SMALL INFLATION MODEL OF MONGOLIA (SIMOM) †

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April 2008

† Opinions expressed in this paper are of the authors and do not necessarily correspond to the opinions of the institutions they work for. The authors wish to thank Boldbaatar Dagva, Ryszard Kokoszczyński and Ewa Wróbel for their comments and suggestions to the model. All the further comments and suggestions are very welcome.

ABSTRACT

This paper describes a preliminary version of the small inflation model of Mongolia (SI-MOM), a successor of the inflation model built at the Bank of Mongolia (in cooperation with the National Bank of Poland) by Urgamalsuvd Nanjid in July 2007. The model is rooted in theoretical concepts, however – due to the fact that it will be used for regular inflation forecasting at the Bank of Mongolia – it is the empirical adequacy and consistency, which played the most important role in solutions applied while building it. The SIMOM consists of ten estimated equations – domestic currency loan rate and foreign currency loan rate equations, the IS curve, the LM curve, the exchange rate equation, the Phillips curve in terms of the net inflation (excluding food prices and fuel prices), food price dynamics and fuel price dynamics equations as well as approximating (ad-hoc) equations for the real GDP and public wage. In the paper we discuss each equation and present in detail estimation results.

The intended primary use of the model is analysis of the monetary transmission mechanism and the inflation process in Mongolia, estimation of dynamic responses of selected variables to different shocks hitting the Mongolian economy as well as forecasting macroeconomic categories (e.g. exchange rate, output gap, inflation) over a medium term, consistent with the lags in the monetary transmission mechanism.

Conclusions from the paper are the following: Mongolian inflation is driven by a large number of shocks, both internal and external. At the same time the effectiveness of the monetary transmission mechanism is relatively weak (although stronger than previously perceived). The exchange rate channel seems to be the most important channel of monetary transmission mechanism in Mongolia.

I. INTRODUCTION

It is widely recognized that due to the lags in the monetary transmission mechanism, monetary policy actions should be forward-looking. Therefore inflation forecasts constitute extremely important input to the decision making process at central banks. They are also principal communication tool of central banks.

Central banks use many sources of information to predict future inflation rate. For this purpose they usually make inflation forecast by using different types of economic models, characterized by different degrees of theoretical and empirical coherence (Pagan, 2002, 2003). Moreover, central banks – especially inflation targeting ones – collect information on private agents' (producers', consumers', financial markets') inflation expectations, which affect the inflation process (Łyziak, 2005).

In recent years, the Bank of Mongolia has also paid attention to enlarging the information set used in the decision making process and making it more forward looking. Research studies on the Mongolian economy and econometric models aimed at forecasting macroeconomic performance have been developed.

In this paper, we present a new small scale model SIMOM built to analyse features of the monetary transmission mechanism and of the inflation process in Mongolia. Moreover, we formulate some recommendations on the future improvement in terms of modeling and forecasting at the Bank of Mongolia, especially in the context of likely adoption of the inflation targeting strategy in future.

Evaluating the model we took into account the three following characteristics:

- Firstly, we analysed statistical properties of the model equations and their economic consistency.
- Secondly, we derived responses of selected variables to different types of shocks and assessed their adequacy on the basis of our knowledge concerning the Mongolian economy.
- Thirdly, we performed additional checks of the forecasting properties of the endogenous part of the model.

This paper is structured in the following way. Section II presents a detailed description of the model. Section III shows estimation results of parameters of the model equations. Section IV presents simulations of the model, while section V is focused on forecasting accuracy of the model. Finally, section VI offers some conclusions and recommendations.

II. DETAILED DESCRIPTION OF THE MODEL

In this section we present a small scale highly aggregated model of the Mongolian economy, SIMOM. Such small-scale models have been used in many central banks to understand monetary transmission mechanism, derive optimal policy rules or forecast inflation (e.g. Bank of England, 1999; Batini and Haldane, 1999; Łyziak, 2002; Kłos et al., 2005). The SIMOM was designed to capture specific features of the inflation process in Mongolia.

The model is both theoretically and empirically based, although empirical consistency was the priority while building it. There are following estimated equations in the model:

- **Domestic currency loan rate equation:** domestic currency loan rate depends on: (1) its lag; (2) monetary policy rate; (3) reserve money (M0); (4) seasonal dummy variables.
- **Foreign currency loan rate equation:** foreign currency loan rate depends on: (1) its lag; (2) monetary policy rate; (3) reserve money (M0); (4) a seasonal dummy variable.
- **IS curve:** output gap depends on: (1) real average loan rate; (2) real effective exchange rate; (3) foreign demand (Chinese economic growth); (4) change in exported commodity prices (copper and gold prices); (5) reserve money (M0); (6) a dummy variable.
- **LM curve:** reserve money (M0) depends on: (1) its lag; (2) monetary policy rate; (3) real GDP; (4) Fiscal expenditure; (5) seasonal dummy variable; (6) dummy variable related to changes in regulation on central bank bill auctions.
- **Exchange rate equation:** USD/MNT exchange rate depends on: (1) its lag; (2) interest rate disparity; (3) PPP deviation; (4) change in exported commodity price (gold); (5) fiscal expenditure relative to GDP (proxy for the risk premium); (6) cross exchange rate of Yuan against US dollar.
- **Phillips curve:** net inflation depends on: (1) its lag; (2) fuel price inflation; (3) output gap, (4) public wage growth; (5) import price growth; (6) a seasonal dummy variable.
- **Food price dynamics:** food price inflation depends on: (1) its lag; (2) net inflation; (3) headline inflation; (4) dummy variable related to significant increase in oil price and exchange rate; (5) a seasonal dummy variable.
- **Fuel price dynamics:** fuel price inflation depends on: (1) growth of oil price in the world market; (2) changes in the USD/MNT exchange rate; (3) a seasonal dummy.
- **Real GDP equation (approximating equation, ad-hoc specification):** GDP in real term depends on: (1) its lag; (2) the output gap; (3) seasonal dummy variables.
- **Public wage equation (approximating equation, ad-hoc specification):** public wage depends on: (1) its lag; (2) real GDP; (3) change in exported commodity prices (copper and gold prices); (4) seasonal dummy variables.

The equations and identities of the model are the following:

INTEREST RATES

Domestic currency loan rate equation:

$$lr_t^{dc} - lr_{t-1}^{dc} = c_{lr^{dc}} + \alpha_1\left(lr_{t-1}^{dc} + \alpha_2 m0_{t-1}\right) + \alpha_3\left(i_{t-2} - i_{t-3}\right) + \alpha_4 S^2 + \alpha_5 S^3, \quad \alpha_1 < 0 \tag{1}$$

Foreign currency loan rate equation:

$$lr_t^{fc} - lr_{t-1}^{fc} = c_{lr^{fc}} + \beta_1\left(lr_{t-1}^{fc} + \beta_2 m0_{t-1}\right) + \beta_3(i_{t-1} - i_{t-2}) + \beta_4 S^2, \ \beta_1 < 0 \tag{2}$$

Average loan rate in nominal and real terms:

$$lr_t^{ave} = w_t^{fc} lr_t^{fc} + \left(1 - w_t^{fc}\right) lr_t^{dc} \tag{3}$$

$$lr_{q,t}^{ave} = lr_t^{ave} / 4 \tag{4}$$

$$rlr_{q,t}^{ave} = lr_{q,t}^{ave} - \pi_{t-1} \tag{5}$$

IS CURVE

$$\hat{y}_t = c_{\hat{y}} + \gamma_1 rlr_{q,t-3}^{ave} + \gamma_2 e_{t-3}^r + \gamma_3\left(\Delta_4 y_{t-2}^{China}\right) + \gamma_4\left(p_{t-3}^{cop} - p_{t-4}^{cop}\right) + \gamma_5\left(p_{t-0}^{gold} - p_{t-1}^{gold}\right) + \\ + \gamma_6\left(m0_{t-3} - m0_{t-4}\right) + \gamma_7 D_{Q4,03} \tag{6}$$

LM CURVE

$$m0_t = \phi_1 m0_{t-1} + \phi_2 i_t + \phi_3 y_t + \phi_4 rfe_t + \phi_5 D_{Q3,07} + \phi_6 S^4 \tag{7}$$

EXCHANGE RATE EQUATION

$$e_t^{USD/MNT} = \varphi_1 e_{t-1}^{USD/MNT} + \varphi_2 e_{t-2}^{USD/MNT} + \varphi_3\left(lr_t^{dc} - i_t^f\right) + \varphi_4 dev\_ppp_{t-1} + \\ + \varphi_5\left(p_{t-2}^{gold} - p_{t-3}^{gold}\right) + \varphi_6 rfe_{t-3} + \varphi_7 e_{t-1}^{RMB/USD} \tag{8}$$

