Macro-financial model: A proposal for Chile[1]

PRELIMINARY VERSION

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Agenda

- Summary
- Motivation
- The model
- Calibration and Simulations
- Final Remarks

Summary

Question

- In an otherwise standard RBC model, we include financial frictions to assess the effects of different shocks on real and financial variables in the Chilean economy.

Objective

- To analyze different channels of shocks transmission in an economy affected by financial frictions. Also, assess the effects of macroprudential policy.

What we do:

- We develop a model of production, consumption and financial intermediation.
- Our model incorporates financial frictions: Default and liquidity constraints.
- We introduce a heterogeneous interbank market: Two banks with different risk profiles.
- It captures the effects of monetary, real and macroprudential shocks on financial and real variables of the economy.

Context for the question

- Current literature does not include heterogeneous banking sector and endogenous default, in an emerging country, altogether.
- Usually, the financial literature includes informational frictions, as in Bernanke et. al. (1999) and Kiyotaki and Moore (2012).
- Some models follow a New-Keynesian framework of a small open economy that includes financial frictions and nominal rigidities (Medina & Soto (2007) and García-Cicco et al. (2014)).
- Our paper provides a complementary vision to this literature. In particular, we can analyze combined macroprudential regulations to study its optimality properties as in Goodhart, Kashyap, Tsomocos and Vardoulakis (2013).

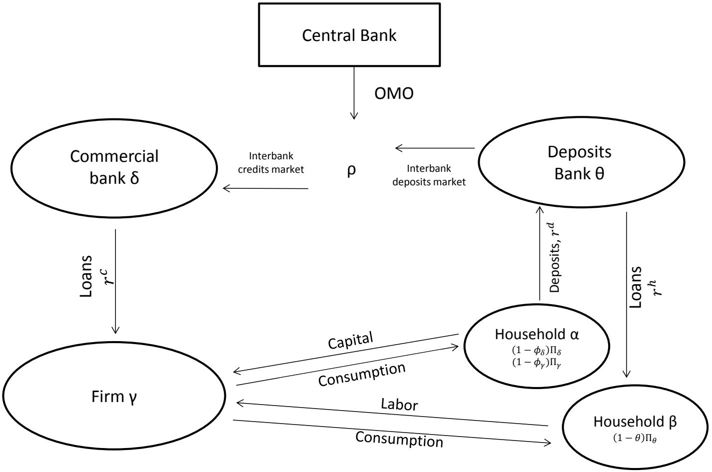
Model background

Related literature

- A detailed analysis about endogenous default is provided by Goodhart et al. (2005, 2006a and 2006b), Dubey et al. (2005) and Shubik and Wilson (1977).
- The Cash-in Advance (CIA) model to introduce money is developed in Grandmont and Younes (1972).
- Espinoza and Tsomocos (2015) incorporates liquidity and default in a general equilibrium framework.
- De Walque et al. (2010) considers an extension of RBC model and includes default as the main financial friction.
- Our model is general enough to encompass De Walque et al. (2010) and allow for macro-prudential policy.

The model

Flows of the economy



Household α

$$\max_{b_t^\alpha, d_t^\alpha, q_{k,t}^\alpha} U^\alpha = E_0 \sum_{t=0}^{\infty} \beta^t \{u(b_t^\alpha) + u(e_{k,t}^\alpha - q_{k,t}^\alpha)\}$$

s.t.,

$$b_t^\alpha + d_t^\alpha \leq (1 + r_{t-1}^d) \frac{d_{t-1}^\alpha R_t^\alpha}{(1+\pi_t)} + p_t^k q_{k,t}^\alpha + (1-\phi_\gamma)\Pi_t^\gamma + (1-\phi_\delta)\Pi_t^\delta \tag{1}$$

consumption + deposits ≤ return from deposits + return from capital + profits

Household β

$$\max_{b_t^\beta, L_t^\beta, \mu_t^\beta, \nu_t^\beta} U^\beta = E_0 \sum_{t=0}^{\infty} \beta^t \{ u\left(b_t^\beta\right) + u\left(\bar{N} - L_t^\beta\right) - \frac{\lambda^\beta}{2(1+\pi_t)^2} \max[0, \mu_{t-1}^\beta (1-\nu_t^\beta)]^2 \}$$

