Dynamic Stochastic General Equilibrium Models for Emerging Economies: The Case of Chile

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Motivation

- Using new quantitative techniques compare (under a defined metric) different structural monetary models.
- Does neoclassical models outperform new Keynesian ones?
  - Neoclassical models pay more attention to the way the money is justified in an economy.
  - New Keynesian models pay more attention to price rigidities as a manner to include nominal variables

Introduction

- We proposed to compare one neoclassical model versus two new Keynesian Models.
  - Neoclassical: A slightly modified version of Bergoeing & Soto (2005)
  - New Keynesian: Two of the four models presented in Rabanal & Rubio-Ramírez (2005).

Introduction

- Calibration Versus Estimation? Advantages of Bayesian Method.

- We used four Chilean time series (two real and two nominal variables) to match the data with the models.

Introduction

- The structure that follows:
  - Section2. The Models and Estimation Approach.
  - Section 3. Results.
  - Section4. Conclusions.

The Models and Estimation Approach

- Bergoeing & Soto (2005)
  - CIA Restriction
  - Utility function depends on consumption, work and government expenditures.
  - Four sources of uncertainty :
    - Technological Shock
    - Money rate shock
    - Shock on government expenditures.
    - Shock in tax rate.

$$\max E\sum_{t=0}^{\infty}\beta^t\left\{\alpha\log c_{1t}+(1-\alpha)\log(c_{2t}+\pi g_t)-\gamma h_t\right\},\qquad 0<\beta<1$$

$$(1+\tau_t)(c_{1t}+c_{2t})+i_t+\frac{m_{t+1}}{p_t}\le(w_t h_t+r_t k_t)+\frac{m_t}{p_t}+\frac{T_t}{p_t}$$

$$(1+\tau_t)p_t c_{1t}\le T_t+m_t$$

$$Y_t=e^{z_t}K_t^{\theta}H_t^{1-\theta}\quad,\quad 0<\theta<1$$

$$k_{t+1}=(1-\delta)k_t+i_t$$

The government

The government finances a sequence of expenditures throughout creation of money and from collection of taxes.

$$p_t g_t+T_t=\tau_t p_t(c_{1t}+c_{2t})+M_{t+1}-M_t \qquad (1)$$

We assume that money grows to an exogenous rate μ:

$$M_{t+1}=e^{\mu_t}\cdot M_t \qquad (2)$$

Finally the economy must fulfill the identity that equals the product with the different expenses' types:

$$c_{1t}+c_{2t}+i_t+g_t=e^{z_t}K_t^{\theta}H_t^{1-\theta}$$

$$z_{t+1}=(1-\rho_z)\bar{z}+\rho_z z_t+\varepsilon_{t+1}^{z}$$

$$\mu_{t+1}=(1-\rho_\mu)\bar{\mu}+\rho_\mu\mu_t+\varepsilon_{t+1}^{\mu}$$

$$g_{t+1}=(1-\rho_g)\bar{g}+\rho_g g_t+\varepsilon_{t+1}^{g}$$

$$\tilde{\tau}_{t+1}=(1-\rho_\tau)\bar{\tilde{\tau}}+\rho_\tau\tilde{\tau}_t+\varepsilon_{t+1}^{\tau}$$

The Models and Estimation Approach

- Rabanal & Rubio-Ramírez (2005)
  - Model 1 [RR1]. Stick price mechanism [Calvo, 1983].
  - Model 2 [RR2]. Partial price indexation according to the rate of inflation of last period. Similar as in Smet & Wouters (2003).

$$y_t = E_t y_{t+1} - \sigma\left(r_t - E_t \Delta p_{t+1} + E_t g_{t+1} - g_t\right)$$

$$y_t = a_t + \left(1-\delta\right)n_t$$

$$r_t = \rho_r r_{t-1} + \left(1-\rho_r\right)\left[\gamma_\pi \Delta p_t + \gamma_y y_t\right] + z_t$$

$$\Delta p_t = \beta E_t \Delta p_{t+1} + \kappa_p\left(mc_t + \lambda_t\right)$$

$$\Delta p_t = \gamma_b \Delta p_{t-1} + \gamma_f E_t \Delta p_{t+1} + \kappa'_p\left(mc_t + \lambda_t\right)$$