PRICE SYSTEM

Phillips curve (net inflation equation):

$$\pi_t^N = c_{\pi^N} + \theta_1 \pi_{t-1}^N + \theta_2 \pi_t^O + \theta_3 \hat{y}_{t-3} + \theta_4\left(p_{t-2}^{IM\_D} - p_{t-3}^{IM\_D}\right) + \theta_5\left(w_{t-2}^P - w_{t-3}^P\right) + \theta_6 S^2 \tag{9}$$

Food price dynamics:

$$\pi_t^F = c_{\pi^F} + \delta_1\left(\pi_{t-1}^F + \pi_{t-1}\right) + \delta_2 \pi_{t-1}^N + \delta_3 \pi_{t-2}^F + \delta_4 S^2 \tag{10}$$

Fuel price dynamics:

$$\pi_t^0 = c_{\pi^0} + \lambda_1\left(p_{t-2}^{oil} - p_{t-3}^{oil}\right) + \lambda_2\left(p_t^{oil} - p_{t-1}^{oil}\right) + \lambda_3\left(e_{t-3}^{USD/MNT} - e_{t-4}^{USD/MNT}\right) + \lambda_4 S^1 \tag{11}$$

Quarterly CPI inflation:

$$\pi_t = w_t^F \pi_t^F + w_t^O \pi_t^O + \left(1 - w_t^F - w_t^O\right) \pi_t^N \tag{12}$$

Annual CPI inflation:

$$\Pi_t = (1+\pi_t)(1+\pi_{t-1})(1+\pi_{t-2})(1+\pi_{t-3})-1 \quad (13)$$

$$\Pi_t^N = (1+\pi_t^N)(1+\pi_{t-1}^N)(1+\pi_{t-2}^N)(1+\pi_{t-3}^N)-1 \quad (14)$$

$$\Pi_t^F = (1+\pi_t^F)(1+\pi_{t-1}^F)(1+\pi_{t-2}^F)(1+\pi_{t-3}^F)-1 \quad (15)$$

$$\Pi_t^O = (1+\pi_t^O)(1+\pi_{t-1}^O)(1+\pi_{t-2}^O)(1+\pi_{t-3}^O)-1 \quad (16)$$

APPROXIMATING EQUATIONS (AD-HOC SPECIFICATIONS)

Real GDP equation:

$$y_t - y_{t-1} = \vartheta_1 \hat{y}_t + \vartheta_2 S^1 + \vartheta_3 S^2 + \vartheta_4 S^4 \quad (17)$$

Public wage equation:

$$w_t^P = c_{w^P} + \eta_1 w_{t-1}^P + \eta_2 y_t + \eta_3 p_{t-1}^{gold\&cop} + \eta_4 S^1 + \eta_5 S^2 + \eta_6 S^3 \text{ or:} \quad (18)$$

$$w_t^P = w_{t-1}^P + \pi_{t-1} \quad (19)$$

DEFINITIONS

Prices (CPI):

$$p_t = p_{t-1} + \pi_t \quad (20)$$

$$p_t^F = p_{t-1}^F + \pi_t^F \quad (21)$$

Import prices:

$$p_t^{IM\_D} = p_t^{IM\_F} - e_t^{USD/MNT} \quad (22)$$

$$p_t^{IM\_F} = w_t^{RMB}\left(p_t^{china} - Index^{RMB}\right) + \left(1 - w_t^{RMB}\right)p_t^{USA}, \quad w_t^{RMB} = 0.05 \quad (23)$$

Exchange rates:

$$e_t^n = e_t^{USD/MNT} + w_t^{RMB} e_t^{RMB/USD}, \; w_t^{RMB} = 0.05 \quad (24)$$

$$e_t^r = e_t^n + p - p^{IM\_F} \quad (25)$$

PPP deviation:

$$dev\_ppp_t = e_t^{USD/MNT} - ppp_t \quad (26)$$

$$ppp_t = p_t - w_t^{RMB}\left(p_t^{china} - Index^{RMB}\right) + \left(1 - w_t^{RMB}\right)p_t^{USA}, w_t^{RMB} = 0.05 \quad (27)$$

Nominal GDP:

$$y_t^n = \hat{y}_t + p \quad (28)$$

Fiscal expenditure relative to GDP:

$$rfe_t = fe_t - y_t^n \quad (29)$$

Other prices:

$$p_t^{gold\&cop} = w_t^{cop} p_t^{cop} + \left(1 - w_t^{cop}\right) p_t^{gold} \quad (30)$$

$$p_t^{China} = p_{t-4}^{China} + \pi_t^{China} \quad (31)$$

$$p_t^{USA} = p_{t-4}^{USA} + \pi_t^{USA} \quad (32)$$

The following symbols have been used:

lr^{dc} - domestic currency loan rate in nominal terms (annual);

i - short-term BoM bill rate (monetary policy rate) in nominal terms (annual);

$m0$ - reserve money M0 (in logs);

S^d - d-quarter seasonal dummy;

lr^{fc} - foreign currency loan rate in nominal terms (annual);

lr^{ave} - weighted average of domestic and foreign currency loan rates in nominal terms (annual);

lr_q^{ave} - weighted average of domestic and foreign currency loan rates in nominal terms (quarterly);

rlr_q^{ave} - weighted average of domestic and foreign currency loan rates in real terms (quarterly);

w_t^{fc} - weight of foreign currency loans in total loans;

π - inflation, quarter on quarter;

$\hat{y}$ - output gap;

e^r - real effective exchange rate (in logs);

Δy^{China} - real GDP growth rate in China;

p^{cop} - copper price (in logs);

p^{gold} - gold price (in logs);

$D_{Q4,03}$ - dummy variable for the 4th quarter 2003;

$D_{Q3,07}$ - dummy variable for the 3rd quarter 2007 (related to the changing of required reserve regulation);

y_t - real GDP (in logs);

$e_t^{USD/MNT}$ - USD/MNT exchange rate (in logs);

i_t^f - LIBOR 3M in nominal terms;

ppp - USD/MNT exchange rate (in logs) consistent with purchasing power parity (PPP);

dev_ppp - deviation of the USD/MNT exchange rate (in logs) from *ppp*;

$p^{gold\&cop}$ - weighted price index of gold and copper (in logs);

w_t^{cop} - copper weight in the weighted average price index of copper and gold;

rfe - fiscal expenditures related to the GDP;

π^N - net inflation (price growth of consumer goods and services excluding food and fuels), quarter on quarter;

π^F - food price dynamics, quarter on quarter;

π^O - fuel price dynamics, quarter on quarter

w^F - weight of food in the CPI basket;

w^O - weight of fuels in the CPI basket;

$p_t^{IM\_F}$ - import prices in foreign currency (in logs);

p^{IM_D} - import prices in domestic currency (in logs);

w^P - wage in the public sector (in logs);

p^{oil} - USD oil price per barrel in international markets (in logs);

Π - CPI inflation, year-on-year;

Π^N - net inflation, year-on-year;

Π^F - food price dynamics, year-on-year;

Π_t^O - fuel price dynamics, year-on-year;

p - headline consumer price index (CPI);

p^F - food price index;

$e^{RMB/USD}$ - RMB/USD exchange rate (in logs);

e^n - nominal effective exchange rate (in logs);

w^{RBM} - Chinese RMB weight used to calculate the nominal effective exchange rate (5%);

p^{china} - Chinese CPI (in logs);

p^{USA} - US CPI (in logs);

y^n - nominal GDP (in logs);

