Monetary and Macro-Prudential Policy at the BSP: A Bayesian DSGE Approach

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Abstract

This paper develops a small open-economy model with financial frictions to explore the usefulness of additional macro-prudential monetary policy rule for the BSP. Bayesian estimation results that the policy rate is an effective stabilization tool for inflation, while foreign interest rates play a strong role in the volatility of the current account and GDP.

1 Introduction

The economy of the Philippines has seen much turbulence during the past two decades. Figure 1 pictures the evolution of real GDP, consumption, Government spending, the Trade Balance and investment. All data are transformed with a one-sided Hodrik-Prescott filter. We see that there are wide fluctuations in investment, the trade balance, and government spending, particularly in the years following the onset of the global financial crisis in 2008.

Figure 1: Macro Variables: GDP and Components

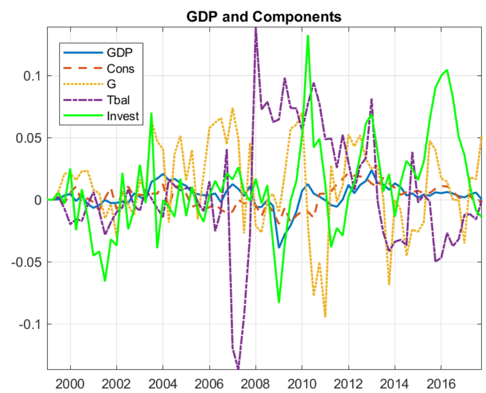


Figure 2 pictures the adjustment of the financial system net worth, the ex-post excess returns or risk premium, measured by the difference between the Philippine 90 day bond yield less the LIBOR 90-day rate and the ex-post rate of depreciation, as well as the share of the financial sector as a proportion of GDP. The net worth variable and financial sector/GDP ratio filtered by the one-sided HP filtering, while the excess returns were detrended. We see that the risk premium was more volatile prior to the time of the global crisis but that the net worth of the financial system increased after 2008, but fell quite a bit after 2014.

Figure 2: Financial Indicators

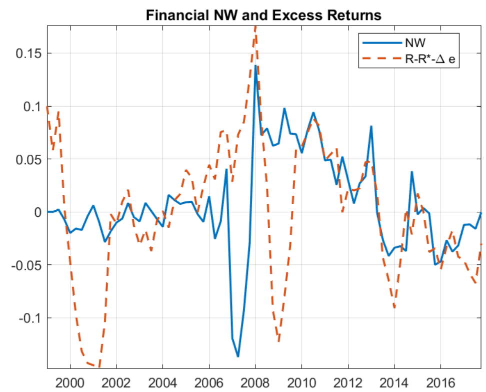
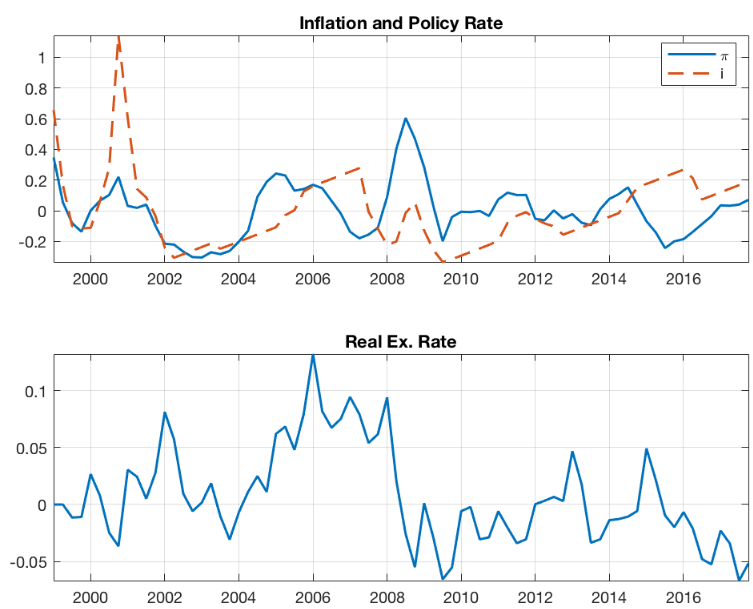


Figure 3 pictures the real exchange rate, the policy rate and the quarterly inflation rate. We see that the exchange rate is much more volatile than inflation and the policy rate, which remained relatively stable. This picture shows us that prior to the financial crisis the Philippine real exchange rate was relatively high, but depreciated significantly at the time of the global crisis.

Figure 3: Inflation, Interest and Real Exchange Rates



These charts suggest that fluctuations in the risk premium and the real exchange rate play a significant role in shaping the adjustment of the trade balance and GDP, a well as the net worth of the financial sector and investment.

Table 1 gives the inward and outward measures of connectness, based on Diebold and Yilmaz (2014), for eight macroeconomic variables (Investment, the trade balance, consumption, net worth of the financial sector, the spread between the domestic interest rate and the LIBOR plus depreciation, the inflation rate, the policy rate, and the real exchange rate. The real variables were seasonally adjusted and log first differences while the nominal variables were detrended.

The Diebold and Yilmaz (2014) approach consists of a VAR estimation and obtained the forecast error variance decomposition. We estimated the model with six lags, with a forecast horizon of 20 quarters. Since the matrix is an asymmetric one, it serves as a measure of the inward and outward connectness of the variables, by telling us how much of the forecast error of each variable is due to the shocks of the other variables in the VAR model. Some variables may play a larger role in explaining the forecast error of others, while other variables play little role in explaining their forecast error variance.