$$a_t = \rho_a a_{t-1} + \varepsilon_t^a$$

$$g_t = \rho_g g_{t-1} + \varepsilon_t^g$$

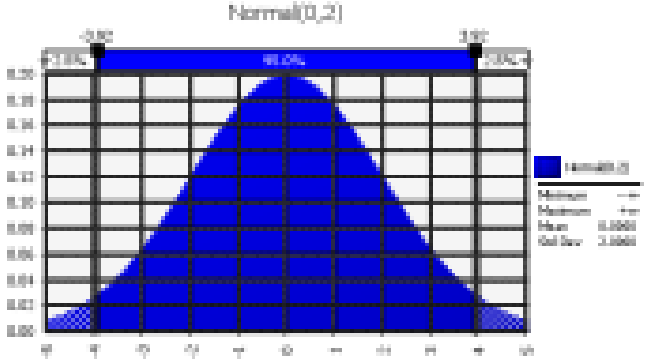
$$z_t = \varepsilon_t^z$$

$$\lambda_t = \varepsilon_t^\lambda$$

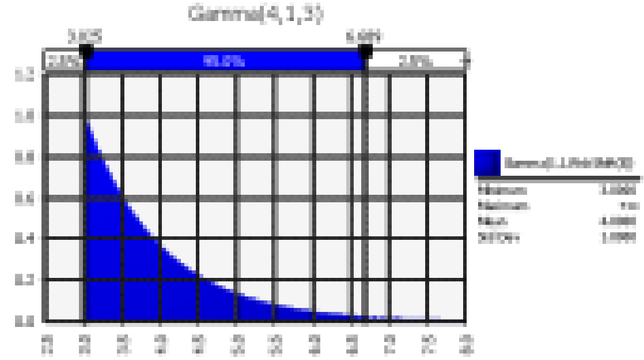
The Models and Estimation Approach

- The Bayesian Estimation: Something between maximum likelihood estimation and calibration…
  1. Establish optimality conditions (First Order Conditions).
  2. Propose *priors* about the deep parameters probability distributions.
  3. Evaluate the likelihood function. Implies linearizing the DGE system of equations, apply the kalman filter and use Markov Chain Monte Carlo methods to get the posterior distribution of the guessed parameters.

