of default $\theta^w$ is the prob. of $A_t$
- $\delta^w_t$ - loss given default
- Cost of negotiating the debt $\Omega^w_{t+1} \left( \delta^w_{t+1} \mu^w_{t+1} (1 + r^w_{t+1}) \right)^{1+\psi}$

$$\Pi^w_{t+1} = p^w_{t+1} A^w_{t+1} (k^w_{t+1})^\alpha (l^w_{t+1})^{1-\alpha} - (1 - \delta^w_{t+1}) \mu^w_{t+1} (1 + r^w_{t+1}) - \mu^w_{t+1} (1 + r^w_{t+1})$$

$$-w_{t+1} l^w_{t+1} - \frac{\Omega^w_{t+1}}{1+\psi} \left( \delta^w_{t+1} \mu^w_{t+1} (1 + r^w_{t+1}) \right)^{1+\psi} + p^K_{t+1} k^w_{t+1} (1 - \tau)$$ (3)

- Firms’ decision to default creates pecuniary externality
- Higher expected default rate raises the interest rate ax ante
- Macro variable:

$$\Omega^w_t = \Omega^w_{ss} (\frac{\mu^w_{ss} (1 + r^w_{ss})}{GDP_{ss}})^\omega (\delta^w_{ss})^\gamma (\frac{GDP_t}{\mu^w_{t} (1 + r^w_{t})})^\omega \frac{1}{(\delta^w_{t})^\gamma}. \quad (4)$$
Heterogeneous vs. homogeneous banking sector

- We estimate two models: with heterogeneous and homogeneous banking sectors in an economy.
- For the homogeneous banking sector case we assume that the banking system is populated only by big, systemically important, banks.
- For the heterogeneous banking sector case we assume that the banking system is populated by big, systemically important, banks and small banks.
- Small banks lend to one borrower, which makes them ex-post either "lucky" or "unlucky", depending on the state of a borrower, while big banks lend to a pull of "lucky" and "unlucky" firms.
Heterogeneous vs. homogeneous banking sector

Banks have different exposure to secured vs unsecured lending:

- A fraction of unsecured (secured) debt is higher for small (large) banks,
- Shocks to TFP affect repayment rate on unsecured debt,
- Shocks to Copper price affect capital price and collateral value through the exchange rate,

As a result, small banks are mostly sensitive to domestic shocks, large banks - to external shocks:

- The variance decomposition shows that changes in NPLs rate of small banks come mostly from TFP shocks (59.9%) while for large banks it is mostly from copper price shocks (64.5%).
- This is because small banks are more sensitive to unsecured (risky) credit, while large banks are more sensitive to secured credit and fluctuations in the value of collateral.
- The response of financial variables is accelerated and amplified when bank heterogeneity is accounted for.
New-born systemically important large banks are capitalised with equity of $e_{t}^{big}$. They accept deposits from households, extend secured and unsecured loans to firms. The first period budget constraint of a systemically important bank is given by

$$\mu_{t+1}^{big,s} + \mu_{t+1}^{big,u} = d_{t+1}^{big} + e_{t}^{big}$$

(5)
The capital adequacy ratio is defined as the ratio of bank capital to risk weighted assets net of reserves (\(rwa_{t}^{big}\)):

\[
k_{t}^{big} = \frac{e_{t}^{big}}{rwa_{t}^{big}} = \frac{e_{t}^{big}}{(r\bar{w}\mu_{t+1}^{big,u} + r\bar{w}\mu_{t+1}^{big,s})}
\]  

(6)

Big banks then choose how much of secured and unsecured debt to lend out to firms:

\[
\Pi_{t+1}^{big} = \theta^{w}(1 + r_{t+1}^{w,u})(1 - \delta_{t+1}^{w})\mu_{t+1}^{bank,u} + (1 - \theta^{w})(1 + r_{t+1}^{w,u})\mu_{t+1}^{big,u} + \\
(1 + r_{t+1}^{w,s})\mu_{t+1}^{big,s} - (1 + r_{t+1}^{d})d_{t+1}^{big},
\]  

