The role of exchange rate in Mongolia: A shock absorber or a source of shocks?

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THE ROLE OF THE EXCHANGE RATE IN MONGOLIA: A SHOCK ABSORBER OR A SOURCE OF SHOCKS?

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Abstract

The paper examines the role of exchange rate in Mongolia using a theoretical framework of a stochastic small open economy model. Based on a Structural Vector AutoRegression (SVAR) framework with zero long-run restrictions on quarterly data for the period 2000:Q1 to 2011:Q2, we highlight that real demand shock is the main source of business cycle and real exchange rate fluctuations. Furthermore, our analysis outlines that exchange rate acts as a shock absorber in the economy rather than a source of shocks. These results lend additional support to the macroeconomic policy of a flexible exchange rate for Mongolia. As a result, this implies the flexible exchange rate policy promotes monetary policy independence to control and stabilize inflation and output in Mongolia.

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1. INTRODUCTION

Small open economies are easily influenced by external and internal shocks. Under such stylized circumstances, appropriate exchange rate policy can play a vital role in managing shocks. Based on standard economic theory such as the conventional open economy AS-AD model shows that under flexible exchange rate, demand shocks have very limited effect on inflation and output in the short run. On the contrary, this analogy is reversed in case of a fixed exchange rate. Since a flexible exchange rate regime promotes an independent monetary policy, it allows (to a large extend) the interest rate and nominal exchange rate to absorb demand shocks. As advocated by Sorensen & Whitta-Jacobsen 2010, the need for furt her adjustments in output and inflation due to a shock is reduced as. To this end, countries experiencing significant and frequent demand shocks may desire a relatively flexible exchange rate to stabilize the inflation and output.

In recent years, a number of studies (such as An & Kim, 2010; Artis & Ehrmann, 2000; Bjornland, 2004; Clarida & Gali, 1994; Edwards & Yeyati, 2005; Farrant & Peersman, 2006; Funke, 1997 & 2000; Goo & Siregar, 2009; Kim & Lee, 2008; Korhonen & Mehrotra, 2009; Thomas, 1997) have explored this vital role of exchange rate policy. In case of specific Asian economies, An & Kim (2010), Goo & Siregar (2009), Kim & Lee (2008) have studied the role of exchange rate in case of Japan, Indonesia & Thailand, and South Korea, respectively. These studies highlight that exchange rate acts as shock absorber for Japan, while it is a source of shock in case of South Korea. For Indonesia and Thailand, the exchange rate seems to be source of shocks before the Asian Financial Crisis (AFC) but a shock absorber post AFC. However, to date there has been no study carried-out on Mongolia. As a result, our study is focussed on Mongolia.

In addition to no prior studies, the Mongolian economy has very unique and challenging macroeconomic issues. Being a landlocked, small open economy relying heavily on export of raw commodities exports to drive its economic growth and development, it is more vulnerable to shocks emanating from the global commodities market and demand shocks from its major trading partners (China and Russia). Under these circumstances, adopting an appropriate exchange rate regime to counter such demand shocks would minimize social welfare loss in the economy. While it seems such policy issues are easily dealt with by adopting flexible exchange rate, the case of Mongolia on this issue has been a tumultuous one. As reported by the recent IMF Article IV mission report (IMF, 2011), outlines that despite the move to floating exchange rate regime in 1993 it was *de facto* fixed, based on the conventional method of exchange rate setting. It was not until 2008 that Mongolia moved to its *de jure* floating exchange rate. However, even with this change, the Mongolian exchange has complex setting. Mongolia (through the Bank of Mongolia (BOM)) instituted a two multiple currency practices[2] (MCPs) subject to IMF's jurisdiction. The main argument for this decision has been justified on the role flexible exchange rate as an instrument to stabilize the economy with minimum welfare loss when external (demand) shocks occur.

However, this policy has been criticized for its discontents, particularly based on the claims that exchange rate flexibility will cause the adverse consequences by – (1) increasing the exchange rate pass-through to inflation rates; (2) promoting dollarization in banks' balance sheet; and (3) increasing the already high external debt through dollarization. In spite of this discontents, the IMF (2011) (based on a cursory analysis) reports that flexible exchange rate

[2] As reported by IMF the modalities of the multi-price auction system has contributed to the MCP.

arrangement for Mongolia seems to deliver the benefits of a shock absorber. Therefore, we seek to provide a concrete view on the role of exchange rate in Mongolia and whether the action on exchange rate policy taken by BOM is consistent. Consequently, we explore empirically whether exchange rate is really an effective shocks absorber or a source of shocks in the face of different economic shocks experienced by the Mongolian economy. More specifically, our paper examines empirically the role of exchange rate in the business cycle and inflation in Mongolia and try to answer two key questions – (1) What are sources of real exchange rate and business cycle fluctuations?; and (2) Does the flexible exchange rate helps to absorb the effect of shocks, thereby reducing the short run fluctuations of output and inflation?