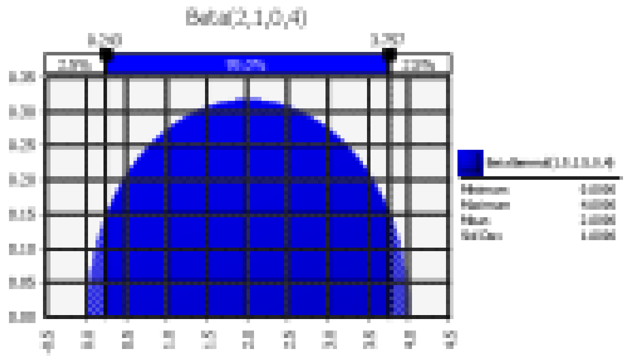
Priors



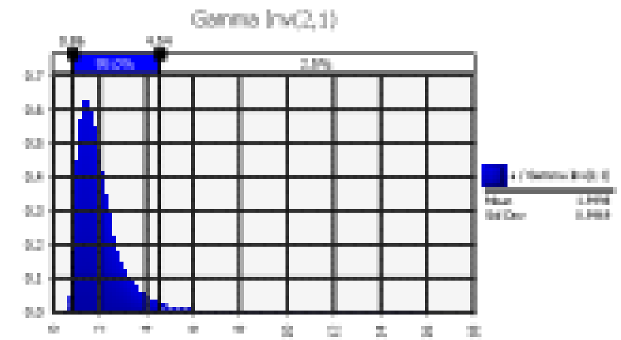
Distribución Normal



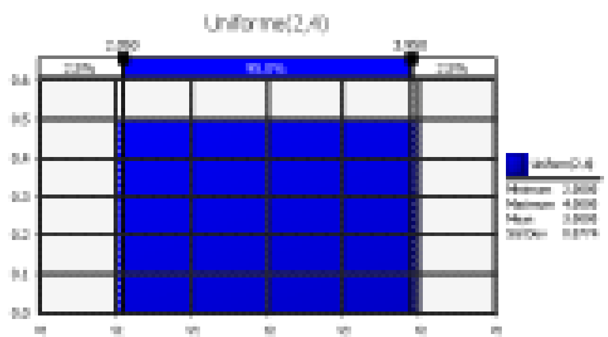
Distribución Gamma



Distribución Beta



Distribución Gamma Inversa



Distribución Uniforme

The Models and Estimation Approach

- Bergoeing & Soto (2005) – Parameters

Table 1. Values of the Parameters and Specification of Priors – BS Model

Parameter	Value	Parameter	Value/Prior
θ	0.350	ψ_1	-3.500
δ	0.020	γ	Beta(1.9, 0.5,0.3)
β	0.993	ρ_z	Uniform(0.5, 1)
α	0.710	ρ_μ	Uniform(0, 1)
π	0.010	ρ_g	Uniform(0, 1)
$\bar{z}$	0.000	ψ_2	Uniform(10,30)
$\bar{\mu}$	0.040	$stdev\left(\varepsilon^z\right)$	InvGamma(0.1, ∞)
$\bar{g}$	0.089	$stdev\left(\varepsilon^\mu\right)$	InvGamma(0.1, ∞)
$\bar{\tilde{\tau}}$	0.200	$stdev\left(\varepsilon^g\right)$	InvGamma(0.1, ∞)
