Monetary and Macroprudential Policy at the Bangko Sentral ng Pilipinas: *A Bayesian DSGE Approach*

Paul McNelis
Fordham University

Cristeta Bagsic
Center for Monetary and Financial Policy

BANGKO SENTRAL NG PILIPINAS

The usual disclaimer applies.

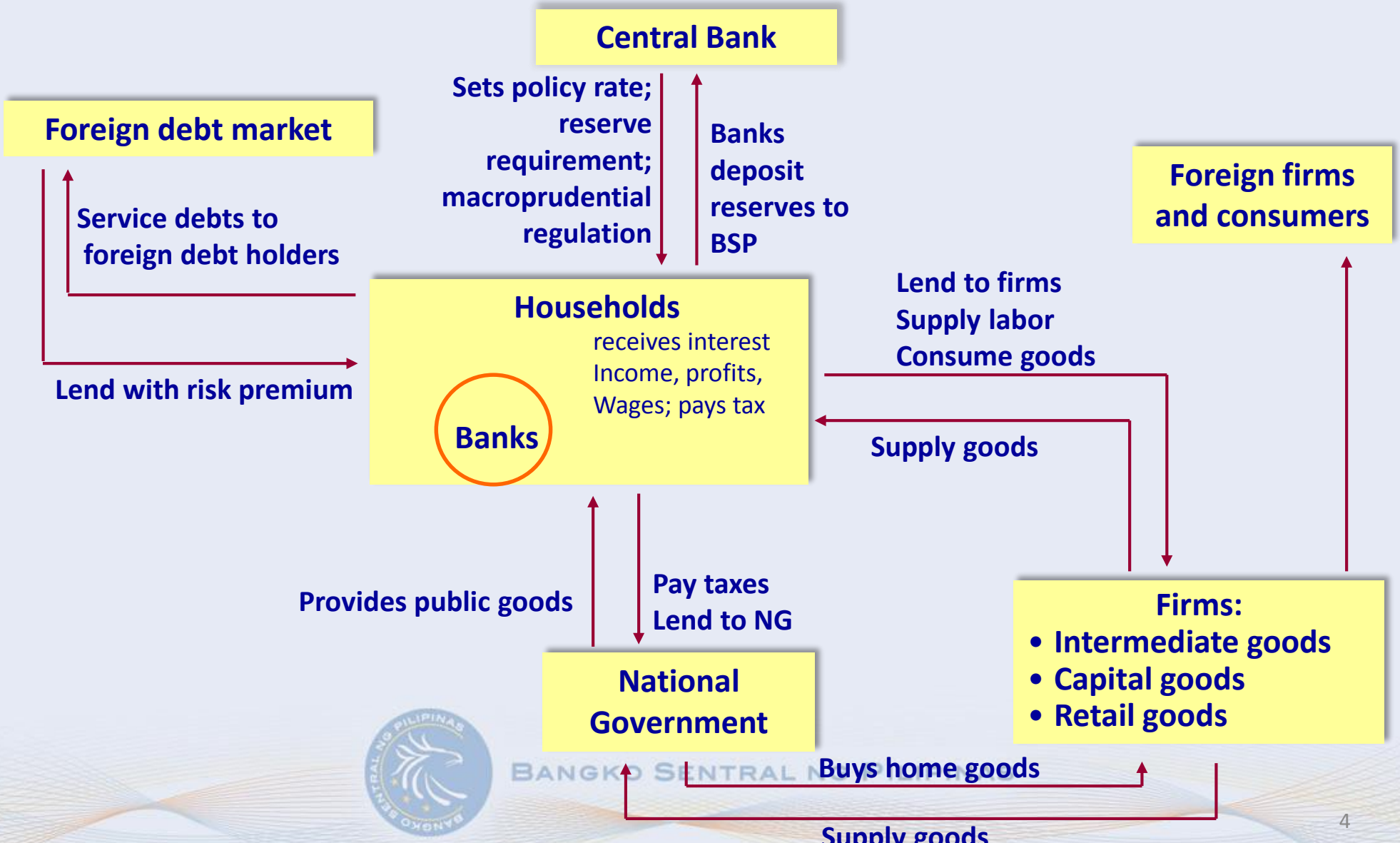
Objective:

To look into how monetary and macroprudential policy of the BSP has achieved its objectives using a model with financial friction via the banking sector