s.t.,

$$b_t^\beta \leq \frac{\mu_t^\beta}{(1+r_t^h)} + (1-\phi_\theta)\Pi_t^\theta \tag{2}$$

consumption $\leq$ loan taken from deposits bank + profits

$$\nu_t^\beta \mu_{t-1}^\beta \leq L_{t-1}^\beta w_{t-1} \tag{3}$$

loan repayment $\leq$ labor income

$$N_0 = \bar{N} \tag{4}$$

Firm γ

$$\max_{\mu_t^\gamma,\nu_t^\gamma,b_{L,t}^\gamma,b_{k,t}^\gamma,\Pi_t^\gamma} U^\gamma = E_0 \sum_{t=0}^{\infty} B^t \{u(\Pi_t^\gamma) - \frac{\lambda^\gamma}{2(1+\pi_t)^2} \max[0, \mu_{t-1}^\gamma(1-\nu_t^\gamma)]^2\}$$

s.t.,

$$b_{L,t}^\gamma + b_{k,t}^\gamma \leq \frac{\mu_t^\gamma}{1+r_t^c} + e_t^\gamma \tag{5}$$

money spent in labor and capital $\leq$ loan taken from the commercial bank + equity

$$\Pi_t^\gamma = \frac{y_{t-1}}{(1+\pi_t)} - \frac{\mu_{t-1}^\gamma \nu_t^\gamma}{(1+\pi_t)} \tag{6}$$

profits = period sales of commodities − loan repayment

$$y_t = A(L_t^\gamma)^\alpha (k_t^\gamma)^{1-\alpha}; \qquad L_t^\gamma = b_{L,t}^\gamma / w_t; \qquad i_t = k_t - k_{t-1}(1-\delta); \qquad i_t^\gamma = b_{k,t}^\gamma / p_{k,t}^\gamma \tag{7}$$

$$e_t^\gamma = \phi_\gamma \Pi_t^\gamma \tag{8}$$

Equity=Retained profits

Deposits bank θ

$$\max_{x^\theta_{h,t}, d^\theta_{IB,t}, d^\theta_{\alpha,t}, \nu^\theta_{\alpha,t}} U^\theta = E_0 \sum_{t=0}^{\infty} \hat{\beta}^t \{ u\left(\Pi^\theta_t\right) - \frac{\lambda^\theta_k}{2} \max[0, \bar{k}^\theta_t - k^\theta_t]^2 - \frac{\lambda^\theta_d}{2(1+\pi_t)^2} \max[0, d^\theta_{\alpha,t-1}(1-\nu^\theta_{\alpha,t})]^2 \}$$

s.t.,

$$x^\theta_{h,t} + d^\theta_{IB,t} \leq \frac{d^\theta_{\alpha,t}}{1+r^d_t} + e^\theta_t \qquad where, e^\theta_t = \phi_\theta \Pi^\theta_t \tag{9}$$

Credit extension+deposits in interbank market $\leq$ deposits from household α + equity

$$\Pi^\theta_t = \frac{1}{(1+\pi_t)} \left[R^\theta_{h,t} x^\theta_{h,t-1}(1+r^h_{t-1}) + R^\theta_{IB,t} d^\theta_{IB,t-1}(1+\rho_{t-1}) - \nu^\theta_{\alpha,t} d^\theta_{\alpha,t-1} \right] \tag{10}$$

Profits = Expected loan and deposits in IB market repayments − deposits

$$k^\theta_t = \frac{e^\theta_t(1+\pi_t)}{\tilde{\omega} R^\theta_{h,t} x^\theta_{h,t-1}(1+r^h_{t-1}) + \bar{\omega} R^\theta_{IB,t} d^\theta_{IB,t-1}(1+\rho_{t-1})} \tag{11}$$

capital adequacy requirement

Commercial bank δ

$$\max_{x^{\delta}_{\gamma,t},\mu^{\delta}_{IB,t},\nu^{\delta}_{IB,t}} U^{\delta} = E_0 \sum_{t=0}^{\infty} \hat{\beta}^{t} \{ u\left(\Pi^{\delta}_{t}\right) - \frac{\lambda^{\delta}_{k}}{2} \max[0, \bar{k}^{\delta}_{t} - k^{\delta}_{t}]^2 - \frac{\lambda^{\delta}}{2(1+\pi_t)^2} \max[0, \mu^{\delta}_{IB,t-1}(1-\nu^{\delta}_{IB,t})]^2 \}$$

s.t.