$\rho_{\tilde{\tau}}$	0.010	$stdev\left(\varepsilon^{\tilde{\tau}}\right)$	InvGamma(0.1, ∞)

The Models and Estimation Approach

- Rabanal & Rubio-Ramírez (2005) – Parameters

Table 1. Values of the Parameters and Specification of Priors –RR-1 and RR-2 Models

Parameter	Value / Prior
β	0.99
δ	0.35
$\bar{\varepsilon}$	6.00
ω	0.70
$1/\sigma$	Gamma(2.5, 1.76)
$1/\left(1-\theta_p\right)$	Gamma(2, 1.42)
γ_π	Normal(1.5, 0.25)
γ_y	Normal(0.125, 0.125)

Parameter	Prior
γ	Normal(1, 0.5)
ρ_r	Uniform(0, 1)
ρ_a	Uniform(0, 1)
ρ_g	Uniform(0, 1)
$stdev\left(\varepsilon^a\right)$	InvGamma(0.01, ∞)
$stdev\left(\varepsilon^g\right)$	InvGamma(0.01, ∞)
$stdev\left(\varepsilon^z\right)$	InvGamma(0.01, ∞)
$stdev\left(\varepsilon^\lambda\right)$	InvGamma(0.01, ∞)

The Models and Estimation Approach

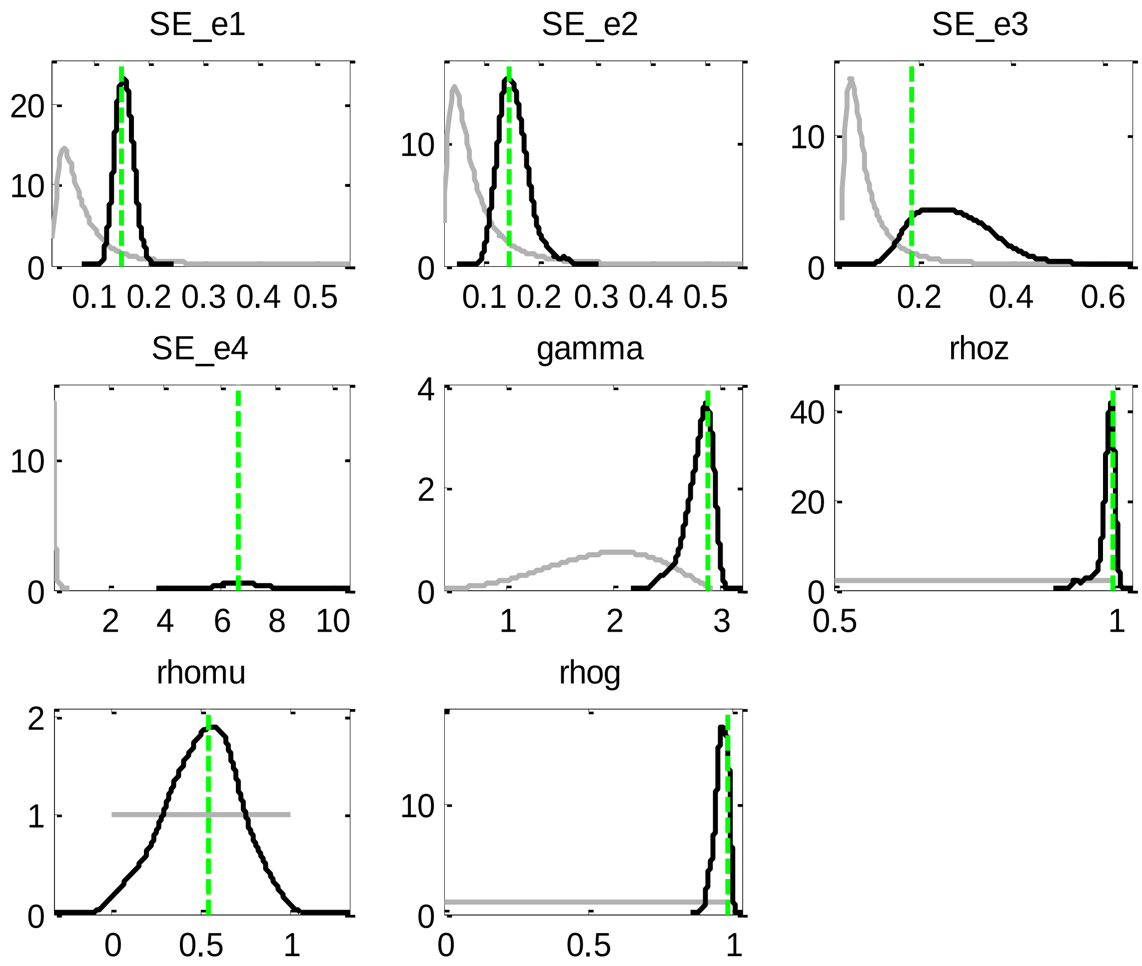
- Some of the parameters were fixed to attain stability when solving the system.

