Central Bank Review 18 (2018) 107–128

Contents lists available at ScienceDirect

Central Bank Review

journal homepage: http://www.journals.elsevier.com/central-bank-review/

Monetary and macroprudential policy in a commodity exporting economy: A structural model analysis

Gan-Ochir Doojav [a, *], Undral Batmunkh [b]

[a] Research and Statistics Department, Bank of Mongolia[1], Baga Toiruu-3, 15160, Ulaanbaatar 46, Mongolia
[b] Monetary Policy Department, Bank of Mongolia[1], Baga Toiruu-3, 15160, Ulaanbaatar 46, Mongolia

A R T I C L E I N F O

Article history:
Received 27 April 2018
Received in revised form
4 June 2018
Accepted 4 June 2018
Available online 9 August 2018

JEL classification:
C11
C51
E52
E58

Keywords:
Commodity shocks
Macroprudential policy
Monetary policy
Reserve requirements
Capital requirements
Small open economy model
Bayesian analysis

A B S T R A C T

We build a structural small open economy model to examine the impact of monetary and macroprudential policy actions in a commodity exporting economy. The model incorporates labor market, credit market, macroprudential policy tools such as time-varying capital and reserve requirements, and shocks of FDI, commodity demand and commodity price. The model is estimated by Bayesian techniques using quarterly data for Mongolia in 2005–2017. The main results are (i) external and government spending shocks play important role on the business cycle fluctuations, (ii) capital and reserve requirements are more effective in curbing the credit growth (or changing bank lending rate), while the policy rate has stronger impact on inflation and exchange rate compared to the macroprudential tools, and (iii) combining macroeconomic and monetary policy measures is important in reducing welfare loss. These results suggest that synergies between monetary and macroprudential policy may ensure both macroeconomic and financial stability.

1. Introduction

Structural macroeconomic modeling plays a vital role in economic policy discussions. Until recently, the modeling efforts have focused on the structural features of agents' behavior that drive business cycle fluctuations and the roles of monetary and fiscal policy in curbing undesirable macroeconomic volatility. However, the recent global financial crisis (GFC) has shown that problems in the financial sector can damage the real economy, and monetary policy measures aimed at achieving price stability combined with micro-prudential regulations are not sufficient to ensure financial stability.

In recent years, policymakers and economists are focusing on the role of macroprudential policy in limiting excessive volatility in the financial sector and its consequent impact on economic performance. While progress in modeling for macroprudential policy analysis has been substantial, there remain numerous challenges (Kiley, 2016). In particular, the progress has been slower in case of developing empirically viable structural models in the open economy setting. Therefore, one of the modeling challenges is to incorporate macroprudential policy tools, time-varying capital and reserve requirements, in a country-specific open economy model. For instance, commodity dependent developing countries like Mongolia are prone to boom and bust cycles of commodity prices and surges of capital inflows (i.e., FDI in the mining sector). Large sums of FDI and export revenues often lead to credit boom, which are closely associated with risks of financial instability. The main tool to address such risk as recommended by the Basel III is the countercyclical capital buffer.

This paper builds a structural small open economy model to examine effects of monetary and macroprudential policy measures

* Corresponding author.
E-mail addresses: doojav_ganochir@mongolbank.mn (G.-O. Doojav), undral@mongolbank.mn (U. Batmunkh).

Peer review under responsibility of the Central Bank of the Republic of Turkey.

[1] The opinions expressed herein are those of the authors and do not necessarily reflect the official views of Bank of Mongolia.

https://doi.org/10.1016/j.cbrev.2018.06.001
1303-0701/

in a commodity exporting economy. The model incorporates important features such as labor market, credit market, macroprudential policy tools such as capital and reserve requirements, and shocks of FDI, commodity demand and commodity price. The model is estimated using Bayesian techniques on the Mongolian data over the period 2005Q1-2017Q2. This paper contributes to the literature on macroeconomic modeling for monetary and macroprudential policies by empirically evaluating the model in the case of Mongolia and conducting a comparative assessment of the effectiveness of policy rate, capital requirement and reserve requirement tools in achieving macroeconomic and financial stability.

A number of papers (i.e., Angelini et al., 2014, Suh, 2012, Quint and Rabanal, 2014) have studied macroprudential and monetary policy interactions in dynamic stochastic general equilibrium (DSGE) models. However, most of the papers focus on effects of loan to value ratio or capital requirement in the setting of a closed economy. Several papers (i.e., Aguirre and Blanco, 2015; Carvalho and Castro, 2017) examined the effect of capital requirements and reserve requirements on commodity dependent developing economies based on a Bayesian-estimated structural small open economy model.

This paper is structured as follows. Section 2 provides background on central bank policy in Mongolia. Section 3 describes the model. Section 4 discusses data, estimation and the fitness of the model. Section 5 discusses the impact of policy instruments based on impulse response functions, forecast error variance decompositions, historical decompositions and welfare analysis. The final section concludes with policy implications.

2. Central bank policy in Mongolia

2.1. The country background

Mongolia's longer-term prospects are promising given its large deposit of natural resources, yet natural resource based development is known to be challenging. Main policy challenge is to strengthen the economy's resilience to cope with negative external shocks and to transform its natural resource wealth into assets that support sustainable development. On the contrary, increased extractive activities in the mining sector have changed the structure of the economy from agriculture and manufacturing to mining, thereby increasing its vulnerability to external shocks.

As a small open economy highly dependent on production and exports of mining commodities, Mongolian economy is prone to price swings of commodities such as coal and copper at the global market and foreign investors' sentiment towards the mining sector. Similar to the real sector, the bank-centered financial sector is dependent on cycles of capital flow driven by the mining sector. Thus it is no coincidence that real sector boom and bust cycles driven by the commodity prices are often followed by credit boom and bust cycles in the financial sector.

In recent years, Mongolian economy experienced boom-bust cycles on several occasions. With the extraction of strategic mines coupled with positive sentiment at the global commodity market, Mongolia received large capital inflows, mirrored by large current account deficits and high economic growth between 2009 and 2012. Although it could have been a blessing, Mongolia failed to lead its economy into a sustainable economic growth path and suffered enormously from the global commodity market downturn during 2012–2013. With minerals accounting for up to 90 percent of total exports, the sharp drop in commodity prices starting 2012 had severe impact on the balance of payments and fiscal stance. In addition, these external shocks were amplified by expansionary policy measures during 2012–2016. Loosening macroeconomic policy actions (through both monetary and fiscal policies) to buffer the economy from external shocks supported growth for a while, but at the cost of increasing public debt, weakening the balance of payments and reducing banks' asset quality. Consequently, rating agencies were racing to downgrade Mongolia's sovereign ratings and investors' confidence was weakening. A large budget deficit was inevitable due to fiscal consolidation, while balance of payment pressures and speculative attacks were rapidly depleting foreign reserves of the country.

In this time of challenge, the government of Mongolia decided to go with the IMF and in May 2017, the Executive Board of the IMF approved a three-year extended arrangement under the Extended Fund Facility program for Mongolia with a total amount of about US$434.3 million (or 435 percent of quota) to support the country's economic reform agenda. Under the program, fiscal consolidation was made through tax increases and expenditure cuts, large foreign debt payments were refinanced, banking sector reforms were initiated, and flexible exchange rate regime combined with a tight monetary policy enabled Mongolia to stabilize the economy and increase its official reserves. These policy actions combined with neutral external conditions led to economic recovery and investor and business confidences improved following the approval of the IMF-supported package.

Currently, structural reforms are underway to lay the foundations for long-term growth and build resilience against the boom-bust cycle. The key near-term objective is to strengthen the banking sector and enhance fiscal policy making. The task to strengthen the banking system, a crucial part of the program to ensure that the banks can support sustainable and inclusive economic growth, is underway: Currently under the Asset Quality Review on Mongolian banks, soundness and resilience of the financial institutions are assessed, and some improvements of the regulatory and supervisory framework are made. On the fiscal side, steady progress is made in strengthening tax administration, tax policy, and budgetary controls by establishing a Fiscal Council. These adjustments and structural reforms are expected to stabilize the economy and lay the basis for sustainable and inclusive growth in the long run. Fiscal consolidation would put public debt on a declining path over the course of the program, thus leave room for the banking sector to extend more credit to the private sector, over time.

2.2. Monetary policy

Mongolia has a relatively closed, bank-based financial system, which is growing rapidly. Currently, 14 registered commercial banks account for 95 percent of the total financial system assets and the ratio of total bank loans to GDP is 52 percent. Though foreign banks are not present in Mongolia, overseas financial institutions hold certain shares of domestic bank equities and have established their representative offices. Hence, banks play vital role in money creation and in the transmission of monetary policy measures.

Prior to July 2007, the Bank of Mongolia (BOM) had announced operating targets for monetary aggregates. During that period, monetary policy operated through a mixture of open-market operations and direct controls on bank interest rates, reserve requirements and various other balance sheet restrictions. The BOM managed the money market rate by operating in the market for settlement funds to achieve its operational targets, which meant that there was considerable volatility in the market rates. In July 2007, the BOM began announcing the policy rate (i.e., the desired level for the money market rate) as a new operational target of monetary policy. Since then, the BOM has been conducting independent monetary policy using the policy rate as its main instrument to signal its policy stance. The policy rate is set with the aim of influencing the aggregate demand and prices in the economy. As an operating target, it is periodically adjusted by the Monetary Policy Committee (MPC). In February 2013, the MPC at the BOM decided to introduce an interest rate corridor system in order to strengthen the interest rate channel of monetary policy. Establishing such corridor system played a significant role in maintaining the short term interbank market rates within desired levels.

2.3. Macroprudential policy

Banking sector lending is highly concentrated (in mining, construction, trading, and household sectors), as there are few investment opportunities available domestically. Like other developing and transition economies, Mongolian banking sector is not without any challenges. For instance, it is characterized by extremely short maturities on financial liabilities. Thus, the term for business loan is relatively short (less than two years). Volatile capital flows and dollarization of domestic liability lead to exchange rate risk on banks or their customers because of underdeveloped market tools for foreign exchange hedging. Furthermore, banks have relatively low capital compared to assets and are highly leveraged, making them more vulnerable to liquidity problems. Given the history of bank failures, change in public confidence for a bank quickly triggers bank runs. Accordingly, the banking sector is subject to both domestic and external shocks.

Although there was no institution which held the official responsibility of macroprudential policy until recently, the BOM as a supervisor of the banking system as well as the monetary policy authority, has been playing key role in mitigating the impact of external shock on both real and the financial sectors. As the mandate of the BOM states, its primary objective is price stability and any decision regarding the monetary policy rate was aimed at keeping the inflation rate close to its target, while keeping a close look at the overall health of the financial sector. In addition, as a banking supervisory institution, its measures were mainly of the nature of micro-prudential policy. Nevertheless, some tools such as the reserve requirement, loan-To-Value (LTV) and Debt-To-Income (DTI) ratios on mortgage loans under the Housing Mortgage Program and risk weights of certain credits or assets have been actively employed, though not specifically under the framework of macroprudential policy. For instance, in 2013, with the initiation of the Housing Mortgage Program, the BOM set maximum LTV ratio at 70 percent and maximum DTI ratio at 45 percent. And foreign exchange credits are weighted at 120 percent in the calculation of the risk weighted assets and capital adequacy ratios. Capital adequacy ratio is 14 percent for six systematically important banks, of which each hold more than 5 percent of the total assets of the banking system and 12 percent for the remaining banks. Recently, the BOM decided to differentiate the reserve requirements on domestic and foreign currency liabilities and set at 10.5 and 12 percent, respectively.

In January 2018, through the amendment of the Central Bank law, conduct of macroprudential policy has become an official responsibility of the Bank of Mongolia. According to the amendment, the BOM shall formulate and implement macroprudential policy using tools to prevent and mitigate risks that may adversely affect financial stability. Currently, the BOM is planning to introduce more comprehensive prudential tools, which can better ameliorate the destabilizing impacts of large-scale financial flows, credit concentration in the housing sector and financial dollarization.

3. The model

In this paper, we employ a log-linearized version of a small open economy New Keynesian DSGE model that is primary built on Smets and Wouters (2007), Adolfson et al. (2008), Justiniano and Preston (2010a, b) and Galí et al. (2011). The model consists of a domestic economy populated with households, domestic producers, import retailers, labor unions, banks, a central bank and a government. The domestic economy is small in the sense that it is a price taker and assumed to have negligible impact on the rest of the world. The variant of the model also contains labor market, credit market, macroprudential policy tools such as capital and reserve requirements and shocks of FDI, commodity demand and prices.

In the rest of the section, we discuss the micro foundations of the model and describe the log-linearized equations of the model under relevant headings. All variables in the model are log-linearized around their steady state values. Capital letters with star and small letters denote steady state values of variables and their deviations from their steady-state values, respectively. Small letters with star denote foreign variables.

3.1. Households

The economy is populated by a (large) representative household who lives infinitely, as employed by Galí et al. (2011). The household consumes final consumption goods, supplies labor services, invests in either domestic or foreign one-period bonds and owns the capital stock.

Consumption. The household optimization problem closely follows Smets and Wouters (2007) and Galí et al. (2011). However, following Gerali et al. (2010), we assume that α_p share of households have savings, while remaining $(1-\alpha_p)$ share of households take loans to smooth their consumptions. This additional assumption changes the real interest term in the consumption function. The household maximizes its lifetime utility subject to the budget constraint by choosing optimally how much to consume and invest. The optimality condition with respect to consumption result in the dynamics of consumption (c_t) given by

$$c_t - hc_{t-1} = E_t(c_{t+1} - hc_t) - \sigma^{-1}(1-h)\Big(\alpha_p(r_t - E_t\pi_{t+1} + (1-\alpha_p)(r_{l,t} - E_t\pi_{t+1})) + \sigma^{-1}(1-h)(\varepsilon_{c,t} - E_t\varepsilon_{c,t+1}) + \sigma^{-1}(\sigma-1)(W_*L_*/C_*)(n_t - E_t n_{t+1})\Big) \quad (1)$$

where r_t is domestic short term nominal interest rate, π_t is inflation, $r_{l,t}$ is bank lending rate, n_t is employment, h is external habit parameter, σ is the elasticities of intertemporal substitution, α_p is the share of households with savings, $\varepsilon_{c,t}$ is a preference disturbance. Current consumption (c_t) depends on a weighted average of past and expected future consumption, the weighted average of ex ante real short term (bank deposit) and bank lending interest rates, expected change in employment $(n_t - E_t n_{t+1})$ and a preference disturbance. The disturbance is assumed to follow a process with an IID-Normal error term $(\varepsilon_{c,t})$: $\varepsilon_{c,t} = \rho_c\varepsilon_{c,t-1} + \rho_{c,Hcr}\varepsilon_{Hcr,t} + \varepsilon_{c,t}$, where $\varepsilon_{Hcr,t}$ and $\varepsilon_{g,t}$ are shocks to household credit and government spending, respectively. The parameter W_*L_*/C_* is the labor income to household consumption ratio in the steady state. Inclusion of employment in the consumption equation helps to reflect the fact that consumption rises as economy recovers and employment increases.

International risk sharing and the modified UIP. As shown by Adolfson et al. (2008), the household's optimality condition with respect to investment decision provides an uncovered interest rate parity (UIP), restricting the relative movements of domestic and foreign interest rates and change in the nominal exchange (Δe_t) rate as follows:

$$r_t - r_t^* = (1-\phi_e)E_t\Delta e_{t+1} - \phi_e\Delta e_t - \phi_a a_t + \varepsilon_{rp,t} \quad (2)$$

where, r_t^* denotes the foreign nominal interest rate, a_t is net foreign asset (as share of the steady state output) and $\varepsilon_{rp,t}$ is the risk premium disturbance, assumed to follow a first order autoregressive process with an IID-Normal error term: $\varepsilon_{rp,t} = \rho_{rp,t}\varepsilon_{rp,t} + \varepsilon_{rp,t}$. The change in nominal exchange rate is defined as

$$\Delta e_t = \pi_t - \pi_t^* + \Delta q_t \quad (3)$$

where π_t^* is foreign inflation, and by definition, the real exchange rate (q_t) is as follows:

$$q_t = e_t + p_t^* - p_t = \psi_{F,t} + (1-\alpha)s_t \quad (4)$$

where α is the share of foreign goods in the aggregate consumption bundle and s_t is the terms of trade. The law of one price gap ($\psi_{F,t}$) is defined as

$$\psi_{F,t} = e_t + p_t^* - p_{F,t} \quad (5)$$

where p_t^* is foreign price and $p_{F,t}$ is import price. As introduced by Adolfson et al. (2008), $\phi_e > 0$ in the modified UIP equation (2) governs how much the expected depreciation is allowed to affect the risk premium in the UIP condition and helps the model to reproduce the empirical evidence on delayed real exchange rate overshooting, as the modification allows 'mechanical' sources of endogenous persistence for the nominal exchange rate. The parameter ϕ_a is the country risk premium elasticity with respect to the net foreign asset.

Investment and capital accumulation. As in Smets and Wouters (2003, 2007), the household owns the capital stock, which is rented out to the domestic producers of intermediate goods at a given rental rate of r_t^k. The household can increase the supply of rental services from capital (k_t^s) either by investing in additional capital, which takes one period to be installed (k_{t-1}) or by changing the utilization rate (u_t) of already installed capital:

$$k_t^s = k_{t-1} + u_t \quad (6)$$

As in the literature, the accumulation of installed capital (k_t) is a function of not only the flow of gross investment (i_t), but also of the relative efficiency of these investment expenditures as captured by the investment-specific technology disturbance ($\varepsilon_{i,t}$):

$$k_t = (1-\delta)k_{t-1} + \delta(i_t + \varepsilon_{i,t}) \quad (7)$$

where δ is depreciation rate of capital.