$$x^{\delta}_{\gamma,t} \leq \frac{\mu^{\delta}_{IB,t}}{1+\rho_t} + e^{\delta}_{t} \qquad where,\ e^{\delta}_{t} = \phi_{\delta}\Pi^{\delta}_{t} \tag{12}$$

Credit extension to firm $\leq$ Loan taken from IB market + financial capital

$$\Pi^{\delta}_{t} = \frac{1}{(1+\pi_t)} \left[R^{\delta}_{\gamma,t} x^{\delta}_{\gamma,t-1}(1+r^{c}_{t-1}) - \nu^{\delta}_{IB,t}\mu^{\delta}_{IB,t-1} \right] \tag{13}$$

profits = Expected loan repayment − repayment to IB market

$$k^{\delta}_{t} = \frac{e^{\delta}_{t}(1+\pi_t)}{\omega R^{\delta}_{\gamma,t} x^{\delta}_{\gamma,t-1}(1+r^{c}_{t-1})} \tag{14}$$

capital adequacy requirement

Proposition 1: Interest rates

Household α:

$$(1 + r_t^d) = \mathbb{E}_t \frac{1}{\beta} \frac{u'(c_t^\alpha)}{u'(c_{t+1}^\alpha)} (1 + \pi_{t+1}) \frac{1}{R_{t+1}^\alpha} \tag{15}$$

Firm γ:

$$(1 + r_t^c) = \frac{\partial y_t}{\partial L_t} \frac{1}{w_t} \tag{16}$$

$$(1 + r_t^c) = \frac{\partial y_t}{\partial b_{f,t}^\gamma} \tag{17}$$

In the limit case, if $\delta \to 1$, $(1 + r_t^c) = \frac{\partial y_t}{\partial k_t} / p_t^k$. Then, the marginal rate of technical substitution (MRTS) between labor and capital holds,

$$\frac{\partial y_t / \partial L_t}{\partial y_t / \partial k_t} = \frac{w_t}{p_t^k} \tag{18}$$

Proposition 1: Interest rates

Deposits bank θ:

$$(1+r_t^d) = \left(\frac{1}{\tilde{\omega}} - \frac{1}{\bar{\omega}}\right) \mathbb{E}_t \left(\frac{1}{\tilde{\omega} R^{\theta}_{h,t+1}(1+r_t^h)} - \frac{1}{\bar{\omega} R^{\theta}_{IB,t+1}(1+\rho_t)} \right)^{-1} \tag{19}$$

$$If \ \tilde{\omega} = \bar{\omega} \rightarrow \frac{1+r_t^h}{1+\rho_t} = \mathbb{E}_t \frac{R^{\theta}_{IB,t+1}}{R^{\theta}_{h,t+1}} \tag{20}$$

Commercial bank δ:

$$(1+r_t^c) = \left(1 - \mathbb{E}_t \frac{\frac{(k^{\delta}_{t+1})^2}{e^{\delta}_{t+1}} \lambda^{\delta}_k (\bar{k}^{\delta}_{t+1} - k^{\delta}_{t+1})}{\lambda^{\delta}_{\mu} \mu^{\delta}_{IB,t} (1 - \nu^{\delta}_{IB,t+1})} \right)^{-1} \mathbb{E}_t \frac{1}{R^{\delta}_{\gamma,t+1}} (1+\rho_t) \tag{21}$$