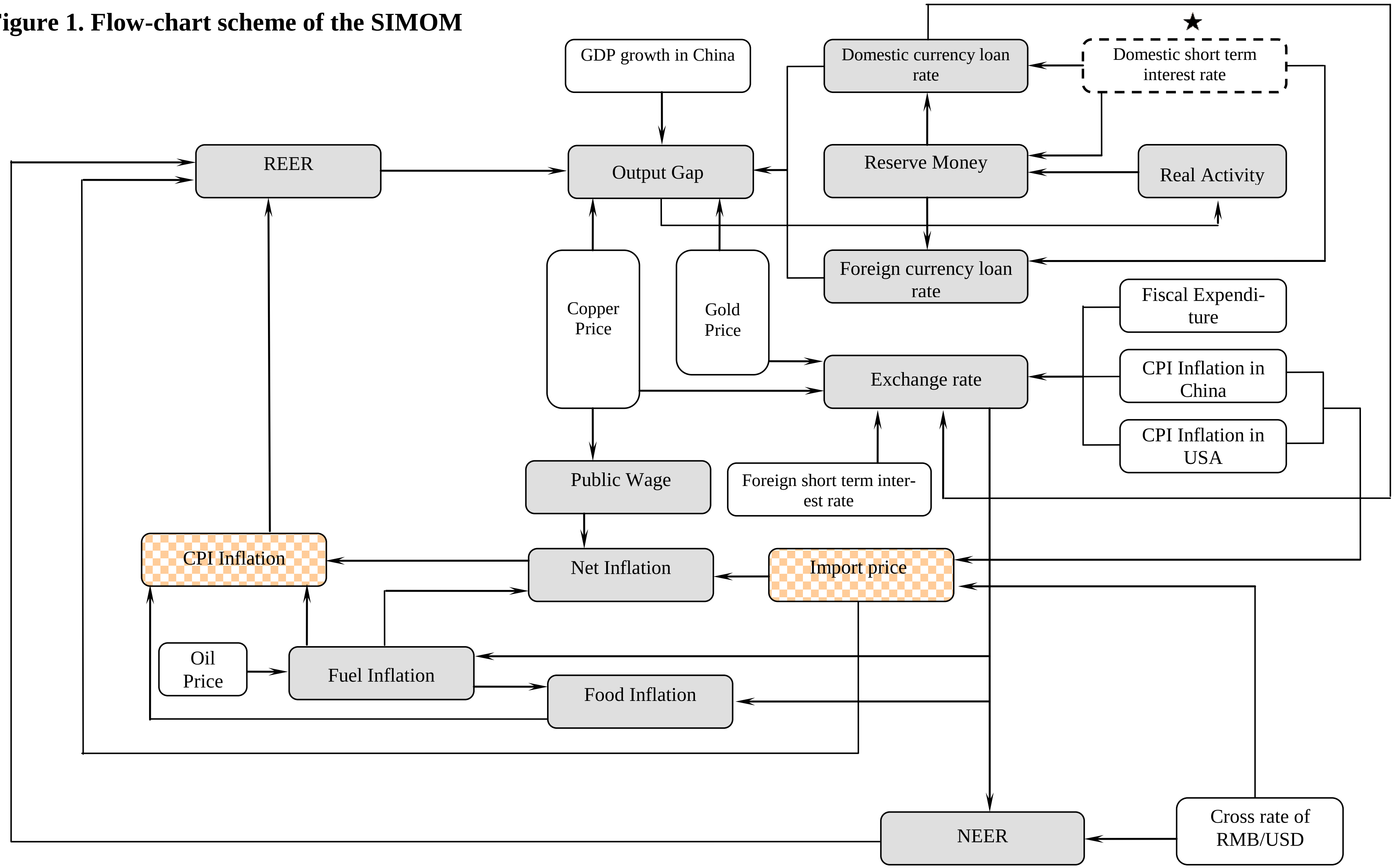
fe - fiscal expenditures, in nominal terms (in logs);

π_t^{China} - Chinese CPI inflation, year-on-year;

π^{USA} - US inflation, year-on-year.

There are 12 endogenous and 10 exogenous variables in the model. The relationships between these variables are summarized using the flow-chart (Figure 1), with endogenous variables shown in the grey boxes. We can use the flow-chart to understand the main linkages in the model.

Figure 1. Flow-chart scheme of the SIMOM



Comments:

★ - Starting point
- Endogenous variables
- Exogenous variables
- Identities

III. ESTIMATION RESULTS

We estimated the model with OLS technique equation by equation using quarterly time series covering the period 2001Q1-2008Q1. Model variables are not subject to seasonal adjustment – the exception is the GDP series, which is used to determine the output gap. However, in some of the equations there is a need to include seasonal dummies in order to capture strong seasonality in the Mongolian economy. The model uses a statistical measure of the output gap (obtained with the use of Hodrick-Prescott filter). Data sources are presented in the Annex 1 and equations' estimations with principal diagnostics are show in Annex 2.

Table 1 presents estimated parameters of the SIMOM.

Table 1. Estimated parameters of the SIMOM

Coefficient	Value (S.E. if estimated)	Interpretation	Equation
$c_{lr^{dc}}$	1.28	Intercept	(1) Domestic currency loan rate equation
α_1	-0.62	ECM parameter	
α_2	0.14	reserve money (long run)	
α_3	0.12	lagged change in monetary policy rate	
α_4	-0.02	2nd quarter seasonal dummy	
α_5	0.01	3rd quarter seasonal dummy	
$c_{lr^{fc}}$	0.73	Intercept	(2) Foreign currency loan rate equation
β_1	-0.69	ECM parameter	
β_2	0.07	reserve money (long run)	
β_3	0.12	lagged change in monetary policy rate	
β_4	0.01	2nd quarter seasonal dummy	
$c_{\hat{y}}$	-1.27	Intercept	(3) IS curve
γ_1	-0.26	lagged weighted average loan rate in real terms	
γ_2	-0.15	lagged real effective exchange rate	
γ_3	2.79	lagged Chinese GDP growth	
γ_4	-0.07	growth in the copper price, 3 lags	
γ_5	-0.26	lagged growth in the gold price	
γ_6	0.14	lagged reserve money	
γ_7	-0.04	dummy variable for 2003Q4	
ϕ_1	0.61	lagged reserve money	
ϕ_2	-1.26	monetary policy rate	

Coefficient	Value (S.E. if estimated)	Interpretation	Equation
ϕ_3	0.16	real activity (real GDP)	**(4) LM curve**
ϕ_4	0.23	lagged relative fiscal expenditures	
ϕ_5	-0.22	4^{th} quarter seasonal dummy	
ϕ_6	-0.06	dummy variable for 2007Q3	
φ_1	0.50	lagged exchange rate (1 lag)	**(5) Exchange rate equation**
φ_2	0.43	Interest rate disparity	
φ_3	0.09	lagged PPP deviation	
φ_4	0.06	change in the gold prices	
φ_5	0.14	lagged relative fiscal expenditures (risk premium)	
φ_6	-0.04	lagged exchange rate of Yuan against US dollar	
φ_7	-0.17	lagged exchange rate (2 lags)	
c_{π^N}	0.01	Intercept	**(6) Phillips curve (net inflation equation)**
θ_1	-0.33	lagged net inflation	
θ_2	0.08	fuel price inflation	
θ_3	0.15	lagged output gap	
θ_4	0.27	lagged import price growth	
θ_5	0.12	lagged public wage growth	
θ_6	-0.03	2^{nd} quarter seasonal dummy	
c_{π^F}	-1.90	Intercept	**(7) Food price dynamics**
δ_1	-0.41	Relative price	
δ_2	1.19	Net Inflation	
δ_3	-0.42	Food price inflation	
δ_4	0.11	dummy variable for 2007Q4	
c_{π^O}	0.04	Intercept	**(8) Fuel price dynamics**
λ_1	0.41	change in the oil price per barrel in the world market, 2 lags	
λ_2	0.18	change in the oil price per barrel in the world market, 3 lags	
λ_3	-2.05	change in USD/MNT exchange rate	
λ_4	-0.09	1^{st} quarter seasonal dummy	
ϑ_1	0.84	output gap	**(9) Real GDP equation (ad-hoc**
ϑ_2	-0.40	1^{st} quarter seasonal dummy	

Coefficient	Value (S.E. if estimated)	Interpretation	Equation
ϑ_3	0.44	2nd quarter seasonal dummy	**specification)**
ϑ_4	0.08	4th quarter seasonal dummy	
c_{w^P}	-6.06	Intercept	**(10) Public wage equation (ad-hoc specification)**
η_1	0.74	lagged public wage	
η_2	0.52	real GDP	
η_3	0.04	Weighted average price of copper and gold	
η_4	0.22	1st quarter seasonal dummy	
η_5	0.07	2nd quarter seasonal dummy	
η_6	-0.11	3rd quarter seasonal dummy	

The estimated coefficients seem to be in line with our expectations, economic intuition and data typical for small open economies. Signs of estimated coefficients are theoretically and empirically consistent. Diagnostic tests of the SIMOM equations are satisfactory (see Annex 2).

IV. SIMULATIONS OF THE MODEL

After estimating the model we checked its dynamic properties by conducting different simulations. They allowed us analyzing responses of different variables to a number of shocks and comparing them with our intuition. Below we present the response of annual inflation to the following shocks:

(1) ***Chinese GDP growth impulse:*** increase of the Chinese GDP growth by 1 pp for 4 quarters;

(2) ***Fiscal expenditure impulse:*** increase of fiscal expenditures by 10% for 1 quarter;

(3) ***Domestic interest rate temporary impulse:*** increase of the domestic short-term interest rate by 1 pp for 4 quarters (or for 8 quarters);

(4) ***Domestic interest rate permanent impulse:*** increase of the domestic short-term interest rate permanently;

(5) ***Oil price impulse:*** increase of oil prices in international markets by 10% for 4 quarters;

(6) ***Copper price impulse:*** increase of the copper price by 10% for 4 quarters;

(7) ***Gold price impulse:*** increase of the gold price by 10% for 4 quarters;

(8) ***Chinese inflation impulse:*** increase of Chinese inflation by 1 pp for 4 quarters;

(9) ***RMB/USD cross exchange rate impulse:*** increase of the RMB/USD exchange rate (USD appreciation) by 1% for 1 quarter;

(10) ***US inflation impulse:*** increase of the US inflation by 1 pp for 4 quarters;

(11) ***Food price impulse:*** increase of the q-o-q food inflation by 1 pp for 1 quarter;

(12) ***Foreign interest rate impulse:*** increase of the foreign short-term interest rate by 1 pp for 4 quarters.