We assume that the household chooses only the utilization rate, in order to maximize its intertemporal objective function, while the household's demand for investment good (i_t) is determined by

$$i_t = w_{FDI}(fdi_t + q_t) + (1-w_{FDI})cr_t^F + \varepsilon_{i,t} \quad (8)$$

where w_{FDI} is the steady-state FDI-total investment ratio, fdi_t is FDI, cr_t^F is firm's real credit and $\varepsilon_{i,t}$ represents a disturbance to the investment-specific technology process and is assumed to follow a first-order autoregressive process with an IID-Normal error term ($\varepsilon_{i,t}$): $\varepsilon_{i,t} = \rho_i\varepsilon_{i,t-1} + \varepsilon_{i,t}$. We assume that FDI follows a first-order autoregressive process with an IID-Normal error term as follows:

$$fdi_t = \rho_{fdi} fdi_{t-1} + \varepsilon_{fdi,t} \quad (9)$$

where $\varepsilon_{fdi,t}$ is an IID-normal FDI shock. FDI is modelled as a complete exogenous shock, meaning that the directions of FDI flows are uncertain. It is usually the case for resource rich countries as FDI mainly flows to the mining sector. For example, Mongolia faced sudden flood of FDI during 2010–2013 encouraged by the development of the Oyu Tolgoi (OT) copper and gold deposit, which is the largest foreign investment project ever in Mongolia and attracted more than $6 billion (50 per cent of GDP) in FDI for its first phase. However, sudden stop of FDI occurred in 2014 and continued until 2017 because of sharp decline in commodity prices, completion of the first phase of the OT project, and political risk and uncertainties surrounding the mining sector. Munkhchimeg and Tsenguunjav (2016) have shown that FDI inflows in Mongolia are mainly determined by commodity prices (copper, coal and gold) and country risk premium rather than domestic macroeconomic indicators.

The household's optimality condition with respect to capital utilization implies that the degree of capital utilization is a positive function of the rental rate of capital:

$$u_t = u_a r_t^k \quad (10)$$

where $u_a = (1-\kappa)/\kappa$ and κ is a positive function of the elasticity of the capital utilization adjustment cost function and normalized to be between zero and one. When κ is closer to one, it is extremely costly to change the utilization of capital, thus it remains constant.

3.2. Firms

The country produces three final goods (consumption, investment and export). The final consumption good is produced using domestic homogenous good with import inputs. The final investment good is produced using only domestic homogenous good. There are two types of exports (non-commodity and commodity), which are produced using only domestic homogenous good. The final good sectors are perfectly competitive.

Production of the domestic homogenous good. Homogenous domestic good (y_t) is produced using a Dixit-Stiglitz technology. There is a monopolistic competition in the markets for domestic intermediate goods: each intermediate good is produced by a single firm. Domestic firms produce a variety of intermediate goods by using labor and physical capital inputs.

The aggregate domestic homogenous good production is determined by

$$y_t = \Omega k_t^s + (1-\Omega)n_t + \varepsilon_{a,t} \quad (11)$$

The output is produced using capital (k_t^s) and labor services (employment, n_t). Total factor productivity ($\varepsilon_{a,t}$) is assumed to follow a first-order autoregressive process with an IID-Normal error term ($\varepsilon_{a,t}$): $\varepsilon_{a,t} = \rho_a\varepsilon_{a,t-1} + \varepsilon_{a,t}$. The parameter Ω captures the share of capital in production.

Turning to the monopolistic competitive intermediate goods market, cost minimization by domestic firms implies that the rental rate of capital (r_t^k) is negatively related to the capital-labor ratio and positively to the real wage (ω_t) (both with unit elasticity):

$$r_t^k = -(k_t^s - n_t) + \omega_t \quad (12)$$

As shown by Justiniano and Preston (2010a, b), the real marginal cost (mc_t) is determined as

$$mc_t = (1-\Omega)\omega_t + \Omega r_t^k + ((1-\Omega)\upsilon_n + \Omega\upsilon_k)r_t + \alpha s_t - \varepsilon_{a,t} \quad (13)$$

Following Rabanal (2007) and Christiano et al. (2010), the cost channel of monetary policy is introduced by assuming that a portion of firms' working capital (υ_k percent of rental cost of capital and υ_n percent of its wage bill) must be borrowed at a rate, r_t. We include the short-term interest rate (r_t) in the marginal cost instead of the bank lending rate ($r_{l,t}$) based on the following two assumptions: (i) loan is extended by working capital provider and (ii) working capital loan terms are very short, as the firm owners borrow at the beginning of each quarter and pay back with interest at the end of each quarter. As implied by equation (13), the marginal cost is a positive function of wage, rental rate, short term interest rate and ratio of import price to domestic price.

Price setting of domestic and import retail firms. Domestic firms producing intermediary operate in a monopolistic competitive market. Owing to price stickiness, introduced by Calvo (1983), and partial indexation to lagged inflation of those prices that cannot be re-optimized, employed by Smets and Wouters (2003), prices of domestic intermediate good adjust only sluggishly to their desired markup. Profit maximization by price-setting domestic firms gives the following standard New-Keynesian Phillips curve:

$$\pi_{H,t} - \delta_H \pi_{H,t-1} = \beta E_t(\pi_{H,t+1} - \delta_H \pi_{H,t}) + k_H mc_t + \varepsilon_{p^H,t} \quad (14)$$

where $k_H = \frac{(1-\theta_H)(1-\theta_H\beta)}{\theta_H}$, δ_H is the domestic indexation parameter and θ_H is the parameter for domestic price stickiness. Domestically produced good inflation ($\pi_{H,t}$) depends positively on past and expected inflation, real marginal cost and a price markup disturbance ($\varepsilon_{p^H,t}$).

There is also a monopolistic competition in the markets for imported goods: each good is imported by a single firm. Import retail firms buy differentiated consumption goods from the rest of the world and sell them to an aggregator of imported goods in the domestic market. As derived by Justiniano and Preston (2010a, b), profit maximization by price-setting, importer firms gives the following New-Keynesian Phillips curve:

$$\pi_{F,t} - \delta_F \pi_{F,t-1} = \beta E_t(\pi_{F,t+1} - \delta_F \pi_{F,t}) + k_F\left(\psi_{F,t} + \upsilon_F r_t\right) + \varepsilon_{p^F,t} \quad (15)$$

where $k_F = \frac{(1-\theta_F)(1-\theta_F\beta)}{\theta_F}$, δ_F is the import indexation parameter and θ_F is import price stickiness parameter. Imported good inflation ($\pi_{F,t}$) depends positively on past and expected inflation, the law of one price gap, the short-term interest rate reflecting the cost channel of monetary policy, and a price markup disturbance ($\varepsilon_{p^F,t}$). The disturbances are assumed to follow a first order autoregressive process with an IID-Normal error terms: $\varepsilon_{p^H,t} = \rho_{p^H,t}\varepsilon_{p^H,t} + \varepsilon_{p^H,t}$ and $\varepsilon_{p^F,t} = \rho_{p^F,t}\varepsilon_{p^F,t} + \varepsilon_{p^F,t}$.

Demand for intermediate inputs driven by productions of final consumption, investment and export. Final consumption goods are produced by a representative competitive firm using the homogenous domestic good ($c_{h,t}$) and the homogenous composite of consumption import goods ($c_{m,t}$), and purchased by households. The representative firm takes the price of final consumption goods output (p_t), the input prices ($p_{H,t}$ and $p_{F,t}$) as given. The firm's profit maximization leads to the demand for intermediate inputs:

$$c_{h,t} = c_t + \eta\left(p_t - p_{H,t}\right) = c_t + \eta\alpha s_t \quad (16)$$

$$c_{m,t} = c_t + \eta\left(p_t - p_{F,t}\right) = c_t - \eta(1-\alpha)s_t \quad (17)$$

where η is the elasticity of substitution between domestic and foreign goods.

Consumption good inflation (π_t, inflation based on Consumer Price Index, CPI) is related to the price of inputs by

$$\pi_t = \pi_{H,t} + \alpha \Delta s_t \quad (18)$$

where $\Delta s_t = s_t - s_{t-1}$, $\pi_{F,t} = p_{F,t} - p_{F,t-1}$ and $\pi_{H,t} = p_{H,t} - p_{H,t-1}$ are change in terms of trade and inflations of imported goods and domestic goods, respectively. Deviation of the CPI inflation from domestic goods price inflation is equal to the difference between imported and domestic goods prices, weighted by the significance of those goods in the CPI basket. By definition, changes in terms of trade (Δs_t) is determined as

$$\Delta s_t = \pi_{F,t} - \pi_{H,t} \quad (19)$$

Final investment goods are produced by a representative competitive firm using only domestic homogenous good and purchased by households. Thus, profit maximization leads to the following demand for the domestic intermediate input ($i_{h,t}$):

$$i_{h,t} = i_t \quad (20)$$

For final export sector, it is assumed that a certain share of total exports is natural resources. Therefore, total export consists of non-resource and resource exports, and their demands are modelled differently. Following Nimark (2009) and Jääskelä and Nimark (2011), the specification of export demand reflects the following empirical fact documented by Chen et al. (2008): commodity markets are largely independent of the developments in the individual exporting countries and can be treated as exogenous when considering individual countries.

For the non-commodity export, the demand depends on world output and relative price of the exported goods (which depends on the marginal cost of production) as in a standard set-up for the open economy models (i.e., Adolfson et al., 2008). However, in line with the empirical fact, demand for commodity export is exogenously determined as it depends on world output and the resource demand shock ($\varepsilon_{com,\,t}$), capturing variations in resource exports that are unrelated to the relative cost of export goods and level of foreign output. Real foreign demands for domestic non-commodity ($x_{nr,\,t}$) and commodity exports ($x_{r,\,t}$) are therefore given by

$$x_{nr,\,t} = \eta\left(s_t + \psi_{F,t}\right) + y_t^* \quad (21)$$

$$x_{r,t} = y_t^* + \varepsilon_{com,t} \quad (22)$$

where y_t^* is foreign (world) GDP, η is the domestic price elasticity of substitution, which is assumed to be equal to the foreign price elasticity of substitution. The commodity demand disturbance ($\varepsilon_{com,t}$) is assumed to follow a first-order autoregressive process with an IID-Normal error term: $\varepsilon_{com,t} = \rho_{com,t}\varepsilon_{com,t-1} + \varepsilon_{com,t}$. The exogenous shock to the resource export demand may help (i) to explain the variation in total exports and exchange rates, and (ii) to absorb some demand for the domestic resources from countries, which are not included in the data series representing the world. Thus, the inclusion of the demand shock can help in preventing biases arising in the estimates of parameters.

3.3. Labor market

Sticky wage and unemployment rates are introduced in the model based on the framework of Galí et al. (2011). The utility function with preference shifter employed by Galí et al. (2011) does not change the main features of the model, and the preference allows us to parameterize the strength of short run wealth effects on labor supply. In the framework, workers' unions, setting nominal wages, act in an uncoordinated way, and each union represents workers who specialize in a given type of labor. As discussed by Erceg et al. (2000), Calvo (1983) framework is also considered in the wage setting. Since the labor is heterogeneous (i.e., imperfect substitutes), unions representing each type of labor have monopolistic power to set nominal wages for the given type of labor.

In the monopolistically competitive labor market, the wage markup ($\mu_{\omega,t}$) will be equal to the difference between the real wage (ω_t) and the marginal rate of substitution between working and consuming (mrs_t)[2] and also equal to a linear function of unemployment (un_t),

$$\mu_{\omega,t} = \omega_t - mrs_t = \omega_t - (z_t + \varphi n_t + \varepsilon_{l,t}) \quad (23)$$

$$\mu_{\omega,t} = \varphi un_t \quad (24)$$

where φ is the elasticity of labor supply with respect to the real wage, $\varepsilon_{l,t}$ is labor supply disturbance, which is assumed to follow a first order autoregressive process with an IID-Normal error term: $\varepsilon_{l,t} = \rho_{l,t}\varepsilon_{l,t} + \varepsilon_{l,t}$, and endogenous reference shifter (z_t), determined as follows.

$$z_t = (1-\vartheta_z)\, z_{t-1} + \vartheta_z\big(-\varepsilon_{c,t} + (\sigma/(1-h))(c_t - hc_{t-1})\big) \quad (25)$$

The real wage, ω_t, is defined as

$$\omega_t = \omega_{t-1} + \pi_t^{\omega} - \pi_t \quad (26)$$

where π_t^{ω} is nominal wage inflation.

The unions face Calvo-style wage setting, and because of nominal wage stickiness and partial indexation of wages to inflation, wage inflations adjust only gradually to the desired wage markup (i.e., wage Phillips curve):

$$\pi_t^{\omega} - \delta_\omega \pi_{t-1} = \beta E_t(\pi_{t+1}^{\omega} - \delta_\omega \pi_t) - \lambda_\omega\left(\mu_{\omega,t} - \mu_{\omega,t}^{n}\right) \quad (27)$$

where $\lambda_\omega \equiv \frac{(1-\theta_\omega)(1-\beta\theta_\omega)}{\theta_\omega(1+\varphi\varepsilon_\omega)}$ and $\mu_{\omega,t}^{n} = 100 \cdot \varepsilon_{\omega,t}$. The wage inflation ($\pi_t^{\omega}$) is a function of past and expected wage inflations, current and past CPI inflation, the wage markup and a wage markup disturbance ($\varepsilon_{\omega,t}$), which is assumed to follow a first order autoregressive process with an IID-Normal error term: $\varepsilon_{\omega,t} = \rho_{\omega,t}\varepsilon_{\omega,t} + \varepsilon_{\omega,t}$.

θ_ω and δ_ω are respectively wage indexation and wage stickiness parameters, and φ and ε_ω respectively denote the elasticity of marginal disutility of work and wage elasticity of the relevant labor demand.

By definition, labor force (l_t) is given by

$$l_t = n_t + un_t \quad (28)$$

3.4. Financial market

The financial market is modeled similar to the one developed by Aguirre and Blanco (2015). The dynamics of non-financial sector credit (cr_t) is defined as

$$cr_t = \varsigma cr_t^H + (1-\varsigma)cr_t^F \quad (29)$$

where cr_t^H is households' credit, cr_t^F is firms' credit and ς is the share of households' credit in the total credit. The credit is a function of output, bank lending rate, capital requirement (car_t) and reserve requirement (rr_t):

$$cr_t^H = \lambda_1^H y_t - \lambda_2^H r_{l,t} - \lambda_3^H car_t - \lambda_4^H rr_t + \varepsilon_{Hcr,t} \quad (30)$$

$$cr_t^F = \lambda_1^F y_t - \lambda_2^F r_{l,t} - \lambda_3^F car_t - \lambda_4^F rr_t + \varepsilon_{Fcr,t} \quad (31)$$

where $\varepsilon_{Hcr,t}$ and $\varepsilon_{Fcr,t}$ are disturbances to household and firm credits, respectively and are assumed to follow a first order autoregressive process with an IID-Normal error terms: $\varepsilon_{Hcr,t} = \rho_{Hcr,t}\varepsilon_{Hcr,t} + \varepsilon_{Hcr,t}$ and $\varepsilon_{Fcr,t} = \rho_{Fcr,t}\varepsilon_{Fcr,t} + \varepsilon_{Fcr,t}$.

The first two variables, namely output and the lending rate, are key determinants of the credit. Following Quint and Rabanal (2014), we introduce macroprudential tools that focus on shaping the credit market conditions in a countercyclical manner. The macroprudential measures affect credit supply and spreads by imposing higher capital requirements and reserve requirement. Within the macroprudential measures, the financial intermediaries are only allowed to lend a proportion of their loanable funds, thus tightening macroprudential measures (i.e., capital and reserve requirements) will decrease the credit supply. Furthermore, they will pass the cost of not being able to lend the full amount of funds to their customers. Hence, a tightening of credit conditions following macroprudential measures will increase the lending rate for borrowers.[3] To include these channels, we add capital and reserve requirements into equations (30), (31) and (33).

In the model, banks extend loans to households and firms in an environment of monopolistic competition as assumed by Carletti et al. (2007), Henzel et al. (2009) and Hülsewig et al. (2009). Banks face frictions when setting the loan rate as in Calvo (1983) and maximize their profits. Because of the interest rate stickiness, bank lending rates adjust only gradually to the spread between the bank lending rate and cost of funding.

$$r_{l,t} - r_{l,t-1} = \beta E_t(r_{l,t+1} - r_{l,t}) - k_B(r_{l,t} - cf_t) + \varepsilon_{lr,t} \quad (32)$$

where $k_B = \frac{(1-\theta_B)(1-\theta_B\beta)}{\theta_B}$. The bank lending rate ($r_{l,t}$) depends positively on past and expected bank lending rates, the cost of funding (cf_t) and a disturbance to bank lending rate ($\varepsilon_{lr,t}$). The cost of funding is assumed to be a function of policy rate, non-performing loan (npl_t), capital requirement and reserve requirement:

$$cf_t = r_t + \mu_1 npl_t + \mu_2\, car_t + \mu_3\, rr_t \quad (33)$$

The sum of last two terms in equation (35) can be also called "regulation premium" as they are set by regulation and add extra costs. The disturbance is assumed to follow a first order autoregressive process: $\varepsilon_{lr,t} = \rho_{lr}\varepsilon_{lr,t-1} + \varepsilon_{lr,\,t}$, where $\varepsilon_{lr,\,t}$ is an IID-Normal shock to bank lending rate.