In doing so, this paper employs a stochastic open macro economy model, based on the work of Bjornland (2004) on Norway. Using the theoretically consistent Blanchard & Quah (1989) (BQ) decomposition in a Structural Vector Autoregression model (SVAR) framework on quarterly data from 2000:Q1 to 2011:Q2. The use of BQ-SVAR analysis enables us to classify the shocks into nominal, real demand, labor supply and productivity shocks and explore their interactions through impulse response analysis and forecast error variance decompositions (FEVD).

Foreshadowing the results, we find that exchange rates acts as a shock absorber in case of Mongolia. This is highlighted by the impulse response and FEVD. Moreover, novelty of our research is based on – (1) strong appeal to the theoretical foundations of stochastic open macro-economy; (2) an appropriate quantitative methodology reflective of the structural theoretical foundations; and (3) first study on using Mongolian data and adding to the current policy debate on exchange rate policy in Mongolia.

Given the introduction to the topic and exploration literature in this section, the rest of the paper is organized as follows: Section 2 presents a description of the theoretical model and SVAR methodology, based on Bjornland (2005); Section 3 describes the data set and reports empirical results, including SVAR estimates, impulse responses and FEVD of the each variable. Finally, section 4 concludes the paper with a discussion of policy implications.

2. AN OPEN MACRO ECONOMY MODEL AND ITS IDENTIFICATION IN THE SVAR

2. 1 A stochastic open macro economy model

We draw insights of our theoretical model from the work of Bjornland (2004). As presented by Bjornland (2004) we start with the simple extension of the Keynesian stochastic open macro economy model to the Blanchard and Quah (1989) model. In this model, the structural equations defined in their natural logarithms at levels and first differences of their logarithms (represented by the difference operator, Δ) are as follows:

[1] $$y_t = m_t - p_t + d_t + \alpha\theta_t + \beta q_t$$

[2] $$y_t = n_t + \theta_t$$

[3] $$p_t = w_t - \theta_t$$

[4] $$w_t = w \big| [E_{t-1} n_t = l_{t-1}]$$

[5] $$l_t = \gamma(w_t - p_t) + \lambda_t$$

[6] $$q_t = \Delta m_t + \pi d_t + \delta\theta_t + \sigma\lambda_t$$

Equation (1) is a simplified version of an open-economy aggregate demand (y_t), which depends on real money balance ($m_t - p_t$), real demand shock in the goods market (d_t), productivity (θ_t) and the real exchange rate ($q_t = e_t + p_t^* - p_t$). Both the real exchange rate and productivity are included in the aggregate demand. Justification for this is provided by the fact that higher level of productivity would imply higher aggregate demand ($\alpha > 0$) through investment or consumption decisions (permanent income effects). The depreciation (increase) of real exchange rate improves the trade balance and thus increases the aggregate demand through increasing competiveness and switching expenditures ($\beta > 0$).

Equation (2) represents the long-run production function with the assumption of a constant returns to scale (CRS) technology, where real output (y_t) depends on employment (n_t) and productivity (θ_t). Equation (3) is a price-setting rule where domestic price is a markup on nominal wages (w_t) adjusted for productivity (θ_t). Equation (4) is a wage-setting behavior as described in Blanchard and Quah (1989). In Equation (4) targeted nominal wages (w_t) are chosen one period in advance to achieve full employment. However, the labor supply is not constant. Equation (5) is a labor supply function as depicted in Balmaseda et al. (2000), labor supply (l_t) increases with the real wage, $w_t - p_t$, with $\gamma > 0$ and other supply factors (λ_t).

Equation (6) is the real exchange rate dynamics[3] that highlights both short-term volatility and long-run deviations from purchasing power parity (PPP). Long-run deviations from PPP are caused by the influence of real shocks with large permanent effects (Bjornland & Hungnes 2002). Consistent with the theory, the real exchange rate (q_t) is characterized as a function of changes in money supply (Δm_t), real demand innovations (d_t) and some fundamentals such as productivity (θ_t) and labor supply factors (λ_t). Moreover, consistent with the overshooting model of Dornbush (1976) and the Mundell-Fleming model with flexible prices, the monetary changes only explain the short-term volatility and have no impact on real exchange rate in the long run. Furthermore, these models also predict that real demand expansion appreciates the real exchange rate through increasing the interest rate, accompanied by capital inflows and balance of payment surplus ($\pi < 0$). While the productivity and labor supply, proxies for the fundamentals in the economy, will determine the real output in the long run. For a small commodity producing country like Mongolia, the discovery of natural resources may have the same effects on the exchange rate as the introduction of new technology (increases in productivity) that appreciates the real exchange rate in the long run ($\delta < 0$)[4]. A flexible price model suggests that a positive labor supply shock declines the domestic price that depreciates real exchange rates ($\sigma > 0$).