Below we inspect in detail the results of the monetary transmission mechanism simulation, in which we change the short-term domestic interest rate by 1 pp for 8 quarters (Figure 2) as well as present annual inflation responses to the shocks defined above (Figure 3).

In the monetary transmission mechanism simulation we present inflation response to the interest rate changes including both interest rate channel and exchange rate channel effects and separately we assess the importance of the interest rate channel. It seems that the exchange rate channel constitutes the dominant channel of monetary transmission mechanism in the Mongolian economy.

The maximum impact of monetary policy changes on inflation manifests in the 9th quarter after an 8-quarter interest rate impulse. It equals approximately 0.3 pp. Monetary policy actions are relatively good in terms of their impact on inflation. As far as the maximum impact is concerned, the effects of interest rate changes defined above are roughly the same as:

- oil price change by less than 1% (average absolute quarterly change: 6%);
- change in the Chinese GDP by 0.1 pp (average absolute quarterly change: 0.6 pp);
- increase of fiscal expenditures by 7.5% (average absolute quarterly change: 20%);
- change in copper price by 2.5% (average absolute quarterly change: 8%).

Figure 2, part 1: Reaction of different variables to the increase of the domestic short-term interest rates by 1 pp for 8 quarters

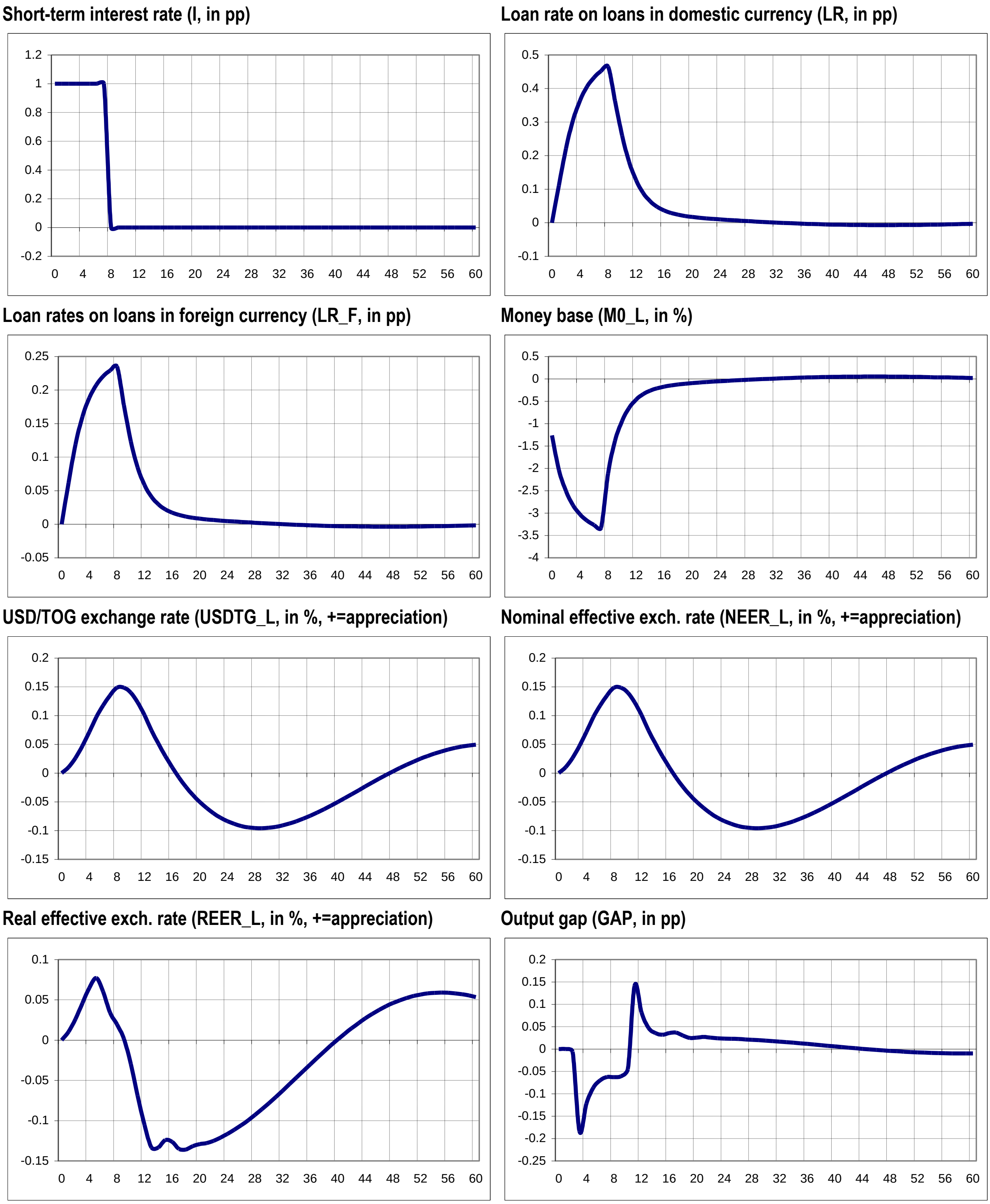
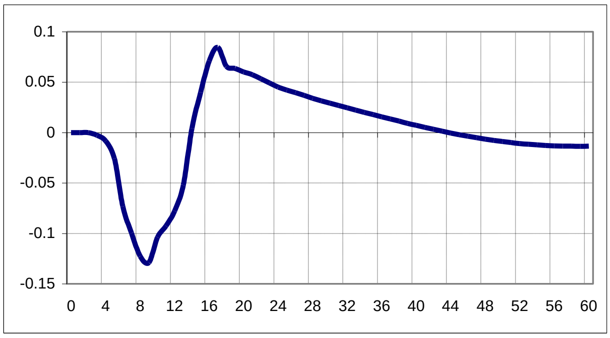
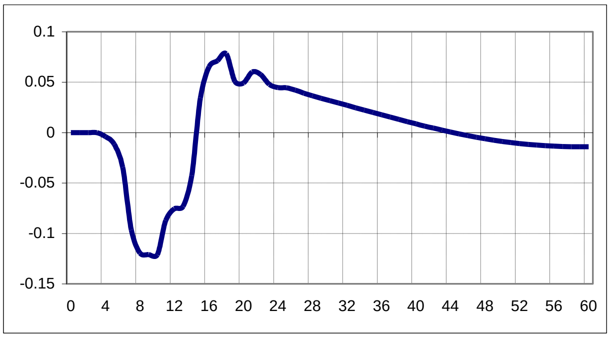


Figure 2, part 2: Reaction of different variables to the increase of the domestic short-term interest rates by 1 pp for 8 quarters

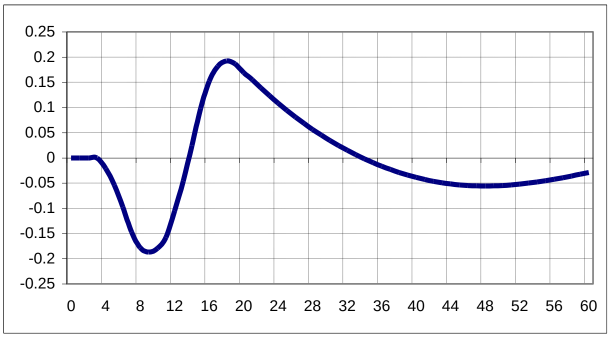
Annual net inflation (ANINF, in pp)



Annual food inflation (AFINF, in pp)



Annual fuel inflation (AOINF, in pp)



Annual CPI inflation (AINF, in pp)