Table 1: Connectedness

Inward Connectedness								
								Dependent Variable:
Shock:	Inv	Tbal	C	NW	Spread	Inf	R	RexR
Inv	**0.445**	0.036	0.014	0.019	0.069	0.053	0.049	**0.064**
Tbal	0.047	**0.212**	**0.073**	**0.052**	**0.102**	**0.057**	0.033	**0.077**
C	**0.095**	0.025	**0.252**	0.011	**0.111**	0.040	0.024	**0.055**
N	0.020	0.445	0.047	0.095	0.020	0.014	0.071	0.028
Spread	0.014	0.036	0.212	0.025	0.051	0.035	0.059	0.006
Inf	0.071	0.014	0.073	0.252	0.017	0.095	0.044	0.004
R	0.028	0.019	0.052	0.011	0.512	0.156	0.061	0.054
Rexr	0.065	0.069	0.102	0.111	0.044	0.075	0.014	0.009
Outward Connectedness								
								Shock:
Dep Var:	Inv	Tbal	C	NW	Spread	Inf	R	RexR
Inv	0.445	0.047	0.095	0.020	0.014	0.071	0.028	0.065
Tbal	0.036	0.212	0.025	0.051	0.035	0.059	0.006	0.035
C	0.014	0.073	0.252	0.017	0.095	0.044	0.004	0.026
N	0.019	0.052	0.011	0.512	0.156	0.061	0.054	0.068
Spread	0.069	0.102	0.111	0.044	0.075	0.014	0.009	0.035
Inf	0.053	0.057	0.040	0.070	0.140	0.519	0.175	0.068
R	0.049	0.033	0.024	0.015	0.014	0.021	0.281	0.034
RexrR	0.064	0.077	0.055	0.015	0.032	0.007	0.009	0.180

Given the external vulnerability of the Philippine economy, this study makes use of Bayesian estimation of a dynamic stochastic general equilibrium model to identify the key factors driving the volatility of GDP and the trade balance. Drawing on recent work by Gertler and Karadi (2011) and KasukeAoki et al. (2016), which specifically incorporate financial frictions at the banking sector level, we identify the relative importance of domestic shocks to the quality of capital, government spending, and consumption demand, as well as shocks to domestic and foreign interest rates and well as confidence shocks in the domestic financial system. Our results show that the shocks to quality of capital and confidence in the banking system play major roles in output and inflation variables as well as for financail stability.

2 The Model

2.1 Households

The household sector consumes C_t, provides labor services L_t at wage W_t borrows $E_t B_t^*$ from international markets at a gross rate of interest R_t^*,and can make deposits or buy risk-free government bonds B_t or with a gross return of $R_t = (1 + r_t)$.The variable E_t is the nominal exchange rate and P_t is the price level. The household is also subject to a real lump-sum tax $\bar{T}$.

The household maximizes the intertemporal welfare function (1) with utility function defined in (2) subject to the budget equation (3).

$$\max E_t \sum_{\iota=0}^{\infty} \beta^{\iota} U(C_t, L_t) \tag{1}$$

$$U(C_t, L_t) = \frac{(C_t - hC_{t-1})^{1-\varsigma}}{1-\varsigma} - \chi \frac{L_t^{1+\varphi}}{1+\varphi} \tag{2}$$

$$C = WL_t + \Pi_t - R_{t-1}^* E_{t-1} B_{t-1}^* + E_t B_t^* + R_t B_{t-1} - B_t - T \tag{3}$$

The parameter β $(0 < \beta < 1)$ is a discount factor, h $(h > 0)$ is a habit persistence coefficient, ς is the coefficient of relative risk aversion, χ $(\chi > 0)$ is the disutility of labor, and φ $(\varphi > 0)$ is the Frisch labor-supply elasticity. Π_t is net profits from ownership of financial and non-financial firms The household receives profits from firms, Π_t^f, as well as from banks, $\Pi_{t,}^{b}$. Hence, $\Pi_t = \Pi_t^b + \Pi_t^f$.

The variable Θ_b^b represents adjustment costs for accumulating household foreign debt above or below the steady-state level $\bar{B}^*$:

$$\Theta_t^b = 0.5\theta_b (B_t^* - \bar{B}^*)^2 \tag{4}$$

Household accumulates foreign debt according to the following law of motion:

$$
\begin{aligned}
E_t B_t^* &= R_{t-1}^* E_{t-1} B_{t-1}^* + C + \Theta_t^b \\
&+ B_t^g + \bar{T} - R_{t-1} B_t^g - W_t L_t - \Pi_t
\end{aligned} \tag{5}
$$

The Euler equations are below.. The variable ϱ_t is the marginal utility of consumption while $\Lambda_{t,t+1}$ is the stochastic discount factor, which is subject to a autoregressive shock process:

$$\Lambda_{t,t+1} = \frac{\varrho_{t+1}}{\varrho_t} exp(\xi_t^C)$$

$$\xi_t^C = \rho_C \xi_{t-1}^C + \epsilon_t^C$$

$$\epsilon_t^C \sim N(0, \sigma_C^2)$$

The first order conditions show that the presence of tax rates and habit persistence affect the marginal utility of consumption and the equilibrium marginal disutility of labor.

$$\varrho_t = (C_t - hC_{t-1})^{-\varsigma} - \beta h \boldsymbol{E_t} (C_{t+1} - hC_t)^{-\varsigma} \tag{6}$$

$$\chi L_t^{\varphi} = \varrho_t W_t / P_t \tag{7}$$

$$1 = \beta R_t^* \left[\Lambda_{t,t+1} \frac{E_{t+1}}{E_t} \right] + \vartheta^b (B_t^* - \bar{B}^*) \tag{8}$$

$$1 = \beta R_t \Lambda_{t,t+1} \tag{9}$$

Given the presence of adjustment costs for foreign debt accumulation by households, the familiar interest parity relation between the interest rate differentials and expected depreciation now becomes:

$$R_t = \left\{ \left[\frac{E_{t+1}}{E_t} \right] R_t^* + \vartheta^b (B_t^* - \bar{B}^*) \Lambda_{t,t-1}^{-1} \right\} \tag{10}$$

We assume that the foreign interest rate follows a stochastic autoregressive process:

$$R_t^* = \bar{R}^* exp(\xi_t^{R^*}) \tag{11}$$

$$\xi_t^{R^*} = \rho_{R^*} \xi_{t-1}^{R^*} + \epsilon_t^{R^*}$$

$$\epsilon_{R^*,t} \sim N(0, \sigma_{R^*}^2)$$

2.2 Firm Production and Pricing

The production sector contains three types of firms: intermediate goods-producing firms, capital-goods producing firms, and retail firms.