Consistent with Bjornland (2004) model, we introduce four stochastic shocks in our model. These shocks are nominal (ε_t^n), productivity (or labor demand) (ε_t^{pr}), labor supply (ε_t^{ls}) and

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[3] For a small open economy, the inclusion of the real exchange rate into the model is important for reflecting the real exchange rate channel to analyze the effects of different shocks.

[4] The idea is noted in Bjornland (2004) and the relationship between productivity and the real exchange rate in the long run is clearly described in Balassa (1964) and Samuelson (1964).

real demand (ε_t^{rd}). As discussed in Bjornland (2004), a key feature of the model is that supply shocks are separated into productivity and labor supply shocks. The separation of aggregate supply shocks is also useful for Mongolia since these shocks have different effects on the economy. All m_t, θ_t, λ_t and d_t are assumed to be simple random walks, driven by serially uncorrelated orthogonal shocks:

[7] $$m_t = m_{t-1} + \varepsilon_t^n$$

[8] $$\theta_t = \theta_{t-1} + \varepsilon_t^{pr}$$

[9] $$\lambda_t = \lambda_{t-1} + \varepsilon_t^{ls}$$

[10] $$d_t = d_{t-1} + \varepsilon_t^{rd}$$

In solving the reduced form of the model to arrive at the four main structural equations to estimate using the BQ-SVAR method, we slightly depart from the Bjornland (2004) model and, solve our model for change in prices (Δp_t) rather than solving for unemployment. This is done largely due the data constraints, as we were unable to obtain data on unemployment for Mongolia. However, our model is still consistent with literature (see Bjornland, 2004 note on alternative method of solving the model). Thus solving for $\Delta(w-p)_t, \Delta y_t, \Delta q_t$, and Δp_t in the stochastic form yields:

[11] $$\Delta(w-p)_t = \varepsilon_t^{pr}$$

[12] $$\Delta y_t = (1+\beta)\Delta\varepsilon_t^n - \beta\Delta\varepsilon_{t-1}^n + (1+\beta\pi)\Delta\varepsilon_t^{rd} + (1+\gamma)\varepsilon_t^{pr} + (\alpha-\gamma+\beta\delta)\Delta\varepsilon_t^{pr} + \varepsilon_{t-1}^{ls} + \beta\sigma\Delta\varepsilon_t^{ls}$$

[13] $$\Delta q_t = \Delta\varepsilon_t^n + \pi\varepsilon_t^{rd} + \delta\varepsilon_t^{pr} + \sigma\varepsilon_t^{ls}$$

[14] $$\Delta p_t = \varepsilon_{t-1}^n + \beta\Delta\varepsilon_{t-1}^n + (1+\beta\pi)\varepsilon_{t-1}^{rd} - \varepsilon_t^{pr} + (\alpha-\gamma+\beta\delta)\varepsilon_{t-1}^{pr} - (1-\beta\sigma)\varepsilon_{t-1}^{ls}$$

Equation (11) indicates that the real wages, $rw_t = (w-p)_t$, could only be affected by productivity shocks (ε_t^{pr}) in the long run. Equation (12) implies that due to nominal and real rigidities, all four shocks can affect real output (y_t) in the short run. However, in the long run, only productivity (ε_t^{pr}) and labor supply shocks (ε_{t-1}^{ls}) influence real output, and accumulation of these shocks. Equation (13) suggests that all shocks, except nominal shocks, have long run effect on real exchange rate, and only nominal shocks ($\Delta\varepsilon_t^n$) influence real exchange rate (q_t) in the short run. While equation (14) shows that in the short run, only nominal shocks ($\Delta\varepsilon_{t-1}^n$) influence prices ($p_t$). On the other hand, all shocks have long run effect on prices.

No specific policy variables, defining fiscal and monetary policies, are included. However, nominal shocks' effect on the key macroeconomic variables is identified in our model. As indicated earlier, our modeling approach is consistent with Clarida and Gali (1994), and is appropriate for Mongolia since it is difficult to choose a stable and effective monetary policy instrument. For instance, short-term interest rate has been used as monetary policy instrument since 2007, and before that, the Bank of Mongolia was implementing reserve money targeting. In addition, though there was not explicit exchange rate target, the exchange rate was pegged up to 2008. Nevertheless, the nominal shock included in the model would captures the effects of the surge in fiscal expenditure and money supply in recent years, the major forces contributing to the economic overheating that has recently created inflationary and real exchange rate appreciation pressures.