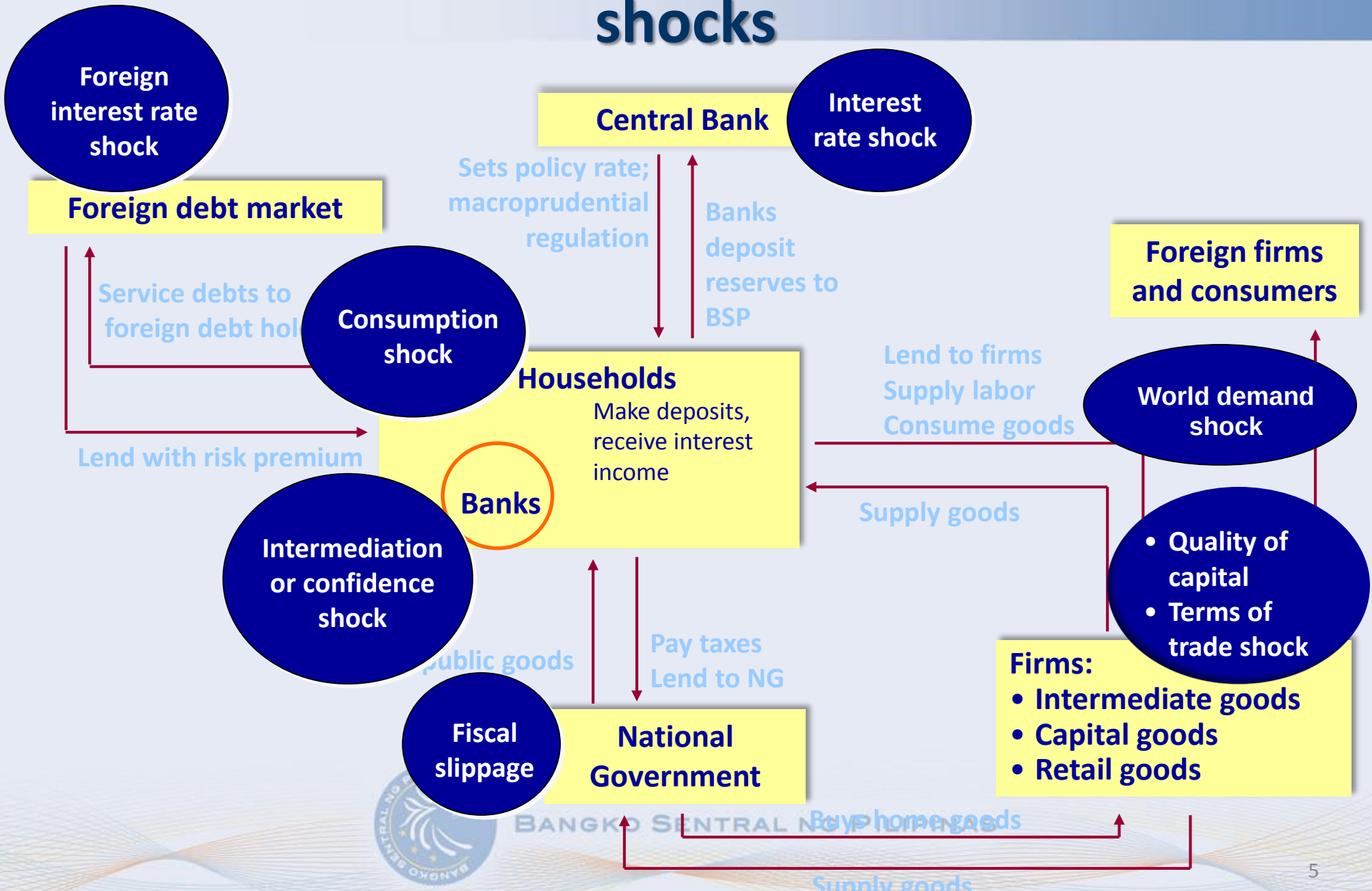
The Model

- Quarterly data from 1999-2017
  - GDP, private consumption, government consumption, fixed capital formation, trade balance, net worth of the banking sector, inflation, 90-d LIBOR, 91-day Tbill, real effective exchange rate, policy rate
  - the choice of 1999 as the beginning period: earliest publicly available data for banking sector net worth
  - Nominal variables are detrended using Hodrick-Prescott method; while real variables were deseasonalized using X-12 Arima.
- Estimation procedure:
  - *Calibration*
  - *Bayesian method*

Schematic Diagram of the Model



Schematic Diagram of the Model: Risks and shocks



Households

- Maximizes inter-temporal utility, where consumption is subject to habit persistence
- household sector consumes C_t, provides labor services L_t at wage W_t, borrows $E_tB^*_t$ from international markets at a gross rate of interest R^*_t, can make deposits or buy risk-free government bonds B_t with a gross return of $R_t = (1 + r_t)$, receives net profits from ownership of financial and non-financial firm, pays lump-sum tax T

Banking sector as source of friction a la GK (2011)

- borrows from households and pay a gross rate, holds reserves on these deposits, at the central bank, given by the ratio ψ_t. They also lend to firms a total of $Q_t S_t$ which yields a gross return of R^k_{t+1}
- Banking sector maximize terminal wealth V_t
- V_t must be greater than divertible assets, otherwise, depositors will not lend to bank

$$V_t \geq \lambda_t Q_t S_t^b$$

Banking sector as source of friction

- Λ_t : no-confidence factor; portion of total lending $Q_t S_t$ that depositors believe bankers can divert
  - Gertler and Karadi (2011): banking sector as the source of financial frictions due to the presence of this moral hazard problem
- Bernanke et al. (1996): credit- constrained firms as the source of frictions
- Villa (2014): GK specification is superior as the banking sector is a powerful "amplification" channel and provides a better solution to the "small shocks, large cycles" puzzle

Firms: Intermediate, final goods, capital goods

Intermediate goods producers: to produce intermediate output Y_t

- combine labor L_t, imported intermediate goods M_t purchased at world price P^*_t, and effective capital K_t (that is capital which is subjected to both a utilization rate U_t and a quality factor ξ_t)
- The depreciation rate varies over time, as a function of the utilization rate of effective capital.
- borrow S_t at price Q_t to pay for capital, incurring a gross cost R^k to be paid the following period

Firms: Intermediate, final goods, capital goods

Final goods at monopolistic competitive pricing:

- Competitive final goods firms buy intermediate goods and assemble them. Final output is a composite of intermediate goods and differentiated by retailers
- Retailers set nominal prices in a staggered fashion. Each retailer resets its optimal price P_t^o with probability $(1-\sigma_p)$. For the fraction of retailers that cannot adjust, the price is automatically increased at the aggregate inflation rate multiplied by an indexation parameter

Firms: Intermediate, final goods, capital goods

Capital goods at monopolistic competitive pricing:

- The intermediate goods are also sold to capital-producing firms.
- An adjustment cost θ^k_t is incurred wrt changes in investment from time (t-1) to time (t)

$$\Theta_t^K = .5\theta^k \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1 \right)^2 (I_\tau + I^s)$$

- Tobin's Q is given by

$$Q_t = 1 + \theta^k \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1 \right) (I_\tau + I^s) + .5\theta^k \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1 \right)^2 +$$

$$\beta \Lambda_{t,t+1} .5\theta^k \left(\frac{(I_{\tau+1} + I^s)}{(I_\tau + I^s)} - 1 \right) \frac{(I_{\tau+1} + I^s)^2}{(I_\tau + I^s)^2}$$

Fiscal and monetary authorities

- Government spending G_t follows as AR(1) stochastic process relative to its steady state, and spending is financed by lump-sum taxes T
- Government bonds evolve according to the budget constraint:

$$B_t^g = R_t B_{t-1}^g + G_t - \bar{T}$$

Fiscal and monetary authorities

- monetary authorities adopt a Taylor rule for the gross nominal interest rate, $(1+i_t)$, given by

$$(1+i_t) = \left[(1+\bar{i})(1+\pi_t)^{\kappa^\pi}(1+y_t)\right]^{(1-\rho)}(1+i_{t-1})^{\rho}exp(\xi_t^R)$$

where $(1+\pi_t)$ is the gross inflation rate and the ratio $(1+y_t) = (Y_t/\bar{Y})$ is the deviation of output from steady-state output. The Taylor rule is also subject to the stochastic shock ξ_t^R, which follows an autoregressive process.