(7)

Given \(\{\delta_{t+1}^{w}, r_{t+1}^{w,u}, r_{t+1}^{w,s}, r_{t+1}^{d}\}\), banks maximize:

\[
\max_{\mu_{t+1}^{big,u}, \mu_{t+1}^{bank,s}, d_{t+1}^{big}} \mathbb{E}_{t/\beta_{t}}^{h} \left( \prod_{t+1}^{big} \right)^{1 - \zeta_{big}} \cdot \left( \frac{1}{1 - \zeta_{big}} \right) - a_{cap}0.5[k_{t}^{big} - \bar{k}_{big}]^{2}
\]  

(8)
Small banks

Small banks have the following BC:

$$\mu_{t+1}^{\text{small},s} + \mu_{t+1}^{\text{small},u} = d_{t+1}^{\text{small}} + e_t^{\text{small}}$$  \hspace{1cm} (9)

Lucky small bank receives a profit:

$$\bar{\Pi}_{t+1}^{\text{small}} = (1 + r_{t+1}^{w,u})\mu_{t+1}^{\text{small},u} + (1 + r_{t+1}^{w,s})\mu_{t+1}^{\text{small},s} - (1 + r_{t+1}^{d})d_{t+1}^{\text{small}},$$  \hspace{1cm} (10)

Unlucky small bank receives a profit:

$$\Pi_{t+1}^{\text{small}} = (1 + r_{t+1}^{w,u})(1 - \delta_{t+1}^{w})\mu_{t+1}^{\text{small},u} + (1 + r_{t+1}^{w,s})\mu_{t+1}^{\text{small},s} - (1 + r_{t+1}^{d})d_{t+1}^{\text{small}},$$  \hspace{1cm} (11)

For a small bank capital adequacy ratio looks like:

$$k_t^{\text{small}} = \frac{e_t^{\text{small}}}{r_w^{\text{small},u}} = \frac{e_t^{\text{small}}}{(r_w^{\mu_{t+1}^{\text{small},u}} + r_w^{\mu_{t+1}^{\text{small},s}})}$$  \hspace{1cm} (12)

Given $$\{\delta_{t+1}^{w}, r_{t+1}^{w,u}, r_{t+1}^{w,s}, r_{t+1}^{d}\}$$, banks maximize:

$$\mathbb{E}_t^\beta^{\text{small}}\left[ (1 - \theta^{w})\bar{\Pi}_{t+1}^{\text{small}}\frac{1 - \varsigma^{\text{small}}}{1 - \varsigma^{\text{small}}} + \theta^{w}\frac{\bar{\Pi}_{t+1}^{\text{small}}1 - \varsigma^{\text{small}}}{1 - \varsigma^{\text{small}}} \right]$$  \hspace{1cm} (13)

$$-a_{\text{cap}}0.5[k_t^{\text{small}} - \bar{k}^{\text{small}}] + \lambda^{\text{small},u}\frac{\mu_{t+1}^{\text{small},u}}{\mu_{\text{ss}}^{\text{small},u}}$$
The CB and the Government

- The Central Bank controls the interest rate $i^b_t$ according to the following rule:

$$\frac{1 + i^b_t}{1 + i^b_{ss}} = \left( \frac{1 + i^b_{t-1}}{1 + i^b_{ss}} \right)^{\rho_i} \left( \frac{1 + \pi^cpi_t}{1 + \pi^cpi_{ss}} \right)^{1 + \rho \pi} \left( \frac{GDP_t}{GDP_{ss}} \right)^{\rho_{gdp}} \varepsilon^i_t,$$ (14)