Results

- Data: Quarterly time series between 1998:01 and 2009:02, 46 observations.
- Variables: Chilean price inflation, real wages, nominal interest rates and per capita real product.
- All series demeaned.
- The series of inflation, the real product per capita and the index of real wages were seasonally adjusted.
- Real product and wages were detrended using the HP filter.

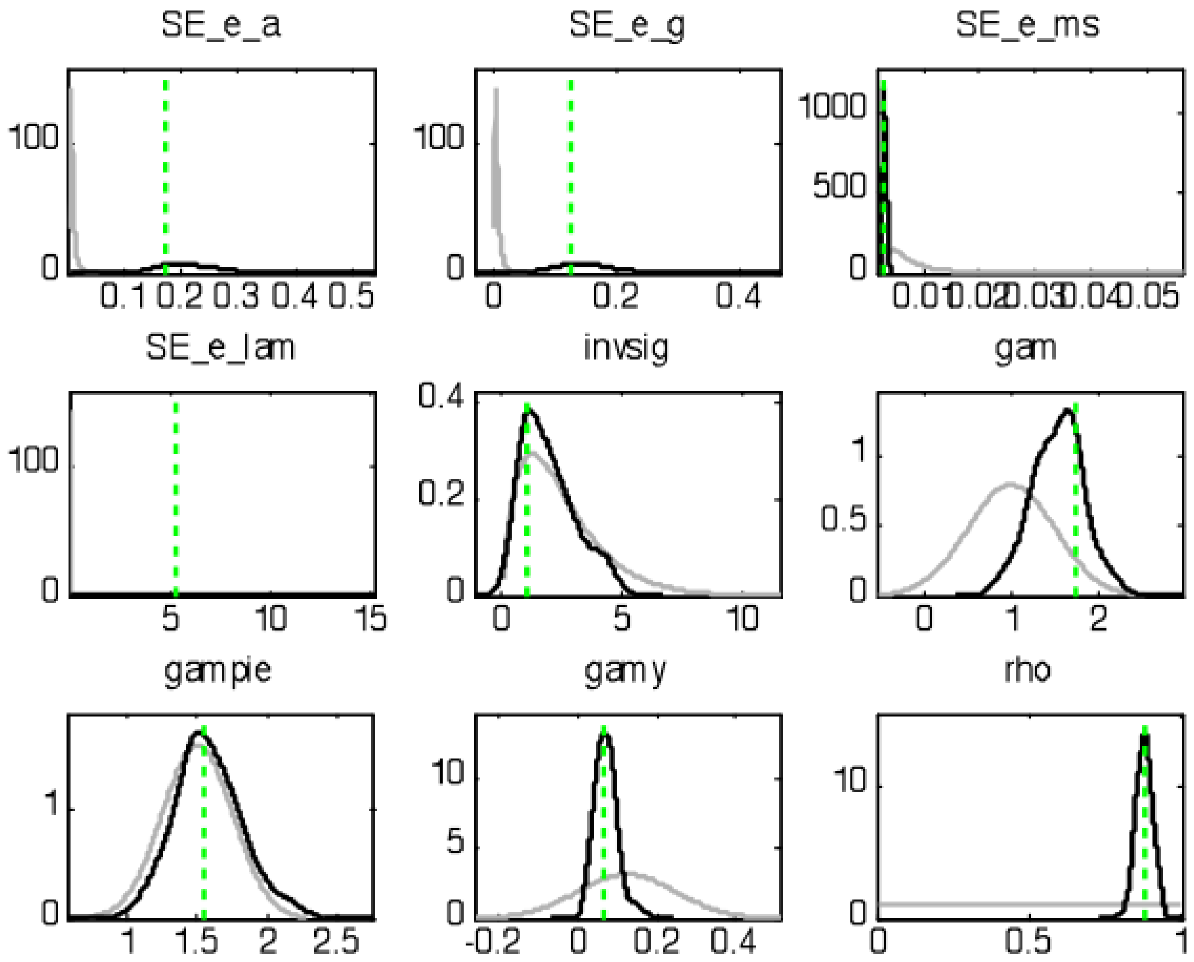
Results

- Priors and posteriors – BS Model



Results

- Priors and posteriors – RR1 Model



Results

- Priors and posteriors – RR1 Model

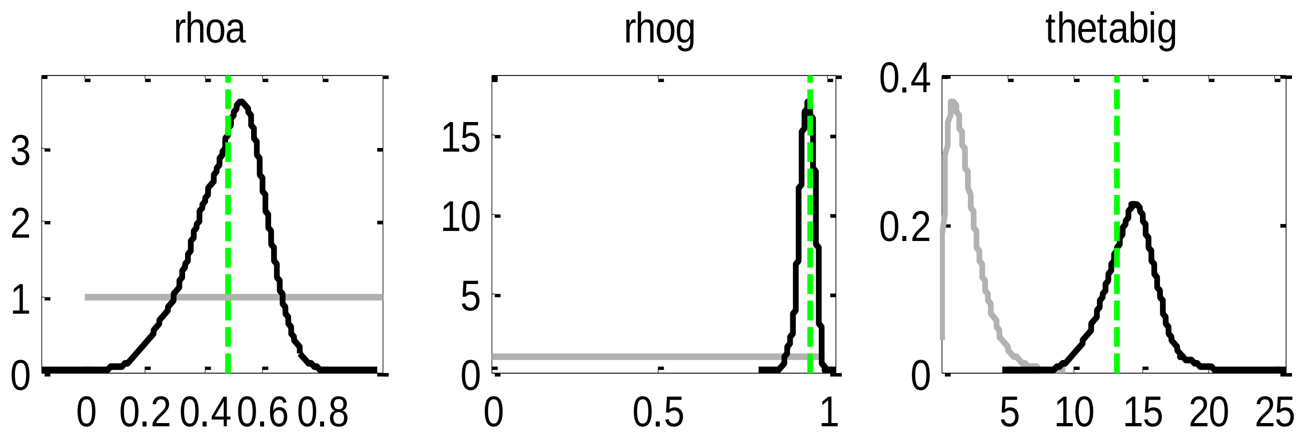


Figure A2. Prior and Posterior Distributions (prior = gray line, posterior= black line).
RR1 Model