The total non-performing loan (NPL) is weighted average of households' (npl_t^H) and firms' (npl_t^F) non-performing loans:

$$npl_t = \gamma_1 npl_t^H + \gamma_2 npl_t^F \quad (34)$$

It is assumed that non-performing loans are a function of lagged value, economic activity and exchange rate variability, in line with their observed behavior.

$$npl_t^H = \xi_1^H npl_{t-1}^H - \xi_2^H y_t + \xi_3^H \Delta e_t + \varepsilon_{Hnpl,t} \quad (35)$$

$$npl_t^F = \xi_1^F npl_{t-1}^F - \xi_2^F y_t + \xi_3^F \Delta e_t + \varepsilon_{Fnpl,t} \quad (36)$$

where $\varepsilon_{Hnpl,t}$ and $\varepsilon_{Fnpl,t}$ are disturbances to non-performing loans of households and firms, which are assumed to follow a first order autoregressive process with an IID-Normal error terms: $\varepsilon_{Hnpl,t} = \rho_{Hnpl,t}\varepsilon_{Hnpl,t-1} + \varepsilon_{Hnpl,t}$ and $\varepsilon_{Fnpl,t} = \rho_{Fnpl,t}\varepsilon_{Fnpl,t-1} + \varepsilon_{Fnpl,t}$. This specification is consistent with empirical results for the Mongolian economy. For instance, lending rate depends negatively

[2] As explained by Galí et al. (2011), equation (19) allows us to correctly identify both wage markup shock and labor supply shock.

[3] Theoretical derivation of how CAR and RR ratios affect the lending rate can be found in Angelini et al. (2014) and Areosa and Coelho (2013), respectively.

on output gap and positively on non-performing loans and reserve requirement, and the interest rate pass-through from the short-term interest rate to lending rate is weak (Gan-Ochir, 2016a; Gan-Ochir and Kaliappa, 2016).

3.5. Fiscal, monetary and macroprudential policy

We assume that government spending is determined by the following process:

$$g_t = \rho_g g_{t-1} + \rho_{gfdi} fdi_t + \rho_{gx} x_{ry,t} + \rho_{gpcop} p_t^{com} + \varepsilon_{g,t} \quad (37)$$

where $\varepsilon_{g,t}$ is IID-Normal government spending shock, respectively. In equation (37), we assume that government spending positively responds to foreign direct investment (fdi_t), commodity demand ($x_{ry,t}$) and commodity prices (p_t^{com}). It is in line with the 'spend as you go' approach, where revenue generated from positive external shocks are spent by the government.

Monetary policy reaction function is given by the following standard Taylor-type rule:

$$r_t = \rho_R r_{t-1} + (1-\rho_R)\left(\chi_\pi \pi_t + \chi_y y_t + \chi_{\Delta e}\Delta e_t\right) + \varepsilon_{r,t} \quad (38)$$

where $\varepsilon_{r,t}$ is a monetary policy shock, which follows a first-order autoregressive process with an IID-Normal error term: $\varepsilon_{r,t} = \rho_r \varepsilon_{r,t-1} + \varepsilon_{r,t}$. The monetary authority follows a generalized Taylor rule by gradually adjusting the policy controlled interest rate (r_t) in response to inflation, output (measured as deviation from trend) and change in exchange rate. In the empirical analysis, we formally test whether the Bank of Mongolia responds to changes in nominal exchange rate and/or non-financial sector credit.

Finally, the model is closed by introducing the following (time-varying) capital requirement (CAR) and reserve requirement (RR) reaction functions:

$$car_t = \varpi_1 car_{t-1} + (1-\varpi_1)(\varpi_2 y_t + \varpi_3 cr_t) + \varepsilon_{car,t} \quad (39)$$

$$rr_t = \upsilon_1 rr_{t-1} + (1-\upsilon_1)(\upsilon_2 y_t + \upsilon_3 cr_t) + \varepsilon_{rr,t} \quad (40)$$

where $\varepsilon_{car,t}$ is disturbance to capital requirement and $\varepsilon_{rr,t}$ is disturbance to reserve requirement.

These are assumed to follow a first order autoregressive process with an IID-Normal error terms: $\varepsilon_{car,t} = \rho_{car,t}\varepsilon_{car,t} + \varepsilon_{car,t}$ and $\varepsilon_{rr,t} = \rho_{rr,t}\varepsilon_{rr,t} + \varepsilon_{rr,t}$. The macroprudential authorities follow a generalized rule by gradually adjusting policy-controlled prudential measures (car_t and/or rr_t) in response to output and credit cycles. The rules allow us to examine the effectiveness of macroprudential policies. In the empirical analysis, we study several versions of the rules shown in equations (39) and (40). Similar rules have been employed by other studies (Angelini et al., 2014 and Aguirre & Blanco, 2015).

3.6. Foreign variables

In the model, the foreign output (y_t^*), inflation (π_t^*), interest rate (r_t^*) and the world relative commodity price (p_t^{com*}) (i.e., the world commodity price-to-foreign CPI ratio) is assumed to follow a first-order autoregressive process:

$$y_t^* = \rho_{y^*} y_{t-1}^* + \varepsilon_{y^*,t} \quad (41)$$

$$\pi_t^* = \rho_{\pi^*} \pi_{t-1}^* + \varepsilon_{\pi^*,t} \quad (42)$$

$$r_t^* = \rho_{i^*} r_{t-1}^* + \varepsilon_{r^*,t}, \quad (43)$$

$$p_t^{com*} = \rho_{com} p_{t-1}^{com*} + \rho_{cy}\varepsilon_{y^*,t} + \varepsilon_{P_{com}^*,\,t} \quad (44)$$

where $\varepsilon_{y^*,t}$ is foreign output shock, $\varepsilon_{\pi^*,t}$ is an IID-Normal foreign inflation shock, $\varepsilon_{r^*,t}$ is an IID-Normal foreign interest rate shock, and $\varepsilon_{P_{com}^*,\,t}$ is an IID-Normal commodity price shock.

3.7. Resource constrains

The goods market equilibrium. The resource constraint for domestic homogenous output is given by

$$y_t = c_y c_{h,t} + g_y g_t + i_y i_{h,t} + x_{nry} x_{nr,\,t} + x_{ry} x_{r,t} + u_y u_t \quad (45)$$

Output (y_t) is absorbed by consumption of domestic goods ($c_{h,t}$), investment of domestic goods (i_{ht}), government spending (g_t), capital-utilization cost ($u_y u_t$) that is a function of the capital utilization rate (u_t) and commodity and non-commodity exports. c_y is the steady-state share of domestic consumption good in output and equals $1- g_y - i_y - x_{nry} - x_{ry}$, where g_y, i_y, x_{nry} and x_{ry} are respectively the steady-state government spending-output ratio, investment-output ratio, non-resource export-output ratio and resource export-output ratio. $u_y = R^k k_y$, where R^k is steady-state rental rate of capital and k_y is steady-state capital-output ratio.

Net foreign assets and balance of payment. As shown by Adolfson et al. (2008) and Justiniano and Preston (2010a, b), the dynamics of net foreign assets expressed in terms of domestic currency as a share of steady-state output multiplied by current period CPI (a_t) is obtained from the balance of payment (BOP), which implies that expenses on imports and new purchases of net foreign assets must be equal to revenues from commodity and non-commodity exports, net FDI and interest from previously purchased net foreign assets:

$$a_t = \frac{1}{\beta} a_{t-1} + x_{nry}(x_{nr,\,t} - \alpha s_t) + x_{ry}\left(q_t + p_t^{com} + x_{r,t}\right) - m_y(q_t + c_{m,t}) + fdi_y(q_t + fdi_t) \quad (46)$$

where m_y and fdi_y are respectively the steady-state import-output ratio and FDI-output ratio. The relative commodity price (the commodity price-to-foreign CPI ratio) that domestic resource firms take (p_t^{com}) is given by

$$p_t^{com} = \alpha_r p_t^{com*} + (1-\alpha_r) p_{t-1}^{com} \quad (47)$$

where p_t^{com*} is the commodity price in foreign currency, which is determined in world markets and is unaffected by economic developments in the domestic economy. In the long-run, we assume that the Law of One Price holds for resources. However, following Rees et al. (2016) we allow for a delay in the short-term pass-through into the prices that domestic resource firms face. We do this to account a real-world friction in the degree of resource price pass-through: a portion of commodity exports is sold according to predetermined price contracts. We assume that $100 \times \alpha_r$ percent of any changes in overseas resource price feeds into domestic resource prices within the same quarter of the price change.

Equations (1)–(47) determine 47 endogenous variables. The stochastic behavior of the system of linear rational expectations equations is driven by 21 exogenous shocks. Next we turn to the estimation of the model.

4. Data and estimation

4.1. Data

The model is estimated using 23 quarterly time series over the period 2005:Q1 to 2017:Q2 as observable variables: log-differences of seasonally adjusted (s.a.) real GDP, s.a. real household consumption, s.a. real investment (real gross capital formation), s.a. real commodity export, real wage, nominal exchange rate, employment, real net inward FDI, real household credits, real firm credits, consumer price index, price index of domestically produced goods, global relative commodity price index (commodity price index-to-US GDP deflator ratio), US GDP deflator, unemployment rate, policy rate (annual), bank lending rate (annual), NPL ratio of households, NPL ratio of firms, effective capital adequacy ratio, effective reserve requirement and Federal funds rate. The full description and sources of the data used are given in the Appendix.

Prior to empirical analysis, the data is transformed as follows: all variables including log-differenced (scaled by 100) and level series are de-meaned separately in order to ensure that the series used in the estimation are stationary as they represent the business cycle-related part of the original variables. The corresponding measurement equation is:

$$Y_t = \begin{bmatrix} dlGDP_t \\ dlCONS_t \\ dlINV_t \\ dlREXP_t \\ dlWAG_t \\ dlEXCH_t \\ dlEMP_t \\ dlFDI_t \\ dlHLOAN_t \\ dlFLOAN_t \\ dlCPI_t \\ dlCPI_t \\ UNEMP_t \\ PRATE_t \\ LRATE_t \\ HNPL_t \\ FNPL_t \\ CAR_t \\ RR_t \\ dlPCOM_t^* \\ GROWTH_t^* \\ dlGDPDEP_t^* \\ FEDFUNDS_t^* \end{bmatrix} = \begin{bmatrix} d\overline{y} \\ d\overline{c} \\ d\overline{i} \\ d\overline{x_r} \\ d\overline{rw} \\ d\overline{e} \\ d\overline{n} \\ d\overline{rfdi} \\ d\overline{cr^H} \\ d\overline{cr^F} \\ \overline{\pi} \\ \overline{\pi_H} \\ \overline{un} \\ 4*\overline{r} \\ 4*\overline{r_l} \\ \overline{npl^H} \\ \overline{npl^F} \\ \overline{car} \\ \overline{rr} \\ \overline{p^{com*}} \\ \overline{y^*} \\ \overline{\pi^*} \\ 4*\overline{r^*} \end{bmatrix} + \begin{bmatrix} y_t - y_{t-1} \\ c_t - c_{t-1} \\ i_t - i_{t-1} \\ x_{rt} - x_{rt-1} \\ rw_t - rw_{t-1} \\ e_t - e_{t-1} \\ n_t - n_{t-1} \\ rfdi_t - rfdi_{t-1} \\ cr_t^H - cr_{t-1}^H \\ cr_t^F - cr_{t-1}^F \\ \pi_t \\ \pi_{H,t} \\ un_t \\ 4*r_t \\ 4*r_{lt} \\ npl_t^H \\ npl_t^F \\ car_t \\ rr_t \\ p_t^{com*} - p_{t-1}^{com*} \\ y_t^* \\ \pi_t^* \\ 4*r_t^* \end{bmatrix} \quad (48)$$

where l and dl stand for 100 times log and log difference, respectively. The variables with bar in equations stand for the steady state values, which are the historical average of the corresponding series.

4.2. A Bayesian inference and prior distribution of the parameters

We estimate non-calibrated parameters (θ) of the model using Bayesian estimation techniques.[4] In the Bayesian framework, a prior distribution on parameters $p(\theta)$ is updated by sample information contained in the likelihood function $L(Y^T|\theta)$ to form a posterior distribution $p(\theta|Y^T)$

$$p\left(\theta|Y^T\right) \propto L\left(Y^T\middle|\theta\right)p(\theta) \quad (49)$$

The prior is based on 'non-sample' information, so that the Bayesian techniques provide ideal framework for combining different sources of information (Del Negro and Schorfheide, 2011). Since the mapping from the DSGE model to its $L(Y^T|\theta)$ is nonlinear in θ, construction of the posterior distribution is too complicated to evaluate analytically. Hence, simulation techniques such as Markov chain Monte Carlo (MCMC) methods, with the likelihood obtained at each draw through the Kalman filter, are used to obtain draws from the posterior distribution shown in (42). In estimating structural model, the choice of MCMC procedure is usually the Random Walk Metropolis (RWM) algorithm, which belongs to a more general class of Metropolis-Hastings algorithms. A detailed discussion of numerical techniques such as the RWM and Kalman filter algorithms is provided in An and Schorfheide (2007), Fernandez-Villaverde (2010), Guerrón-Quintana and Nason (2012) and Del Negro and Schorfheide (2011, 2013).

The Bayesian framework naturally focuses on the evaluation of relative model fit. Bayes factors or posterior odds ratios[5] are used to measure the relative merits amongst a number of competing models. The Bayes factor of model $\mathcal{M}_j$ versus model $\mathcal{M}_s$ is given by

$$\mathcal{BF}_{j,s|Y^T} = p\left(Y^T\middle|\mathcal{M}_j\right) \Big/ p\left(Y^T\middle|\mathcal{M}_s\right) \quad (50)$$

which summarizes the sample evidence in favor of $\mathcal{M}_j$ over $\mathcal{M}_s$. The terms $p(Y^T|\mathcal{M}_j)$ and $p(Y^T|\mathcal{M}_s)$ are the marginal likelihoods of $\mathcal{M}_j$ and $\mathcal{M}_s$, respectively. The marginal likelihood for a given model $\mathcal{M}_i$ is calculated as $p(Y^T|\mathcal{M}_i) = \int L(Y^T|\theta,\mathcal{M}_i)p_i(\theta|\mathcal{M}_i)d\theta$, where $L(Y|\theta,\mathcal{M}_i)$ is the likelihood function $^\theta$for the data Y^T conditional on the parameter vector and on the model. The marginal likelihood measure automatically penalizes models with additional parameters and increasing degrees of complexity.

We estimate the mode of the posterior distribution by maximizing the log posterior function shown in equation (42). In the second step, the RWM algorithm is used to get the posterior distribution and to evaluate the marginal likelihood of the model. All numerical estimations, evaluations and simulations in this paper are done using Dynare.

Christopher Sims's 'csminwel' optimization routine is used to obtain the posterior mode and to compute the Hessian matrix at the mode. To test the presence of the identification problem more than 20 optimization runs are launched. Different optimization routine always converges to the same mode value. Since a unique mode for the model is found, the Hessian from the optimization routine is used as a proposal density, properly scaled ($c = 0.185$) to attain an acceptance rate between 20 and 30 percent. For the RWM results, two independent chains are generated with 500,000 draws each, of which 200,000 are used as an initial burn-in phase. Convergence of the chains is monitored using both the univariate and the multivariate convergence diagnostics variants of Brooks and Gelman (1998).

Moving on to the specifications of the priors, there are two sets of priors for the model parameters. The first set includes a small number of parameters that are calibrated. Discount factor for Mongolia (β) is set to 0.9925, which is consistent with the average of real interbank interest rate (i.e., 3 percent) over the estimation

[4] Bayesian methods help estimate models with cross-equation restrictions by dealing with misspecification and identification problems, well. In the presence of those problems, advantages of the approach over alternatives are discussed by Canova (2007) and An and Schorfheide (2007).

[5] If there are M competing models, and one does not have strong view on which model is the best one (i.e., hence chooses equal prior weight for each model, $1/M$), the posterior odds ratio is equal to the Bayes factor.

sample. The parameter governing openness, α, is set at 0.36, which is the average share of imported goods in consumption basket. The steady state value of the labor income to household consumption ratio (W_*L_*/C_*) is fixed at 0.42, which is the average of the ratio over the period 2005–2016. Capital depreciation rate (δ) is assigned a value of 0.04 (on a quarterly basis), which is chosen slightly higher than the values used in advanced countries. The steady-state value of FDI to GDP ratio (fdi_y) is fixed at 0.2, which is the average of the ratio over the estimation period. The share of FDI in total investment (w_{FDI}) and the share of import in GDP (m_y) are respectively set at 0.4 and 0.69, which respectively correspond to the average values of the ratios over the estimation period. Share of household credit in total credit (ς) is set at 0.39, also the average during the estimation period. γ_1 and γ_2 are respectively set at 0.578592 and 0.565698 based on the simple regression result of the equation (36) over the estimation period. The parameters governing the strength of the monetary policy cost channel (i.e., working capital channel) are set to $\upsilon_n = \upsilon_k = \upsilon_f = 1$, assuming that all payments of inputs are financed in advance. Finally, the steady-state values of the government spending to GDP ratio (g_y), investment to GDP ratio (i_y), commodity export to GDP ratio (xr_y) and non-commodity export to GDP ratio (xnr_y) are respectively calibrated to $g_y = 0.12$, $i_y = 0.25$, $xr_y = 0.275$, $xnr_y = 0.025$, which are the average of the ratios over the estimation period.