Exports

Domestic production includes exports

- The demand for export goods is a function of the relative price of such goods as well as world demand, X^*_t

$$X_t = \left(\frac{P_t}{S_t P_t^*}\right)^{-\epsilon} X_t^*$$

- The firm remits profits to the household. The profits of the firms includes the real trade balance, $X_t - S_t P^*_t M_t/P_t$

Calibrated Parameters

Table 2: Calibrated Parameters

discount factor	β	0.99
adjustment cost for debt	θ_b	.03
habit persistence	h	0.815
relative utility weight of labor	χ	3.40
inverse Frisch elasticity of labour supply	φ	0.276
capital share	α	0.33
depreciation rate	$\bar{\delta}$	0.025
inverse elasticity of investment to Q	θ^k	1.728
government share of GDP	G/Y	0.2
start-up transfer	ω	0.002
divertible fraction	$\bar{\lambda}$	0.382
banker continuation probability	θ	0.972
steady state leverage	ϕ	4
steady state premium	$(R^k - R)400$	1.0

Christiano: calibrate those that affect the steady state, estimate those that affect dynamics of the system

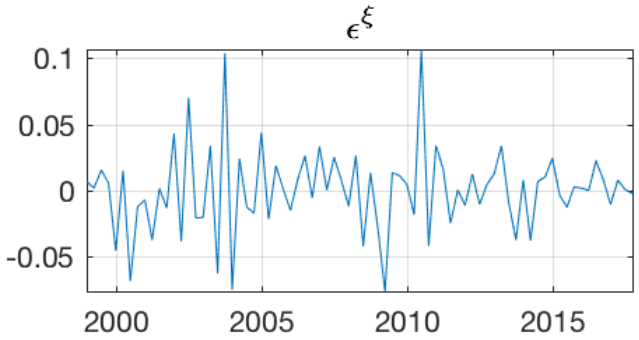
Table 3: Bayesian Estimates of Parameters and Volatilities

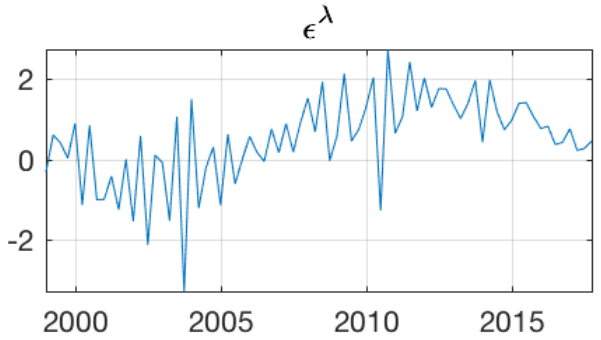
Priors				Posteriors		
	Mean	Std	Distribution	Mean	Inf	Sup
Autoregressive Coefficients						
ϱ_ξ	0.5	0.2	Beta	0.989	0.988	0.990
ϱ_λ	0.5	0.2	Beta	0.888	0.863	0.913
ϱ_{R^*}	0.5	0.2	Beta	0.794	0.757	0.827
ϱ_C	0.5	0.2	Beta	0.990	0.989	0.990
ϱ_g	0.5	0.2	Beta	0.742	0.491	0.987
ϱ_{MC}	0.5	0.2	Beta	0.980	0.971	0.990
ϱ_{X^*}	0.5	0.2	Beta	0.989	0.980	0.998
ϱ_{P^*}	0.5	0.2	Beta	0.452	0.152	0.740
Calvo Parameter						
γ	0.5	0.2	Beta	0.645	0.611	0.679
Taylor Rule Parameters						
ρ	0.5	0.2	Beta	0.637	0.615	0.661
κ^π	1.5	0.1	Normal	1.775	1.744	1.800
κ^y	0.5	0.1	Normal	0.405	0.242	0.562
Volatilities						
σ_ξ	0.01	2	Inv.Gamma	0.032	0.026	0.037
σ_λ	0.01	2	Inv.Gamma	1.238	1.043	1.445
σ_{R^*}	0.01	2	Inv.Gamma	0.099	0.082	0.117
σ_R	0.01	2	Inv.Gamma	0.090	0.077	0.103
σ_g	0.01	2	Inv.Gamma	0.138	0.011	0.268
σ_{X^*}	0.01	2	Inv.Gamma	0.169	0.146	0.192
σ_{MC}	0.01	2	Inv.Gamma	0.064	0.053	0.075
σ_C	0.01	2	Inv.Gamma	0.076	0.064	0.086
σ_{P^*}	0.01	2	Inv.Gamma	0.007	0.002	0.012

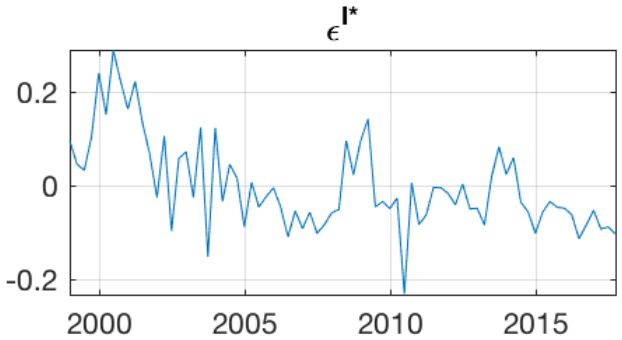
- Priors: a priori belief and uncertainty about the model and its parameters
- Posteriors: priors are revised by confronting model with data

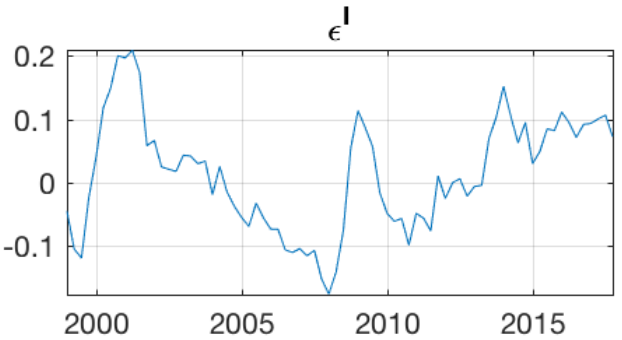
- Ex-post results show that the Taylor principle is observed in the Philippines: the coeffcient of inflation (with prior of 1.5) is 1.775
- there is persistence in interest rate with posterior estimate of ρ at 0.637 (but more flexible than some other central banks' at around 0.7-0.8);
- the coeffcient of output gap at around 0.405 on average versus Taylor's 0.5.