Results

- Priors and posteriors – RR2 Model

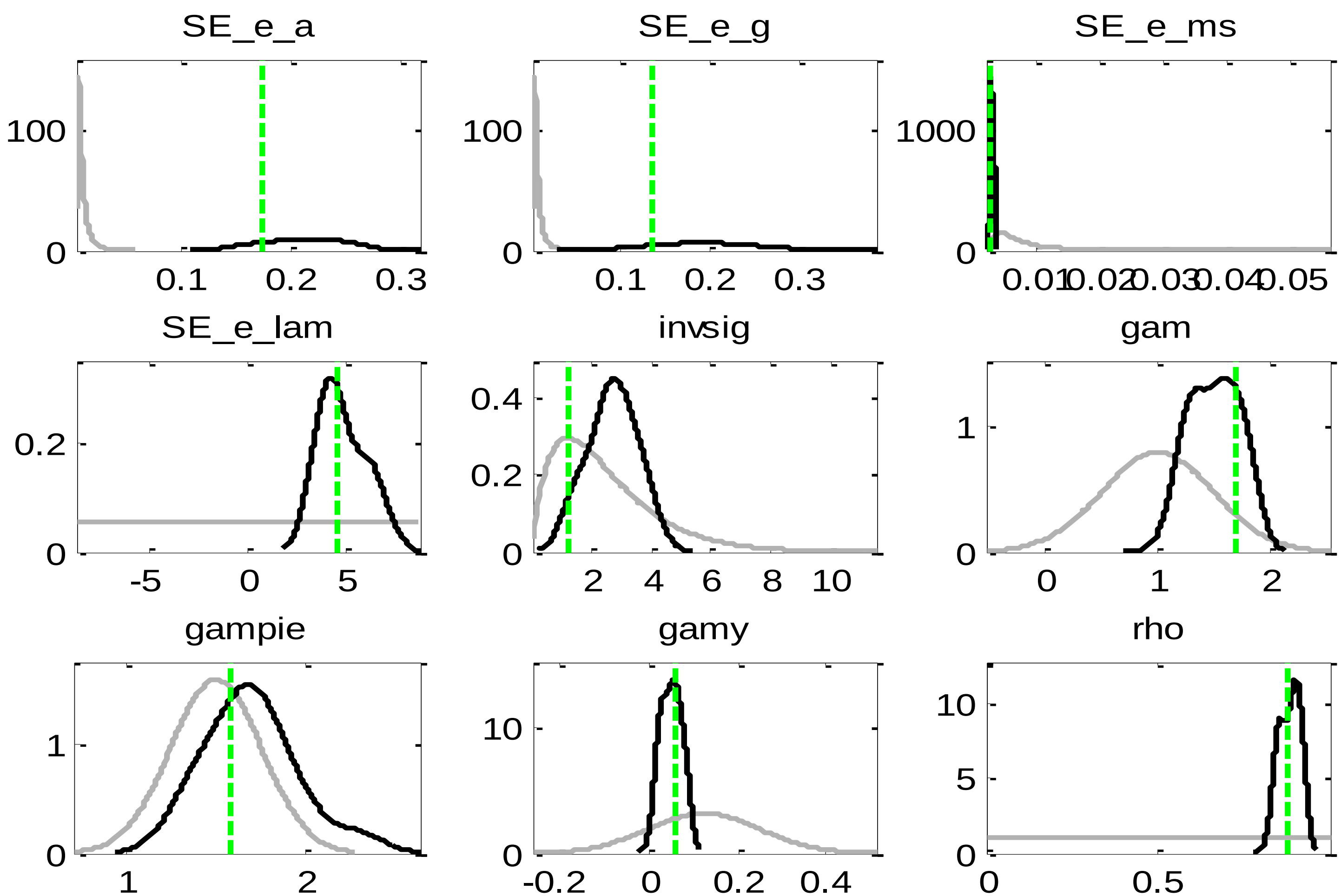


Figure A3. Prior and Posterior Distributions (prior = gray line, posterior= black line). RR2 Model