- The Government owns the copper endowment and receives all the copper profits

- The Government Budget Constraint:

$$G_t + p_t^{imp} G_t^{imp} + B_t^g - 1 \left( \frac{1 + i^b_{t-1}}{1 + \pi_t} \right) = B_t^g + p_t^{c,dom} C_t + T^w$$ (15)
# Calibration: matching financial variables moments

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\beta^h$</td>
<td>0.9829</td>
<td>Household’s time preference</td>
<td>Calibration</td>
</tr>
<tr>
<td>$\theta^h$</td>
<td>1</td>
<td>Household’s disutility from labor</td>
<td>Calibration</td>
</tr>
<tr>
<td>$\gamma^h$</td>
<td>0.84</td>
<td>Household’s labor elasticity</td>
<td>Medina &amp; Soto (2007)</td>
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<td>$\sigma^h$</td>
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<td>Household’s risk aversion</td>
<td>Calibration</td>
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<tr>
<td>$\phi^h$</td>
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<td>Household’s preference for domestic goods</td>
<td>Medina &amp; Soto (2007)</td>
</tr>
<tr>
<td>$\nu^c$</td>
<td>1.12</td>
<td>Elasticity of substitution between domestic and foreign consumption goods</td>
<td>Medina &amp; Soto (2007)</td>
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<td>$\phi^i$</td>
<td>0.5</td>
<td>Share of domestic goods in investment</td>
<td>Medina &amp; Soto (2007)</td>
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<td>Elasticity of substitution between domestic and foreign investment goods</td>
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<td>$\beta^\text{bank}$</td>
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<td>Bank’s time preference</td>
<td>Calibration</td>
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<tr>
<td>$\xi^\text{bank}$</td>
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<td>Bank’s risk aversion</td>
<td>De Walque et al. (2010)</td>
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<td>$\delta^f$</td>
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<td>Loss given default</td>
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<td>$k^\text{big}$</td>
<td>0.105</td>
<td>Capital requirements for big banks</td>
<td>Calibration</td>
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<tr>
<td>$k^\text{small}$</td>
<td>0.13</td>
<td>Capital requirements for small banks</td>
<td>Calibration</td>
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<tr>
<td>$\bar{\gamma}$</td>
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<td>Bank’s risk weight</td>
<td>Basel III</td>
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<td>$\tau$</td>
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<td>$\alpha$</td>
<td>0.33</td>
<td>Capital share in wholesaler’s production</td>
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<td>$\text{coll}$</td>
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<td>Collateral value of capital</td>
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<tr>
<td>$\theta^w$</td>
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<td>Fraction of firms defaulting</td>
<td>Calibration</td>
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<td>$\theta^c$</td>
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<td>Elasticity of retailer’s output</td>
<td>Calibration</td>
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<td>$\epsilon^w$</td>
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<td>Elasticity of labor demand</td>
<td>Calibration</td>
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## Calibration: matching financial variables moments

<table>
<thead>
<tr>
<th>Calibrated ratios</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
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</thead>
<tbody>
<tr>
<td>$\frac{C}{GDP}$</td>
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<td>Aggregate Consumption to GDP</td>
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<tr>
<td>$\frac{\mu_{big},u}{\mu_{big}}$</td>
<td>0.19</td>
<td>Big bank unsecured lending to total lending</td>
<td>Calibration</td>
</tr>
<tr>
<td>$\frac{\mu_{small},u}{\mu_{small}}$</td>
<td>0.34</td>
<td>Small bank unsecured lending to total lending</td>
<td>Calibration</td>
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<tr>
<td>$\frac{\mu_{big},u}{\mu_{big}}$</td>
<td>0.21</td>
<td>Big bank unsecured lending to total lending</td>
<td>Calibration</td>
</tr>
</tbody>
</table>
## Estimation results: estimated parameters