The second set of 99 parameters to be estimated and their prior distributions are listed in Table 1. Priors for parameters, unrelated to the credit market and macroprudential policy tools are selected fairly consistent with those used in the literature (e.g., Smets and Wouters, 2007; Adolfson et al., 2008; Justiniano and Preston, 2010a; b; Galí et al., 2011). Priors for the parameters governing the lending rate dynamics are chosen in line with those used by Henzel et al. (2009) and Hülsewig et al. (2009). Prior distributions of parameters in credit and NPL equations are chosen from Aguirre and Blanco (2015). We set diffuse priors for parameters in CAR and RR rules, which are in line with Suh (2012), and Quint and Rabanal (2014). As a common choice, inverse gamma distribution is selected for all standard deviations of shocks, and prior variances are chosen as diffuse for shocks.

4.3. *Posterior estimates of the parameters*

The last two columns in Table 1 report the posterior estimates (i.e., posterior mean and 90 percent probability interval of the posterior distribution) of the model parameters. The data provides large amount of information about the values of the model parameters, as the posteriors significantly shift from the priors. This implies that the estimated model reflects certain features of the Mongolian economy. The estimated parameters of key macroeconomic equations are in line with those found in other studies (i.e., Dutu, 2012, Gan-Ochir and Dulamzaya, 2014) that estimate DSGE models using Bayesian techniques in the case of Mongolia. For this reason and given the focus of this paper, only selected parameters are considered.

The degrees of domestic and import price stickiness (θ_H and θ_F) are estimated as 0.71 and 0.83, respectively implying that prices of domestic and imported goods are re-optimized on average every 3.4 and 5.5 quarters, respectively. The estimated degree of price indexation presents adequate source of endogenous persistence in both domestic and imported goods price dynamics, with coefficient values of $\delta_H = \delta_F = 0.39$, suggesting that backward and forward-looking parameters of the Phillips curves are 0.28 and 0.7, respectively.

The degree of wage stickiness (θ_ω) is estimated as 0.03 at the posterior mean, while estimated wage backward indexation parameter (δ_ω) is 0.45, which is relatively high compared to other countries. These results suggest that wage setting manly depends on inflation rather than wage re-optimization of the labor union. The inverse of the Frisch labor supply elasticity is 2.62. The estimated steady-state wage markup is 19 percent, which is consistent with historically high rate of unemployment in Mongolia.

The posterior mean of the parameter, ϑ_z, controlling for the short-run wealth effects on labor supply, is estimated as 0.06, implying that the preference in Mongolia is closer to the preference function suggested by Greenwood et al. (1988). Monetary policy is inertial with the parameter (ρ_R) of around 0.9 and is implemented as anti-inflationary policy with the parameter (χ_π) of about 1.4.

The risk premium parameter (ϕ_e), which shows the degree of impact of expected depreciation on the risk premium, is estimated as 0.46 at the posterior mean. This suggests that the violation of the standard UIP condition in Mongolia, and the presented UIP modification helps to reproduce the literature finding that the empirical response of real exchange rate to monetary shocks are long-lasting and hump-shaped. The capital share in production (Ω) is estimated at relatively high value (0.51).

The degree of lending rate stickiness (θ_B) is estimated as 0.7 at the posterior mean, implying that banks re-optimize their lending rates on average every 3.3 quarters. Moreover, the estimation results confirm that NPL ratio, policy rate, capital and reserve requirements significantly affect the bank lending rate.

Degrees of smoothing in interest rate, capital requirement and reserve requirement rules are estimated with coefficients of 0.8–0.9. The estimated interest rate rule supports the hypothesis that the Bank of Mongolia responds to changes in the nominal exchange rate, since the parameter, $\chi_{\Delta e}$, is estimated as 0.56 at the posterior mean. This hypothesis is also formally tested using the Bayes factor in Section 4.4. The CAR strongly responds to the output compared to the reserve requirement. Household credits mainly depend on the business cycle, whereas firm credit is significantly affected by the changes in the effective CAR. Compared to firm NPL, the household NPL is more likely to be associated with the business cycle and changes in the nominal exchange rate.

The data contains a large amount of information about the parameters of the shock process. In particular, standard deviations of household consumption, total investment, FDI, government spending, commodity demand shocks are estimated in relatively high values depending on the fluctuations in the observed variables.

4.4. *Fitness of the model and evaluation*

In order to assess the in-sample fit of the estimated model, Fig. 1 reports the actual data and the Kalman filtered, one-sided estimate[6] of the observed variables, computed using the posterior mean of the estimated parameters.

The in-sample fit of the model appears to be reasonably well in the sense that general movements of most variables are replicated by the model. In particular, the model fits the actual data quite well in the second half of the sample, suggesting that the estimated model can be employed in examining a number of key macroeconomic issues. However, the model can be further improved as the in-sample fit is good for variables with low fluctuations, but weak for variables with high fluctuations.

The Bayes factor is employed to measure the relative merits of

[6] The Kalman filter estimates are also called as one step ahead predictions and can be interpreted as the fitted value of a regression.

Table 1
Prior densities and posterior estimates.

	Parameters	Prior Distribution			Posterior Distribution	
		Density	Mean	Sd.	Mean	Mean
Structural parameters						
h	Habit	B	0.5	0.15	0.48	[0.27, 0.69]
σ	Intertemporal ES	G	1.2	0.1	1.19	[1.02, 1.35]
η	Elasticity H-F goods	G	1.5	0.1	1.53	[1.37,1.70]
θ_H	Calvo domestic prices	B	0.6	0.15	0.71	[0.60,0.83]
δ_H	Indexation domestic	B	0.5	0.2	0.39	[0.24, 0.53]
φ	Inverse Frisch	N	2.0	1.0	2.62	[1.93, 3.32]
θ_F	Calvo import prices	B	0.6	0.15	0.83	[0.73, 0.93]
δ_F	Indexation foreign	B	0.5	0.2	0.39	[0.11, 0.66]
α_p	Share of patient households	B	0.5	0.1	0.48	[0.32, 0.63]
u_y	Capital cost-output ratio	B	0.5	0.1	0.03	[0.004, 0.06]
ϕ_a	Interest debt elasticity	IG	0.01	1.0	0.004	[0.002, 0.005]
ϕ_e	UIP modification	B	0.5	0.1	0.46	[0.38, 0.54]
θ_ω	Calvo wages	B	0.4	0.20	0.03	[0.00, 0.06]
δ_ω	Indexation wages	B	0.5	0.20	0.45	[0.13, 0.78]
$\mathscr{M}_\omega$	Steady state wage markup	N	1.25	0.25	1.19	[0.29, 1.72]
ϑ_z	Reference shifter	B	0.05	0.025	0.06	[0.02, 0.09]
α_r	Elasticity of commodity price	B	0.5	0.2	0.39	[0.03, 0.71]
Ω	Capital share in production	B	0.3	0.1	0.51	[0.37, 0.65]
κ	Capital utilization	B	0.35	1.0	0.21	[0.10, 0.31]
θ_B	Calvo bank lending rate	B	0.6	0.05	0.70	[0.62, 0.79]
ρ_R	Taylor rule, smoothing	B	0.8	0.1	0.91	[0.88, 0.95]
χ_π	Taylor rule, inflation	G	1.5	0.25	1.41	[1.05, 1.77]
χ_y	Taylor rule, output	G	0.25	0.13	0.14	[0.04, 024]
$\chi_{\Delta e}$	Taylor rule, exchange rate	G	0.25	0.13	0.56	[0.24, 0.85]
λ_1^F	Firm credit, output	N	1	0.25	0.15	[-0.10, 0.40]
λ_2^F	Firm credit, interest rate	B	0.5	0.2	0.54	[0.22, 0.86]
λ_3^F	Firm credit, CAR	B	0.5	0.2	0.57	[0.27, 0.87]
λ_4^F	Firm credit, RR	B	0.5	0.2	0.38	[0.09, 0.65]
λ_1^H	Household credit, output	N	1	0.25	0.57	[0.28, 0.87]
λ_2^H	Household credit, interest rate	B	0.5	0.2	0.52	[0.20, 0.85]
λ_3^H	Household credit, CAR	B	0.5	0.2	0.45	[0.12, 0.76]
λ_4^H	Household credit, RR	B	0.5	0.2	0.37	[0.08, 0.64]
ξ_1^H	Household NPL, lagged	B	0.5	0.2	0.65	[0.45, 0.86]
ξ_2^H	Household NPL, output	B	0.3	0.15	0.03	[0.01, 0.06]
ξ_3^H	Household NPL, exchange rate	B	0.1	0.05	0.02	[0.006, 0.04]
ξ_1^F	Firm NPL, lagged	B	0.5	0.2	0.64	[0.45, 0.84]
ξ_2^F	Firm NPL, output	B	0.3	0.15	0.08	[0.02, 0.14]
ξ_3^F	Firm NPL, exchange rate	B	0.1	0.05	0.10	[0.04, 0.15]
ϖ_1	CAR rule, smoothing	B	0.8	0.1	0.85	[0.76, 0.95]
ϖ_2	CAR rule, output	B	0.5	0.2	0.33	[0.07, 0.58]
ϖ_3	CAR rule, credit	B	0.2	0.1	0.16	[0.03, 0.28]
υ_1	RR rule, smoothing	B	0.8	0.1	0.81	[0.70, 0.93]
υ_2	RR rule, output	B	0.2	0.1	0.19	[0.05, 0.34]
υ_3	RR rule, credit	B	0.2	0.1	0.17	[0.03, 0.30]
μ_1	Cost of funding, NPL	B	0.5	0.2	0.38	[0.14, 0.60]
μ_2	Cost of funding, CAR	B	0.5	0.2	0.28	[0.09, 0.46]
μ_3	Cost of funding, RR	B	0.5	0.2	0.18	[0.05, 0.30]
Persistence of the exogenous processes						
ρ_a	Technology AR(1)	B	0.5	0.2	0.66	[0.54, 0.80]
ρ_c	Preferences AR(1)	B	0.5	0.2	0.36	[0.08, 0.63]
ρ_{cp^F}	Import cost-push AR(1)	B	0.5	0.2	0.30	[0.06, 0.52]
ρ_{cp^H}	Domestic cost-push AR(1)	B	0.5	0.2	0.32	[0.08, 0.57]
ρ_{rp}	Risk premium AR(1)	B	0.8	0.1	0.85	[0.76, 0.94]
ρ_g	Government spending AR(1)	B	0.5	0.2	0.89	[0.82, 0.96]
ρ_n	Labor supply AR(1)	B	0.8	0.1	0.75	[0.61, 0.90]
ρ_w	Wage markup AR(1)	B	0.5	0.2	0.55	[0.36, 0.76]
ρ_r	Monetary policy AR(1)	B	0.25	0.1	0.14	[0.05, 0.24]
ρ_{com}	Commodity demand AR(1)	B	0.5	0.25	0.76	[0.63, 0.88]
ρ_{pcom}	Commodity price AR(1)	B	0.8	0.1	0.90	[0.84, 0.96]
ρ_{comy}	Commodity demand & price	B	0.5	0.2	0.58	[0.28, 0.90]
ρ_{fdi}	FDI AR(1)	B	0.8	0.1	0.77	[0.67, 0.87]
ρ_{Hcr}	Household credit AR(1)	B	0.5	0.2	0.88	[0.80, 0.96]
ρ_{Fcr}	Firm credit AR(1)	B	0.5	0.2	0.89	[0.82, 0.96]
ρ_{car}	Capital requirement AR(1)	B	0.5	0.2	0.18	[0.03, 0.33]
ρ_{rr}	Reserve requirement AR(1)	B	0.5	0.2	0.17	[0.03, 0.31]
ρ_{lr}	Bank lending rate AR(1)	B	0.5	0.2	0.57	[0.32, 0.81]
ρ_{Hnpl}	Household NPL AR(1)	B	0.5	0.2	0.62	[0.39, 0.84]

Table 1 (*continued*)

	Parameters	Prior Distribution			Posterior Distribution	
		Density	Mean	Sd.	Mean	Mean
ρ_{Fnpl}	Firm NPL AR(1)	B	0.5	0.2	0.64	[0.44, 0.84]
$\rho_{c,\,Hcr}$	Consumption, household credit	B	0.5	0.2	0.31	[0.06, 0.56]
ρ_i	Investment	B	0.5	0.2	0.51	[0.32, 0.70]
ρ_{gfdi}	Gov. spending, FDI	B	0.5	0.2	0.09	[0.01, 0.17]
ρ_{gx}	Gov. spending, commodity export	B	0.5	0.2	0.22	[0.03, 0.40]
ρ_{gpcom}	Gov. spending, commodity price	B	0.5	0.2	0.26	[0.04, 0.47]
ρ_{y^*}	Foreign output AR(1)	B	0.5	0.2	0.85	[0.76, 0.94]
ρ_{π^*}	Foreign inflation AR(1)	B	0.5	0.2	0.42	[0.23, 0.61]
ρ_{r^*}	Foreign interest rate AR(1)	B	0.8	0.1	0.95	[0.91, 0.98]
Standard deviations, shock innovations						
σ_a	Sd technology	IG	4.0	2.0	5.69	[4,70, 6,64]
σ_r	Sd monetary policy	IG	0.5	0.5	0.64	[0.48, 0.78]
σ_c	Sd preference	IG	8.0	4.0	18.9	[11.1, 26.6]
σ_i	Sd investment efficiency	IG	20.0	10.0	28.7	[24.1, 33.0]
σ_{cp^H}	Sd domestic-cost push	IG	3.0	2.0	4.68	[3.45, 5.87]
σ_{cp^F}	Sd import-cost push	IG	3.0	2.0	2.52	[1.82, 3.21]
σ_{rp}	Sd risk premium	IG	1.0	1.0	0.84	[0.55, 1.11]
σ_n	Sd labor supply	IG	6.0	3.0	9.40	[7.0, 11.56]
σ_w	Sd wage markup	IG	0.1	0.05	0.05	[0.03, 0.06]
σ_g	Sd Gov. spending	IG	20	10	78.5	[65.6, 91.2]
σ_{com}	Sd commodity demand	IG	8.0	4.0	16.9	[14.2, 19.6]
$\sigma_{P^*_{com}}$	Sd commodity global price	IG	6.0	3.0	10.2	[8.6, 11.8]
σ_{fdi}	Sd FDI	IG	20	10	43.2	[36.2, 49.9]
σ_{lr}	Sd bank lending rate	IG	0.25	0.25	0.35	[0.26, 0.45]
σ_{cr^H}	Sd household credit	IG	4.0	2.0	7.46	[6.21, 8.69]
σ_{cr^F}	Sd firm credit	IG	4.0	2.0	5.74	[4.77, 6.74]
σ_{npl^H}	Sd Household NPL	IG	1.0	0.5	0.62	[0.51, 0.73]
σ_{npl^F}	Sd firm NPL	IG	1.0	0.5	1.47	[1.22, 1.71]
σ_{car}	Sd capital requirement	IG	1.0	1.0	1.56	[1.30, 1.82]
σ_{rr}	Sd reserve requirement	IG	1.0	1.0	2.23	[1.85, 2.61]
σ_{y^*}	Sd foreign output	IG	1.0	0.5	0.80	[0.67, 0.92]
σ_{π^*}	CX foreign inflation	IG	0.15	0.1	0.22	[0.19, 0.26]
σ_{r^*}	CX foreign interest rate	IG	0.15	0.1	0.10	[0.08, 0.12]

Notes: G: Gamma distribution, B: Beta distribution, N: Normal distribution, IG: Inverse Gamma distribution. Figures in brackets indicate 90 percent posterior probability intervals.

alternative models. Table 2 reports the log marginal data densities[7] of models with different policy rules, along with the corresponding Bayes factors, calculated by considering the estimated model (the baseline model) as the null hypothesis. The main incentive here is to assess whether monetary and macroprudential policy rules in the estimated model are supported by the data.

First, we examine whether the policy rate responds to changes in the nominal exchange rate, and in doing so, we compare the baseline model ($\mathscr{M}_0$) with $\mathscr{M}_1$ model. The marginal data densities of $\mathscr{M}_0$ is larger than the densities of $\mathscr{M}_1$ by 6.17 on a log-scale that translates into a Bayes factor of $\mathscr{BF}_{0,1|Y} = 487.2$. According to Kass and Raftery (1995),[8] the Bayes factor of this size offers 'very strong' evidence in favor of $\mathscr{M}_0$ ($\chi_{\Delta e} > 0$). Considering the Bayes factor as evaluation criterion, the data (Y^T) strongly supports the hypothesis that the Bank of Mongolia responds to changes in the nominal exchange rate through the policy rate.

When comparing the baseline model ($\mathscr{M}_0$) to the models with different CAR and RR rules, there is no evidence in favor of $\mathscr{M}_0$ model. As the Bayes factors (i.e., $\mathscr{BF}_{0,2|Y}$, $\mathscr{BF}_{0,3|Y}$, $\mathscr{BF}_{0,4|Y}$, $\mathscr{BF}_{0,5|Y}$) are less than 3, the hypothesis that CAR and RR respond to the business cycle and credit cycle fluctuations cannot be fully rejected, but also cannot be accepted. Therefore, based on the probability interval of the posterior distribution of the parameters in the RR and CAR rules, we keep the estimated RR and CAR rules with $\varpi_2 > 0$, $\varpi_3 > 0$, $\nu_2 > 0$, $\nu_3 > 0$ for further analysis. A possible explanation for why those tools do not significantly respond to the output and credit cycles is that the Bank of Mongolia has not explicitly used those tools for the purpose of macroprudential policy purposes.