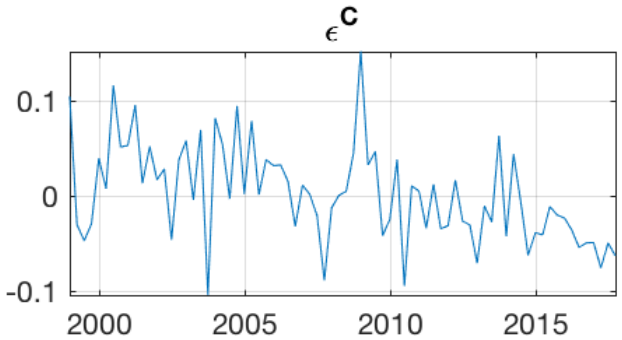
Smoothed Shocks



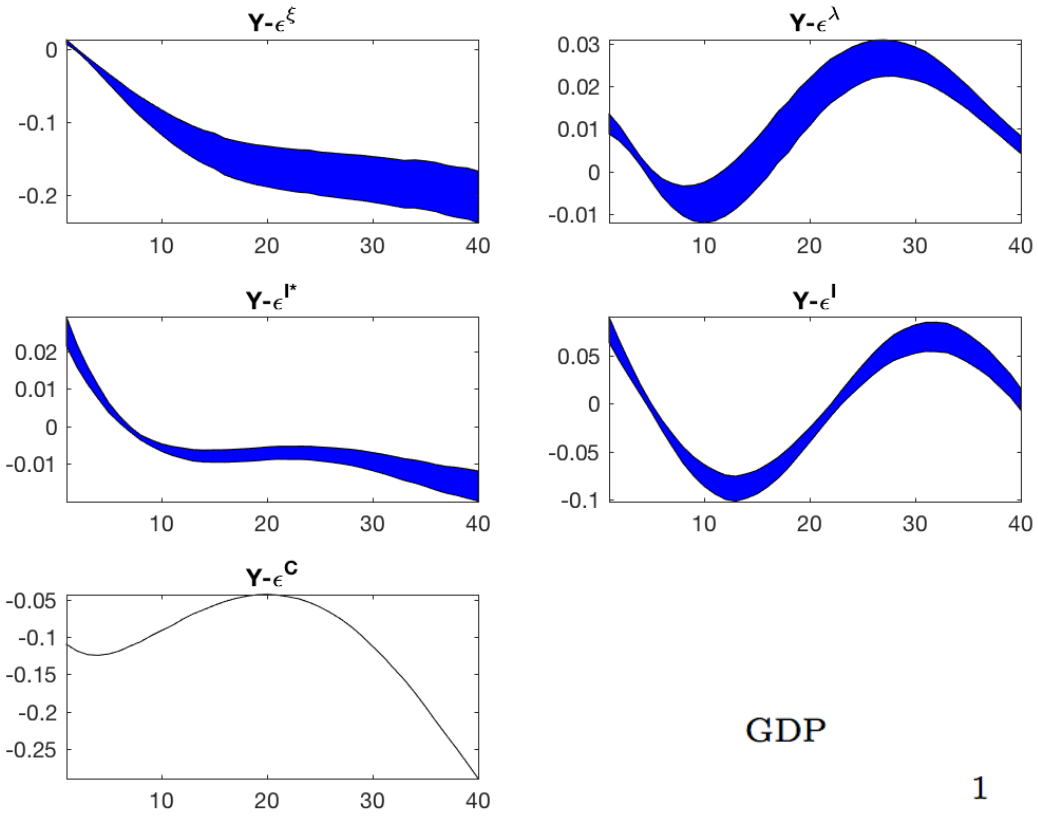


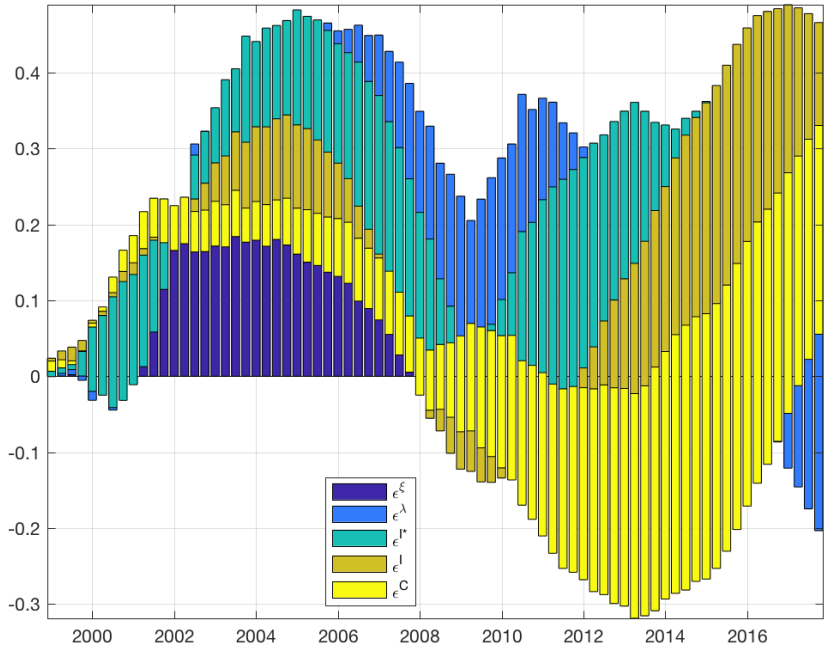






GDP: Impulse Response Paths; Conditional variance decomposition; Historical shock decomposition

