Joint project: Incorporating financial stability considerations in policy analysis: a model for Latin American countries.

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Motivation

- Joint project by 4 central banks (Chile, Colombia, Mexico and Peru).
- Objective: provide a model that can capture main features of those economies and that could be useful for policy analysis, aimed for cross country comparison.
- Common characteristics:

  - Exposure to commodity price fluctuations (all 4 are commodity exporters).

  - Exposure to financial factors (all 4 depend heavily on capital flows and external financing conditions).

  - Less developed financial system, concentrated in the banking sector.

The model

From survey: key ingredients to capture empirical regularities of these economies:

- Small open economy with commodity sector.
- Nominal rigidities with incomplete pass-through.
- Banking sector financing with financial frictions.
- Other rigidities: investment adjustment costs, habit formation in consumption and variable capital utilization.
- Monetary policy using short term interest rate (Taylor Rule).

Modelling strategy

- Depart from baseline model of Christiano, Trabandt and Walentin (JEDC 2011, CTW).
- Main extensions:
  - Domestic financial intermediaries (banks)
  - Commodity sector.
  - Observable country risk premium.

Financial sector extension

Setup

- We borrow the financial sector from Alpanda et al (2014), but we simplify it
- There is a continuum of
  - ***Households***, who deposit savings at banks
  - ***Entrepreneurs***, who use loans and net worth to accumulate capital, and
  - ***Banks***, who intermediate between savers and borrowers
- All agents maximize their objectives (utility and dividends)
- This structure yields two types of spreads:
  - *Deposit spread*,

$$R_{D,t} = R_t(1 + \Upsilon_t^D)$$

  - *Lending spread,*

$R_{E,t} = R_{D,t}(1 + \Upsilon_t^E)$, or $R_{E,t} = R_t(1 + \Upsilon_t^D)(1 + \Upsilon_t^E)$

Monitoring costs and balance sheets

- Households pay a cost to monitor their deposits at Banks

$$c_{h,\tau}+\boxed{\left(1+\Upsilon_t^D\right)\frac{L_{h,\tau}^D}{P_\tau}}+\frac{B_{h,\tau}}{P_\tau R_\tau}+\frac{S_\tau B_{h,\tau}^*}{P_\tau \Phi_\tau R_\tau^*}\leq\frac{W_{h,\tau}}{P_\tau}H_{h,\tau}+R_{D,\tau-1}\frac{L_{h,\tau-1}^D}{P_\tau}+\frac{B_{h,\tau-1}}{P_\tau}+\frac{S_\tau B_{h,\tau-1}^*}{P_\tau}+\frac{\Lambda_{h,\tau}}{P_\tau}$$

- Banks pay a cost to monitor their loans to entrepreneurs

$$\frac{D_{j,\tau}^B}{P_\tau}+R_{D,\tau-1}\frac{L_{j,\tau-1}^D}{P_\tau}+\boxed{\left(1+\Upsilon_\tau^E\right)\frac{L_{j,\tau}^E}{P_\tau}}\leq R_{E,\tau-1}\frac{L_{j,\tau-1}^E}{P_\tau}+\frac{L_{j,\tau}^D}{P_\tau}-\frac{\vartheta^\phi}{2}\left(\frac{D_{j,\tau}^B/D_{j,\tau-1}^B}{\pi_\tau}-\mu_a\right)^2\frac{D_\tau^B}{P_\tau},$$

- The 2 monitoring costs translate into a higher price of credit for entrepreneurs

$$\frac{D_{i,\tau}^E}{P_\tau}+\frac{P_\tau^k}{P_\tau}\left[K_{i,\tau}-(1-\delta)K_{i,\tau-1}+\tau_k\delta K_{i,\tau-1}\right]+\boxed{R_{E,\tau-1}\frac{L_{i,\tau-1}^E}{P_\tau}}\leq\left(1-\tau_k\right)\frac{Z_\tau}{P_\tau}K_{i,\tau-1}+\frac{L_{i,\tau}^E}{P_\tau}-\frac{\vartheta^e}{2}\left(\frac{D_{i,\tau}^E/D_{i,\tau-1}^E}{\pi_\tau}-\mu_a\right)^2\frac{D_\tau^E}{P_\tau},$$

Monitoring costs' structure

The monitoring costs increase with debtors' leverage, capturing in reduced form the mechanism of BGG (1999)

$$1+\Upsilon_t^D = \left(\frac{\gamma_{t-j}}{capb_{t-j} / L_{t-j}^E} \right)^{\chi_D} \exp\left(\tilde{\varepsilon}_{D,t}\right),$$

where $\frac{capb_{t-j}}{L_{t-j}^E}$ is the sector bank-capital-to-loans ratio, and γ_{t-j} is the bank capital requirement

$$1+\Upsilon_t^E = (1+\Upsilon_{t-1}^E)^{\chi_{E,1}} \left[\chi_{E,0} \left(\frac{(1-m_{t-j})}{n_{t-j}/\left(p_{t-j}^k K_{t-j}\right)} \right)^{\chi_{E,3}} \right]^{1-\chi_{E,1}} \exp(\tilde{\varepsilon}_{E,t}),$$

where $\frac{n_{t-j}}{p_{t-j}^k K_{t-j}}$ is entrepreneurs capital-to-assets ratio, and m_{t-j} is the effective loan-to-value ratio

Country risk premium

- Since households can borrow from abroad, we need to close the model with a dynamic premium on foreign bonds $\frac{S_t B^*_{h,t}}{P_t \Phi_t R^*_t}$

$$\Phi_t = \overline{\Phi} \exp\left\{-\tilde{\phi}_a (a_t - \bar{a}) - \tilde{\phi}_s [R^*_t - R_t - (R^* - R)] + \tilde{\phi}_t + \tilde{\phi}_{cp,t}\right\}$$

- where a_t denotes net stock of foreign assets, $\tilde{\phi}_t$ is an unobserved risk shock, and $\tilde{\phi}_{cp,t}$ is an observed country risk premium shock (e.g., EMBI)
- $\tilde{\phi}_a$ ensures a unique steady state for a_t
- $\tilde{\phi}_s$ allows for a delayed exchange rate overshooting

Calibration and estimation results for Mexico

- The calibration of the financial sector for Mexico is
  - Steady state *loans-to-deposit spread* is **3.09 percent**, at annual terms (Banxico)
  - Steady state *deposit-to-target-rate spread* is **0 percent** (assumption)
  - Effective *loans-to-valu*e ratio is **65 percent** (weighted average from CNVB)
  - *Bank capital requirement* is **8 percent** (CNVB).