5. Effect of monetary and macroprudential policy actions

5.1. Impulse response functions: what are the impact of policy instruments?

This section aims to answer the following two questions: (i) what are the impact of monetary and macroprudential policy shocks on the macroeconomic and financial variables and (ii) what does a 1 percent change in lending rate (or credits) either through a tightening of policy rate or reserve requirements or capital requirements imply for other macroeconomic and financial variables?

Fig. 2 reports impulse response functions to a positive 100 basis points the (annual) policy rate shock. The solid and dashed black lines respectively show the posterior mean response and the responses of the 90 percent confidence interval.

[7] Considering that marginal log-likelihood penalizes over-parameterization, the full model does not necessarily rank better if the extra assumptions (cost channel and UIP modification) do not sufficiently help in explaining the data.

[8] Kass and Raftery (1995) provide an interpretative scale to judge the strength of the evidence in favour of an alternative model with respect to the model in the null hypothesis. According to their scale, a Bayes factor between 1 and 3 is 'not worth more than a bare mention', between 3 and 20 suggests a 'positive' evidence, between 20 and 150 suggests a 'strong' evidence, and larger than 150 'very strong' evidence in favour of one of the two models.

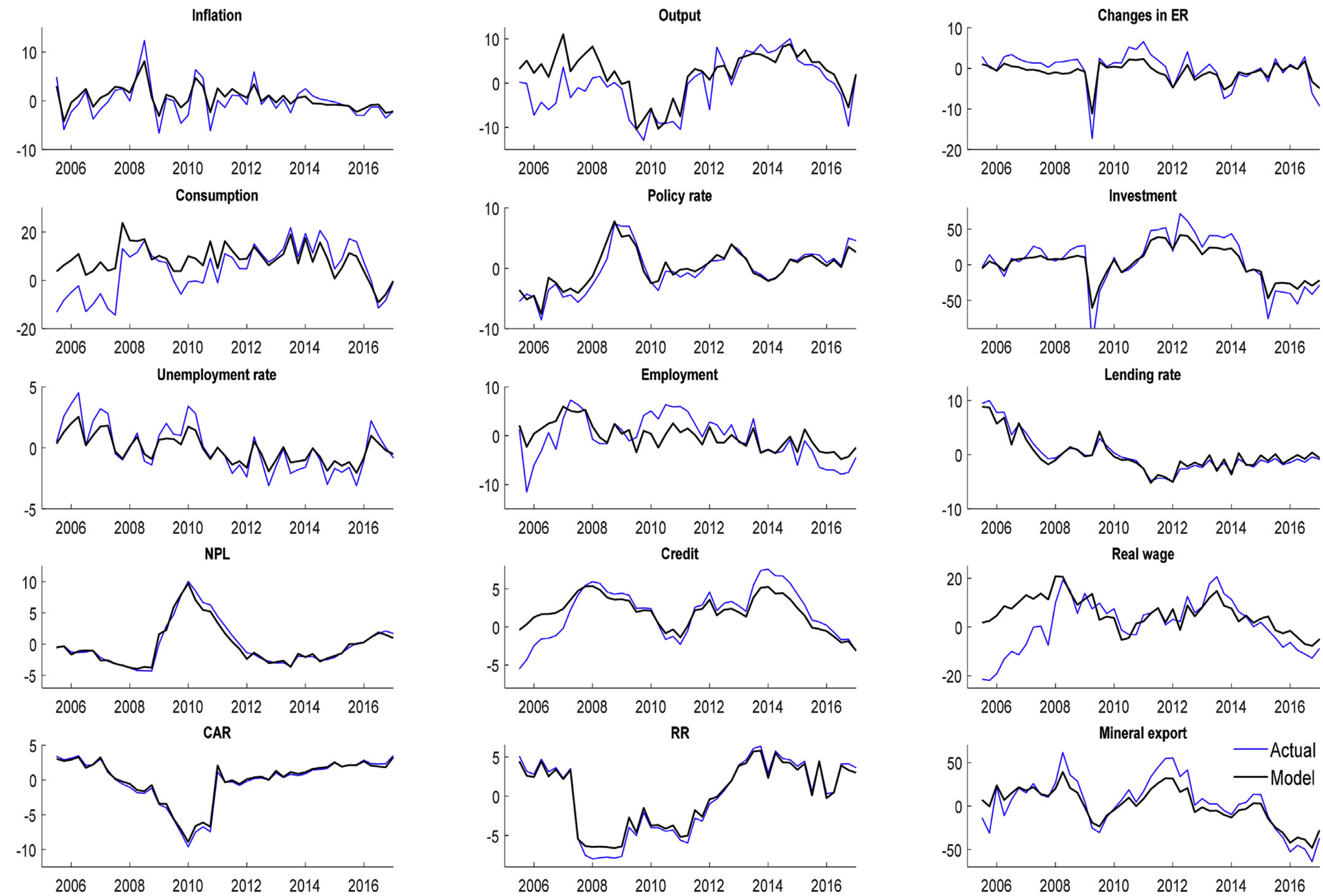


Fig. 1. Selected data and one-sided predicted values.

Table 2
Model comparison: Relative fit of alternative policy rules.

Models ($\mathscr{M}$)	Log marginal data densities ($ln\ L(Y\|\mathscr{M}_i)$)	Bayes factor ($\mathscr{BF}$)
$\mathscr{M}_0$: Baseline model ($\chi_{\Delta e}>0,\ \varpi_2>0,\ \varpi_3>0,\ \nu_2>0,\ \nu_3>0$)	−3062.60	$\mathscr{BF}_{0,0\|Y}=1$
$\mathscr{M}_1$: Model with ($\chi_{\Delta e}=0,\ \varpi_2>0,\ \varpi_3>0, \nu_2>0,\ \nu_3>0$)	−3068.77	$\mathscr{BF}_{0,1\|Y}=487.2$
$\mathscr{M}_2$: Model with ($\chi_{\Delta e}>0,\ \varpi_2=0,\ \varpi_3>0, \nu_2>0,\ \nu_3>0$)	-3061.64	$\mathscr{BF}_{0,2\|Y}=0.4$
$\mathscr{M}_3$: Model with ($\chi_{\Delta e}>0,\ \varpi_2>0,\ \varpi_3=0, \nu_2>0,\ \nu_3>0$)	-3061.63	$\mathscr{BF}_{0,3\|Y}=0.4$
$\mathscr{M}_4$: Model with ($\chi_{\Delta e}>0,\ \varpi_2>0,\ \varpi_3>0, \nu_2=0,\ \nu_3>0$)	-3062.68	$\mathscr{BF}_{0,4\|Y}=1.1$
$\mathscr{M}_5$: Model with ($\chi_{\Delta e}>0,\ \varpi_2>0,\ \varpi_3>0, \nu_2>0,\ \nu_3=0$)	-3061.93	$\mathscr{BF}_{0,5\|Y}=0.5$

Notes: The table reports Bayes factors by comparing the model $\mathscr{M}_0$ to $\mathscr{M}_1$(or $\mathscr{M}_2$ or $\mathscr{M}_3$ or $\mathscr{M}_4$ or $\mathscr{M}_5$). The log marginal data densities reported here is computed from the posterior draws using the Laplace approximation.

The monetary policy shock has the standard features of an aggregate demand shock. The policy rate shock increases the bank lending rate by 15 basis points, and gradually appreciates the real exchange rate in the first 2–3 quarters. When dealing with capital inflows, monetary policy faces a dilemma regarding raising the policy rate, as raising the policy rate in response to a surge in capital inflows would pull more short-term capital inflows, however may also lead to financial instability later through excessive appreciation of exchange rate and credit boom.

The rise in interest rates and the real exchange appreciation lowers investments, household consumptions and exports, thereby GDP declines by 0.5 percent. As the output declines, demand for labor and real wage falls in the economy. As a consequence, inflation decreases by 0.3–0.35 basis points. The effect of monetary policy shock on output and inflation disappears after 10 and 15 quarters, respectively. However, a response of unemployment, NPL and credits to a monetary policy shock is weak as well as not statistically significant. The results are in line with previous studies for Mongolia (i.e., Gan-Ochir and Dulamzaya, 2014, Baksa et al., 2017). Maino et al. (2013) also shows that the impact of policy rate on credit is weak.

Investigating the response of other macroeconomic variables to reserve requirement and capital requirement allows us to improve our knowledge of the transmission mechanism of the two macroprudential policy tools. Fig. 3 presents impulse response functions to a positive shock of 1 percentage point in reserve requirement.

The reserve requirement shock has similar effects with the monetary policy shock. Only differences are the responses of real exchange rate and NPL. Moreover, the responses are less hump-shaped compared to those of the monetary policy shock. In response to the reserve requirement shock, the lending rate increases by 0.3 percentage point after 3 quarters. Total credits initially fall by 0.1 percent and revert back to zero after about 15 quarters. We observe immediate fall in the investment and gradual reduction in the household consumption, which lead to 0.1 percent immediate fall in the GDP. The effects on the GDP revert back to zero after about 10 quarters. The contraction in the production leads to reductions in the demand for labor and the real wage. However, the effects on inflation and the real exchange rate are weak compared to the policy rate shock. NPL increases as a result of weakening economic activities and exchange rate depreciation, but the magnitude of the response is negligible.

Fig. 4 displays impulse response functions to a positive 1 percentage point capital requirement shock.

The shock has qualitatively similar responses with reserve requirement shock. In response to the capital requirement shock, the lending rate rises by 0.55 percentage point after 3 quarters, while total credit decrease by 0.15 percent. The real exchange rate depreciates by more than 0.2 percent after 4 quarters, and the household consumption and investment respectively fall by about 0.4 percent, which lead to 0.2 percent decline in the GDP. The inflation decreases as labor demand and real wage fall. NPL increases as a result of the weak economic activities and the exchange rate depreciation. The exchange rate depreciation in response to both capital requirement and reserve requirement shocks may allow the policy makers to use the macroprudential tools as a complement to the policy rate when dealing with capital inflows.

As considered in the model, a central bank has three policy instruments, policy rate, reserve requirement and capital requirement that affect the lending rate and total credit. A rise in policy rate, a rise in reserve requirement and a rise in capital requirement are three possibilities for a central bank to achieve higher lending rate or lower credit supply.

Table 3 reports how 1 percentage point rise in the lending rate can be achieved either through a tightening of policy rate or reserve requirement or capital requirement and the impact of the required tightening on the other macroeconomic variables.

All reported values are averages over the first 2 quarters. The 1 percent rise in the lending rate can be achieved through 5.9 percentage point rise in the policy rate or 3.5 percentage points rise in

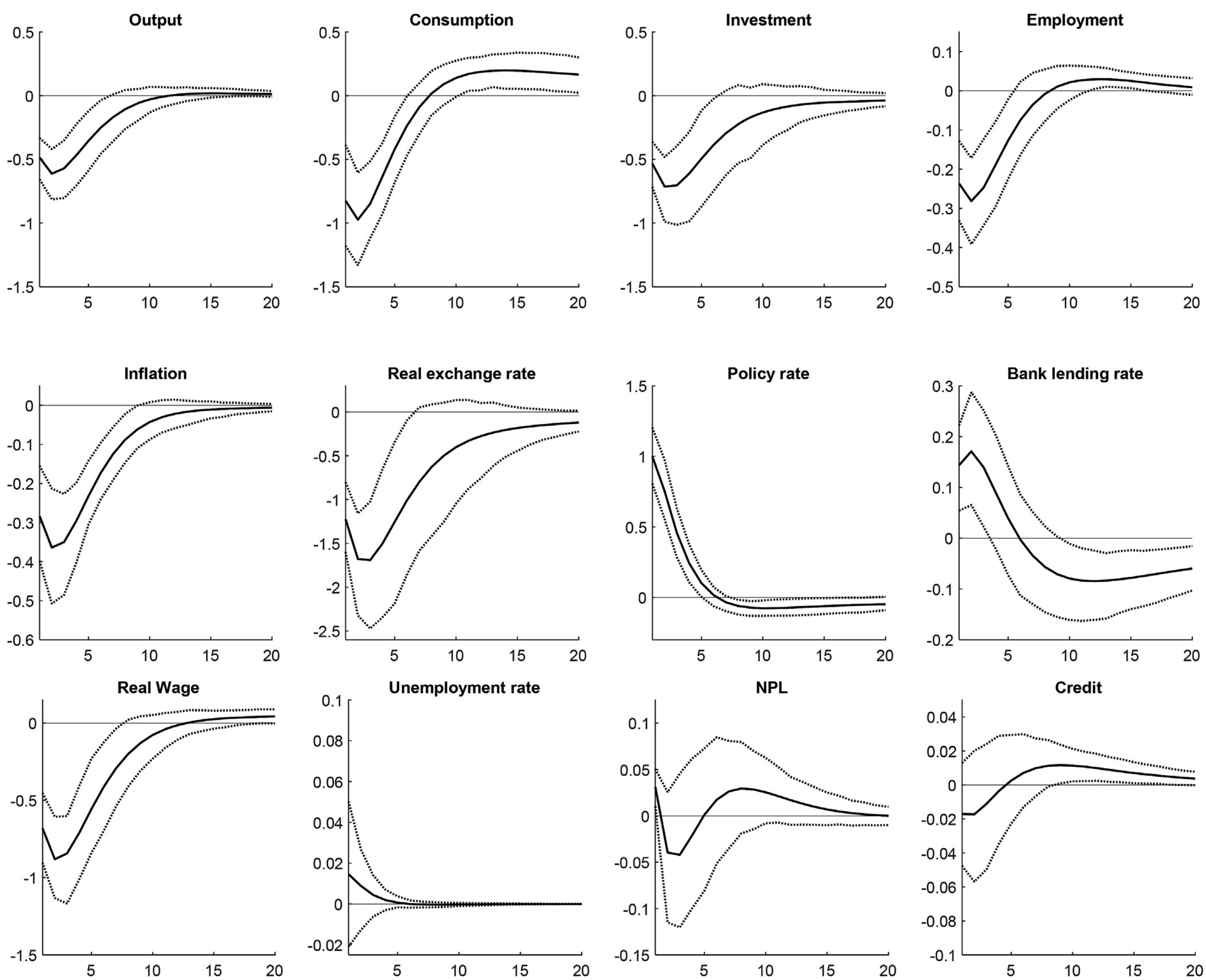


Fig. 2. Impulse response functions to a monetary policy shock.

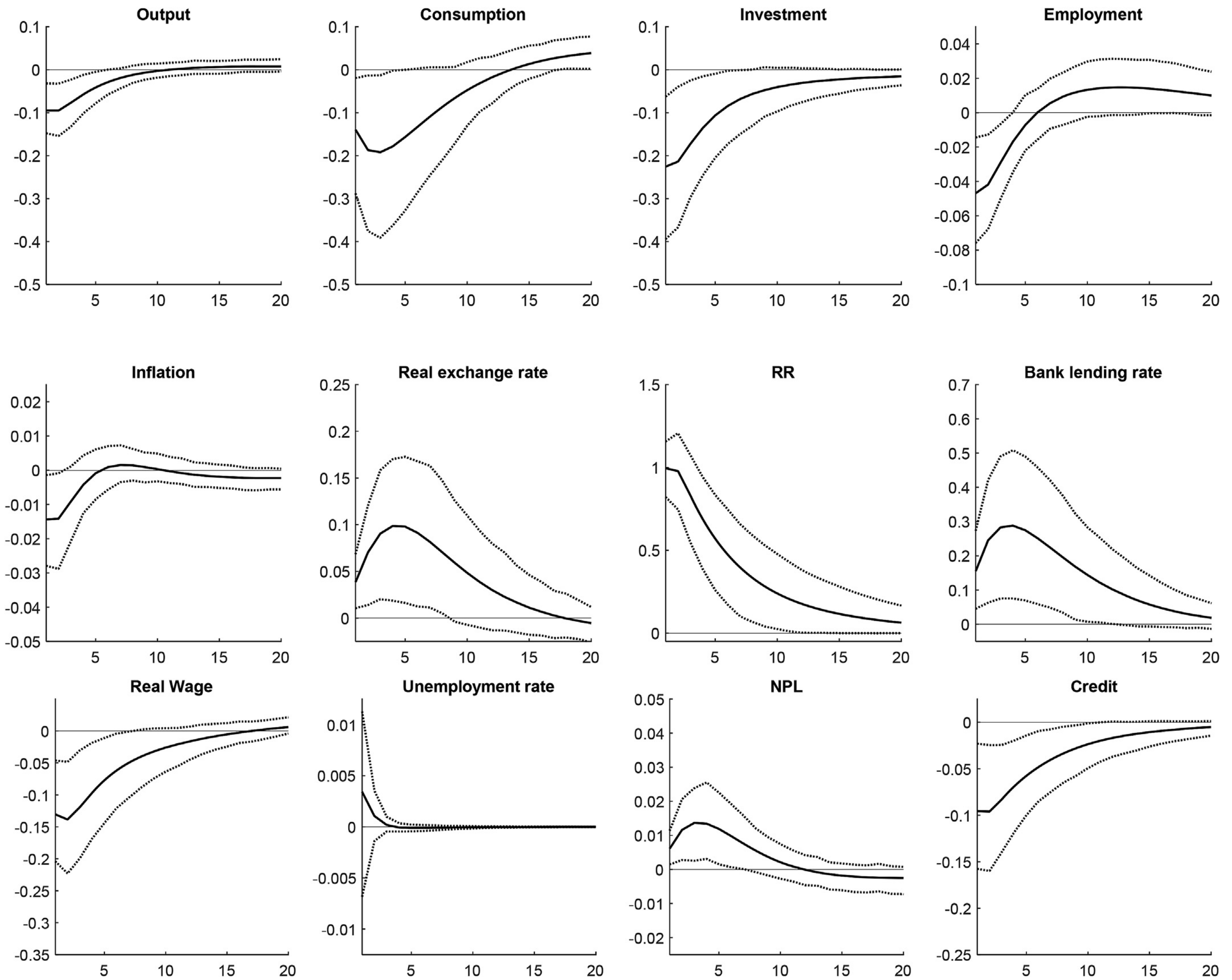


Fig. 3. Impulse response functions to a reserve requirement shock.

reserve requirement or 2 percentage point rise in the capital requirement. It is observed that those changes in the three instruments have very different effects on other macroeconomic variables. The real exchange rate moves in opposite directions. A policy rate hike leads to exchange rate appreciation, while an increase in reserve requirement or capital requirement leads to exchange rate depreciation. The impact of policy rate shock on inflation and GDP is stronger, but the impact on credit supply is weaker compared to the two macroprudential tools. Quantitative effects of 3.5 percentage point increase in reserve requirement and 2 percentage point tightening in capital requirement on the lending rate, credit supply, inflation, GDP and policy rate are quite close to each other.