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<thead>
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</thead>
<tbody>
<tr>
<td></td>
<td>Prior</td>
<td>Std</td>
</tr>
<tr>
<td>household’s adj cost to foreign bonds</td>
<td>$a_{h,b,f}$</td>
<td>0.01</td>
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<tr>
<td>household’s adj cost to firm’s equity</td>
<td>$a_{h,f,e}$</td>
<td>0.01</td>
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<tr>
<td>firm’s adj cost to capital</td>
<td>$a_{w,k}$</td>
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<tr>
<td>firm’s adj cost to secured loans</td>
<td>$a_{w,s}$</td>
<td>0.01</td>
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<tr>
<td>firm’s adj cost to unsecured loans</td>
<td>$a_{w,u}$</td>
<td>0.01</td>
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<tr>
<td>big bank’s adj cost to secured loans</td>
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<td>big bank’s adj cost to unsecured loans</td>
<td>$a_{b,u}$</td>
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<tr>
<td>small bank’s adj cost to secured loans</td>
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<tr>
<td>small bank’s adj cost to unsecured loans</td>
<td>$a_{s,u}$</td>
<td>-</td>
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<td>cap prod adj cost to investment</td>
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<td>capad penalty</td>
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<td>Price and wage setting</td>
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<tr>
<td>Wage stickiness</td>
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<tr>
<td>Price stickiness</td>
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## Estimation results: estimated parameters and shocks

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<tbody>
<tr>
<td></td>
<td>Prior</td>
<td>Std</td>
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<tr>
<td><strong>Taylor rule</strong></td>
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<tr>
<td>interest rate coefficient</td>
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<td>inflation rate coefficient</td>
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<td>GDP growth rate coefficient</td>
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<td><strong>Credit conditions</strong></td>
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<tr>
<td>default amplification in $\Omega$</td>
<td>$\gamma$</td>
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<td>credit to GDP amplification in $\Omega$</td>
<td>$\omega$</td>
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<td>default cost parameter</td>
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<td><strong>Shocks’ persistence</strong></td>
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<tr>
<td>AR(1) persistent oil price shock</td>
<td>$\rho^{p,o}$</td>
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<td>AR(1) persistent TFP shock</td>
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<td>AR(1) monetary policy shock</td>
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<td>AR(1) foreign interest rate shock</td>
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<tr>
<td>AR(1) saver’s time-preference shock</td>
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<tr>
<td><strong>Shocks</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Std. oil price shock</td>
<td>$\epsilon^{p,o}$</td>
<td>0.15</td>
</tr>
<tr>
<td>Std. TFP shock</td>
<td>$\epsilon^a$</td>
<td>0.01</td>
</tr>
<tr>
<td>Std. monetary policy shock</td>
<td>$\epsilon^{mon}$</td>
<td>0.01</td>
</tr>
<tr>
<td>Std. foreign interest rate shock</td>
<td>$\epsilon^{i,for}$</td>
<td>0.01</td>
</tr>
<tr>
<td>Std. saver’s time-preference shock</td>
<td>$\epsilon^{\beta,sav}$</td>
<td>0.01</td>
</tr>
</tbody>
</table>
## Error variance decomposition: heterogeneous case