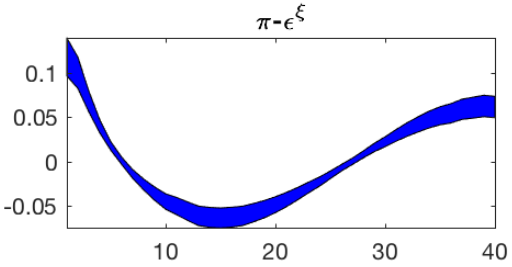


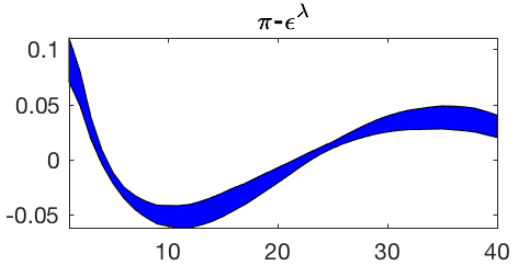


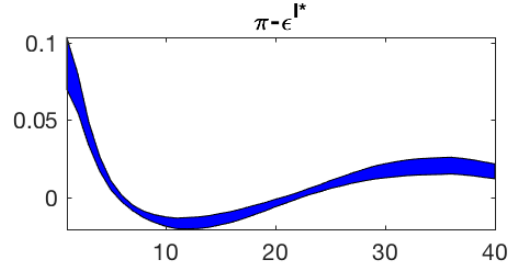
GDP

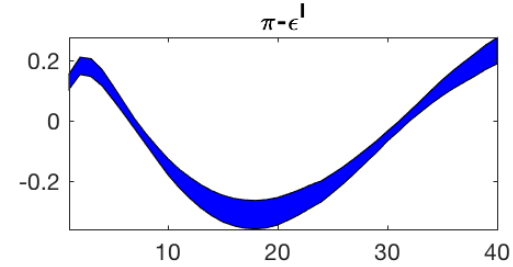
	1	2	3	4	10	12	16
ϵ_{ξ}	0.090	0.057	0.108	0.259	0.842	0.880	0.913
ϵ_{λ}	0.103	0.103	0.088	0.064	0.012	0.008	0.004
ϵ_{R*}	0.516	0.496	0.431	0.326	0.035	0.022	0.012
ϵ_{R}	0.048	0.044	0.037	0.027	0.006	0.006	0.005
ϵ_{c}	0.078	0.103	0.119	0.116	0.026	0.017	0.008

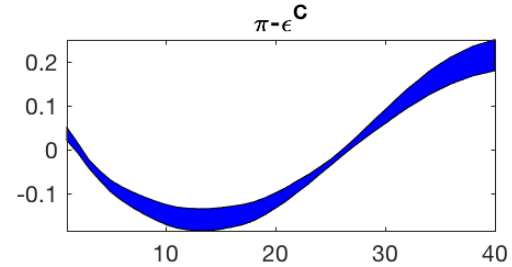
Inflation: Impulse Response Paths; Conditional variance decomposition; Historical shock decomposition

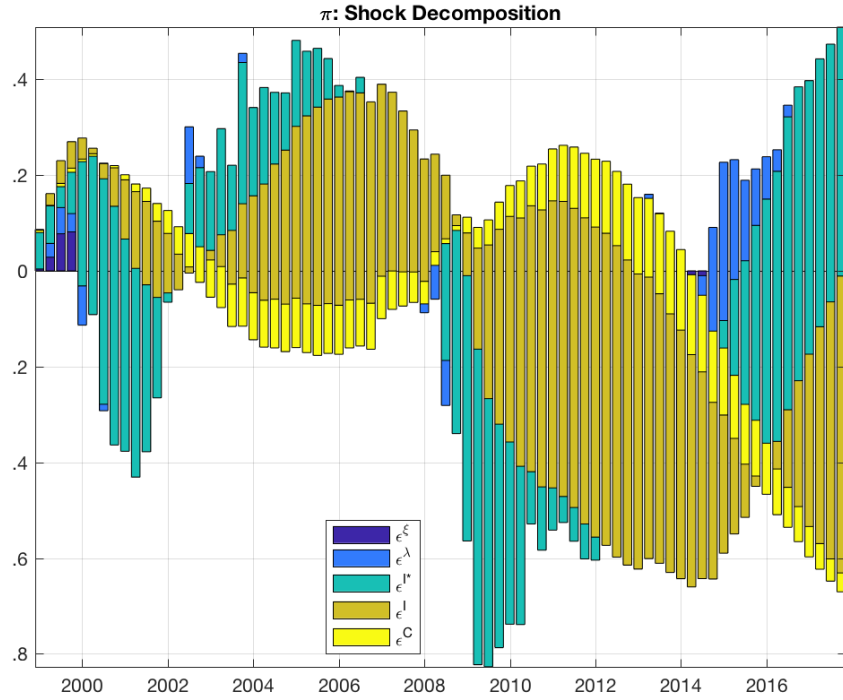






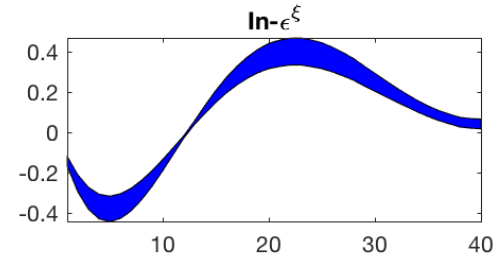


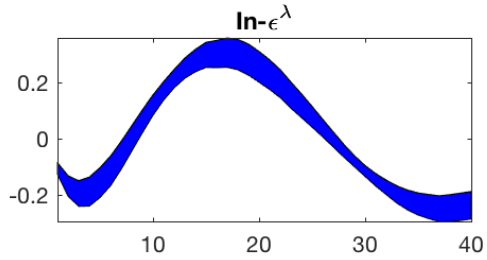


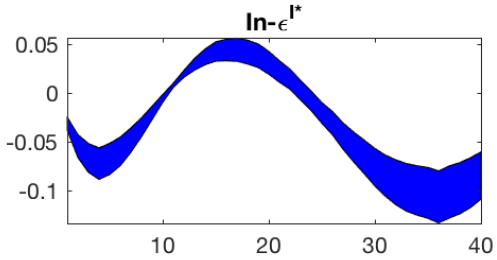


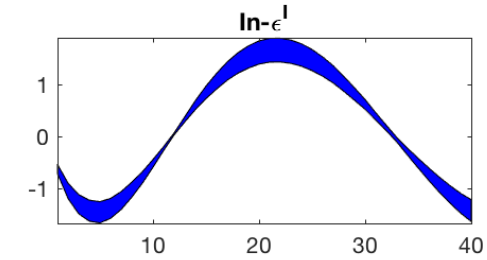
INFL	1	2	3	4	10	12	16
ϵ_{ξ}	0.469	0.490	0.504	0.508	0.445	0.440	0.457
ϵ_{λ}	0.265	0.242	0.224	0.215	0.290	0.301	0.287
ϵ_{R*}	0.247	0.243	0.240	0.237	0.189	0.167	0.134
ϵ_{R}	0.006	0.010	0.015	0.017	0.020	0.026	0.045
ϵ_{c}	0.000	0.000	0.000	0.001	0.013	0.016	0.021