We are also interested in how 1 percent fall in credit supply can be achieved either through a tightening of policy rate or reserve requirement or capital requirement and impact of the required tightening on the other macroeconomic variables. Comparison of the effects of the alternative policy instruments, suggests that the macroprudential tools are more effective than the policy rate in limiting credit growth. In particular, the capital requirement is the most effective instrument when controlling the credit growth and the lending rate.

5.2. Variance decomposition: which shocks are important in business cycle fluctuations?

In this section, we examine the forecast error variance decomposition in order to investigate which shocks play important role in driving business cycle fluctuations and focus on the role of monetary and macroprudential instruments. Since the estimated model is a richer model with many frictions and shocks, it can provide an assessment of the contribution of each shock 'relative' to other shocks. Table 4 reports the unconditional forecast error variance decomposition of selected observed variables evaluated at the posterior mean.

The variance decomposition analysis shows that external and demand shocks play important role in the business cycle fluctuations. External shocks account for more than 25 percent of the unconditional forecast error variance of GDP, 36 percent of the variance of investment, 25 percent of the variance of nominal exchange rate. This result emphasizes the significance of external shocks on Mongolian economy and is in line with the findings of Gan-Ochir and Davaajargal (2017). Demand shocks explain more than 50 percent of the variances of GDP, household consumption, investment and employment.

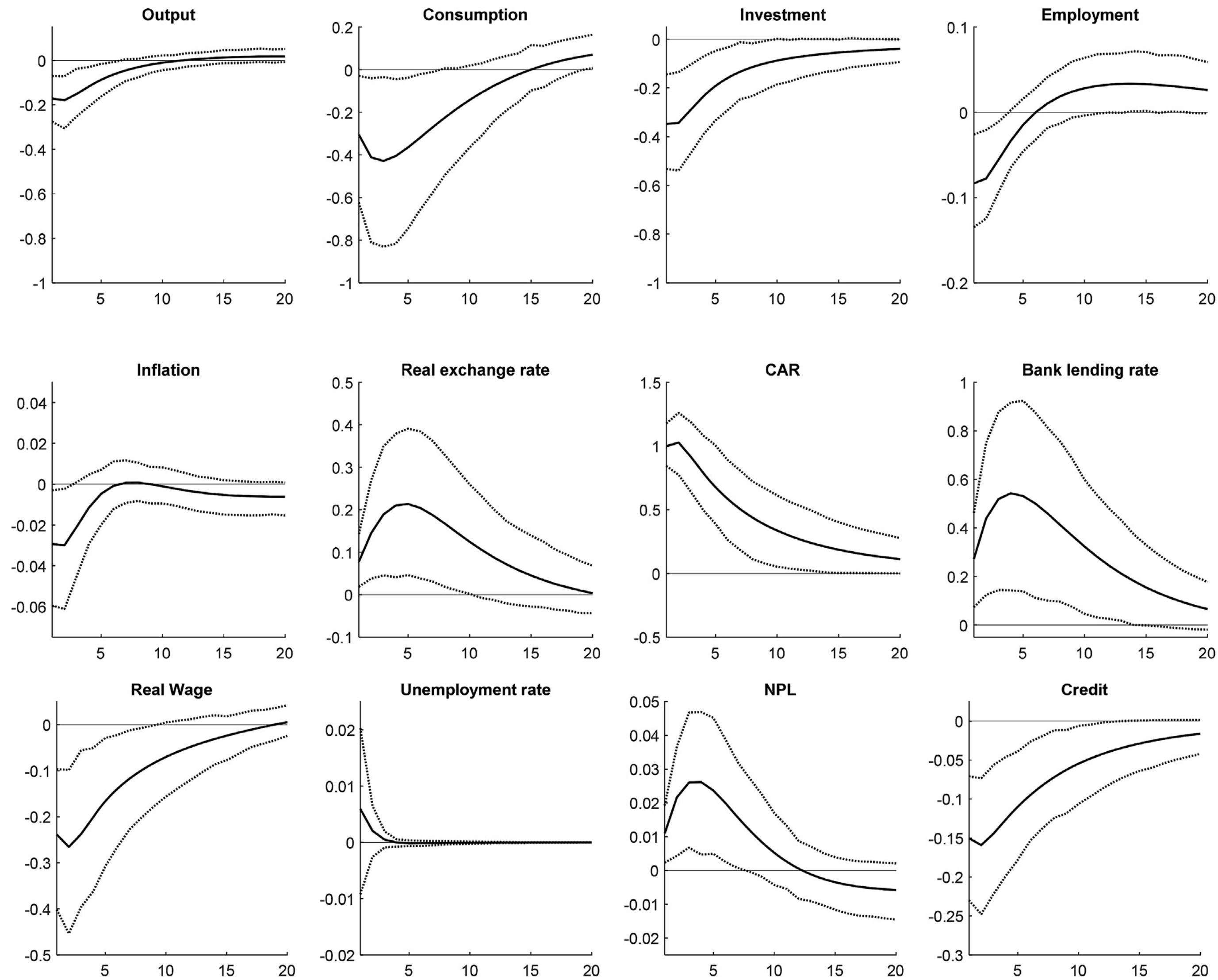


Fig. 4. Impulse response functions to a capital requirement shock.

Table 3
Quantitative impact of monetary and macroprudential policies-policy rate, reserve requirement and capital requirement shock, at posterior mean.

Lending rate	Policy rate shock		Reserve requirement shock		Capital requirement shock	
	+1	pp	+1	pp	+1	pp
Total credits	−0.12	p	−0.34	p	−0.32	p
Inflation	−2.10	pp	−0.05	pp	−0.06	pp
GDP	−3.25	p	−0.35	p	−0.36	p
Real exchange rate	−2.51	p	+0.12	p	+0.17	p
Policy rate	5.90	pp	−0.07	pp	−0.08	pp
Reserve requirement	−0.34	pp	3.50	pp	−0.06	pp
Capital requirement	−0.50	pp	−0.06	pp	2.00	pp

Note: p and pp stands for percent and percentage points, respectively. The numbers shown refer to the response of the variables at the initial stage of the shock (2 quarters).

Supply shocks have significant impact on inflation, unemployment and exchange rate fluctuations as they explain more than 60 percent of their variances. This result also suggests that the inflation volatility is led by supply-side factors. In case of Mongolian economy, high level of policy rate and nominal exchange rate fluctuations are associated with its structural vulnerability to external shocks. External and risk premium shocks jointly account for more than 50 percent of the variances of policy rate and nominal exchange rate fluctuations.

The variances of financial variables except for NPL ratio are mainly explained by the financial shocks. Financial and non-financial shocks respectively explain 60 percent and 40 percent of the variance of the bank lending rate. For NPL ratio, external, demand, supply and financial shocks respectively account for 20 percent, 35 percent, 10 percent and 35 percent of its variance.

Turning now to the importance of individual shock and policy instruments, FDI and commodity export shocks constitute fairly similar portions of the variance of GDP, household consumption, NPL ratio, inflation and nominal exchange rate (Table 5). The FDI shock is more important for the investment and policy rate fluctuations, while commodity demand and price shocks account for significant portion of the variances of labor market variables. Among demand shocks, government spending shock is the most influential shock in macroeconomic fluctuations. This is partially due to the current modeling, which lacks the transmission channel of external shock pass-through to the government budget.

Table 4
Unconditional variance decomposition of selected observed variables.

	External shocks	Risk premium shock	Supply shocks	Demand shocks	Financial shocks
y_t	25.4	0.2	15.0	58.1	1.4
c_t	14.1	6.6	9.4	61.7	8.3
i_t	36.1	0.4	2.2	57.4	3.9
l_t	20.4	0.4	23.6	54.5	1.1
s_t	25.3	1.2	34.0	38.3	1.3
q_t	20.6	6.7	32.5	35.2	4.9
n_t	20.4	0.4	23.1	55.0	1.1
rw_t	24.5	0.5	23.1	50.4	1.6
cr_t	2.5	0.1	1.5	6.0	89.9
npl_t	18.9	0.7	9.9	33.9	36.5
π_t	9.9	4.8	64.6	15.0	5.8
$4*r_t$	23.4	33.0	17.2	13.4	13.0
de_t	15.5	27.2	17.3	23.0	17.1
$\pi_{H,t}$	8.5	1.8	69.3	17.6	2.9
u_t	4.6	0.0	79.3	16.0	0.1
$r_{l,t}$	10.4	13.5	4.3	11.2	60.6
car_t	14.6	0.1	7.3	26.0	52.0
rr_t	5.6	0.0	3.0	10.1	81.3

Notes: The numbers are in percent and correspond to the mean of the posterior distribution of the variance decomposition. In this table, shocks are classified as follows. External shocks: $\varepsilon_{com,t} + \varepsilon_{fdi,t} + \varepsilon_{P^*_{com},t} + \varepsilon_{y^*,t} + \varepsilon_{r^*,t} + \varepsilon_{\pi^*,t}$; Risk premium shock: $\varepsilon_{rp,t}$; Supply shocks: $\varepsilon_{p^F,t} + \varepsilon_{p^H,t} + \varepsilon_{\omega,t} + \varepsilon_{a,t} + \varepsilon_{n,t}$; Demand shocks: $\varepsilon_{c,t} + \varepsilon_{i,t} + \varepsilon_{g,t}$; Financial shocks: $\varepsilon_{r,t} + \varepsilon_{lr,t} + \varepsilon_{Hcr,t} + \varepsilon_{Fcr,t} + \varepsilon_{Hnpl,t} + \varepsilon_{Fnpl,t} + \varepsilon_{rr,t} + \varepsilon_{car,t}$.

However, this result is in line with the fact that recent years' fiscal policies were implemented in a manner that amplified the business cycle fluctuations, despite falling commodity prices.

Contributions of unanticipated monetary and macroprudential policy actions to macroeconomic fluctuations are small. Note that forecast error variance decompositions indicate the importance of unanticipated policy shocks, but do not allow any statements about the importance of systematic policy. The unanticipated policy rate shock is not important for macroeconomic variables except for exchange rates and inflation. It explains 17 percent and 4 percent of the variations in inflation and real exchange rate, respectively. Both reserve requirement and capital requirement shocks are important for the lending rate and the total credit. They drive 10 percent and more than 20 percent of the total credit and of the lending rate fluctuations, respectively. The results suggest that in ensuring the financial stability, macroprudential policy tools such as reserve requirement and capital requirement are more effective than monetary policy rate. The policy rate is effective in stabilizing the macroeconomic environment (i.e., controlling inflation and exchange rate) compared to the other two policy tools.

5.3. Historical decomposition: how do shocks drive the economy over time?

It is important to use the estimated model to analyze historical decomposition, which describes the variation of key variables in the model over time in terms of the structural shocks. Fig. 5 displays historical decompositions of each selected observable variables by focusing on the contributions of each shock (external, demand, supply and financial shocks) over the period 2005:Q2-2017:Q2.

For commodity-based Mongolian economy, external shocks have been the main sources of macroeconomic fluctuations. The historical decomposition analysis confirms that changes in the global economy and markets affect the domestic economy through various channels such as fall in FDI, deterioration in terms of trade and shrinking demand for commodities. External shocks strongly amplified the economic difficulty during the period 2009–2010, the economic boom between 2011 and 2013, and the weak economic activity since 2015. Moreover, the external shocks had severe impact on cyclical component of investment, total credit, real wage and NPL ratio dynamics (Fig. 5A).

Demand shocks have affected the variables in opposite direction from effects of external shocks, except for investments. Volatilities in the investment are mainly explained by the domestic demand shocks. Demand shocks have increased inflation during the period 2012–2015, while supply shocks have played important role on inflation and real wage dynamics. In particular, the inflation volatility is driven by supply shocks, which is in line with the fact that share of food, petroleum, and products and services with government controlled prices in the CPI basket is high and their prices are highly volatile due to seasonality effects and underdeveloped logistics sector. Labor supply shocks pushed real wages to decline since 2014.

Impact of financial shocks on the real economy is estimated to be weak. Although in this paper, the financial shocks are modeled to have impact on investment and household consumption, the channel of financial accelerator is estimated to be weak. Financial shocks reduced inflation in 2014, and since then have been mainly responsible for the movements of financial variables.

5.4. Welfare implications: are coordinated monetary and macroprudential policies welfare loss reducing?

In this section, we aim to determine whether macroprudential policies are welfare enhancing or not. Furthermore, it is of interest whether a combination of monetary and macroprudential policies (policy rate, capital requirement and reserve requirement) would yield greater impact on social welfare. To start, following the footsteps of Angelini et al. (2014), we assume that "enhancing welfare" is equivalent to "reducing loss" and we define loss functions for policy authorities depending on their mandate. A central bank in charge of monetary policy that intends to stabilize inflation, output and changes in nominal exchange rate would aim to minimize welfare loss related to macroeconomic variables. Thus, its loss function is as follows[9]:

[9] As the loss functions are not derived from the utility of a representative household, they do not indicate anything in terms of social welfare, but we interpret them instead as embodying evaluation criteria of a policy maker who is concerned about the volatility of selected macroeconomic and financial variables.

Table 5
Unconditional variance decomposition by selected shocks.

	External shocks			Financial shocks			Demand shocks	
	$\varepsilon_{com,t}+\varepsilon_{P^*_{com},t}$	$\varepsilon_{fdi,t}$	$\varepsilon_{r,t}$	$\varepsilon_{npl^H,t}+\varepsilon_{npl^F,t}$	$\varepsilon_{rr,t}$	$\varepsilon_{car,t}$	$\varepsilon_{g,t}$	$\varepsilon_{i,t}$
y_t	13.8	11.5	0.6	0.0	0.1	0.1	43.6	12.6
c_t	5.4	8.1	1.9	0.7	1.0	1.6	34.5	2.6
i_t	1.0	35.0	0.3	0.0	0.1	0.1	2.7	54.7
l_t	12.1	8.2	0.4	0.0	0.1	0.1	44.1	8.6
s_t	17.3	7.7	0.3	0.1	0.2	0.4	34.8	2.8
q_t	13.0	7.4	4.2	0.1	0.2	0.3	32.8	2.0
n_t	12.1	8.3	0.3	0.0	0.1	0.1	43.7	9.5
rw_t	13.5	10.8	0.8	0.1	0.1	0.2	37.4	10.9
cr_t	1.4	1.1	0.1	0.1	4.3	4.3	4.6	1.2
npl_t	9.9	9.0	0.2	35.6	0.1	0.1	28.5	4.8
π_t	4.7	5.0	5.3	0.0	0.1	0.1	11.5	3.0
$4{*}r_t$	8.7	13.0	9.1	0.4	0.7	1.3	7.1	3.7
de_t	7.9	7.0	16.6	0.0	0.1	0.1	20.6	2.0
$\pi_{H,t}$	4.4	3.9	2.5	0.0	0.1	0.1	14.0	3.0
u_t	2.6	2.0	0.0	0.0	0.0	0.0	8.6	6.9
$r_{l,t}$	4.1	5.5	0.7	7.8	9.9	12.0	7.9	1.5
car_t	7.6	7.0	0.3	0.0	0.1	49.9	21.9	3.7
rr_t	2.9	2.6	0.1	0.0	80.0	0.1	8.5	1.4

Notes: The numbers are in percent and correspond to the mean of the posterior distribution of the variance decomposition.

$$\mathscr{L}^{Macro} \equiv \omega_\pi \sigma_\pi^2 + \omega_{y,\,Macro}\sigma_y^2 + \omega_{\Delta e}\sigma_{\Delta e}^2 \quad (51)$$

Macroprudential authorities (macroprudential policy) stabilize output and financial variables (i.e. credit and the lending rate), and it would aim to minimize welfare loss related to fluctuations in financial variables and output. Thus, its loss function is defined as:

$$\mathscr{L}^{Fin} \equiv \omega_{cr}\sigma_{cr}^2 + \omega_{r_l}\sigma_{r_l}^2 + \omega_{y,Fin}\sigma_y^2 \quad (52)$$

As discussed in this paper, if a single policy authority is responsible for both monetary and macroprudential policies, then its loss function becomes the sum of the above functions (51) and (52):

$$\mathscr{L} \equiv \mathscr{L}^{Macro} + \mathscr{L}^{Fin} = \omega_\pi\sigma_\pi^2 + \omega_y\sigma_y^2 + \omega_{\Delta e}\sigma_{\Delta e}^2 + \omega_{r_l}\sigma_{r_l}^2 + \omega_{cr}\sigma_{cr}^2 \quad (53)$$

where $\omega_y = \omega_{y,Macro} + \omega_{y,Fin}$, the superscripts *Macro* and *Fin* denote the macroeconomic and financial variables that are targeted by monetary and macroprudential policies, respectively.