- And the estimation results imply the following:
  - When $\frac{n_t}{p_t^k K_t}$ increases by 20 percent, $R_{E,t}$ increases by 50 basis points (annual terms)
  - When $\frac{capb_t}{L_t^E}$ decreases by 20 percent, $R_{E,t}$ increases by 40 basis points (annual terms)

Calibration and estimation results for Mexico

- Estimation results in numbers

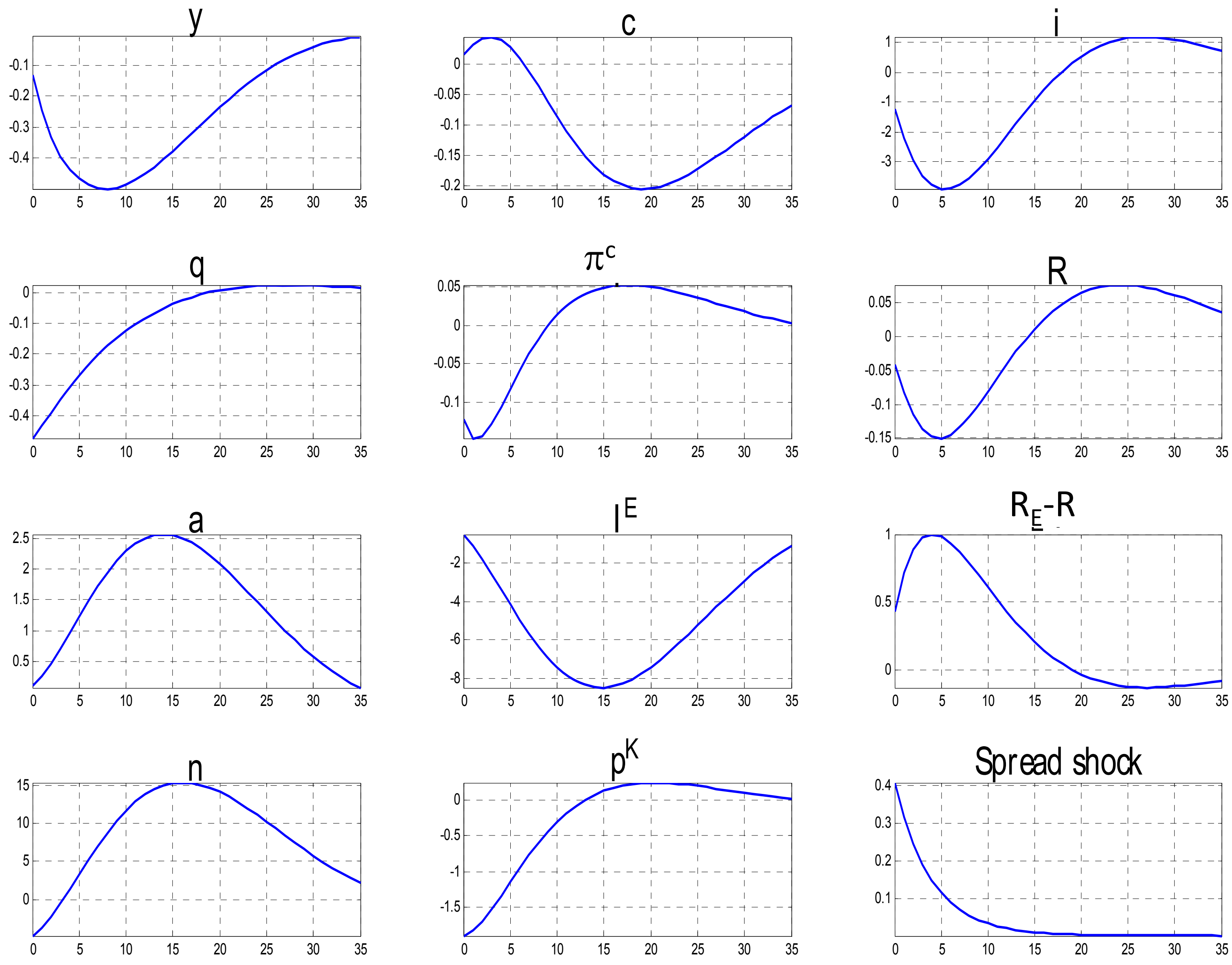
Table 1. Mexico: Results from Metropolis-Hastings, selection