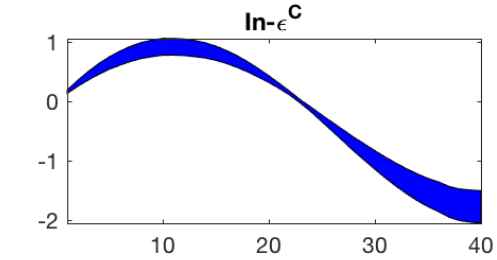
Investments: Impulse Response Paths; Conditional variance decomposition; Historical shock decomposition

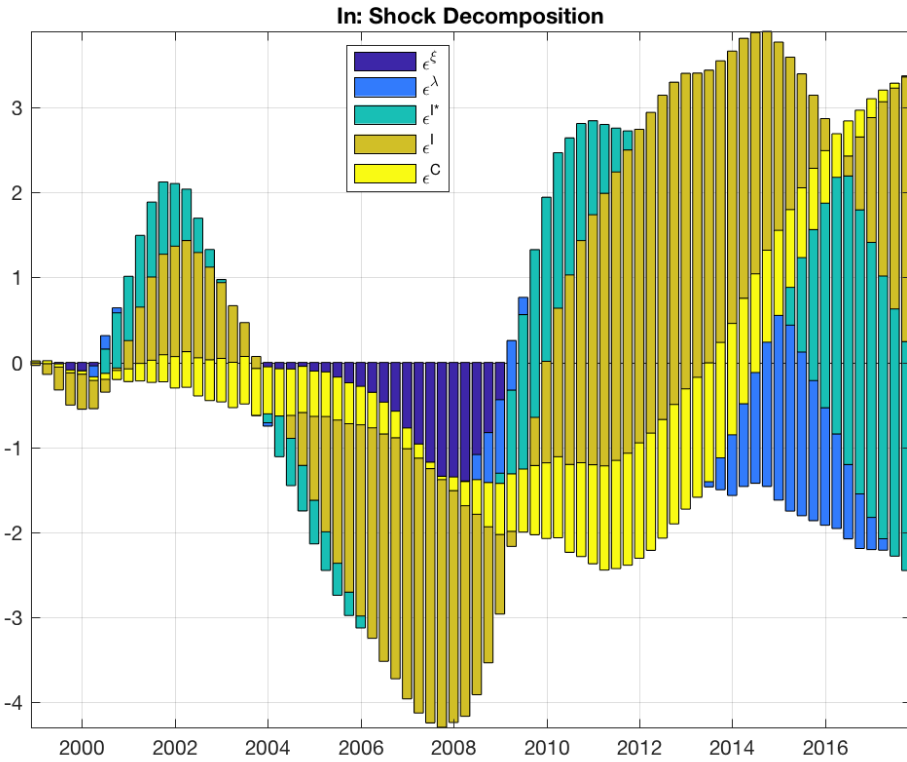






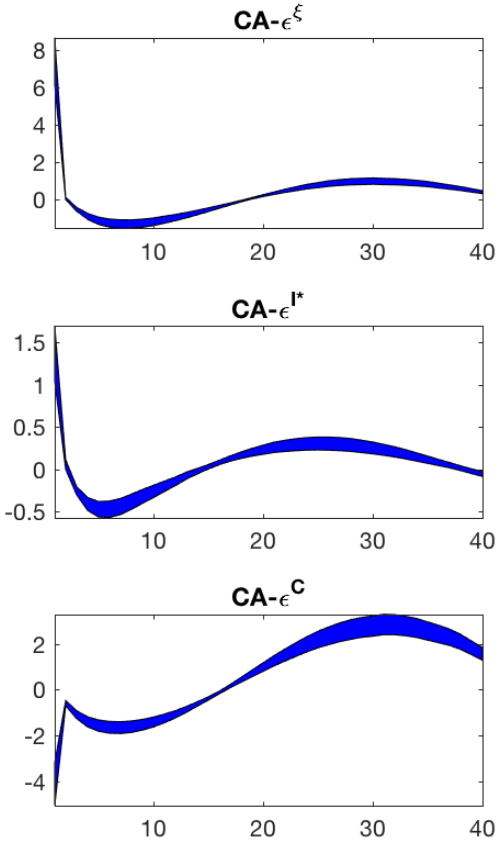


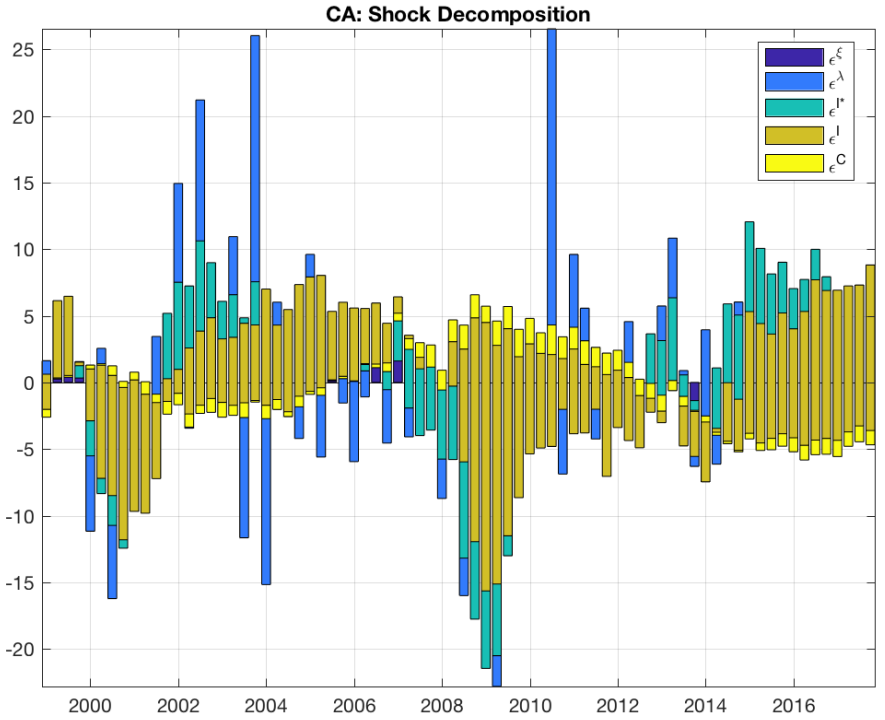




Investment	1	2	3	4	10	12	16
ϵ_{ξ}	0.532	0.557	0.579	0.599	0.604	0.547	0.449
ϵ_{λ}	0.296	0.266	0.236	0.208	0.122	0.158	0.262
ϵ_{R*}	0.026	0.027	0.027	0.026	0.018	0.017	0.015
ϵ_{R}	0.104	0.101	0.100	0.099	0.089	0.080	0.070
ϵ_{c}	0.007	0.008	0.010	0.012	0.032	0.040	0.042