2.2.1 Intermediate goods: domestic and foreign

The firms producing domestic intermediate goods 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 , to produce intermediate output Y_t. The depreciation rate varies over time, as a function of the utilization rate of effective capital.[1]

The production function is described in (12) where A is a productivity term, α_K is the share parameter of capital while α_M is the share parameter for intermediate goods.

$$Y_t = A \left[U_t exp(\xi_t^K)K_t\right]^{\alpha_K} M_t^{\alpha_M} L_t^{1-\alpha_M-\alpha_K} \tag{12}$$

$$K_{t+1} = [1 - exp(\delta_t)]exp(\xi_t)K_t + I_t \tag{13}$$

$$\delta_t = \bar{\delta} + \frac{b}{1+\varsigma} U_t{}^{1+\varsigma} \tag{14}$$

The stochastic term $\xi_t$represents a shock to the quality of capital, and follows a autoregressive stochastic process:

$$\xi_t^K = \rho_K \xi_{t-1}^K + \epsilon_t^K \tag{15}$$

$$\epsilon_t^K \sim N(0, \sigma_K^2)$$

These firms borrow S_t at price Q_t to pay for capital (16), incurring a gross cost R_{t+1}^k to be paid the following period.

$$Q_t S_t = Q_t K_{t+1} \tag{16}$$

The optimal conditions for labor, the utilization rate of capital, the replacement cost of capital are given by the following equations, and the demand for intermediate goods are given by the following equations. The variable P_m is the final price of intermediate goods.

[1]See Gertler and Karadi (2011) for a more complex specification, $\delta(U_t)$

$$W_t = P_t^m(1-\alpha_M-\alpha_K)\frac{Y_t^d}{L_t} \tag{17}$$

$$U_t^{1+\varsigma} exp(\xi_t^K)K_{t-1} = \frac{1}{b}P_t^m \alpha_K Y_t^d \tag{18}$$

$$R_t^k Q_{t-1} = P_t^m(\alpha_K)\frac{Y_t^d}{K_t} + exp\left(\xi_t^K\right)(Q_t-\delta_t) \tag{19}$$

$$S_t P_t^* = P_t^m \alpha_M \left(\frac{Y_t^d}{M_t}\right)$$

The price $P_t^*$is the world price of imported intermediate goods. We assume that this price follows an autoregressive stochastic process:

$$P_t^* = \bar{P}^* exp(\xi_t^{P^*}) \tag{20}$$

$$\xi_t^{P^*} = \rho_{P^*}\xi_{t-1}^{P^*} + \epsilon_t^{P^*} \tag{21}$$

$$\epsilon_t^{P^*} \sim N(0, \sigma_{P^*}^2) \tag{22}$$

2.2.2 Final goods and monopolitic competitive pricing

Competitive final goods firms buy intermediate goods and assemble them. Final output is a composite of intermediate goods indexed by $f \in (0,1)$ differentiated by retailers,

$$Y_t = \left[\int_0^1 Y_t^m(f)^{\frac{\varepsilon-1}{\varepsilon}}df\right]^{\frac{\varepsilon}{\varepsilon-1}} \tag{23}$$

where ε is the elasticity of substitution across varieties of goods. Final goods firms solve the problem of choosing $Y_t(f)$ to minimize the cost of production:

$$\min_{Y_t(f)} \int_0^1 P_t(f)\, Y_t^m(f)\, df \tag{24}$$

$$\text{st}\left[\int_0^1 Y_t^m(f)^{\frac{\varepsilon-1}{\varepsilon}}df\right]^{\frac{\varepsilon}{\varepsilon-1}} \geqslant \bar{Y}_t \tag{25}$$

The demand function for intermediate good f is given by

$$Y_t^m(f) = \left(\frac{P_t(f)}{P_t}\right)^{-\varepsilon} Y_t \tag{26}$$

where P_t is the aggregate wage index.

Equations (26) and (23) imply

$$P_t = \left[\int_0^1 P_t \left(f \right)^{1-\varepsilon} df \right]^{\frac{1}{1-\varepsilon}} \tag{27}$$

Retailers simply purchase intermediate goods at a price equal to the real marginal cost, MC_t, and differentiate them in a monopolistic ally competitive market.

The real marginal cost is derived from the first-order conditions:

$$MC_t = \left(\frac{r_t^K}{\alpha_K} \right)^{\alpha_K} \left(\frac{p_t^*}{\alpha_M} \right)^{\alpha_M} \left(\frac{w_t}{1-\alpha_K-\alpha_M} \right)^{1-\alpha_K-\alpha_M} \tag{28}$$

where $r_K = R_t^K Q_{t-1}/P_t^M$, $w_t = W_t/P_t^M$, and $p_t^* = P_t^*/P_t^M$.