Parameter	Description	Prior			Posterior			
		Dist.	Mean	s.d.	Mean	s.d.	5%	95%
$10\chi_{E,3}$	Elasticity credit spread	Inv-Γ	0.200	Inf	0.064	0.0167	0.0399	0.0884
$10\chi_D$	Elasticity deposit spread	Inv-Γ	0.100	Inf	0.048	0.0223	0.0215	0.0741
$\chi_{E,1}$	Persistence lending spread	β	0.500	0.0750	0.867	0.0200	0.8390	0.8905
ϑ^e	Adj. costs Entrepreneurs	Inv-Γ	0.500	Inf	0.240	0.0804	0.1253	0.3600
ϑ^b	Adj. costs Banks	Inv-Γ	0.500	Inf	0.291	0.1744	0.1069	0.4798
$\rho_{\tilde{\epsilon}_E}$	Persistence credit spread	β	0.500	0.0750	0.820	0.0388	0.7645	0.8850
$\rho_{\tilde{\epsilon}_D}$	Persistence deposit spread	β	0.500	0.0750	0.650	0.0562	0.5593	0.7433
$\sigma_{\tilde{\epsilon}_E}$	S.D. financial shock entrep.	Inv-Γ	0.150	Inf	0.110	0.0201	0.0781	0.1422
$\sigma_{\tilde{\epsilon}_D}$	S.D. financial shock depo.	Inv-Γ	0.150	Inf	0.157	0.0288	0.1099	0.2017
b_{44}	Persistence commodity price	N	0.500	0.5000	0.679	0.1176	0.4882	0.8775
σ_{pco}	S.D. commodity price shock	Inv-Γ	0.500	Inf	1.412	0.1656	1.1498	1.6797

Estimated parameters - financial sector: (all countries)

Estimated parameters: Financial sector				
Posterior mean (results from Metropolis-Hastings)				
	CL	CO	MX	PE
Elasticity				
Credit spread (*100)	1.58	0.86	0.64	0.47
Deposit spread(*100)	0.69	1.63	0.48	0.17
Persistence lending spread	0.43	0.84	0.87	0.43
Persistence				
Credit spread shock	0.42	0.56	0.82	0.57
Deposit spread shock	0.52	0.82	0.65	0.69
Standard deviation				
Credit spread shock	0.19	0.15	0.11	0.25
Deposit spread shock	0.09	0.28	0.16	0.14

IRF of a lending spread shock for Mexico



Commodity sector extension

Introduction

- The countries participating in the joint project are major commodity exporters. Hence, it is important to model the macro impact of commodity price and output fluctuations.
- This impact is not accounted for in the CTW baseline model:
  - Relatively low domestic demand for commodities, while domestic goods in the CTW model are both exported and consumed at home.
  - Commodity prices are in practice taken as exogenous, but the firms in the CTW model act as price setters.
  - Additional shocks to commodity prices and production.
- We therefore extend the CTW model by a commodity sector following Medina and Soto (2007), Medina, Munro and Soto (2007), Hevia and Nicolini (2013), Catao and Chang (2013), and Garcia-Cicco, Kirchner and Justel (2014).

Main assumptions of the commodity sector extension I

- Set of competitive firms that produce a homogeneous commodity good that is entirely exported.
- Thus commodity production has a pure income effect on domestic aggregate demand, which has expansionary effects on the rest of the economy.
- We further assume that a fraction of factor payments of commodity income is transferred abroad to foreign agents.

Main assumptions of the commodity sector extension II

- Specific modelling assumptions:
  - A representative firm produces a quantity ${Y_t}^{Co}$ of commodities.
  - Production evolves exogenously along the balanced growth path of the economy (i.e. ${y_t}^{Co}$= ${Y_t}^{Co}$/ ${z_t}^{+}$ is a stochastic AR(1) process in logs).
  - The entire production is sold abroad at a given foreign price ${P_t}^{Co*}$ that evolves exogenously in real terms (${p_t}^{Co*} = {P_t}^{Co*}/{P_t}^{*}$is stochastic).
  - The income generated in the commodity sector is thus $S_t {P_t}^{Co*} {Y_t}^{Co}$, where S_t is the nominal exchange rate. Domestic agents receive share $\chi \in [0,1]$ of this income and remaining share goes to foreign investors.
- Note: Since Ricardian equivalence holds in the model, it does not matter whether the government or private agents receive the share χ of commodity income, as long as g_t is exogenous.

Modified current account relation I

- The introduction of the commodity sector and the presence of foreign ownership in that sector affect the equation that describes the evolution of net foreign assets.
- Expenses on imports, new purchases of net foreign assets, ${A_{t+1}}^*$, plus factor payments of commodity income to foreign agents must equal income from exports and from previously purchased net foreign assets:

$$S_t {A_{t+1}}^* + expenses\ on\ imports_t + FP\ of\ comm.income_t$$
$$= receipts\ from\ exports_t + {R_{t-1}}^* \Phi_{t-1} S_t {A_t}^*$$

Modified current account relation II

- Factor payments of commodity income equal the share of that income that goes to foreign agents:

$$FP\ of\ commodity\ income_t = (1-\chi)S_t {P_t}^{Co*} {Y_t}^{Co}$$

- Receipts from exports equal exports of the homogenous domestic good plus exports of the commodity good:

$$receipts\ from\ exports_t = S_t {P_t}^X X_t + S_t {P_t}^{Co*} {Y_t}^{Co}$$

- In net, only the share of income from commodity exports received by domestic agents ($\chi S_t {P_t}^{Co*} {Y_t}^{Co}$) affects the accumulation of net foreign assets.

Modified GDP relations

- Further, the production of the commodity sector affects the evolution of GDP and its deflator.
- According to the definition of real GDP, it equals production of the domestic homogeneous good minus capital utilisation costs plus commodity production:

$$GDP_t = Y_t - a(u_t)K_t + {Y_t}^{Co}$$

- Similarly, nominal GDP is defined by (in relative price units of the homogeneous final good):

$${p_t}^{gdp} GDP_t = Y_t - a(u_t)K_t + q_t {p_t}^{c} {p_t}^{Co*} {Y_t}^{Co}$$

where q_t: real exchange rate, ${p_t}^{c}$: CPI relative price.