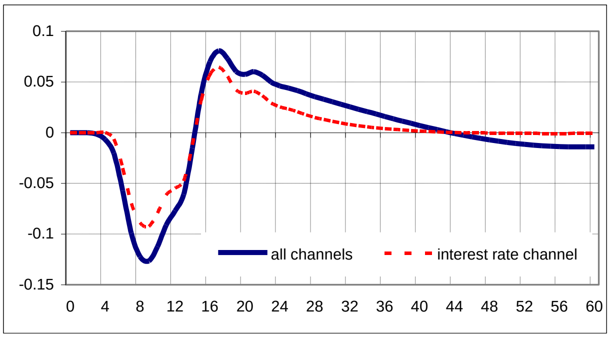
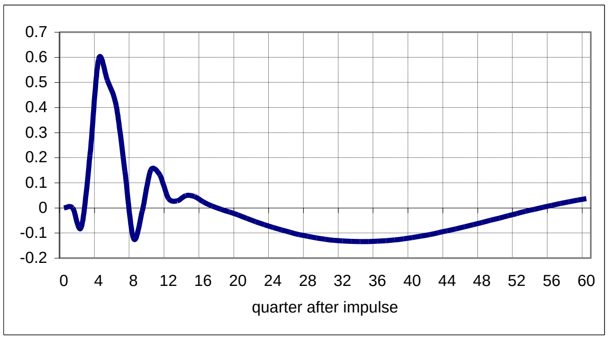
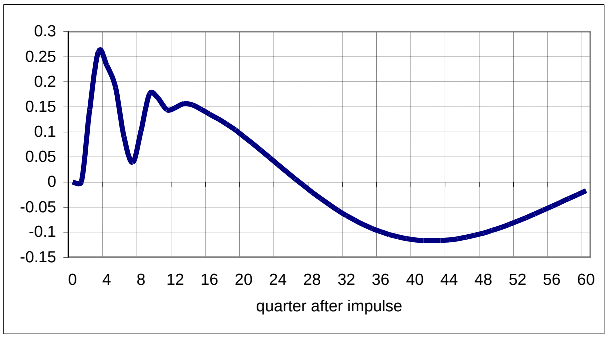


Figure 3, part 1: Annual CPI inflation responses to different impulses

(9) RMB/USD impulse



(10) US inflation impulse



(11) Food inflation impulse

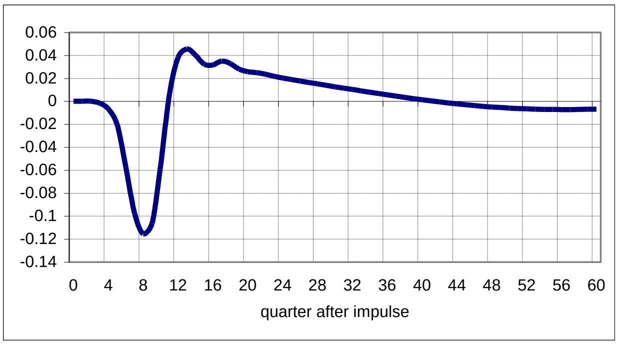
(12) Foreign interest rate impulse

Figure 3, part 2: Annual CPI inflation response to different impulses

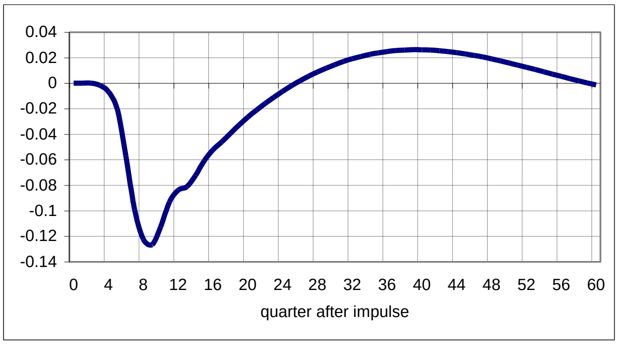
Definition of impulses:

(1) increase of the Chinese GDP growth by 1 pp for 4 quarters; (2) increase of fiscal expenditures by 10% for 1 quarter; (3) increase of the domestic short-term interest rate by 1 pp for 4 quarters; (4) increase of the domestic short-term interest rate permanently; (5) increase of oil prices in international markets by 10% for 4 quarters; (6) increase of the copper price by 10% for 4 quarters; (7) increase of the gold price by 10% for 4 quarters; (8) increase of Chinese inflation by 1 pp for 4 quarters; (9) increase of the RMB/USD exchange rate by 1% for 1 quarter; (10) increase of the US inflation by 1 pp for 4 quarters; (11) increase of the q-o-q food inflation by 1 pp for 1 quarter; (12) increase of the foreign short-term interest rate by 1 pp for 4 quarters.

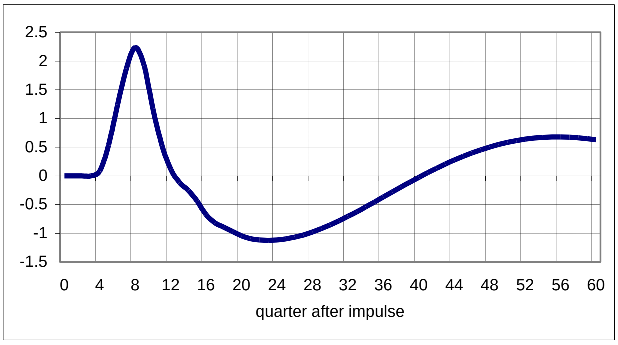
(1) Domestic interest rate impulse, temporary



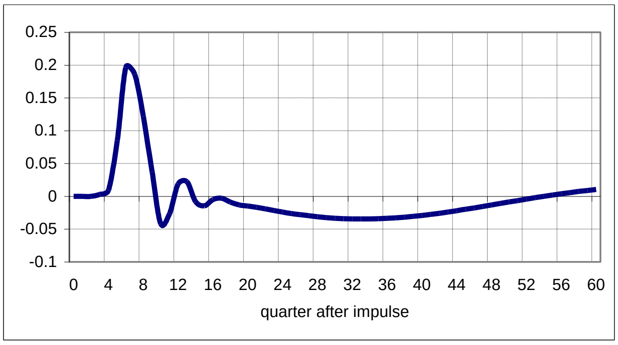
(2) Domestic interest rate impulse, permanent



(3) Chinese growth impulse

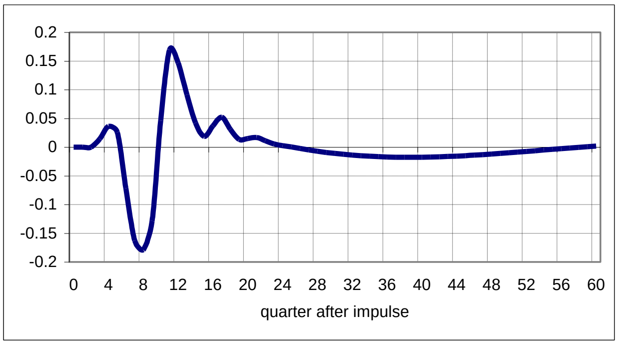


(4) Fiscal expenditure impulse

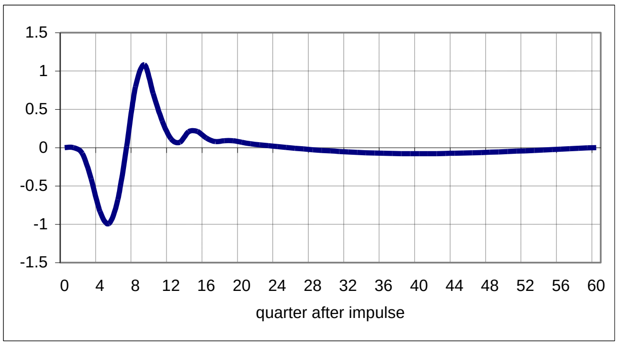


(5) Oil price impulse

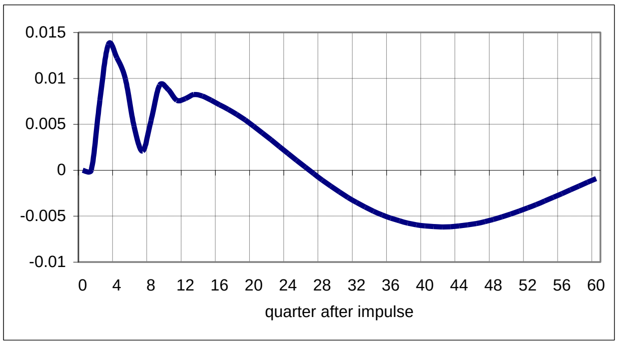
(6) Copper price impulse



(7) Gold price impulse



(8) Chinese inflation impulse



V. FORECASTING ACCURACY

We checked the forecasting accuracy of the SIMOM in the following way:

- We started by cutting our sample and preparing a forecast of endogenous variables starting from 2002Q1. We assumed that all the exogenous variables have their true values (perfect forecast of exogenous variables). Having true data of annual inflation and our forecast, we calculated forecast errors for the first quarter projected (t+1) and for the successive quarters (t+2,…,t+12).
- We repeated the same procedure starting our forecast exercise in 2002Q2, 2002Q3 … and 2008Q1. We obtained a matrix of forecast errors from all runs for different forecast horizons.
- Then we averaged the, calculating mean error (ME), mean absolute error (MAE) and mean absolute percentage error (MAPE).