Retailers set nominal prices in a staggered afashion. 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 parmeter. Hence,

The price for non-optimizing retailers evolves according to the following trajectory from the time the optimal price is set to k-periods ahead:

$$P_t^o \left(f \right), P_t^o \left(f \right) \left(\frac{P_t}{P_{t-1}} \right)^{\sigma_{pi}}, P_t^o \left(f \right) \left(\frac{P_{t+1}}{P_{t-1}} \right)^{\sigma_{pi}} ...P_t^o \left(f \right) \left(\frac{P_{t+k}}{P_{t-1}} \right)^{\sigma_{pi}} \tag{29}$$

where σ_{pi} denotes the degree of price indexation.

A retailer resetting its price in period t maximizes the following flow of discounted profits with respect to P_t^*

$$E_t \sum_{s=0}^{\infty} (\sigma_p \beta)^s \Lambda_{t,t+s} Y_{t+s}(f) \left[\frac{P_t^o(f)}{P_{t+s}} \left(\frac{P_{t+s-1}}{P_{t-1}} \right)^{\sigma_{pi}} - MC_{t+s}) \right] \tag{30}$$

subject to the demand function (26), and the indexation scheme so that $Y_{t+s}(f) = \left[\frac{P_t^o(f)}{P_{t+s}} \left(\frac{P_{t+s-1}}{P_{t-1}} \right)^{\sigma_{pi}} \right]^{-\varepsilon} Y_{t+s}$.

Let MC_t^n denote the nominal marginal cost. The gross mark-up, Γ_t, charged by final good firm f can be defined as $\Gamma_t(f) \equiv P_t(f)/MC_t^n = \frac{P_t(f)}{P_t} / \frac{MC_t^n}{P_t} = p_t(f)/MC_t$. In the symmetric equilibrium all final good firms charge the same price, $P_t(f) = P_t$, the relative price is unity. It follows that, in the symmetric equilibrium, the mark-up is simply the inverse of the real marginal cost. Since our interest is in inflation-targeting as well as financial stability, we add in a shock to the markup pricing process as a marginal-cost shock:

$$\Gamma_t = \left[\frac{1}{MC_t}\right] exp\left[\xi_t^{MC}\right] \tag{31}$$

$$\xi_t^{MC} = \rho_{MC}\xi_{t-1}^{MC} + \epsilon_t^{MC} \tag{32}$$

$$\epsilon_t^{MC} \sim N(0, \sigma_{MC}^2) \tag{33}$$

The first order condition for this problem has the following representation:

$$E_t \sum_{s=0}^{\infty} (\sigma_p \beta)^s \Lambda_{t,t+s} Y_{t+s}(f) \left[\frac{P_t^o(f)}{P_{t+s}} \left(\frac{P_{t+s-1}}{P_{t-1}}\right)^{\sigma_{pi}} - \Gamma_t MC_{t+s}\right] = 0 \tag{34}$$

The equation describing the dynamics for the aggregate price level is given by

$$P_{t+1} = \left[(1-\sigma_p)(P_{t+1}^o(f))^{1-\varepsilon} + \sigma_p \left(P_t \left(\frac{P_t}{P_{t-1}}\right)^{\sigma_{pi}}\right)^{1-\varepsilon}\right]^{1/(1-\varepsilon)} \tag{35}$$

2.2.3 Capital goods

The intermediate goods are also sold to capital-producing firms. An adjustment cost Θ_t^k is incurred with respect to changes in investment from time (t-1) to time (t):

$$\Theta_t^K = .5\theta^k \left(\frac{(I_\tau + I^s)}{(I_{\tau-1} + I^s)} - 1\right)^2 (I_\tau + I^s) \tag{36}$$

Tobin's Q is given by the following equation:

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

$$\beta\Lambda_{t,t+1}.5\theta^k \left(\frac{(I_{\tau+1} + I^s)}{(I_\tau + I^s)} - 1\right)\frac{(I_{\tau+1} + I^s)^2}{(I_\tau + I^s)^2} \tag{37}$$

2.3 Financial intermediaries

The financial intermediaries borrow from households B^h_{t+1} and pay a gross rate R_{t+1}. They are also required to hold reserves on these deposits, at the central bank, given by the ratio ψ_t.

They also lend a total of $Q_t S_t$ which yields a gross return of R^k_{t+1}. Following Yasin et al. (2013), the balance sheet position is given by equation (38) where N_t is current net worth, and includes required reserves holdings. . The the law of motion for the banking sector net worth appears in (39).

$$N_t = Q_t S_t - (1-\psi_t) B_t \tag{38}$$
$$N_{t+1} = \left[R^k_t - \left\{ \frac{R_t - \psi_t}{1-\psi_t} \right\} \right] Q_t S_t + \left\{ \frac{R_t - \psi_t}{1-\psi_t} \right\} N_t \tag{39}$$

The banks objective is to maximize expected terminal wealth V_t, where θ is the probability of staying on or surviving as a banker. The aggregate form is shown in (40).

$$\max V_t = E_t \sum_{\iota=0}^{\infty} (1-\theta)\theta^{\tau} \beta^{\tau+1} \Lambda_{t,t+1+\tau} \left[R^k_{t+i+1} - \left\{ \frac{R_{t+i} - \psi_{t+i}}{1-\psi_{t+i}} \right\} \right] Q S_{t+i} + \left[R^k_t - \left\{ \frac{R_t - \psi_{t+i}}{1-\psi_{t+i}} \right\} \right] Q_t N$$

$$V_t = \upsilon_t Q_t S_t + \eta_t N_t \tag{40}$$
$$\upsilon_t = \left[(1-\theta)\beta\Lambda_{t,t+1} \left\{ \frac{R_{t+i} - \psi_{t+i}}{1-\psi_{t+i}} \right\} + \beta\Lambda_{t,t+1}\theta \left(\frac{Q_{t+\tau} S_{t+\tau}}{Q_t S_t} \right) \upsilon_{t+1} \right]$$
$$\eta_t = \left[(1-\theta)(1-\theta)\beta\Lambda_{t,t+1} \left\{ \frac{R_{t+i} - \psi_{t+i}}{1-\psi_{t+i}} \right\} + \beta\Lambda_{t,t+1}\theta \left(\frac{N_{t+\tau}}{N_t} \right) \eta_{t+1} \right]$$