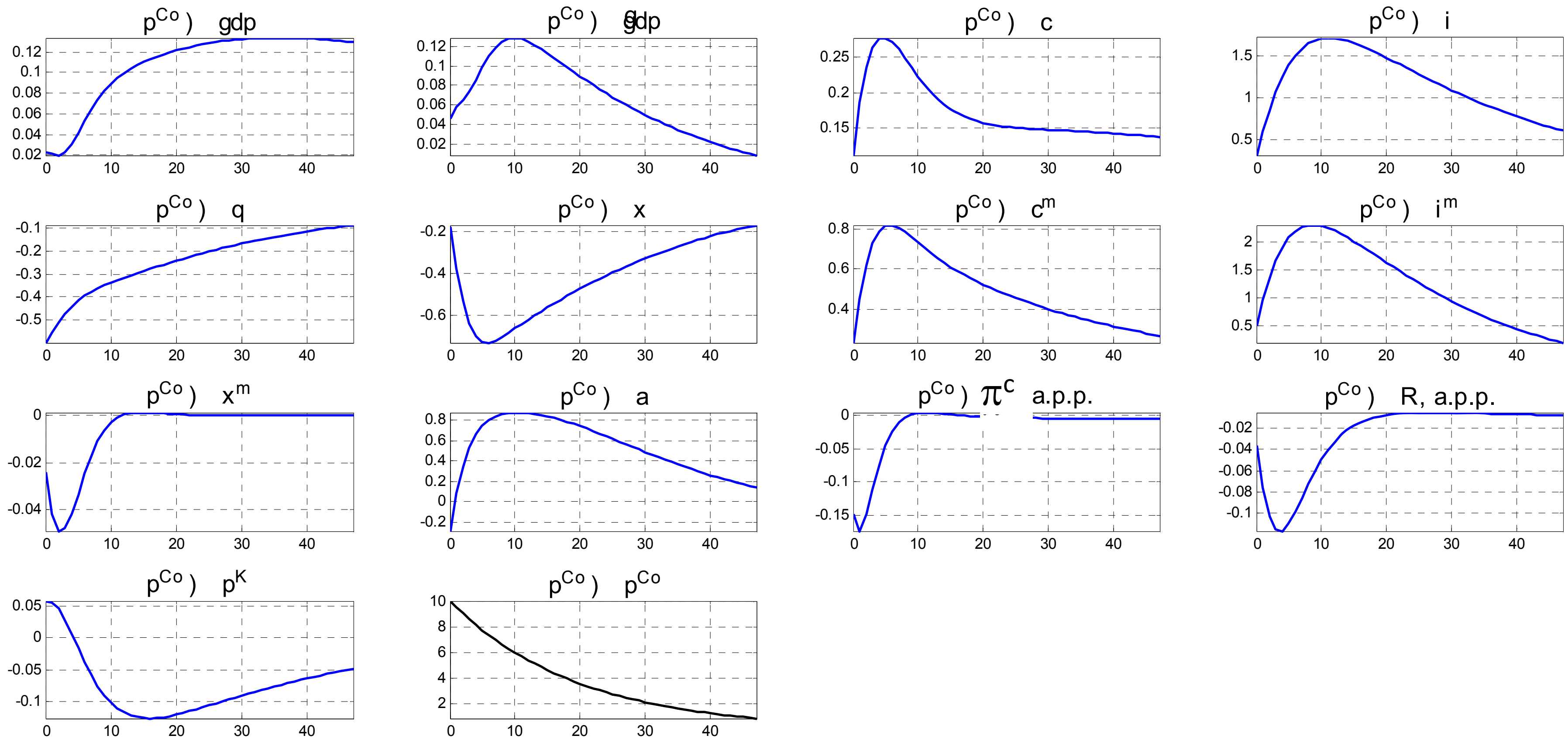
Additional parameters (Chile, 2001-13)

- Calibrated parameters:
  - Domestic share χ: 0.56 (= share of state-owned copper company Codelco plus taxes on foreign profits)
  - Mining exports to GDP ratio $\eta_{y^{Co}}$: 0.15.
- Estimated parameters (posterior mean):
  - Persistence of commodity price shocks $\rho_{p^{Co*}}$: 0.88 (using real copper price as observed variable), s.d. $\sigma_{p^{Co*}}$: 14.8% per quarter.
  - Persistence of commodity production shocks $\rho_{y^{Co}}$: 0.77 (using mining production as observed variable), s.d. $\sigma_{y^{Co}}$: 3%.