Proposition 2: Order of interest rates

Deposits bank θ: If, $i)$ $\mathbb{E}_t R^{\theta}_{IB,t+1} = \mathbb{E}_t R^{\theta}_{h,t+1}$ *and* $\tilde{\omega} > \bar{\omega}$ or $ii)$ $\tilde{\omega} = \bar{\omega}$ *and* $\mathbb{E}_t R^{\theta}_{IB,t+1} > \mathbb{E}_t R^{\theta}_{h,t+1}$ then,

$$r^h_t > \rho_t \tag{22}$$

Commercial bank δ: If the default cost is higher than cost of capital requirement violations then,

$$r^c_t > \rho_t \tag{23}$$

Proposition 3: On the verge Condition

marginal utility of defaulting = marginal disutility of defaulting

$$u'(c_t^{\beta}) = \mathbb{E}_t \frac{1+r_t^h}{(1+\pi_{t+1})^2} \lambda^{\beta} \beta \mu_t^{\beta} (1-\nu_{t+1}^{\beta})$$

$$u'\left(\Pi_t^{\gamma}\right) = \lambda^{\gamma} \left(\frac{\mu_{t-1}^{\gamma}(1-\nu_t^{\gamma})}{(1+\pi_t)} - \phi_{\gamma} B \mathbb{E}_t \frac{1+r_t^c}{(1+\pi_{t+1})^2} \mu_t^{\gamma} (1-\nu_{t+1}^{\gamma}) \right)$$

$$u'\left(\Pi_t^{\theta}\right) = \lambda_d^{\theta} \left(\frac{d_{\alpha,t-1}^{\theta}(1-\nu_{\alpha,t}^{\theta})}{(1+\pi_t)} - \phi_{\theta} \hat{\beta} \mathbb{E}_t \frac{1+r_t^d}{(1+\pi_{t+1})^2} d_{\alpha,t}^{\theta} (1-\nu_{\alpha,t+1}^{\theta}) \right) - \lambda_k^{\theta} \phi_{\theta} (\bar{k}_t^{\theta} - k_t^{\theta}) \frac{k_t^{\theta}}{e_t^{\theta}}$$

$$u'\left(\Pi_t^{\delta}\right) = \lambda_{\mu}^{\delta} \left(\frac{\mu_{IB,t-1}^{\delta}(1-\nu_{IB,t}^{\delta})}{(1+\pi_t)} - \phi_{\delta} \hat{\beta} \mathbb{E}_t \frac{1+\rho_t}{(1+\pi_{t+1})^2} \mu_{IB,t}^{\delta} (1-\nu_{IB,t+1}^{\delta}) \right) - \lambda_k^{\delta} \phi_{\delta} (\bar{k}_t^{\delta} - k_t^{\delta}) \frac{k_t^{\delta}}{e_t^{\delta}}$$

Proposition 3: On the verge Condition

marginal utility of defaulting = marginal disutility of defaulting

$$u'(c_t^\beta) = \mathbb{E}_t \frac{1+r_t^h}{(1+\pi_{t+1})^2} \lambda^\beta \beta \mu_t^\beta (1-\nu_{t+1}^\beta)$$

$$u'\left(\Pi_t^\gamma\right) = \lambda^\gamma \left(\frac{\mu_{t-1}^\gamma (1-\nu_t^\gamma)}{(1+\pi_t)} - \phi_\gamma B \mathbb{E}_t \frac{1+r_t^c}{(1+\pi_{t+1})^2} \mu_t^\gamma (1-\nu_{t+1}^\gamma) \right)$$

$$u'\left(\Pi_t^\theta\right) = \lambda_d^\theta \left(\frac{d_{\alpha,t-1}^\theta (1-\nu_{\alpha,t}^\theta)}{(1+\pi_t)} - \phi_\theta \hat{\beta} \mathbb{E}_t \frac{1+r_t^d}{(1+\pi_{t+1})^2} d_{\alpha,t}^\theta (1-\nu_{\alpha,t+1}^\theta) \right) - \lambda_k^\theta \phi_\theta (\bar{k}_t^\theta - k_t^\theta) \frac{k_t^\theta}{e_t^\theta}$$

$$u'\left(\Pi_t^\delta\right) = \lambda_\mu^\delta \left(\frac{\mu_{IB,t-1}^\delta (1-\nu_{IB,t}^\delta)}{(1+\pi_t)} - \phi_\delta \hat{\beta} \mathbb{E}_t \frac{1+\rho_t}{(1+\pi_{t+1})^2} \mu_{IB,t}^\delta (1-\nu_{IB,t+1}^\delta) \right) - \lambda_k^\delta \phi_\delta (\bar{k}_t^\delta - k_t^\delta) \frac{k_t^\delta}{e_t^\delta}$$