Following Aguirre and Blanco (2015), we use estimated models to capture the potentially stabilizing properties of macroprudential policy as such models reflect the type and magnitude of shocks that the economy faced during the estimation period. Thus, by computing the estimated variance of selected macroeconomic and financial variables under different policies, we approximate the loss which the economy endured during such shocks. A comparison of losses under different combinations of policies based on estimated standard deviations of the selected macroeconomic and financial variables would determine the policies' relative and coordinated effectiveness in reducing loss. For this purpose, the following different models are estimated:

- *Model 1.* A model without macroprudential tools (i.e., capital and reserve requirement): $\mu_2 = \mu_3 = 0$, $\lambda_3^H = \lambda_4^H = \lambda_3^F = \lambda_4^F = 0$ and equations (39) and (40) are excluded from the model,
- *Model 2.* A model with exogenous capital and reserve requirements: $\varpi_2 = \varpi_3 = 0$ and $\nu_2 = \nu_3 = 0$ in equations (39)-(40),
- *Model 3.* A model with exogenous capital requirement: $\varpi_2 = \varpi_3 = 0$ in equation (39),
- *Model 4.* A model with endogenous capital requirement (only responding to credit): $\varpi_2 = 0$ in equation (39),
- *Model 5.* A model with endogenous capital requirement (only responding output): $\varpi_3 = 0$ in equation (39),
- *Model 6.* A model with exogenous reserve requirement: $\nu_2 = \nu_3 = 0$ in equation (40).
- *Model 7.* A model with endogenous reserve requirement (only responding to credit): $\nu_2 = 0$ in equation (40),
- *Model 8.* A model with endogenous capital requirement (only responding output): $\nu_3 = 0$ in equation (40),
- *Model 9.* The model estimated in section 4: capital and reserve requirements are endogenous responding to both credit and output ($\varpi_2 > 0$, $\varpi_3 > 0$, $\nu_2 > 0$, $\nu_3 > 0$).

The empirical strategy employed here (estimating various models for each policy rule) is a valid proxy to estimating and comparing coefficients which reflect behaviors reacting to each policy, that is assumed to be implemented.

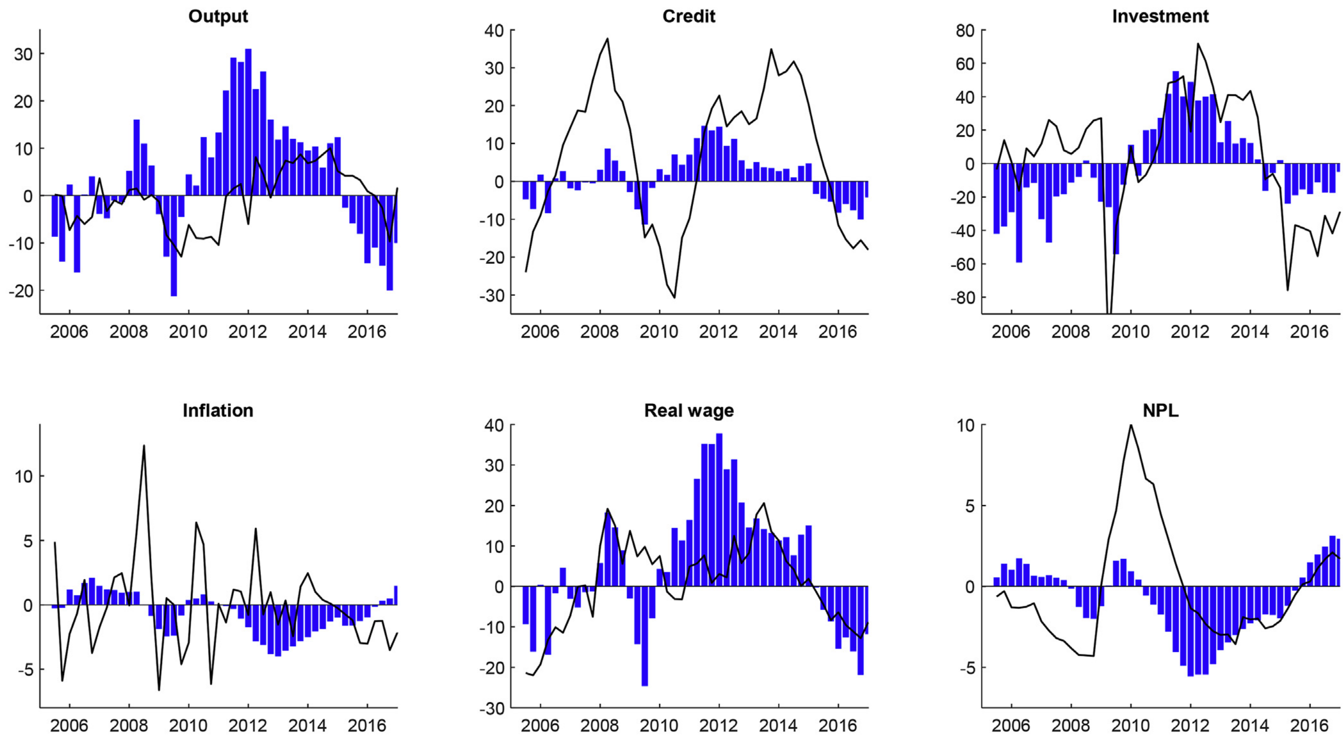
In the first 5 columns of Table 6, standard deviations of macroeconomic and financial variables under different policy (model) specifications are reported. In the last 3 columns corresponding aggregated losses related to macroeconomic and financial variables are calculated based on assumed weights.[10]

As reported in Table 6, Model 1 results in the greatest loss compared to other eight models, meaning that monetary policy measure alone does not reduce the overall loss as much as any combination of monetary and macroprudential policy measures. In other words, macroprudential policies are loss reducing or welfare enhancing compared to monetary policy measures alone.

When it comes to determining a policy combination that minimizes the loss, Model 6 (in this case only by setting the policy rate and capital requirement but not reserve requirement in response to macroeconomic and financial developments) is superior to other models, given that financial variables are assigned equal or greater weights than macroeconomic variables. However, Model 3 (in this case only by setting the policy rate and reserve requirement but not

[10] For robustness check, 3 different allocations of weights are considered, where in the first panel weights are equal, second macroeconomic variables are weighted more, and third financial variables are weighted more.

A. Contribution of external shocks



B. Contribution of demand shocks

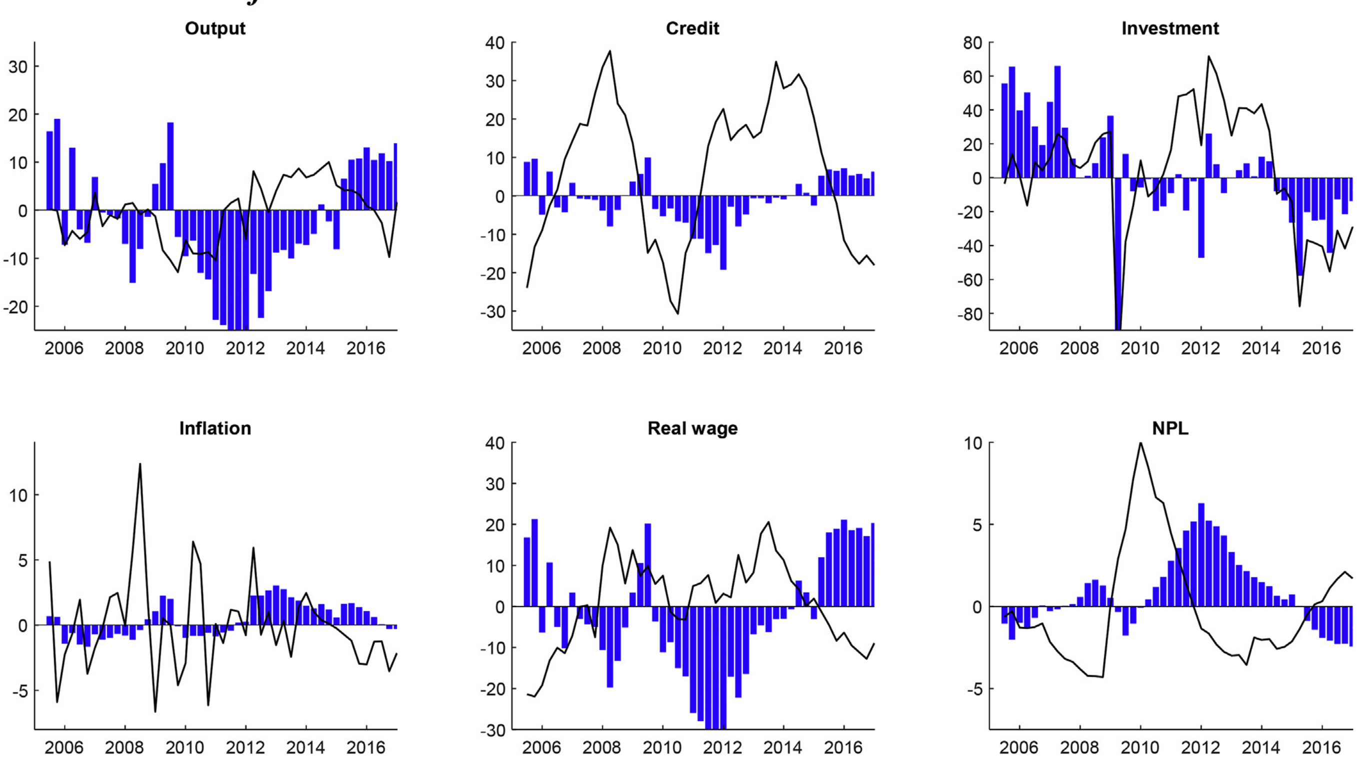
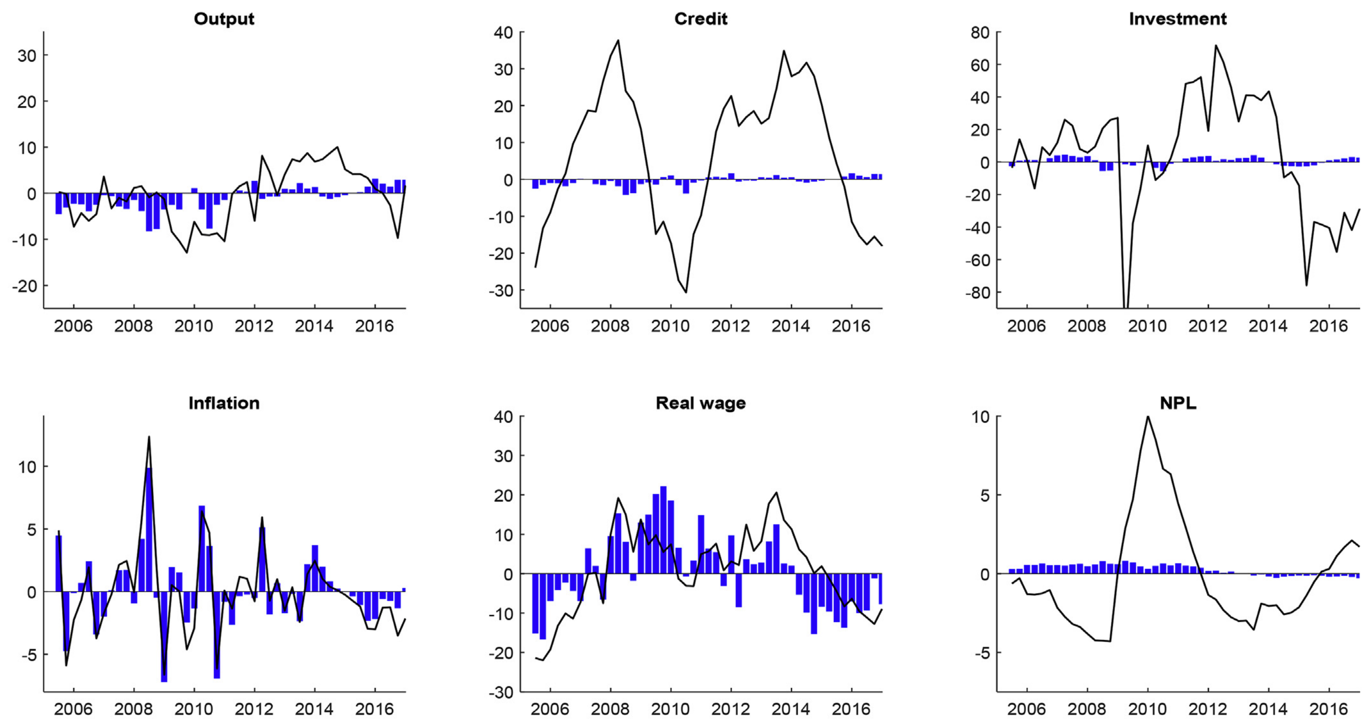


Fig. 5. Historical decomposition of the selected variables.

C. Contribution of supply shocks



D. Contribution of financial shocks

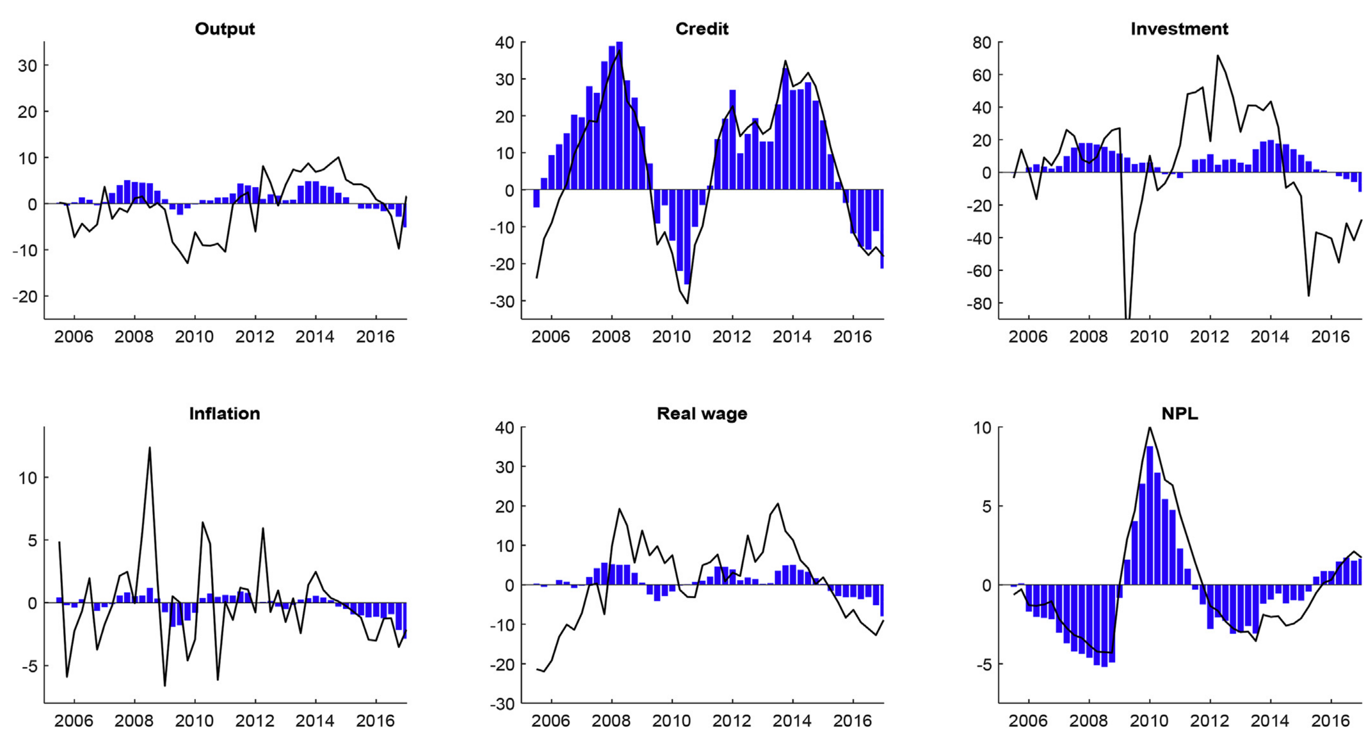


Fig. 5. (*continued*).

capital requirement in response to macroeconomic and financial developments) is superior to other models when macroeconomic variables are given greater weights than financial variables. These results imply that a policy authority's choice of policy combination (the bundle of policy rate and capital requirement or the bundle of policy rate and reserve requirement) may depend on the prioritization of policy objectives. The welfare loss analysis shows that for a policy authority that conducts both monetary and macroprudential policies, a combination of policy rate and capital requirement would result in greater loss reduction, as long as its financial stability objectives are prioritized no less than its macroeconomic stability objectives.