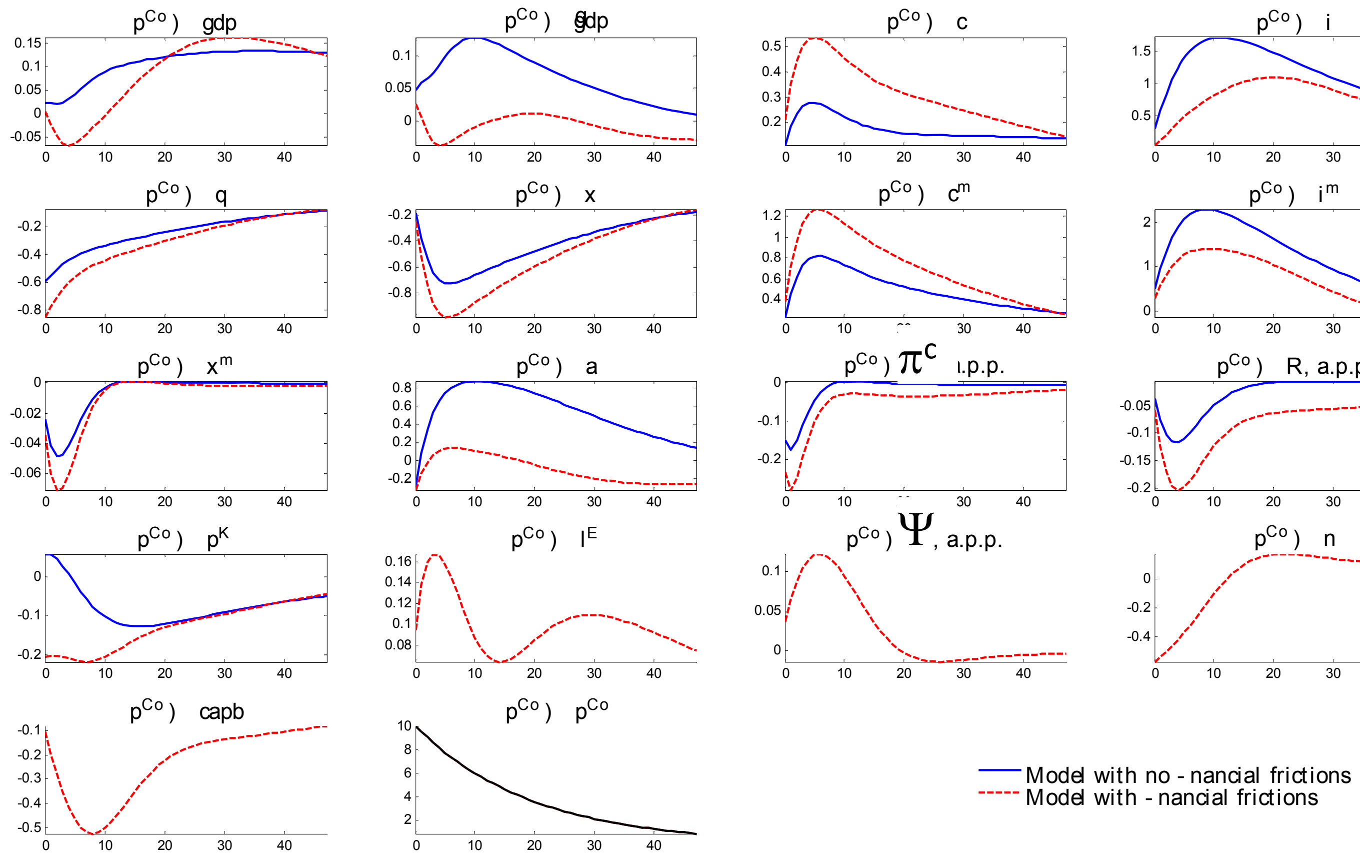
Calibrated and estimated parameters - commodity sector (all countries)

	CL	CO	MX	PE
Commodities	Mainly copper	Oil and others	Oil	Copper and others
Calibrated parameters				
Domestic share	0.56	0.64	1.00	1.00
Mining exports to GDP ratio	0.15	0.07	0.04	0.18
Estimated parameters (M-H posterior mean)				
Commodity price shocks				
Persistence	0.88	0.62	0.68	0.85
Standard deviations	14.8%	10.0%	14.1%	6.1%
Commodity production shocks				
Persistence	0.77	0.74	0.83	0.79
Standard deviations	3.0%	2.5%	9.2%	4.1%

Transmission mechanism: commodity price shock (1)



Transmission mechanism: commodity price shock (2)