Because of the role food price play in determining inflation in Mongolia and inability to forecast them well with the use of our statistical approximating equation, we repeated the procedure described above with food prices assumed exogenous (perfect forecast).

Figures 4 and 5 present the results of the all forecasting runs relative to true inflation with food inflation treated as exogenous and endogenous respectively. It occurs that food price shocks deteriorate forecasting properties of the model in 2004-2005, when the peak of inflation is not able to be predicted by the model.

Figure 4. True inflation and inflation forecasts, food prices exogenous

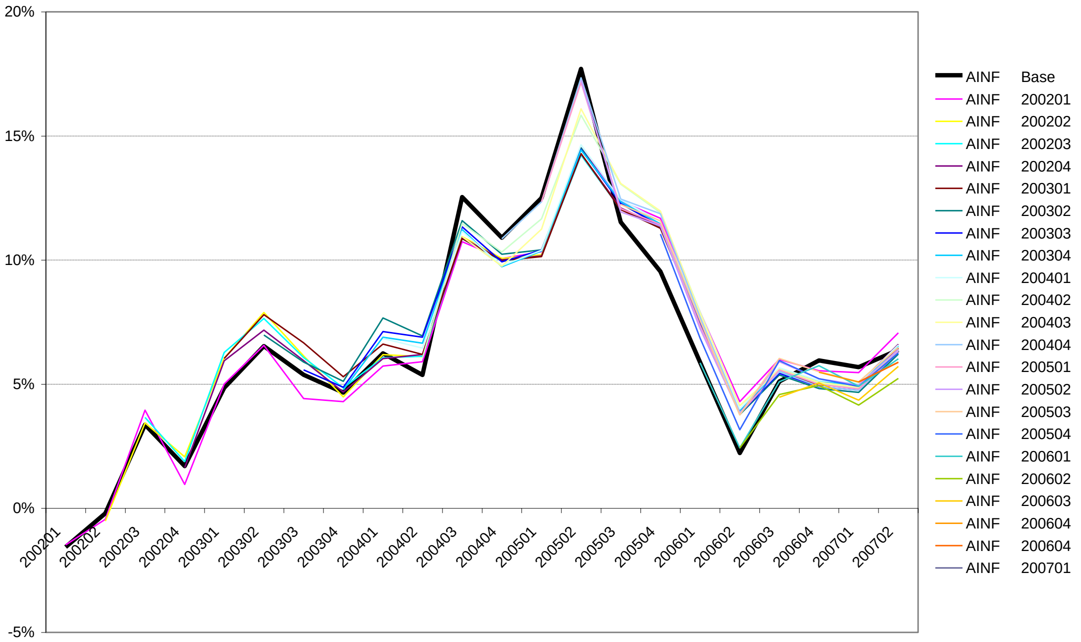
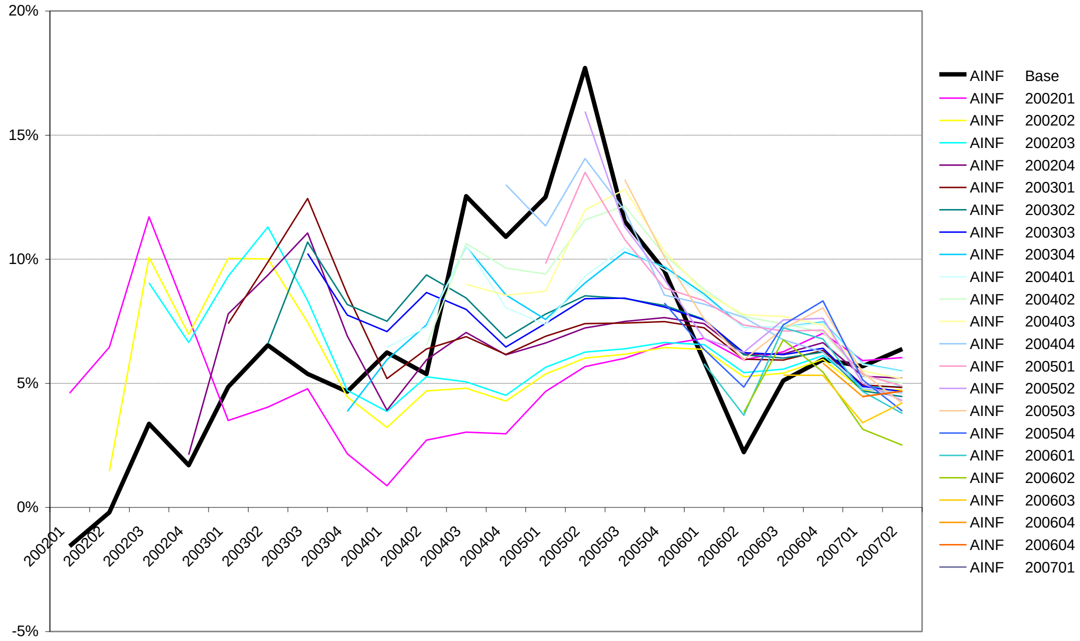


Figure 5. True inflation and inflation forecasts, food prices endogenous



The results of our exercise (Figure 6 and 7) suggest that in the case of food prices treated as exogenous the forecasting errors of the endogenous part of the model are relatively small.

- Mean absolute errors (MAE) increase from approximately 0.5 pp in the first quarter projected to approximately 1.5 pp in the sixth quarter projected and then stabilize.
- Mean absolute percentage errors (MAPE) do not exceed 20% of the value of true annual inflation.

However, if we treat food prices as endogenous, the forecasting accuracy of the model deteriorates significantly (MAE increases to 4.5 pp and MAPE reaches 110% of true inflation), even with statistical properties of the equation for food price changes being satisfactory. It is due to huge shocks to food prices, which are not possible to be predicted with a purely statistical approach.

Figure 6. Mean absolute error

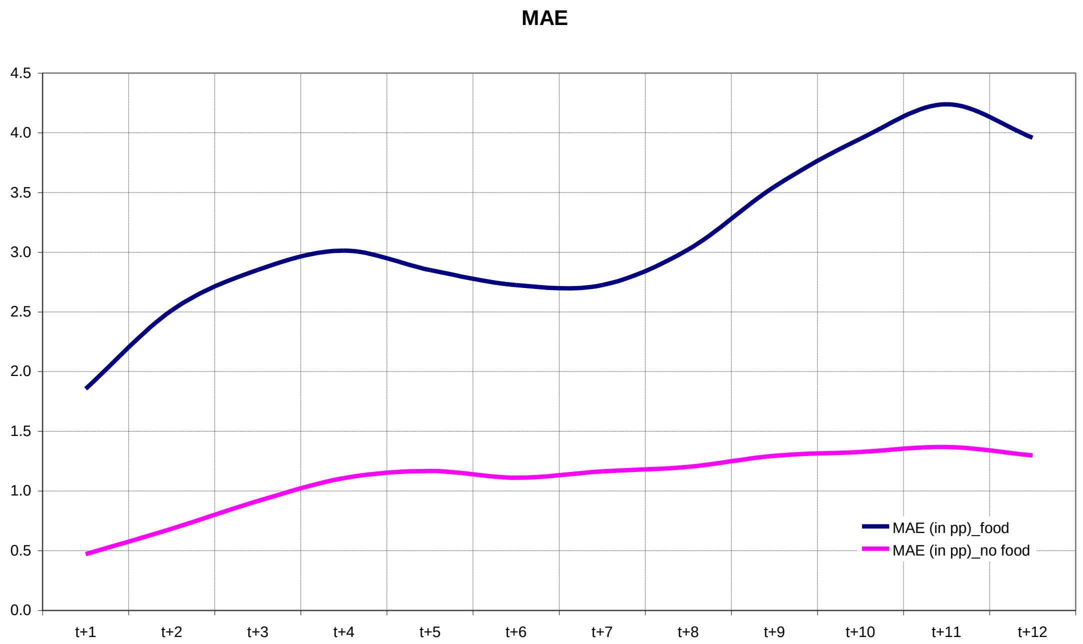
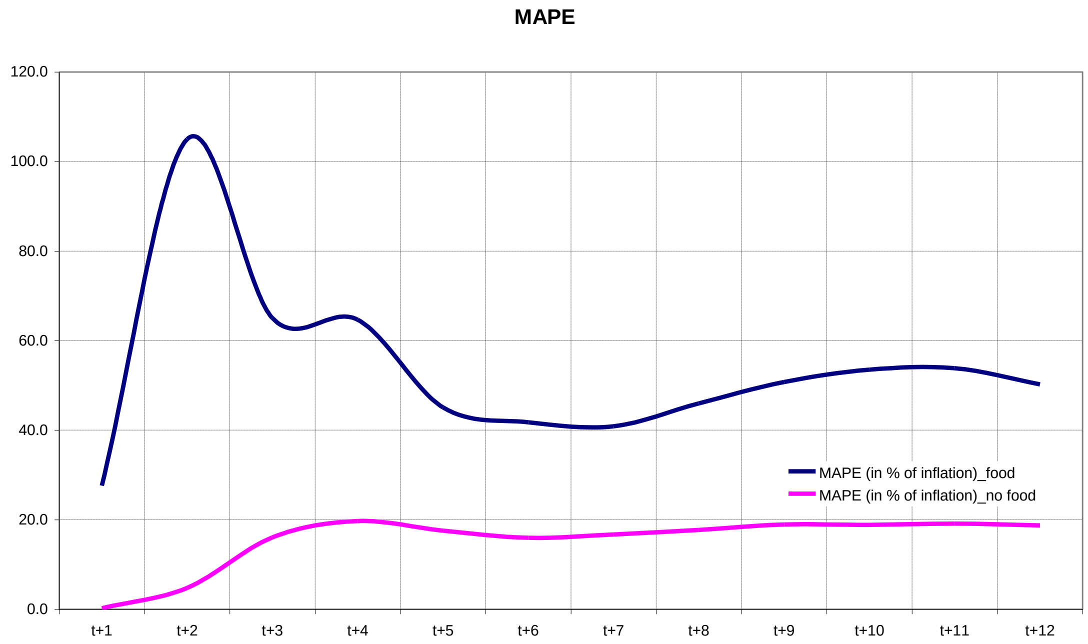