Results

- Priors and posteriors – RR2 Model

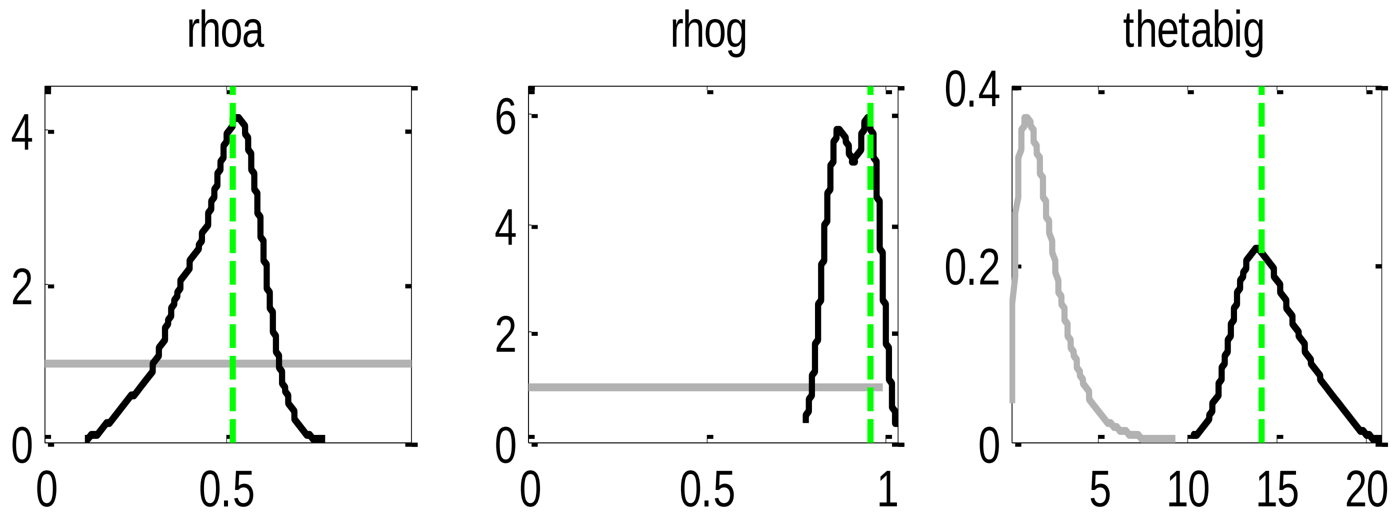


Figure A3. Prior and Posterior Distributions (prior = gray line, posterior= black line). RR2 Model

Results

- Evaluating the empirical data versus the models simulations:

Table 1. Chile: Observed and Simulated Volatility

	Volatility			
		Model		
	Observed	BS	RR-1	RR-2
GDP	0.141	0.184	0.125	0.144
Nominal Interest Rate	0.010	0.066	0.010	0.017
Real Wage	0.638	0.617	0.391	0.563
Inflation	0.007	0.061	0.004	0.009
	Volatility with respect to GDP volatility			
	Observed	BS	RR-1	RR-2
GDP	1.00	1.00	1.00	1.00
Nominal Interest Rate Nominal	0.07	0.36	0.08	0.12
Real Wage	4.51	3.35	3.14	3.92
Inflation	0.05	0.33	0.03	0.06

Results

- Evaluating empirical data versus the models simulations:

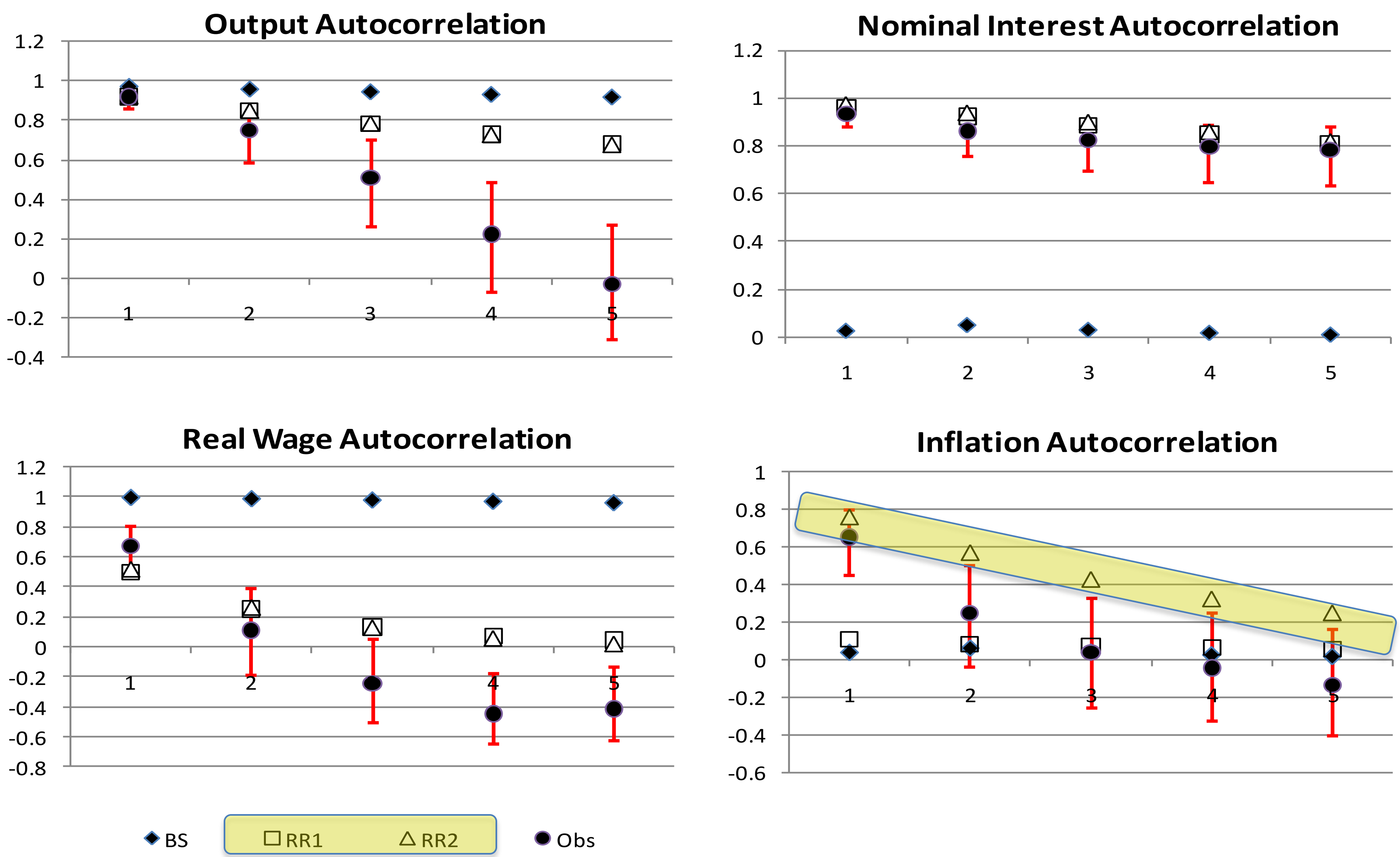


Table A1. Mean of the Prior and Posterior Distributions

Parameter	Prior Distribution		Posterior Distribution			
		Mean	Mean			
			BS	BS-2	RR-1	RR-2
γ	Beta(1.9, 0.5,0.3)	1.90	2.8149	2.8272		
ρ_z	Uniform(0.5, 1)	0.75	0.9757	0.9789		
ρ_μ	Uniform(0, 1)	0.50	0.4458	0.4487		
ρ_g	Uniform(0, 1)	0.50	0.9763	0.9688		
ψ_2	Uniform(10.30)	20.00	23.5861			
$stdev(\varepsilon^z)$	InvGamma(0.1, ∞)	0.10	0.1390	0.1403		
$stdev(\varepsilon^\mu)$	InvGamma(0.1, ∞)	0.10	0.1279	0.1426		
$stdev(\varepsilon^g)$	InvGamma(0.1, ∞)	0.10	0.2469	0.2906		
$stdev(\varepsilon^v)$	InvGamma(0.1, ∞)	0.10	2.6356	4.4815		
$1/\sigma$	Gamma(2.5, 1.76)	2.50			1.6396	2.2359
$1/(1-\theta_p)$	Gamma(2, 1.42)	2.00			14.3831	14.6576
γ_π	Normal(1.5, 0.25)	1.50			1.5965	1.6222
γ_y	Normal(0.125, 0.125)	0.125			0.0689	0.1079
γ	Normal(1, 0.5)	1.00			1.6014	1.5678
ρ_r	Uniform(0, 1)	0.50			0.8801	0.9047
ρ_a	Uniform(0, 1)	0.50			0.5096	0.5131
ρ_g	Uniform(0, 1)	0.50			0.9382	0.9126
$stdev(\varepsilon^a)$	InvGamma(0.01, ∞)	0.01			0.2022	0.2006
$stdev(\varepsilon^g)$	InvGamma(0.01, ∞)	0.01			0.1480	0.1766
$stdev(\varepsilon^z)$	InvGamma(0.01, ∞)	0.01			0.0030	0.0030
$stdev(\varepsilon^\lambda)$	InvGamma(0.01, ∞)	0.01			6.5365	5.2586

Results

¿Which model adjust better the data?

Model	BS	BS-2	RR-1	RR-2
$\log(\hat{L})$	106.93	101.15	345.54	363.78
$PO_{[illegible]}$	3.40	3.60	1.05	1

The difference between one (BS) and the other (BS-2) is that the BS model estimates the ψ_2 parameter, whereas the BS-2 maintain it fixed in its mean prior value.

Conclusions

- We compared separately the behavior of the observed and simulated series (volatility and autocorrelations)
- Volatility
  - of the main macroeconomic aggregates we found that the BS model have just an acceptable performance explaining the volatility of real variables such as GPD or real wage, but it has a poor performance simulating volatility of nominal variables such as nominal interest rate and inflation.

Conclusions

- New Keynesian models outperform results from the BS model and adjust quite well volatility from nominal and real variables.

- In what concerns to autocorrelations, our findings were that the RR-1 and RR-2 models outperform clearly the BS model

Conclusions

- We would expect that a complete characterization of the models will support the new Keynesian models to the detriment of our neoclassical model.
- That is true after calculating the odds ratio between models. Our results indicate that there exists strong and decisive evidence in favor of the RR-2 model against models RR-1 and BS.

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