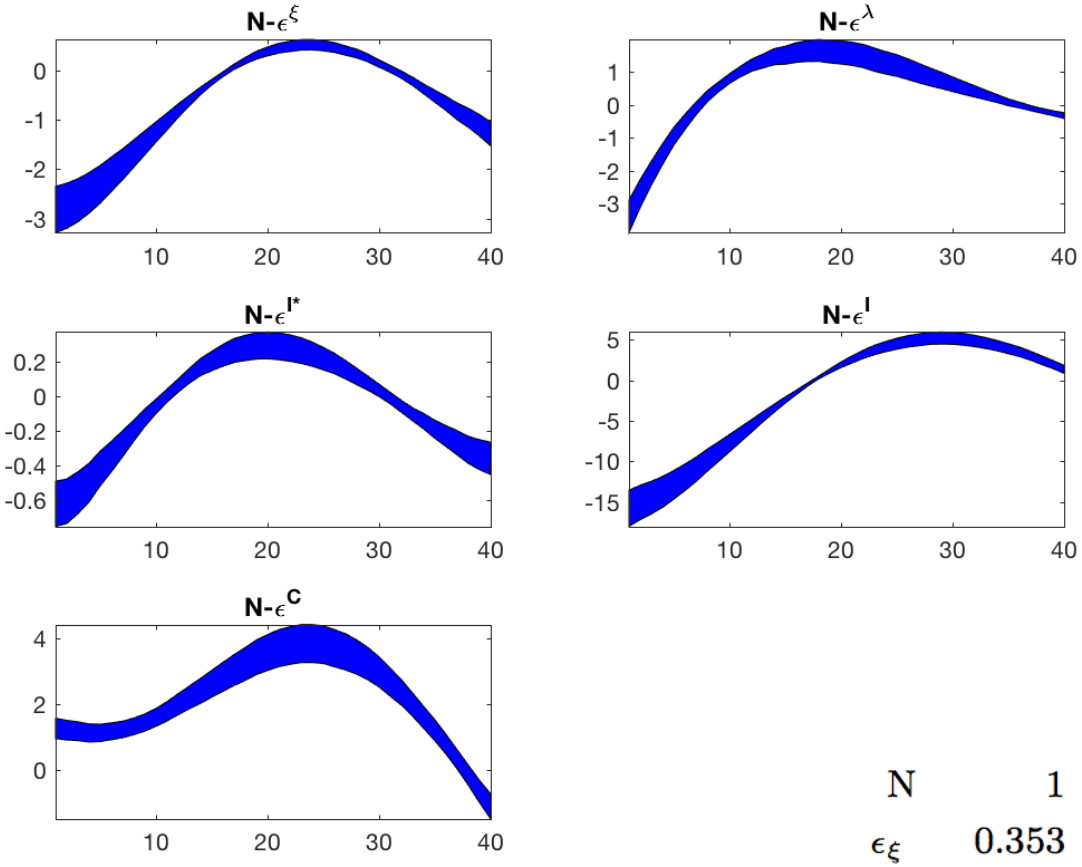
Current account: Impulse Response Paths; Conditional variance decomposition; Historical shock decomposition

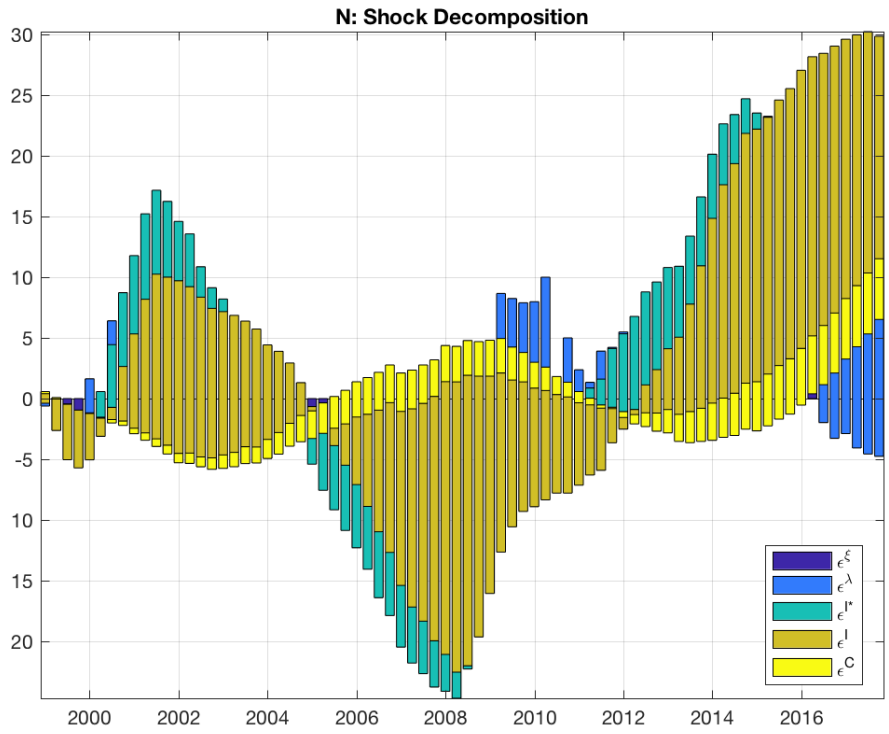




CA	1	2	3	4	10	12	16
ϵ_{ξ}	0.317	0.312	0.307	0.303	0.314	0.319	0.323
ϵ_{λ}	0.501	0.507	0.514	0.519	0.512	0.507	0.501
ϵ_{R^*}	0.011	0.011	0.011	0.011	0.015	0.015	0.015
ϵ_{R}	0.163	0.162	0.160	0.157	0.150	0.150	0.151
ϵ_{c}	0.001	0.001	0.001	0.001	0.002	0.002	0.002