The terminal wealth variable plays a central role, because foreign depositors will only lend if the terminal value exceeds a fraction λ_t of total assets:

$$V_t \geq \lambda_t Q_t S^b_t \tag{41}$$

The variable λ_t represents the fraction of outstanding assets which depositor believe that bankers can divert to their own use. They thus demand that terminal value of banking-sector wealth be at least equal to the amount of assets which can be diverted by the bankers to their own use.

This time varying no-confidence factor is is subject to an autoregressive stochastic process:

$$\lambda_t = \bar{\lambda} exp(\xi^{\lambda}_t) \tag{42}$$

$$\xi_t^\lambda = \rho_\lambda \xi_{t-1}^\lambda + \epsilon_t^\lambda$$

$$\epsilon_t^\lambda \sim N(0, \sigma_\lambda^2)$$

As noted by Villa (2014), Gertler and Karadi (2011) explicitly model the banking sector as the source of financial frictions due to the presence of this moral hazard problem. This friction differs from the more common specification of financial frictions, due to Bernanke et al. (1996), which features credit-constrained firms as the source of frictions. She finds that both forms of frictions are empirically relevant for both the Euro Area and the United States. She also notes that the GK specification is superior. since the presence of the banking sector as as a powerful "amplification" channel and provides a better solution to the "small shocks, large cycles" puzzle.

Substituting the condition when the constraint holds into (40) gives the expression for the net worth of surviving banks N_t^e as (43). Banks are assumed to survive with probability θ and households are also willing to lend $\omega/(1-\theta)Q_t S_{t-1}^b$ to start new banks. The net worth of new banks N_t^n is (44). The expression for aggregate net worth is in (46) below.

$$N_t^e = \left[R_t^k - \left\{\frac{R_t(1-\psi_t)}{(1-\psi_t)}\right\}\right]\phi_{t-1} + \left\{\frac{R_t(1-\psi_t)}{(1-\psi_t)}\right\}N_{t-1} \tag{43}$$

$$N_t^n = \frac{\omega}{(1-\theta)}Q_t S_{t-1} \tag{44}$$

$$N_t = \theta N_t^e + (1-\theta)N_t^n \tag{45}$$

$$N_t = \theta\left[\left[R_t^k - \left\{\frac{R_t(1-\psi_t)}{(1-\psi_t)}\right\}\right]\phi_{t-1} + \left\{\frac{R_t(1-\psi_t)}{(1-\psi_t)}\right\}\right]N_{t-1} + \omega Q_t S_{t-1} \tag{46}$$

2.4 Fiscal and Monetary Policy

We assume that government spending follows as AR(1) stochastic process relative to its steady state:

$$G_t = \bar{G}exp(\xi_t^G) \tag{47}$$

$$\xi_t^G = \rho_G \xi_{t-1}^G + \epsilon_t^G \tag{48}$$

$$\epsilon_t^G \sim N(0, \sigma_G^2) \tag{49}$$

The symbol $\bar{G}$ represents steady-state government spending which is financed by a lump-sum tax $\tilde{T}$. Government bonds evolve according to the budget constraint:

$$B_t^g = R_t B_{t-1}^g + G_t - \bar{T} \tag{50}$$

The monetary authorities adopt a Taylor rule for the gross nominal interest rate, $(1+i_t)$, given by equation 51, 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.

$$(1+i_t) = \left[(1+\bar{i})(1+\pi_t)^{\kappa^\pi}(1+y_t)\right]^{(1-\rho)} (1+i_{t-1})^\rho exp(\xi_t^R) \tag{51}$$

$$\xi_t^R = \rho_R \xi_{t-1}^R + \epsilon_{R,t} \tag{52}$$

$$\epsilon_t^R \sim N(0, \sigma_R^2) \tag{53}$$

The real risk-free return, of course, is simply the nominal gross rate adjusted by the gross inflation rate, with $R_t = (1+i_t)/(1+\pi_t)$.

We central bank also makes use of the required reserve ratio as an additional policy instrument:

$$\psi_t = \bar{\psi} + \kappa[(R_t^k - \bar{R}_t) - (\bar{R}^k - \bar{R})) \tag{54}$$

The central bank sets the required reserve ratio in an optimal manner, as a function of the spread (relative to its steady-state value, in order to minimize the volatility of financial sector net worth.

2.5 Foreign Debt

In addition to prividing consumption, investment and goverment consumption goods, as well as related adjustment costs for investment, domestic production includes exports:

$$Y_t = C_t + I_t + G_t + X_t + \Theta_t^K$$

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

$$X_t = \left(\frac{P_t}{S_t P_t^*}\right)^{-\epsilon} X_t^* \tag{55}$$

World demand itself evolves as stochastic autoregressive process relative to tis steady state value:

$$X_t^* = X^* \bar{exp}\left(\xi_t^X\right) \tag{56}$$

$$\xi_t^{X^*} = \rho_X \xi_t^{X^*} + \epsilon_t^{X^*} \tag{57}$$

$$\epsilon_t^{X^*} \sim N(0, \sigma_{X^*}^2) \tag{58}$$

The firm remits profits to the household. The profit of the firm is given by the following expression:

$$\Pi_t = Y - W_t L_t / P_t - S_t P_t^* M_t / P_t - R_t Q_t S_{t-1} \tag{59}$$

The profits of the firms includes the real trade balance, $X_t - S_t P_t^* M_t / P_t$. The accumulation of foreign debt comes from the household budget constraint, given by equation 3.