Calibration: Estimated parameters

Parameter	Value	Source	Parameter	Value	Source
$\bar{A}$	1	Calibration	λ_β	0.003	Calibration
$\bar{M}$	0.5	Calibration	λ_γ	0.029	Calibration
$\bar{\eta}^{CB}$	1	Calibration	λ_d^θ	7.98	Calibration
$\bar{K}$	100	Calibration	λ_δ	5	Calibration
$\bar{N}$	1	Calibration	λ_k^θ	0.0009	Calibration
$\hat{k}^\theta$	0.08	Chilean regulation	λ_k^δ	0.0009	Calibration
$\hat{k}^\delta$	0.08	Chilean regulation	σ	1	García-cicco et al. (2014)
ρ^A	0.043	Own estimation	α	0.33	García-cicco et al. (2014)
ρ^{CB}	0.043	Own estimation	β	0.97	King and Rebelo (1999)
$\rho^{\lambda,\beta}$	0.5	Own estimation	$\hat{\beta}$	0.99	de Walque et. al.(2010)
$\rho^{k,\delta}$	0.5	Own estimation	B	0.98	King and Rebelo (1999)
$\rho^{k,\theta}$	0.5	Own estimation	$\tilde{\omega}$	1	Chilean regulation
$\sigma^{\lambda,\beta}$	10%	Own estimation	$\bar{\omega}$	0.2	Chilean regulation
σ^A	3, 5%	Own estimation	ω	0.6	Chilean regulation
σ^{CB}	3, 5%	Own estimation	ϕ_θ	0.5	de Walque et. al.(2010)
$\sigma^{k,\theta}$	50%	*Basel III*	ϕ_γ	0.3	Own estimation
$\sigma^{k,\delta}$	50%	*Basel III*	ϕ_δ	0.5	de Walque et. al.(2010)
δ	0.015	García-cicco et al. (2014)			

Calibration: Steady state

Variable	Steady state	Variable	Steady state	Variable	Steady state
π	0	N_0	1	η_1^θ	-2.88
p_k	1,17	L_β	0.4517	η_2^θ	-2.81
r_d	0.035	η_1^β	-0.027	R_γ^δ	0.9861
r_h	0.244	η_2^β	-0.023	x_γ^δ	49.94
R_α	0.996	r_c	0.0587	μ_{IB}^δ	51.65
b_α	83.66	μ^γ	52.87	ν_{IB}^δ	0.9914
d_α	84.82	ν^γ	0.9861	k^δ	0.0089
e_k^α	100	η_1^γ	-0.022	η_1^δ	-2.299
q_k^α	28.22	η_2^γ	-0.021	η_2^δ	-2.224
Π_γ	68.11	ρ	0.0439	M_{CB}	0.5
Π_δ	0.931	R_h^θ	0.8323	η^{CB}	1
Π_θ	0.729	R_{IB}^θ	0.9914	A	1
η_1^α	-0.012	x_h^θ	36.21	y	120.23
w	82.96	d_{IB}^θ	48.97	k	1881.47
ν_β	0.8323	d_α^θ	87.79	b_L^γ	37.48
μ_β	45.03	ν_α^θ	0.996	b_k^γ	32.89
b_β	36.58	k^θ	0.0077		

Cyclical Properties of financial and real variables

	Mean ($E(\cdot)$)		Standar Dev. ($\sigma(\cdot)$)	
	Data	Model	Data	Model
ρ	3.97%	4.44%	1.87%	0.14%
r_d	4.13%	3.51%	1.89%	0.029%
r_c	7.64%	6.01%	1.69%	0.47%
r_h	25.56%	25.51%	3.49%	4.01%
R_h^θ	94,6%	82.54%	1,34%	2.62%
R_γ^δ	99,3%	98.52%	0,26%	0.31%
I/Y	21.4%	24.8%	3.5%	4.1%
L_β	0.25	0.449	-	0.011