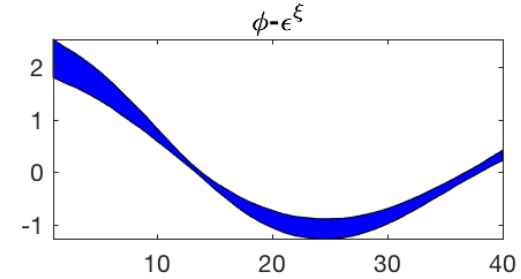
Net worth: Impulse Response Paths; Conditional variance decomposition; Historical shock decomposition

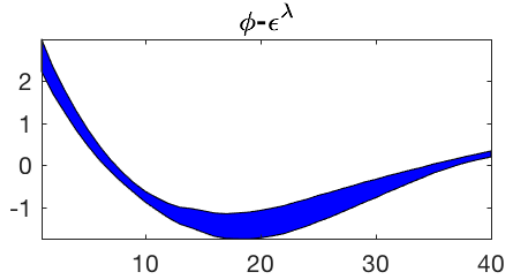


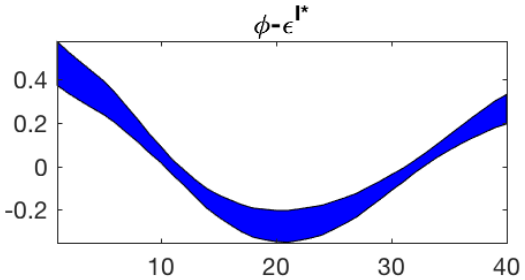


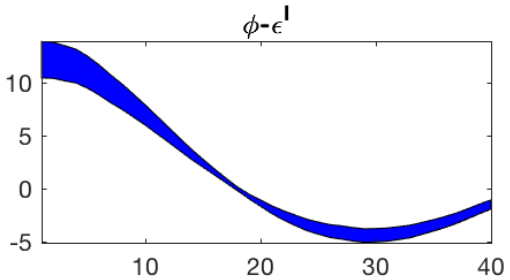
N	1	2	3	4	10	12	16
ϵ_{ξ}	0.353	0.385	0.415	0.442	0.511	0.500	0.457
ϵ_{λ}	0.508	0.466	0.426	0.390	0.291	0.301	0.350
ϵ_{R*}	0.018	0.019	0.020	0.021	0.019	0.018	0.018
ϵ_{R}	0.114	0.122	0.130	0.137	0.164	0.163	0.151
ϵ_{c}	0.001	0.001	0.001	0.001	0.002	0.002	0.005

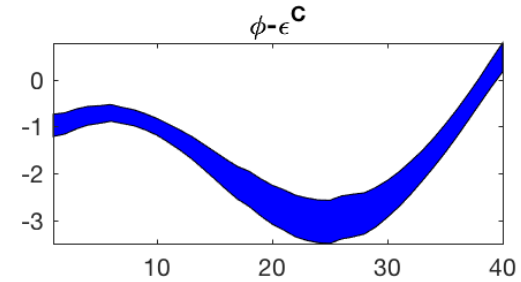
Leverage: Impulse Response Paths; Conditional variance decomposition; Historical shock decomposition

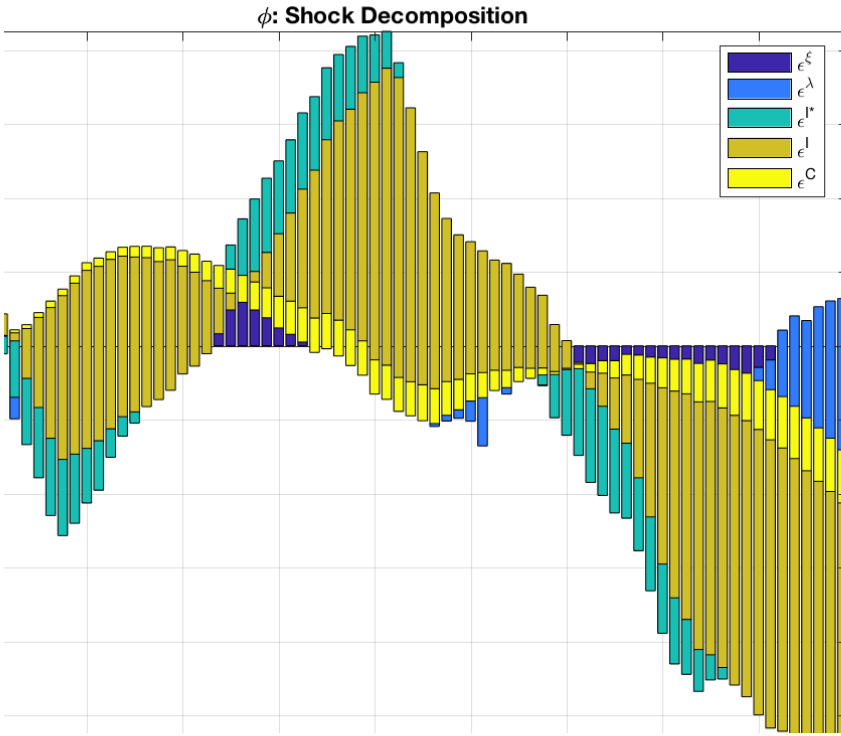












ϕ	1	2	3	4	10	12	16
ϵ_{ξ}	0.352	0.379	0.405	0.427	0.468	0.449	0.397
ϵ_{λ}	0.509	0.465	0.424	0.387	0.297	0.316	0.382
ϵ_{R*}	0.018	0.018	0.019	0.019	0.018	0.018	0.017
ϵ_{R}	0.114	0.130	0.144	0.157	0.203	0.203	0.184
ϵ_{c}	0.001	0.001	0.001	0.001	0.001	0.002	0.004

Conclusion

- Monetary policy: policy rate remains an effective stabilization tool for stabilization.
  - Able to generally hold inflation low and stable from 2009 and since 2016 counter- balancing the inflationary pressures coming from the rising foreign interest rates and providing stimulation to GDP since 2011 along with foreign interest rates,
  - Able to enhance financial stability as it became the main positive driver to the banking sector net worth from 2012 and to the decline in leverage since 2013.
- Macroprudential (in terms of the regulation on capital requirements from Basel regulation) has immediate impact on reining in risky behavior
- The monetary and financial stability policy of the BSP has helped contain leverage

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