6. Conclusion

This paper examined the impact of monetary and macroprudential policy measures using a New Keynesian small open economy model based on the features of a commodity exporting economy. The model incorporates important features such as labor market, credit market, macroprudential policy tools such as capital and reserve requirements, and shocks of FDI, commodity demand and commodity price. It is estimated using Bayesian techniques on the Mongolian data over the period 2005Q1-2017Q2.

Considering the Bayes factor as evaluation criterion, the hypothesis that the Bank of Mongolia responds to changes in the nominal exchange rate through the policy rate is confirmed, while it is rejected that capital and reserve requirements respond to economic and credit cycles. Empirical results show that external and domestic shocks are important sources of Mongolian business cycle fluctuations. External shocks have been the root of the boom-bust cycles in the economy. As the external and government spending shocks played predominant roles in business cycle fluctuations, impacts of unanticipated change in monetary and macroprudential policy tools have been weak in recent years. External and domestic demand shocks respectively account for 25 percent and 40 percent of the forecast error variance of GDP, while unanticipated shocks of monetary and macroprudential policy jointly explain less than 1 percent of the variance.

Nevertheless, systematic and countercyclical monetary and macroprudential policy actions are important to smooth the macroeconomic and financial market fluctuations as the policy shocks have the standard features of an aggregate demand shock. Comparison of responses to different policy shocks indicates that the policy rate is important in controlling inflation and exchange rate, consistent with mainstream macroeconomic theory, while capital and reserve requirements provide a potential way of curbing credit growth without appreciating the exchange rate. Therefore, when economic and financial cycles move in an opposite direction, the policy rate is helpful in achieving the macroeconomic stability, while macroprudential tools such as capital and reserve requirements can serve as complements to the policy rate in ensuring financial stability. In addition, as the loss function analysis confirms, we find that macroprudential policy measures are welfare enhancing and the combination of the two policy measures (policy rate and capital requirement) would result in greater loss reduction, unless the policy authority's macroeconomic stability objectives are prioritized over its financial stability objectives.

Though these results have yielded significant insights about the importance of macroprudential policy in Mongolia, the current model can be further extended to introduce frictions originating

Table 6
Loss functions of alternative models: interaction between monetary and macroprudential policies.

	Loss functions[a]					Loss functions		
	π	y	Δe	cr	r_l	$\mathscr{L}^{Macro}$	$\mathscr{L}^{Fin}$	$\mathscr{L}$
Equal weights: $\omega_\pi = \omega_y = \omega_{\Delta e} = \omega_{cr} = \omega_{r_l} = \frac{1}{5}$								
Model 1	5.78	25.07	7.38	4.32	8.61	7.65	2.59	10.23
Model 2	4.45	21.92	6.38	3.59	8.02	6.55	2.32	8.87
Model 3	4.43	20.64	6.73	3.65	7.68	6.36	2.27	8.63
Model 4	4.73	24.49	6.66	3.88	8.92	7.18	2.56	9.74
Model 5	4.44	22.66	6.52	3.40	7.83	6.72	2.25	8.97
Model 6	5.18	20.41	6.87	3.03	7.44	6.49	2.09	8.59
Model 7	4.85	22.61	7.24	6.30	9.03	6.94	3.07	10.01
Model 8	4.16	23.94	6.63	3.67	9.81	6.95	2.70	9.64
Model 9	4.57	22.13	6.09	3.53	8.56	6.56	2.42	8.98
More weights on macroeconomic variables: $\omega_\pi = \omega_y = \omega_{\Delta e} = \frac{2}{8}$ and $\omega_{cr} = \omega_{r_l} = \frac{1}{8}$								
Model 1	5.78	25.07	7.38	4.32	8.61	9.56	1.62	11.17
Model 2	4.45	21.92	6.38	3.59	8.02	8.19	1.45	9.64
Model 3	4.43	20.64	6.73	3.65	7.68	7.95	1.42	9.37
Model 4	4.73	24.49	6.66	3.88	8.92	8.97	1.60	10.57
Model 5	4.44	22.66	6.52	3.40	7.83	8.41	1.40	9.81
Model 6	5.18	20.41	6.87	3.03	7.44	8.12	1.31	9.42
Model 7	4.85	22.61	7.24	6.30	9.03	8.68	1.92	10.59
Model 8	4.16	23.94	6.63	3.67	9.81	8.68	1.69	10.37
Model 9	4.57	22.13	6.09	3.53	8.56	8.20	1.51	9.71
More weights on financial variables: $\omega_\pi = \omega_y = \omega_{\Delta e} = \frac{1}{9}$ and $\omega_{cr} = \omega_{r_l} = \frac{3}{9}$								
Model 1	5.78	25.07	7.38	4.32	8.61	4.25	4.31	8.56
Model 2	4.45	21.92	6.38	3.59	8.02	3.64	3.87	7.51
Model 3	4.43	20.64	6.73	3.65	7.68	3.53	3.78	7.31
Model 4	4.73	24.49	6.66	3.88	8.92	3.99	4.27	8.25
Model 5	4.44	22.66	6.52	3.40	7.83	3.74	3.74	7.48
Model 6	5.18	20.41	6.87	3.03	7.44	3.61	3.49	7.10
Model 7	4.85	22.61	7.24	6.30	9.03	3.86	5.11	8.97
Model 8	4.16	23.94	6.63	3.67	9.81	3.86	4.49	8.35
Model 9	4.57	22.13	6.09	3.53	8.56	3.64	4.03	7.67

Notes: [a] All variables in the estimated models are in percent. Variances of the selected variables are calculated based on the posterior mean of the parameters.

within financial institutions (i.e., Gertler and Karadi, 2011, Gertler and Kiyotaki, 2011, Gertler and Kiyotaki, 2015) or collateral constraints for the agents who borrow from financial institutions (i.e., Gerali et al., 2010, Christiano et al., 2014). Alternative approaches to model financial frictions may provide grounds (i) to properly examine the transmission and significance of shocks originating within the financial sector and (ii) to assess the importance of macroprudential policies in preventing or mitigating the effects of systematic financial crisis (through bank runs, rollover problems, fire sales, firm defaults etc.).

Appendix. Data description and sources

Output: Real gross domestic product (GDP), constant 2010 prices in MNT, expenditure method, seasonally adjusted; National Statistical Office of Mongolia.

Real consumption: Real household consumption, constant 2010 prices in MNT, seasonally adjusted; National Statistical Office of Mongolia.

Real investment: Real grows capital formation, constant 2010 prices in MNT, seasonally adjusted; National Statistical Office of Mongolia.

Real commodity export: Ratio of seasonally adjusted commodity export (in USD) to seasonally adjusted US GDP implicit price deflator; The Bank of Mongolia and FRED database: GDPDEF.

Real wage: Ratio of national average nominal wage to consumer price index (CPI); National Statistical Office of Mongolia.

Nominal exchange rate: 3-month average of exchange rate (tugrug against USD); The Bank of Mongolia.

Employment: number of employees; National Statistical Office of Mongolia.

Real net inward FDI: Ratio of seasonally adjusted net inward FDI (in USD) to seasonally adjusted US GDP implicit price deflator; The Bank of Mongolia and FRED database: GDPDEF.

Real household credit: Ratio of household credit to consumer price index (CPI); National Statistical Office of Mongolia.

Real firm credit: Ratio of firm credit to consumer price index (CPI), in percent; National Statistical Office of Mongolia.

Inflation: quarterly inflation measured as log difference of CPI; National Statistical Office of Mongolia.

Domestically produced good inflation: quarterly domestic inflation measured as log difference of non-imported good CPI, in percent; Non-imported good CPI is calculated by the authors using the sub-indices of CPI and their weights.

Unemployment rate: Official unemployment rate, in percent; National Statistical Office.

Policy rate (annual): Policy rate, which is 7-day central bank bill rate, in percent; The Bank of Mongolia.

Lending rate (annual): Weighted average lending rate in MNT, in percent; The Bank of Mongolia.

Household NPL ratio: Ratio of household NPL to total household loan outstanding, in percent; Loan report, The Bank of Mongolia.

Firm NPL ratio: Ratio of firm NPL to total firm loan outstanding, in percent; Loan report, The Bank of Mongolia.

Capital requirement: Banking system's effective capital adequacy ratio (i.e., ratio of total equity to risk weighted assets), in percent; The Bank of Mongolia.

Reserve requirement: Banking system's effective reserve requirement ratio (i.e., ratio of banks' current account outstanding at the Bank of Mongolia to banks' total deposit liabilities, from which reserve requirement has to be calculated), in percent; The Bank of Mongolia.

Commodity price index: Price index of Australian thermal coal, PCOALAU; IMF external statistics, *Foreign Output:* Chinese annual GDP growth, in percent; Bloomberg database.

Foreign inflation: Quarterly inflation measured as log difference of seasonally adjusted US GDP implicit price deflator; Federal Reserve Bank of St. Louis, FRED database: GDPDEF.

Foreign interest rate: Federal funds rate, quarterly average; Reserve Bank of Australia, Statistical Table F13 International Official Interest Rates.

References

Adolfson, M., Laseen, S., Linde, J., Villani, M., 2008. Evaluating an estimated New Keynesian Small open economy model. J. Econ. Dynam. Contr. 32 (8), 2690–2721.

Aguirre, H., Blanco, E., 2015. Credit and Macroprudential Policy in an Emerging Economy: a Structural Model Assessment. BIS Working Paper No 504. Bank for International Settlements.

An, S., Schorfheide, F., 2007. Bayesian analysis of DSGE models. Econom. Rev. 26 (2–4), 113–172.

Angelini, P., Neri, S., Panetta, F., 2014. The interaction between capital requirements and monetary policy. J. Money Credit Bank. 46 (6), 1073–1112.

Areosa, W., Coelho, C., 2013. Using a DSGE Model to Assess the Macroeconomic Effects of Reserve Requirements in Brazil. Working Papers 330. Banco Central Do Brasil.

Baksa, D., Mihalyi, D., Romhanyi, B., 2017. Mongolia macro-fiscal Model: Model Guide. Unpublished manuscript. Natural Resource Governance Institute.

Brooks, S., Gelman, A., 1998. General methods for monitoring convergence of iterative simulations. J. Comput. Graph Stat. 7 (4), 434–455.

Calvo, G.A., 1983. Staggered prices in a utility-maximizing framework. J. Monetary Econ. 12 (3), 383–398.

Canova, F., 2007. Methods for Applied Macroeconomic Research. Princeton University Press, Princeton.

Carletti, F., Hartmann, P., Spagnolo, G., 2007. Bank mergers, competition and liquidity. J. Money Credit Bank. 39 (5), 1067–1105.

Carvalho, F., Castro, M., 2017. Macroprudential policy transmission and interaction with fiscal and monetary policy in an emerging economy: a DSGE model for Brazil. Macroecon. Financ. Emerg. Market Econ. 10 (3), 215–259.

Chen, Y.-C., Rogoff, K., Rossi, B., 2008. Can Exchange Rates Forecast Commodity Prices? NBER Working Paper No. 13901 NBER, Cambridge, MA.

Christiano, L., Motto, R., Rostagno, M., 2010. Financial Factors in Economic Fluctuations. Working Paper Series No 1192/May2010. European Central Bank.

Christiano, L., Motto, R., Rostagno, M., 2014. Risk shocks. Am. Econ. Rev. 104 (1), 27–65.

Del Negro, M., Schorfheide, F., 2011. Bayesian macroeconometrics. In: Geweke, J., Koop, G., van Dijk, H. (Eds.), Handbook of Bayesian Econometrics. Oxford University Press.

Del Negro, M., Schorfheide, F., 2013. DSGE model-based forecasting. In: Elliot, G., Timmerman, A. (Eds.), Handbook of Economic Forecasting, vol. 2A. North Holland, pp. 57–367.

Dutu, R., 2012. Business Cycle, Economic Policy and Forecasting: an Investigation into the Mongolian Economy Using a Bayesian-estimated DSGE Model. Unpublished manuscript. Ministry of Finance of Mongolia website.

Erceg, C.J., Henderson, D.W., Levin, A.T., 2000. Optimal monetary policy with staggered wage and price contracts. J. Monetary Econ. 46 (2), 281–313.

Fernandez-Villaverde, J., 2010. The econometrics of DSGE models. SERIEs 1, 3–49.

Galí, J., Smets, F., Wouters, R., 2011. Unemployment in an estimated new Keynesian model. NBER Macroecon. Annu. 26 (1), 329–360.

Gan-Ochir, D., 2016. Resolving High Interest Rate Puzzle in Mongolia. Working Paper, vol. 11. The Bank of Mongolia, pp. 31–63 (in Mongolian).

Gan-Ochir, D., Davaajargal, L., 2017. External shocks and business cycle fluctuations in Mongolia: evidence from a large Bayesian VAR. Money, Finance, Wealth J. 1 (1), 49–71 (in Mongolian).

Gan-Ochir, D., Dulamzaya, B., 2014. The Cost Channel of Monetary Transmission Mechanism: a Bayesian DSGE Approach. Working Paper, 9.2. The Bank of Mongolia, pp. 149–200 (In Mongolian).

Gan-Ochir, D., Kaliappa, K., 2016. Interest rate pass-through in Mongolia. Develop. Econ. 54 (4), 271–291.

Gerali, A., Neri, S., Sessa, L., Signoretti, F.M., 2010. Credit and banking in a DSGE model of the euro area. J. Money Credit Bank. 42 (1), 107–141.

Gertler, M., Karadi, P., 2011. A model of unconventional monetary policy. J. Monetary Econ. 58 (1), 17–34.

Gertler, M., Kiyotaki, N., 2011. Financial intermediation and credit policy in business cycle analysis. Chapter 11. In: Friedman, B.M., Woodford, M. (Eds.), Handbook of Monetary Economics, vol. 3A. Elsevier, pp. 547–599.

Gertler, M., Kiyotaki, N., 2015. Banking, liquidity, and bank runs in an infinite horizon economy. Am. Econ. Rev. 105 (7), 2011–2043.

Greenwood, J., Hercowitz, Z., Huffman, G., 1988. Investment, capacity utilization and the real business cycle. Am. Econ. Rev. 78 (3), 402–417.

Guerrón-Quintana, P., Nason, J., 2012. Bayesian Estimation of DSGE Models. Working Papers, no. 12–14. Federal Reserve Bank of Philadelphia.

Henzel, S., Hülsewig, O., Mayer, E., Wollmershäuser, T., 2009. The price puzzle revisited: can the cost channel explain a rise in inflation after a monetary policy shock? J. Macroecon. 31 (2), 268–289.

Hülsewig, O., Mayer, E., Wollmershäuser, T., 2009. Bank behavior, incomplete

interest rate pass- through, and the cost channel of monetary policy transmission. Econ. Modell. 26 (6), 1310–1327.
Jääskelä, J., Nimark, K., 2011. A medium-scale New Keynesian open economy model of Australia. Econ. Rec. 87 (276), 11–36.
Justiniano, A., Preston, B., 2010a. Monetary policy and uncertainty in an empirical small open economy model. J. Appl. Econom. 25 (1), 93–128.
Justiniano, A., Preston, B., 2010b. Can structural small open-economy models account for the influence of foreign disturbances? J. Int. Econ. 81 (1), 61–74.
Kass, R., Raftery, A., 1995. Bayes factors. J. Am. Stat. Assoc. 90 (430), 773–795.
Kiley, M., 2016. Macroeconomic Modeling of Financial Frictions for Macroprudential Policy Making: a Review of Pressing Challenges. FEDS Notes, May 26, 2016.
Maino, R., Imam, P., Ojima, Y., 2013. Macroprudential Policies for a Resource Rich Economy: the Case of Mongolia. IMF Working Paper WP/13/18. International Monetary Fund.
Munkhchimeg, S., Tsenguunjav, B., 2016. Living with volatilities: capital flows and their implications for central bank policies in Mongolia. Chapter 6. In: Becker, C. (Ed.), Living with Volatilities: Capital Flows and Policy Implications for SEACEN Central Banks. The South East Asian Central Banks (SEACEN) Research and Training Centre, Kuala-Lumpur.
Nimark, K., 2009. A Structural model of Australia as s small open economy. Aust. Econ. Rev. 42 (1), 24–41.
Quint, D., Rabanal, P., 2014. Monetary and macroprudential in an estimated DSGE model of Euro Area. Int. J. Cent. Bank. 10 (2), 169–236.
Rabanal, P., 2007. Does inflation increase after a monetary policy tightening? Answers based on an estimated DSGE model. J. Econ. Dynam. Contr. 31 (3), 1–20, pp. 906-937. 1.
Rees, D., Smith, P., Hall, J., 2016. A multi-sector model of the Australian economy. Econ. Rec. 92 (298), 374–408.
Smets, F., Wouters, R., 2003. An estimated dynamic stochastic general equilibrium model of the euro area. J. Eur. Econ. Assoc. 1 (5), 1123–1175.
Smets, F., Wouters, R., 2007. Shocks and frictions in us business cycle: a Bayesian DSGE approach. Am. Econ. Rev. 97 (3), 586–606.
Suh, H., 2012. Macroprudential Policy: its Effects and Relationship to Monetary Policy. Working Paper No. 12–28. Federal Reserve Bank of Philadelphia.