<table>
<thead>
<tr>
<th></th>
<th>$\epsilon^{p,c}$</th>
<th>$\epsilon^a$</th>
<th>$\epsilon^{mon}$</th>
<th>$\epsilon^{r,tor}$</th>
<th>$\epsilon^{\beta,h}$</th>
<th>$\epsilon_i^{me}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GDP</strong></td>
<td>79.1</td>
<td>18.7</td>
<td>0.04</td>
<td>0.09</td>
<td>0.19</td>
<td>1.86</td>
</tr>
<tr>
<td><strong>cons</strong></td>
<td>46.9</td>
<td>23.0</td>
<td>0.04</td>
<td>11.1</td>
<td>16.2</td>
<td>2.71</td>
</tr>
<tr>
<td><strong>Loans</strong>&lt;sub&gt;big&lt;/sub&gt;</td>
<td>58.9</td>
<td>14.8</td>
<td>0.12</td>
<td>16.0</td>
<td>3.05</td>
<td>7.11</td>
</tr>
<tr>
<td>$\frac{NPL_{big}}{Loans}$</td>
<td>64.5</td>
<td>16.0</td>
<td>0.15</td>
<td>16.1</td>
<td>1.46</td>
<td>1.81</td>
</tr>
<tr>
<td><strong>Loans</strong>&lt;sub&gt;small&lt;/sub&gt;</td>
<td>58.2</td>
<td>15.0</td>
<td>0.12</td>
<td>21.6</td>
<td>3.79</td>
<td>1.34</td>
</tr>
<tr>
<td>$\frac{NPL_{small}}{Loans}$</td>
<td>29.4</td>
<td>59.9</td>
<td>1.09</td>
<td>0.56</td>
<td>0.9</td>
<td>8.22</td>
</tr>
<tr>
<td>$\pi^{cpi}$</td>
<td>53.4</td>
<td>3.05</td>
<td>33.2</td>
<td>8.53</td>
<td>0.22</td>
<td>1.56</td>
</tr>
<tr>
<td>$i^b$</td>
<td>71.2</td>
<td>4.51</td>
<td>7.68</td>
<td>14.4</td>
<td>0.88</td>
<td>1.34</td>
</tr>
<tr>
<td>$p^{o,*}$</td>
<td>91.9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8.10</td>
</tr>
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</table>

### Table: Error variance decomposition: heterogeneous banking sector case
Error variance decomposition: homogeneous case

<table>
<thead>
<tr>
<th>Homogeneous banking sector case</th>
<th>$\epsilon_{p,c}$</th>
<th>$\epsilon_{a}$</th>
<th>$\epsilon_{mon}$</th>
<th>$\epsilon_{r,for}$</th>
<th>$\epsilon_{\beta,h}$</th>
<th>$\epsilon_{i}^{me}$</th>
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</thead>
<tbody>
<tr>
<td>$GDP$</td>
<td>80.8</td>
<td>17.3</td>
<td>0.06</td>
<td>0.04</td>
<td>0.17</td>
<td>1.86</td>
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<tr>
<td>$cons$</td>
<td>56.6</td>
<td>17.8</td>
<td>0.06</td>
<td>10.2</td>
<td>12.8</td>
<td>2.61</td>
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<tr>
<td>$Loans_{bank}^{\text{ banker}}$</td>
<td>76.0</td>
<td>12.5</td>
<td>0.09</td>
<td>5.11</td>
<td>1.81</td>
<td>4.51</td>
</tr>
<tr>
<td>$NPL_{bank}^{\text{ banker}}/Loans$</td>
<td>70.6</td>
<td>13.5</td>
<td>0.52</td>
<td>7.55</td>
<td>0.88</td>
<td>6.96</td>
</tr>
<tr>
<td>$\pi^{cpi}$</td>
<td>60.8</td>
<td>2.21</td>
<td>27.5</td>
<td>8.06</td>
<td>0.12</td>
<td>1.30</td>
</tr>
<tr>
<td>$i^{b}$</td>
<td>78.1</td>
<td>3.07</td>
<td>4.49</td>
<td>12.8</td>
<td>0.51</td>
<td>1.01</td>
</tr>
<tr>
<td>$p^{o,*}$</td>
<td>92.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8.00</td>
</tr>
</tbody>
</table>

Table: Error variance decomposition: homogeneous banking sector case
Shock to Copper Price

Figure: Bayesian IRFs to a positive 1 std copper price shock in homogeneous banking system case

Figure: Bayesian IRFs to a positive 1 std copper price shock in heterogeneous banking system case
Results

Shock to Copper Price

Figure: Bayesian IRFs to a positive 1 std copper price shock in homogeneous banking system case