Figure 7. Mean absolute percentage error



VI. CONCLUSIONS AND RECOMENDATIONS

The results of the model simulations and forecasting exercises presented in this paper lead to some conclusions, which may be important for the monetary policy making in Mongolia:

- CPI inflation in Mongolia is driven by a large number of shocks, both internal (fiscal expenditure shocks, food price shocks) and external (Chinese GDP shocks, US inflation shocks, copper, gold and oil price shocks).

- At the same time the effectiveness of the monetary transmission mechanism is relatively weak (although stronger than previously perceived). The exchange rate channel seems to be the most efficient channel of the monetary transmission mechanism in Mongolia.
- Net inflation, excluding food prices and fuel prices, seems to be useful in modeling inflation in Mongolia and analyzing the link between monetary policy actions and prices in the economy.
- Forecasting properties of the quarterly forecasting model SIMOM are relatively good. However, food price shocks may significantly undermine the forecasting accuracy.

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ANNEX 1. DATA SOURCES

Quarterly real GDP
*Definition: G*ross domestic product (2005 reference prices).
Source: National Statistical Office, unpublished data

Output gap
Definition: The data was obtained by subtracting from a seasonally adjusted quarterly real GDP data the potential output estimated using the Hodrick-Prescott (HP) filter.
Source: author's estimation

Nominal exchange rate (USD/MNT)
Definition: Nominal exchange rate of US dollar against Mongolian Togrog (USD/MNT).
Source: Bank of Mongolia, Monthly Bulletin

Headline consumer price index (CPI)
Definition: Acquisitions consumer price index (December 2005 = 100).
Source: National Statistical Office, Monthly Bulletin

Food price index
Definition: Acquisitions food price index (December 2005 = 100).
Source: National Statistical Office, Monthly Bulletin

Fuel price index
Definition: Acquisitions fuel price index (December 2005 = 100).
Source: National Statistical Office, Monthly Bulletin and author's calculation

Nominal domestic currency loan rate
Definition: Weighted average lending rate of commercial banks (loans in Togrog)
Source: Bank of Mongolia, Monthly Bulletin

Reserve money
Definition: Reserve money or sum of outside banks currency and commercial banks' reserves.
Source: Bank of Mongolia, Monthly Bulletin

Short term central bank bill rate (monetary policy rate)
Definition: 1-week central bank bill rate
Source: Bank of Mongolia, Monthly Bulletin

Nominal foreign currency loan rate
Definition: Weighted average lending rate of commercial banks (loans in foreign currency).
Source: Bank of Mongolia, Monthly Bulletin

Foreign interest rate
Definition: USD LIBOR 3M.
Source: Bloomberg

Chinese economic growth
Definition: Annual growth of Chinese real GDP.
Source: Bloomberg

Chinese inflation
Definition: Chinese annual CPI inflation.
Source: Bloomberg

Exchange rate RMB/USD
Definition: Nominal exchange rate of Chinese Yuan against US dollar.
Source: Bloomberg

US inflation and CPI
Definition: Annual US inflation and US consumer price index
Source: Bloomberg

Oil price
Definition: USD price of crude oil per barrel.
Source: Energy Information Administration of US government

Copper price
Definition: USD price of crude copper per 1 ton.
Source: Bloomberg

Gold price
Definition: USD price of crude gold per 1 ounce.
Source: Bloomberg

Weight of foreign currency loans in total loans
Definition: Foreign currency loans to total loans.
Source: Balance sheet of Commercial bank

Copper weight used for the weighted average price of copper and gold
Definition: Copper weight in total trade of copper and gold.
Source: author's calculation

Fiscal expenditure
Definition: Fiscal expenditure of the total budget account.
Source: Bank of Mongolia, Monthly Bulletin

Wage in the public sector
Definition: Average wage in the public sector (monthly).
Source: National Statistical Office, Monthly Bulletin

Weight of food in the CPI basket
Definition: Weight of food items in the CPI basket.
Source: National Statistical Office, unpublished data

Weight of fuel in the CPI basket
Definition: Weight of fuel items in the CPI basket.
Source: National Statistical Office, unpublished data

Chinese RMB weight used for the calculation of the nominal effective exchange rate
Definition: Share of trade in RMB in total trade.
Source: Bank of Mongolia, International Department, unpublished data

ANNEX 2. ESTIMATION RESULTS OF EQUATIONS OF THE SIMOM

(1) Domestic currency loan rate equation

Dependent Variable: D(LR)
Method: Least Squares
Sample: 2001:1 2008:1
Included observations: 29
Convergence achieved after 5 iterations
Newey-West HAC Standard Errors & Covariance (lag truncation=3)
D(LR)=C(1)*(LR(-1)+0*I(-1)+C(3)*M0_L(-1))+C(4)*D(I(-2))+C(6)
@SEAS(2)+C(7)@SEAS(3)+C(8)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.619242	0.114901	-5.389342	0.0000
C(3)	0.141984	0.010956	12.96001	0.0000
C(4)	0.119251	0.046726	2.552113	0.0178
C(6)	-0.021461	0.010774	-1.991976	0.0584
C(7)	0.013223	0.006430	2.056612	0.0512
C(8)	1.276916	0.225927	5.651895	0.0000

R-squared	0.568933	Mean dependent var	-0.004793
Adjusted R-squared	0.475223	S.D. dependent var	0.023564
S.E. of regression	0.017070	Akaike info criterion	-5.121021
Sum squared resid	0.006702	Schwarz criterion	-4.838132
Log likelihood	80.25480		

(2) Foreign currency loan rate equation

Dependent Variable: D(LR_F)
Method: Least Squares
Sample: 2001Q1 2008Q1
Included observations: 29
Convergence achieved after 8 iterations
Newey-West HAC Standard Errors & Covariance (lag truncation=3)
D(LR_F)=C(1)*(LR_F(-1)+0*I(-1)+C(3)*M0_L(-1))+C(4)*D(I(-1))+C(6)
*@SEAS(2)+C(8)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.685238	0.109832	-6.238960	0.0000
C(3)	0.071372	0.006423	11.11183	0.0000
C(4)	0.117076	0.049969	2.342974	0.0278
C(6)	0.013081	0.006288	2.080092	0.0484
C(8)	0.727983	0.125707	5.791127	0.0000

R-squared	0.615310	Mean dependent var	-0.004138
Adjusted R-squared	0.551195	S.D. dependent var	0.018351
S.E. of regression	0.012294	Akaike info criterion	-5.803826
Sum squared resid	0.003627	Schwarz criterion	-5.568086
Log likelihood	89.15548		

(3) IS curve

Dependent Variable: GAP
Method: Least Squares
Sample: 2002:3 2008:1
Included observations: 23
Newey-West HAC Standard Errors & Covariance (lag truncation=2)
GAP=C(1)+C(3)*LR_AV_R_Q(-1)-0.15*REER_L(-4)+C(5)*CHI_G(-2)
+C(6)*(P_COP_L(-3)-P_COP_L(-4))+C(7)*(P_GOLD_L(-0)
-P_GOLD_L(-1))+C(9)*D2+0*(GAP(-1)-GAP(-2))+C(11)*(LOG(M0(
-3))-LOG(M0(-4)))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.273819	0.051500	-24.73448	0.0000
C(3)	-0.255613	0.151380	-1.688546	0.1107
C(5)	2.788468	0.526521	5.296021	0.0001
C(6)	-0.074794	0.025057	-2.984950	0.0087
C(7)	-0.258858	0.076508	-3.383428	0.0038
C(9)	-0.037257	0.011445	-3.255294	0.0050
C(11)	0.136201	0.053316	2.554608	0.0212