2.6 Calibrated Parameters

We follow GK, Table 1, for the calibration of the model. Briefly the calibration for the household sector is standard, with the discount factor β set at 0.990, with a habit persistence factor h set at 0.815. The relative utility weight of labor is 3.409 and the inverse Frisch elasticity of labor supply is 0.276.

For production, the effective share of capital, α, is 0.330. In the Calvo pricing equation, the probability of keeping prices unchanged is 0.779, and indexation factor γ_p is 0.241. The behavioral relations for the households and firms are standard.

For financial intermediation the key parameters are the survival rate θ, set at a high value of 0.972, and the proportion λ, set at 0.381, which determines whether households are prepared to supply funds to banks. These values assure that the financial system cannot completely collapse.

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

3 Bayesian Estimation and Analysis

3.1 Estimation

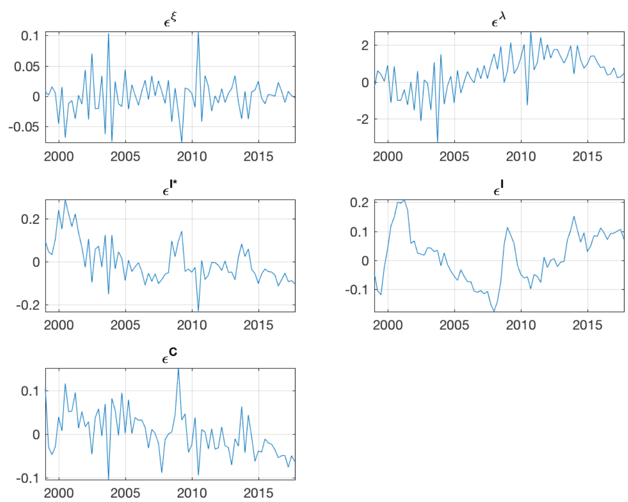
Table 3: Bayesian Estimates of Parameters and Volatilities

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

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

3.2 Smoothed Shocks

Figure 4: Smoothed Shocks



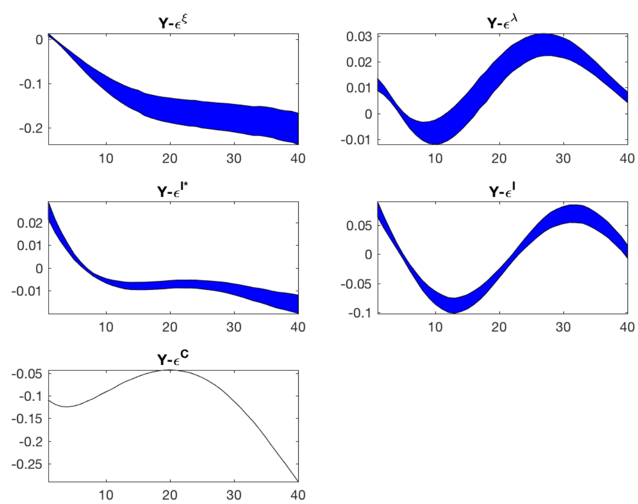
The shock to the quality of capital has been not as large in the last couple of years in comparison to the prior years. Note that around the early to mid-00s, the Philippines suffered from tight fiscal conditions that was resolved by the passing of the Expanded VAT law. Then, the GFC happened. After the GFC, the low interest rate environment on the back of the unconventional monetary policy of Advanced Economies encouraged many firms to borrow cheap which they then used for their capital expenditures.

The shock to the no-confidence factor λ has been increasing since 2005 but this can be mainly or wholly attributed to the implementation of Basel II and III regulations. Basel III kicked in in 2014. That is, net worth increased as a result of banking sector operation and profitability but because of regulations imposed by Basel III.

The shock to the foreign interest rate I^* reflects the tight liquidity immediately then the ultra-easy monetary policy since.

3.3 Impulse Response Analysis

Figure 5: GDP: Impulse Response Paths



Following shocks to capital quality, and the marginal utility of consumption, GDP is negatively affected and does not recover. When the shock comes from an increase in the no-confidence factor on the banking sector and higher domestic interest rate, it takes around a year for the impact on GDP to be negative, getting more negative in the next 2-3 years. A positive shock on the foreign interest rate initially is positive for the GDP as perhaps is it seen as a signal of recovery in the AEs but eventually becomes a negative factor for GDP.

For inflation, the impacts from the five shocks all reflect the variable lags to inflation with the shock from the marginal utility of consumption having a negative effect on inflation with the shortest lag followed by the increase in no-confidence factor to the banking sector. The results also confirms the lag from interest rates of 12-18 months (4-6 quarters).