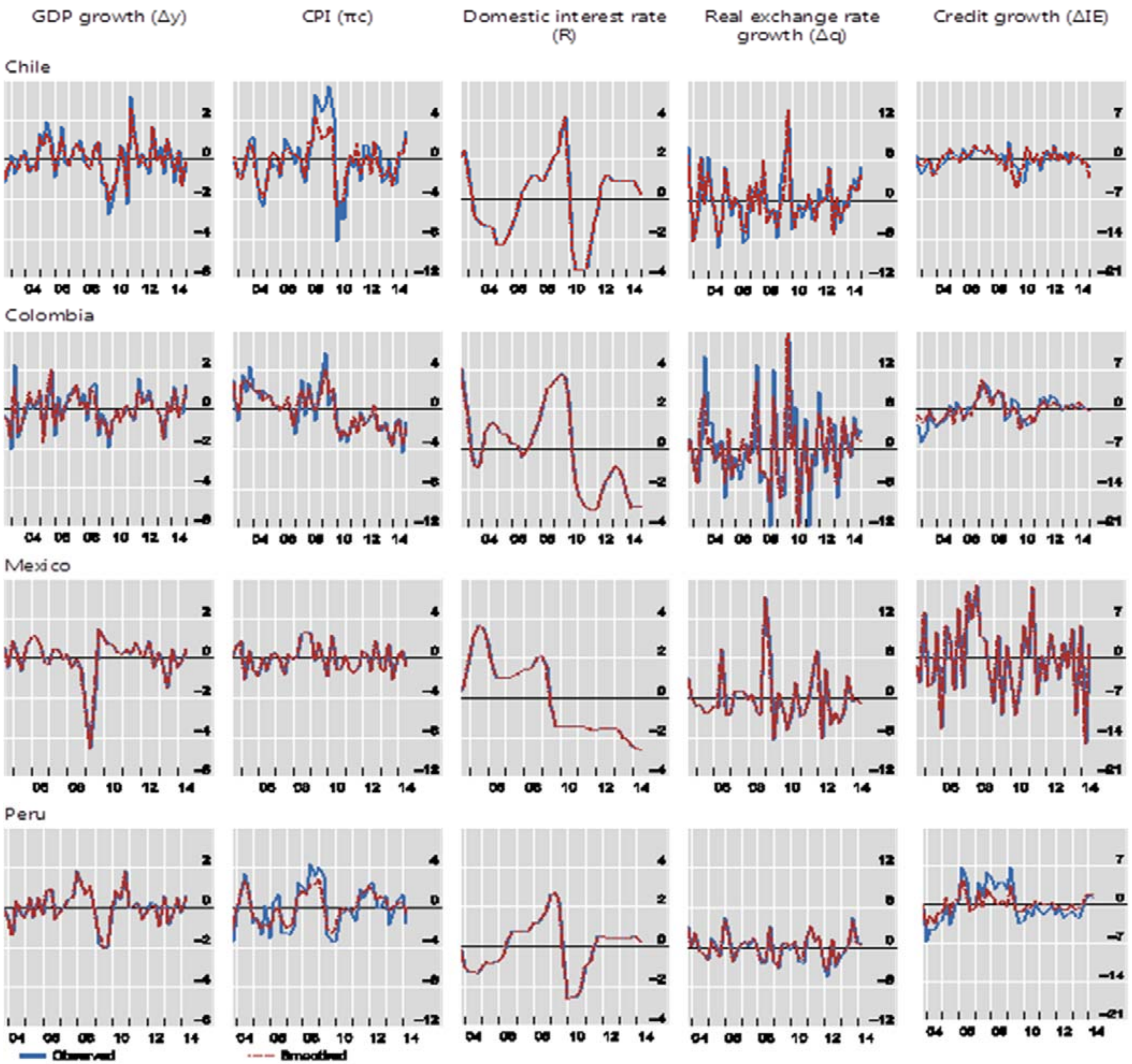


Estimation strategy

- Data: main macroeconomic (real, external and financial) variables (25). Quarterly data. Inflation targeting sample.
- Some differences in data transformation (eg seasonal adjustment, treatment of trends, etc).
- Posterior simulation: 1M draws from the Random Walk MH algorithm (discarding the first 500k draws).
- Different strategies to calculate the mode.
- Computations made with Dynare 4.4.2.

Data

Observed data vs smoothed variables



Smoothed model variables are computed by the Kalman smoother at the posterior mean of the estimates parameters.

Goodness of fit: posterior predictive checking (1)

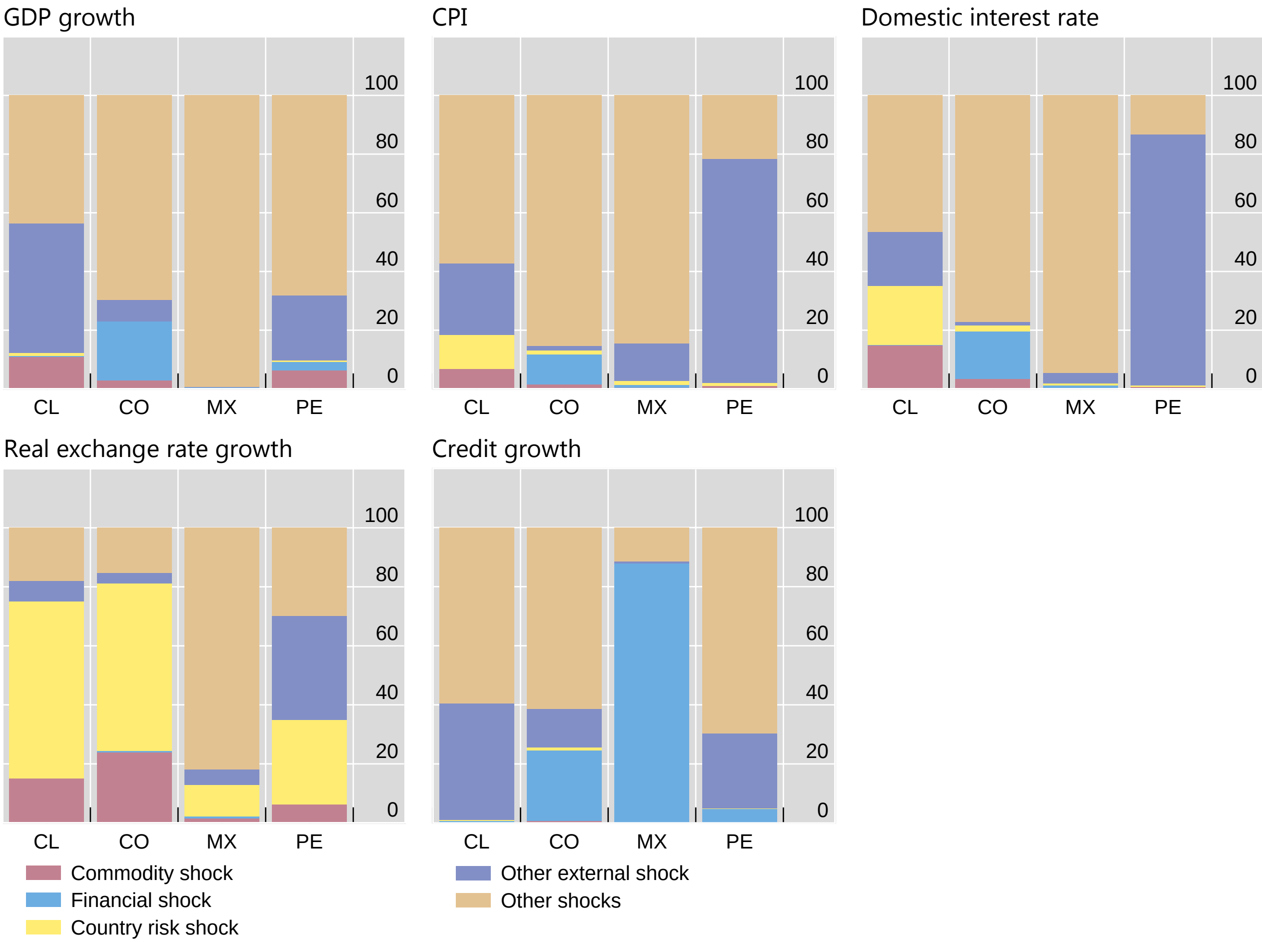
- We simulated 1000 draws of the model at the posterior means
- Each simulation consists of the same observations as in the original sample (and a burning sample)
- The outcome was a set of distributions of model-based moments
- Then we ask how likely is for the model to replicate the observed moment in the data.