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Results

**TFP shock**

**Figure:** Bayesian IRFs to a positive 1 std TFP shock in homogeneous banking system case

**Figure:** Bayesian IRFs to a positive 1 std TFP shock in heterogeneous banking system case
TFP shock

Figure: Bayesian IRFs to a positive 1 std TFP shock in homogeneous banking system case

Figure: Bayesian IRFs to a positive 1 std TFP shock in heterogeneous banking system case
Heterogeneous banking system works as a shock amplifier and a shock propagation mechanism financial variables

- Following positive copper price shock:
  - NPLs of big banks in the heterogeneous case drop by **0.33%** with below **0.20%** drop in the homogeneous case
  - The peak response of lending is **5%** for small banks and **1.5%** for big banks with only **2%** peak response in homogeneous case
  - Peaks of the loans response occur at around **5th** quarter for heterogeneous case and around **10th** quarter for homogeneous case

- Following TFP shock, heterogeneous banking system features higher amplification of loans and NPLs, which again makes it to work as a shock amplifier.
Regulation: Counter-Cyclical Capital Buffer (CCyB)

- Fixed capital adequacy requirement over the business cycle:

\[ k_{t}^{\text{bank}} = k_{ss}^{\text{bank}}, \quad (16) \]

where \( k_{\text{bank}} \) is different for small and big banks.

- Credit-to-GDP ratio CCyB:

\[ k_{t}^{\text{bank}} = k_{ss}^{\text{bank}} + \eta^{\text{gdp}} \text{gap}_{t}^{\text{gdp}} \quad (17) \]

where \( \eta^{\text{gdp}} = 1.5 \) and \( \text{gap}_{t}^{\text{gdp}} \) is defined as:

\[ \text{gap}_{t}^{\text{gdp}} = \frac{\mu_{t+1}^{w}}{GDP_{t}} - \frac{\mu_{ss}^{w}}{GDP_{ss}}. \quad (18) \]
Credit-to-GDP ratio CCyB: copper price shock

Figure: IRFs to a positive 1 std copper price shock in heterogeneous banking system case, fig 1

Figure: IRFs to a positive 1 std copper price shock in heterogeneous banking system case, fig 2
Results

Credit-to-GDP ratio CCyB: TFP shock

Figure: IRFs to a positive 2 std TFP shock in heterogeneous banking system case, fig 1

Figure: IRFs to a positive 2 std TFP shock in heterogeneous banking system case, fig 2
Credit-to-GDP ratio CCyB

The CCyB capital adequacy rule results in:
- Similar responses of GDP and consumption under copper price and TFP shocks
- Smaller amplification of total lending under both shocks
- Reduced volatility of NPLs under both shocks

CCyB rule helps to stabilize financial side of the economy without any negative effect on its real side
Conclusions

- Estimation of a heterogeneous banking sector results in a qualitatively and quantitatively different description of the Chilean Financial Sector.
- The response of financial variables is accelerated and amplified when bank heterogeneity is accounted for.
- Prudential regulation (e.g. CCyB) help to stabilize the economy by affecting growth of risky-credit by small banks.
Chilean credit growth

- Consistent to Goodhart et al. (2006) description of financial fragility periods, past Chilean episodes of vulnerability include sharp contractions in credit...

**Figure:** Real annual credit growth (percentage).

*Source: Martínez et al. (2018).*
Chilean past-due loans

...sizeable increases in default rates,...

Figure: Past due loans ratio (percentage of loans).

Source: Martínez et al. (2018).
Chilean ROA

...and, as a result, periods of considerably low profitability.

- So that it becomes relevant to progress in assessing the impact of several shocks in an integrated model to understand possible channels of shocks transmission and dynamics of key financial variables.

**Figure:** Return over assets (percentage).

Source: Martínez et al. (2018).
Economic activity and country’s external position

- As suggested by De Gregorio (2013), size of impacts depends also on the country’s external position.

Figure: Financial Fragility and Current Account Deficit (percentage)

Source: Own elaboration. Grey areas based on Martínez et al. (2018).