Figure 6: Inflation: Impulse Response Paths

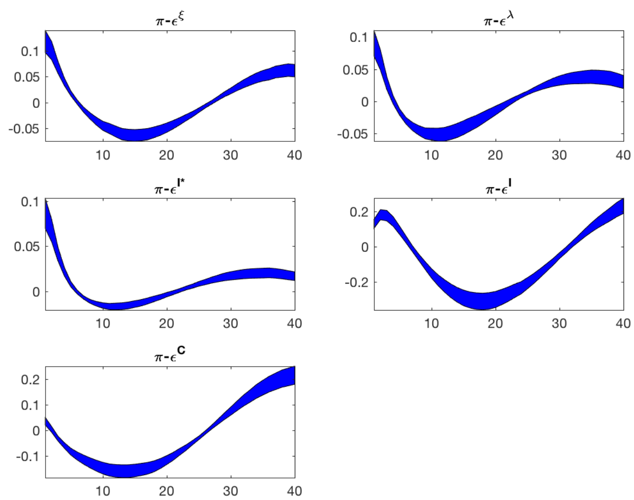


Figure 7: Investment: Impulse Response Paths

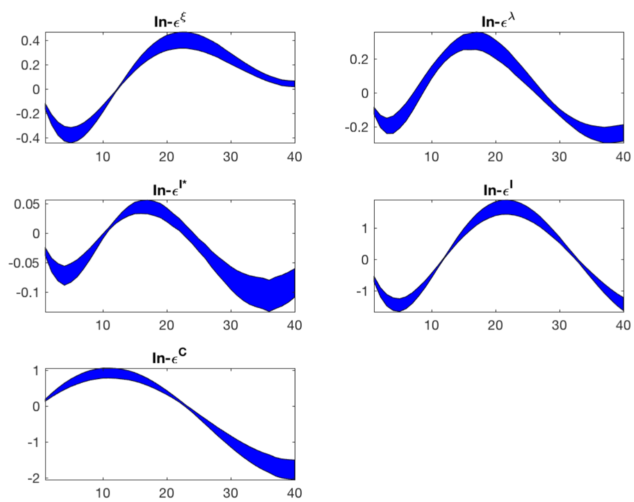


Figure 8: Net Worth: Impulse Response Paths

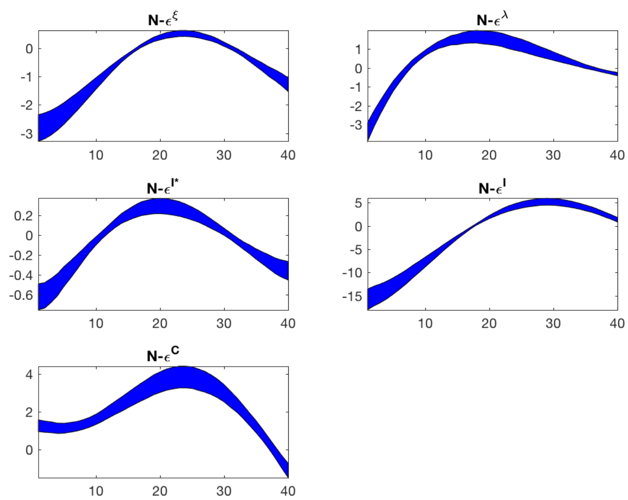
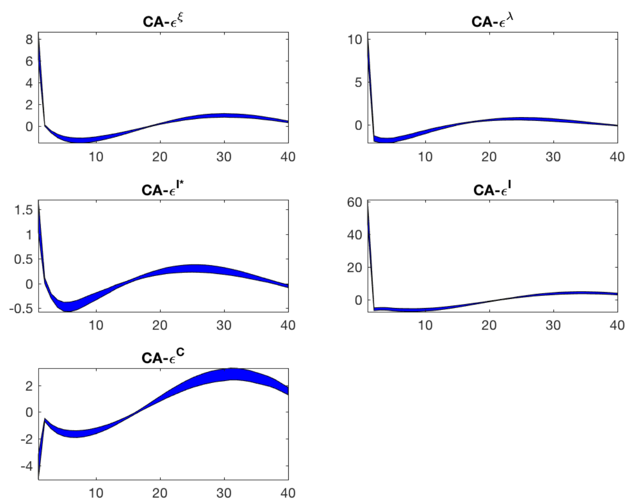


Figure 9: Current Account: Impulse Response Paths



3.4 Conditional Variance Decomposition

Table 4: Conditional Variance 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
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
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
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
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