Goodness of fit: posterior predictive checking (2)

The model can replicate with 95% confidence:		
	Standard deviations	Correlations with output growth
Chile	17/25	18/25
Colombia	17/25	22/25
Mexico	15 /25	11/25
Peru	13/25	20/25

Variance decomposition[1]

In per cent



[1] Contribution of the different shocks to the unconditional variances of the respective variables.

Policy analysis

- Policy exercises:
  - A sudden decrease in commodity prices
  - 3 policy scenarios:
    - Only policy rate.
    - Policy rate + LTV limits
    - Policy rate + capital requirements.
  - Macroprudential policy rule:

$$INST_t = \alpha + \beta VAR_t$$

where VAR_t = real credit

How to measure effectiveness?

- A MPP multiplier:

GDP

$$A) = \left| \frac{\sum(GDP_{MPP+MP} - GDP_{MP})}{\sum MPP} \right|$$

Credit

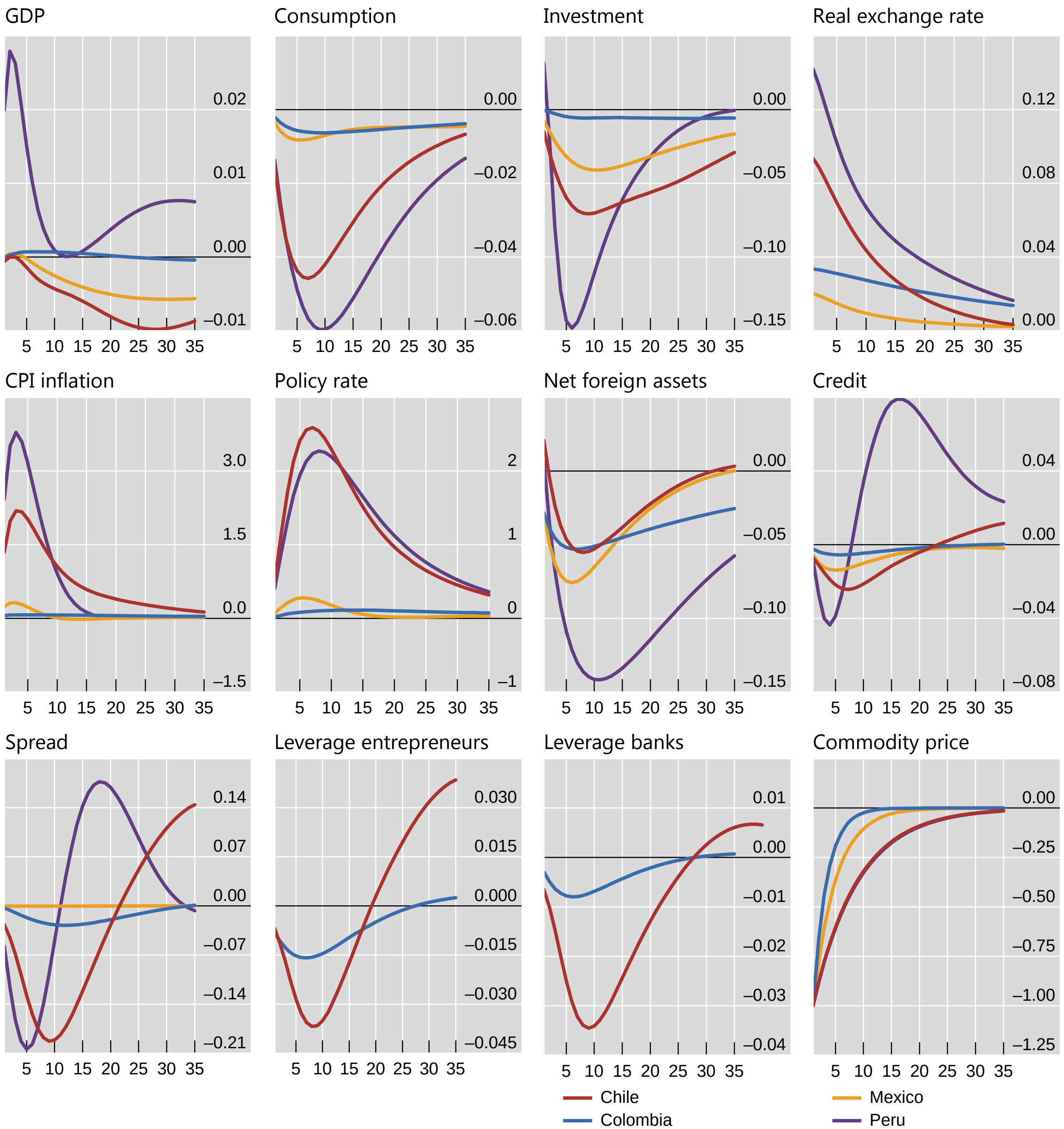
$$B) = \left| \frac{\sum(CR_{MPP+MP} - CR_{MP})}{\sum MPP} \right|$$

- A GDP/Credit sacrifice ratio:

$$\frac{(\boldsymbol{A})}{(\boldsymbol{B})} = \frac{\sum(GDP_{MPP+MP} - GDP_{MP})}{\sum(CR_{MPP+MP} - CR_{MP})}$$