Macro shocks

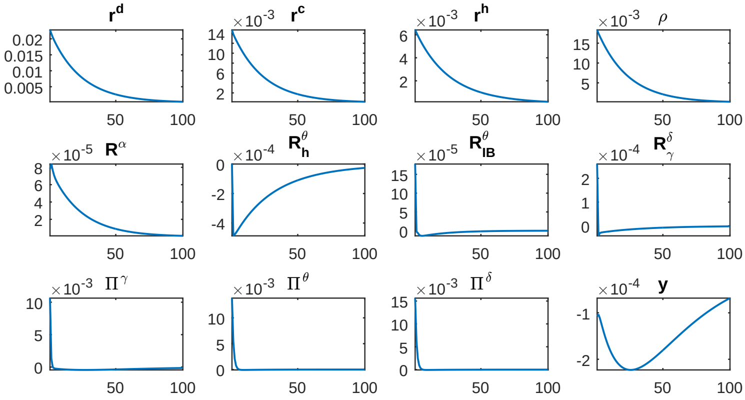


Figure: Shock to money base ($\Delta^{-}3.5\%\ M$). Impulse response functions are in percentage variations with respect to steady state levels.

Macro shocks

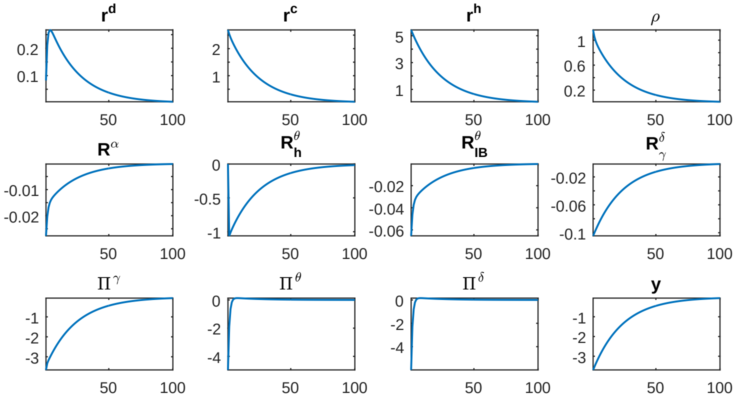
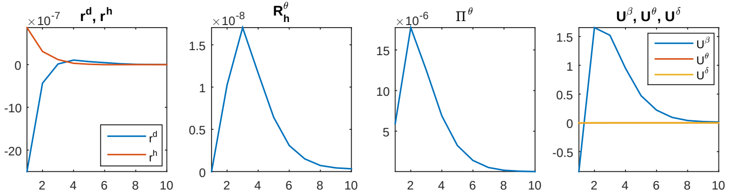


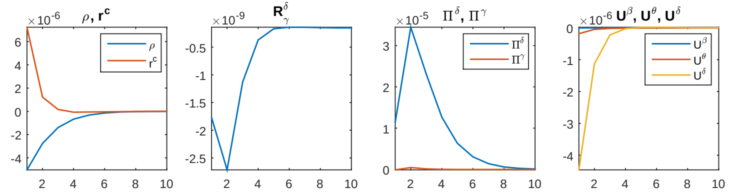
Figure: Shock to Total Factor Productivity ($\Delta^{-}3.5\%$ TFP).Impulse response functions are in percentage variations with respect to steady state levels.

Shocks to Macroprudential Policy

Shock to capital requirements of deposits bank ($\Delta^{+}50\%\ \bar{k}_t^{\theta}$)



Shock to capital requirements of commercial bank ($\Delta^{+}50\%\ \bar{k}_t^{\delta}$)



Final Remarks

- We extend a basic RBC model to include an interbank market.
- Our model includes default and liquidity as the main financial frictions.
- The adjustment of the first moments of our model is reasonably good.
- Our model suggests that shocks emerging from the real sector may affect upon the banking sector, producing "financial instability". Shocks to liquidity (CB) are similar, but the impact is lower.
- Positive shock to capital requirement could be more effective, in terms of welfare, when we affect the bank which gives loans to the household β.

Future steps

- Open our closed economy.
- Improve the fit of the model to financial and real data.
- Finally, test combination of macroprudential policies.