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

3.5 Historical Shock Decomposition

Figure 10: GDP: Shock Decomposition

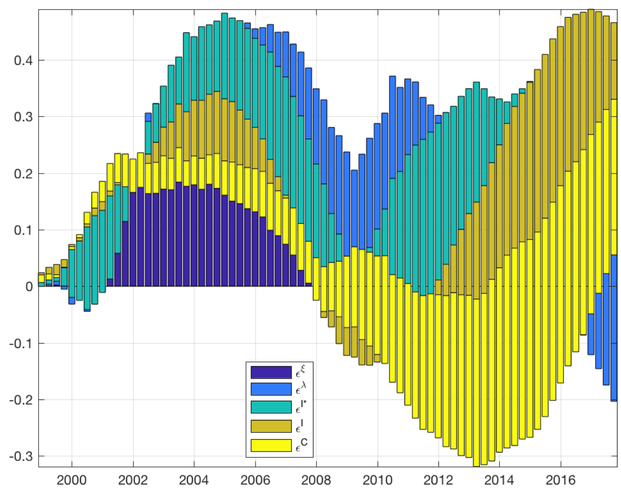


Figure 11: Inflation: Shock Decomposition

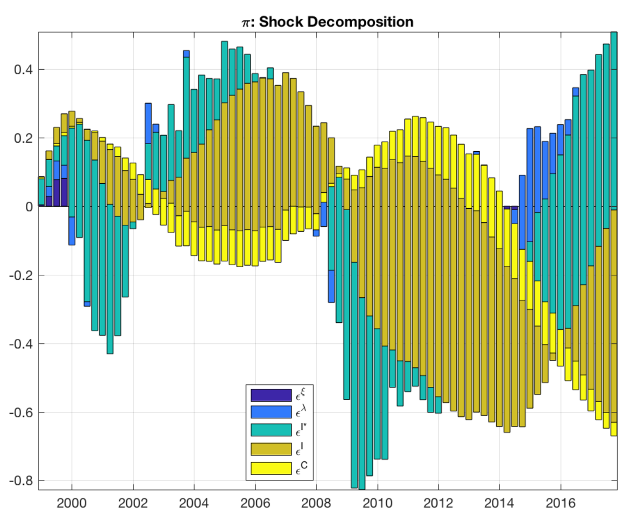


Figure 12: Investment: Shock Decomposition

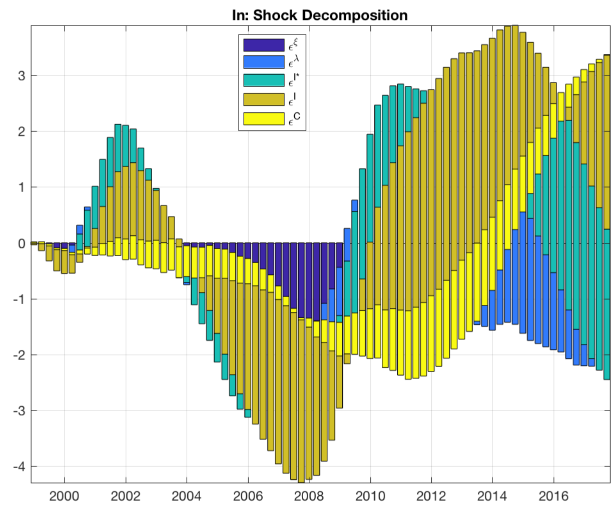


Figure 13: Current Account: Shock Decomposition

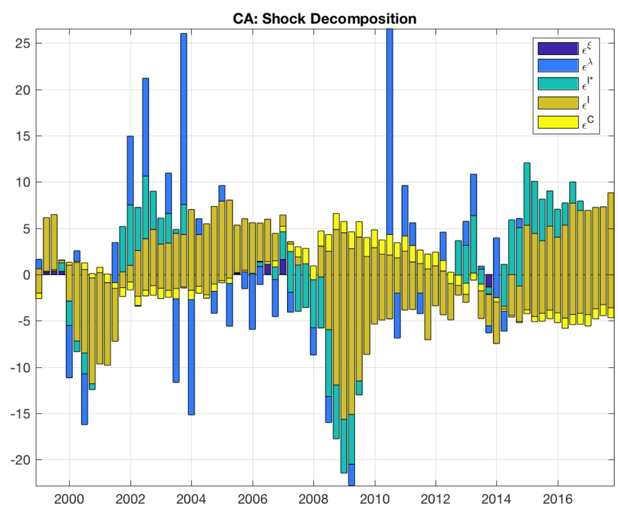


Figure 14: Net Worth: Shock Decomposition

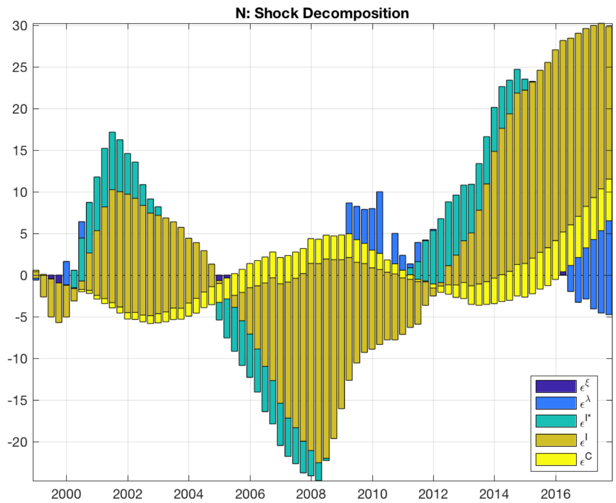
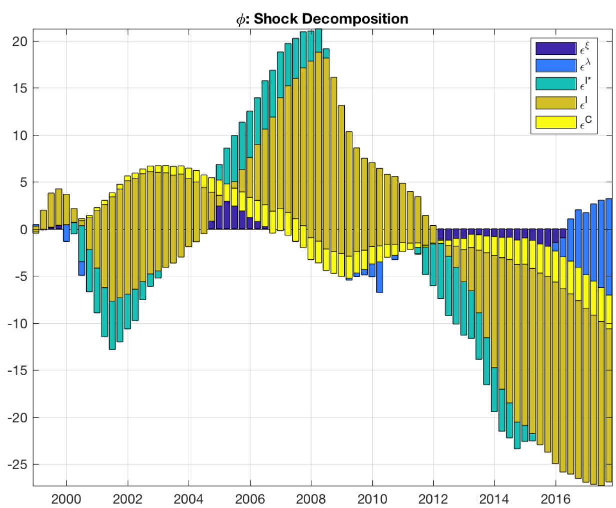


Figure 15: Leverage Ratio: Shock Decomposition



Leverage has been driven mainly by domestic interest rate and the capitalization (no-confidence factor) of the banking sector.

4. Policy experiments

Results from selected policy experiements to follow.

5. Conclusion

Results show that the policy rate remains an effective stabilization tool for inflation. With the end of the era of unconventional monetary policy and bouts of inflation (as opposed to low inflation) becoming the trend, the lesson from Tibergen that there should be at least as many tools as policy targets. On the other hand, the last crisis has shown how financial instability can have lasting impact on the real economy in addition to its harmful effects on the monetary transmission channel. Thus, having clearly designated tools for the objectives of price stability and for financial stability would enhance the effectiveness and efficiency of stabilization policies.

Results also show that monetary policy has been a stabilizing factor in recent years from holding inflation low and stable from 2009 and since 2016 counterbalancing the inflationary pressures coming from the rising foreign interest rates and providing stimulation to GDP since 2011 along with foreign interest rates, as well as enhancing 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.

Being a small, open eonomy, foreign interest rates play a strong role in the volatility of the current account and GDP.

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