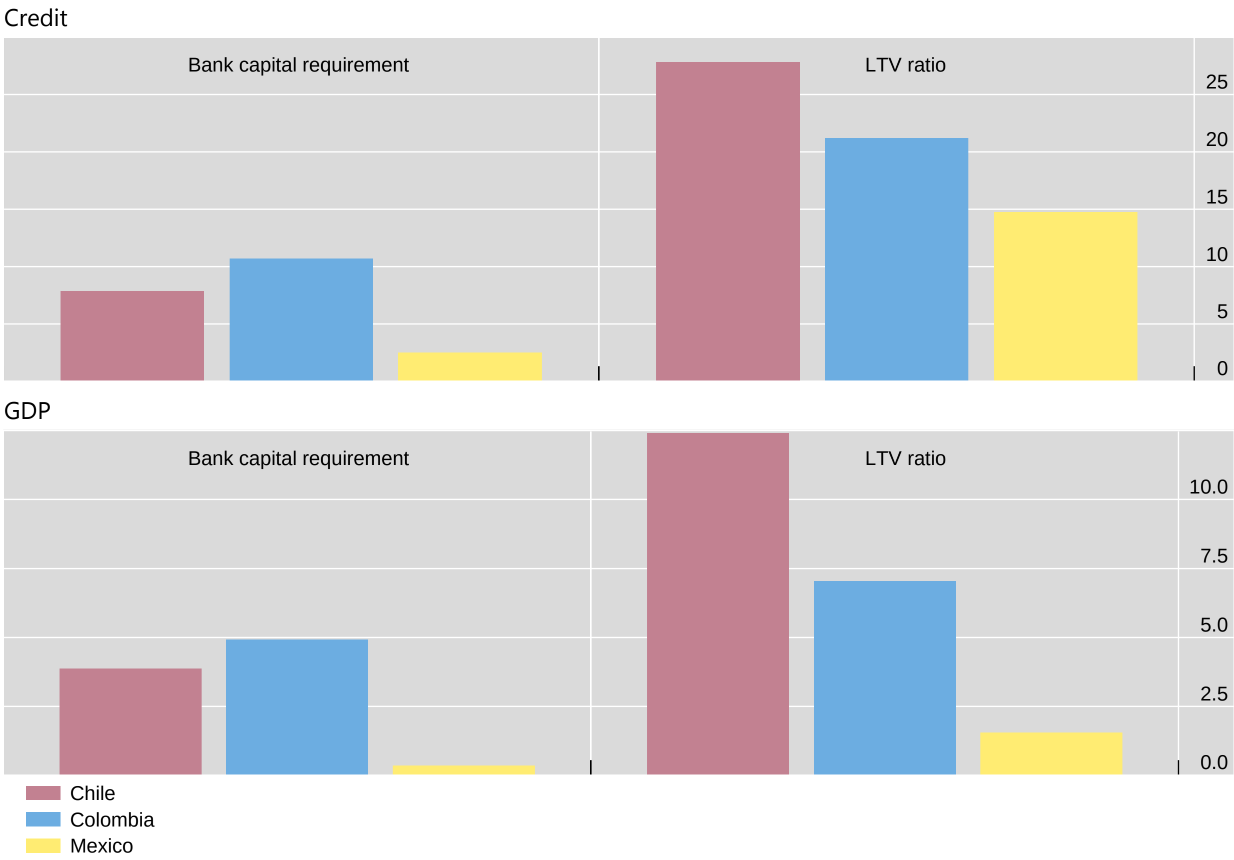
IRFS to a sudden decrease in commodity prices

No MPP case



A sudden decrease in commodity prices: MPP multiplier

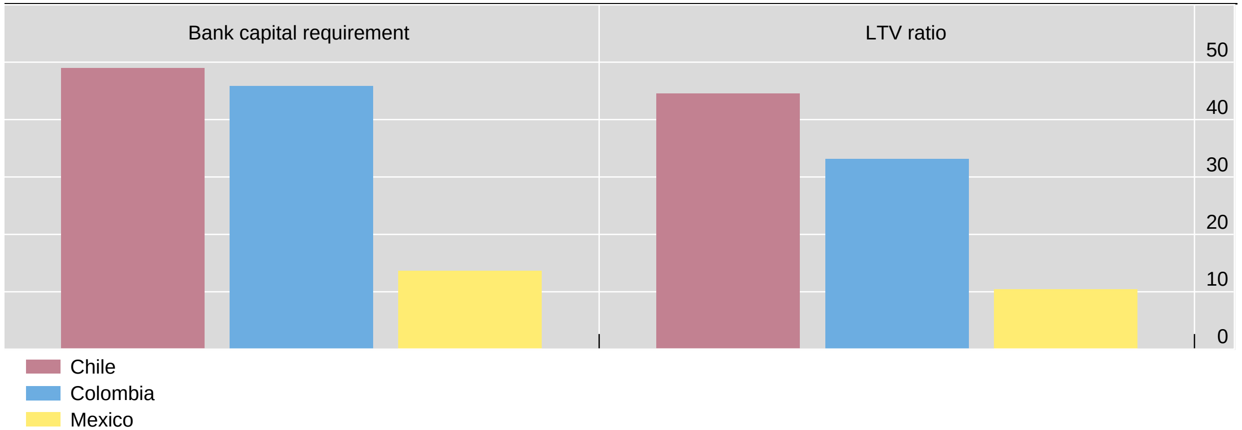
MPP multipliers[1]



[1] Calculated as $100 * \sum_{t=0}^{20}(Y_{MPP+MP} - Y_{MP})/\sum_{t=0}^{20} MPP$, $Y \in \{GDP, Credit\}$.

A sudden decrease in commodity prices: GDP/Credit sacrifice ratio

GDP/Credit sacrifice ratio[1]



[1] Calculated as $100 * \sum_{t=0}^{20}(Y_{MPP+MP} - Y_{MP}) / \sum_{t=0}^{20}(Credit_{MPP+MP} - Credit_{MP})$.

Conclusions

- The model can capture relatively well some of the stylized facts of the 4 economies.
  - Real variables dynamics.
  - Quantitative importance of commodity prices and other external factors.
- However, more work is needed to capture the dynamics of the financial sector.
- Importance of commodity price shocks differ across countries.
- Effectiveness of instruments differ across countries.