R-squared	0.763180	Mean dependent var	-0.004190
Adjusted R-squared	0.674372	S.D. dependent var	0.041506
S.E. of regression	0.023685	Akaike info criterion	-4.402163
Sum squared resid	0.008976	Schwarz criterion	-4.056578
Log likelihood	57.62487	F-statistic	8.593636
Durbin-Watson stat	2.414197	Prob(F-statistic)	0.000278

(4) LM curve

Dependent Variable: M0_L
Method: Least Squares
Sample: 1999Q1 2008Q1
Included observations: 37
Newey-West HAC Standard Errors & Covariance (lag truncation=3)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I	-1.264446	0.633755	-1.995165	0.0549
M0_L(-1)	0.610773	0.101785	6.000609	0.0000
@SEAS(4)	-0.224472	0.039543	-5.676699	0.0000
FEXP_L	0.234383	0.065194	3.595181	0.0011
LOG(GDP)	0.163402	0.065751	2.485156	0.0186
DUM0703	-0.055117	0.038285	-1.439670	0.1600

R-squared	0.975275	Mean dependent var	12.25900
Adjusted R-squared	0.971288	S.D. dependent var	0.517072
S.E. of regression	0.087617	Akaike info criterion	-1.884301
Sum squared resid	0.237976	Schwarz criterion	-1.623071
Log likelihood	40.85956		

(5) Exchange rate equation

Dependent Variable: USDTG_L
Method: Least Squares
Sample: 2000:1 2008:1
Included observations: 33
Newey-West HAC Standard Errors & Covariance (lag truncation=3)
USDTG_L=C(2)*USDTG_L(-1)+C(3)*(LR-I_F)+C(4)*DEV_PPP(-1)+C(8)
*D(P_GOLD_L(-2))+C(10)*FEXP_REL(-3)+C(11)*USDTG_L(-2)
+C(13)*RMBUSD_L(-1)

	Coefficient	Std. Error	t-Statistic	Prob.
C(2)	0.496323	0.128171	3.872337	0.0007
C(3)	0.092922	0.042348	2.194251	0.0373
C(4)	0.062959	0.026729	2.355425	0.0263
C(8)	0.141484	0.048213	2.934580	0.0069
C(10)	-0.039316	0.011493	-3.420735	0.0021
C(11)	0.426274	0.107713	3.957488	0.0005
C(13)	-0.177042	0.068742	-2.575452	0.0160

R-squared	0.946518	Mean dependent var	-7.045582
Adjusted R-squared	0.934177	S.D. dependent var	0.038963
S.E. of regression	0.009996	Akaike info criterion	-6.187334
Sum squared resid	0.002598	Schwarz criterion	-5.869893
Log likelihood	109.0910	Durbin-Watson stat	2.143098

(6) Phillips curve (net inflation equation)

Dependent Variable: QNINF
Method: Least Squares
Sample: 2002Q1 2008Q1
Included observations: 25
Newey-West HAC Standard Errors & Covariance (lag truncation=2)
QNINF=C(1)*QOINF+C(2)*QNINF(-1)+C(4)*GAP(-3)+C(5)
*D(IMP_CPI_D_L(-2))+C(6)*D(LOG(W_P(-2)))+C(8)*@SEAS(2)
+C(9)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.083116	0.025354	3.278269	0.0042
C(2)	-0.332335	0.112208	-2.961766	0.0084
C(4)	0.159537	0.046447	3.434840	0.0030
C(5)	0.271257	0.166376	1.630383	0.1204
C(6)	0.120545	0.029407	4.099136	0.0007
C(8)	-0.028405	0.006071	-4.678977	0.0002
C(9)	0.013176	0.004831	2.727269	0.0138

R-squared	0.787783	Mean dependent var	0.012242
Adjusted R-squared	0.717045	S.D. dependent var	0.021766
S.E. of regression	0.011578	Akaike info criterion	-5.847951
Sum squared resid	0.002413	Schwarz criterion	-5.506665

Log likelihood	80.09938

(7) Food price dynamics

Dependent Variable: QFINF
Method: Least Squares
Sample: 2003:1 2008:1
Included observations: 21
Newey-West HAC Standard Errors & Covariance (lag truncation=2)
QFINF=C(1)*QFINF(-2)+C(2)*QNINF(-1)+C(3)*(LOG(FCPI(-1))-CPI_L(
-1))+C(7)*@SEAS(2)+C(8)*DUM0703+C(11)*DUM0801+C(12)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.427864	0.099380	-4.305315	0.0007
C(2)	1.186077	0.505999	2.344028	0.0344
C(3)	-0.410402	0.130924	-3.134667	0.0073
C(7)	0.108950	0.024246	4.493514	0.0005
C(8)	0.113494	0.018783	6.042253	0.0000
C(11)	0.175425	0.011735	14.94827	0.0000
C(12)	-1.897643	0.602882	-3.147619	0.0071

R-squared	0.816770	Mean dependent var	0.039755
Adjusted R-squared	0.738243	S.D. dependent var	0.076972
S.E. of regression	0.039380	Akaike info criterion	-3.369893
Sum squared resid	0.021711	Schwarz criterion	-3.021719
Log likelihood	42.38388		

(8) Fuel price dynamics

Dependent Variable: QOINF
Method: Least Squares
Sample: 2001Q2 2008Q1
Included observations: 28
Newey-West HAC Standard Errors & Covariance (lag truncation=3)
QOINF=C(1)+C(2)*D(LOG(OIL(-2)))+C(4)*D(LOG(OIL(-0)))+C(5)
D(USDTG_L(-3))+C(7)@SEAS(1)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.037370	0.008924	4.187585	0.0004
C(2)	0.414751	0.098680	4.202975	0.0003
C(4)	0.183016	0.104120	1.757743	0.0921
C(5)	-2.051152	0.779133	-2.632607	0.0149
C(7)	-0.084149	0.025458	-3.305394	0.0031

R-squared	0.452516	Mean dependent var	0.046059
Adjusted R-squared	0.357301	S.D. dependent var	0.096959
S.E. of regression	0.077730	Akaike info criterion	-2.110709
Sum squared resid	0.138966	Schwarz criterion	-1.872815
Log likelihood	34.54992		

(9) Real GDP equation (approximation, ad-hoc specification)

Dependent Variable: LOG(GDP)
Method: Least Squares
Sample: 2002Q1 2008Q1
Included observations: 25
LOG(GDP)=LOG(GDP(-1))+C(3)*GAP+C(4)*@SEAS(1)+C(5)
@SEAS(2)+C(6)@SEAS(4)

	Coefficient	Std. Error	t-Statistic	Prob.
C(3)	0.838282	0.273912	3.060405	0.0059
C(4)	-0.402544	0.020863	-19.29442	0.0000
C(5)	0.437864	0.022714	19.27757	0.0000
C(6)	0.084676	0.022540	3.756676	0.0012

R-squared	0.952921	Mean dependent var	13.39495
Adjusted R-squared	0.946195	S.D. dependent var	0.237929
S.E. of regression	0.055190	Akaike info criterion	-2.810430
Sum squared resid	0.063964	Schwarz criterion	-2.615410
Log likelihood	39.13037		

(10) Public wage equation

Dependent Variable: LOG(W_P)
Method: Least Squares
Sample: 2002:2 2008:1
Included observations: 24
LOG(W_P)=C(1)+C(2)*LOG(GDP)+C(3)*@SEAS(1)+C(4)*@SEAS(2)
+C(5)*@SEAS(3)+C(6)*LOG(W_P(-1))+C(7)*DUM_WP+C(8)
*WP_COPGOLD_L(-1)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-6.055365	1.817289	-3.332087	0.0042
C(2)	0.517032	0.156447	3.304835	0.0045
C(3)	0.216022	0.073904	2.923022	0.0100
C(4)	0.071210	0.021050	3.382908	0.0038
C(5)	-0.109433	0.028925	-3.783396	0.0016
C(6)	0.739546	0.072916	10.14244	0.0000
C(7)	0.139165	0.034176	4.072002	0.0009
C(8)	0.041178	0.022894	1.798606	0.0910

R-squared	0.994207	Mean dependent var	4.612799
Adjusted R-squared	0.991672	S.D. dependent var	0.380068
S.E. of regression	0.034684	Akaike info criterion	-3.623868
Sum squared resid	0.019248	Schwarz criterion	-3.231183
Log likelihood	51.48642	F-statistic	392.2543
Durbin-Watson stat	2.663098	Prob(F-statistic)	0.000000