2.2 Identifying the SVAR

Since the influential paper of Sims (1980), SVAR models have been immensely used due to the ability to simulate dynamic response of macroeconomic variables to particular structural shocks (Leu 2011). Generally, a set of restrictions, widely consistent with economic theory, is applied to identify the SVAR model. In this paper, the main results in (11)-(14) equations are used as restrictions to identify the shocks and estimate the SVAR version of the theoretical model. The VAR approach allows more dynamic relationship between the variables by including lagged variables in the system, and an intercept in the VAR equations permits that equations (7)-(10) could have constant like random walks with drift. The VAR system also provides some more flexibility in the theoretical model. For instance, all four shocks potentially determine the real wage (wr_t) in the short run.

In addition, estimating the stochastic open macro model using SVAR with four variables ($\Delta wr_t, \Delta y_t, \Delta q_t$ and Δp_t), the four structural shocks ($\varepsilon_t^{pr}, \varepsilon_t^{ls}, \varepsilon_t^{rd}$ and ε_t^{n}) can be empirically identified. In the model, all four variables are assumed as non-stationary, I(1), and stationarity, I(0), in their first difference. Thus SVAR model with $\Delta x = [\Delta wr_t, \Delta y_t, \Delta q_t, \Delta p_t]'$ is used in the further analysis. It is assumed that x_t is a covariance stationary vector process, and a restricted form (SVAR form) of the moving average for x_t, containing the vector of original shocks is:

[15] $$x_t = D(L)\varepsilon_t$$

where L is the lag operator and $\varepsilon_t = [\varepsilon_t^{pr}, \varepsilon_t^{ls}, \varepsilon_t^{rd}, \varepsilon_t^{n}]'$ is the (4×1) vector of structural disturbances such as productivity, labor supply, real demand and nominal shocks, respectively. The structural shocks are serially uncorrelated and have a variance-covariance matrix normalized to the identity matrix.

The vector of structural shocks (ε_t) is not observed directly. However, ε_t can be recovered from the estimation of reduced-form (VAR form) moving average representation:

[16] $$x_t = C(L)u_t$$

where the first matrix in the polynomial A(L) is the identity matrix and u_t is a vector of reduced form serially uncorrelated residuals with estimated covariance matrix Ω. Assume that there exist a non-singular matrix, D_0, and the reduced form innovations (u_t) can be written as linear combinations of the structural shocks (ε_t):

[17] $$u_t = D_0\varepsilon_t$$

where $D_{0,ij}$ element of D_0 matrix measures the contribution of j-th structural disturbances to the contemporaneous the reduced form residuals of i-th variables in vector x_t . It is necessary to identify the (4×4) matrix, D_0, to be able to recover the vector of structural shocks (ε_t) from the estimated residual vector (u_t). From [16] and [17], we know that $C(L)D_0 = D(L)$. Thus, if D_0 is identified, the moving average representation in [15] can be derived.

Since $\mathrm{var}(\varepsilon_t)$ is normalized as identity matrix, covariance matrix of residuals can be defined as $\Omega = D_0 D_0'$. For a four variable system, the symmetric matrix ($\Omega = D_0 D_0'$) imposes ten of the sixteen restrictions on the elements in D_0. Therefore, for just identified the structural model, six additional identifying restrictions are needed to identify D_0. These identifying restrictions will be determined from restrictions on the long run multipliers of the $D(L)$ matrix. Blanchard and Quah (1989), Clarida and Gali (1994) suggest that these long run restrictions can be imposed based on economic theory that allows the long run behavior of variables in response to shocks. Furthermore, the long run restrictions help to properly identify the shocks (Thomas 1997).

The long run representation of [15] can be written as:

[18]
$$\begin{bmatrix} \Delta wr_t \\ \Delta y_t \\ \Delta q_t \\ \Delta p_t \end{bmatrix} = \begin{bmatrix} D_{11}(1) & D_{12}(1) & D_{13}(1) & D_{14}(1) \\ D_{21}(1) & D_{22}(1) & D_{23}(1) & D_{24}(1) \\ D_{31}(1) & D_{32}(1) & D_{33}(1) & D_{34}(1) \\ D_{41}(1) & D_{42}(1) & D_{43}(1) & D_{44}(1) \end{bmatrix} \begin{bmatrix} \varepsilon_t^{pr} \\ \varepsilon_t^{ls} \\ \varepsilon_t^{rd} \\ \varepsilon_t^{n} \end{bmatrix}$$

where $D(1) = \sum_{i=0}^{\infty} D_i$ shows the long run matrix of $D(L)$[5]. The theoretical model, described on [11]-[14] equations, suggests that only productivity shocks influence the real wage in the long run, so: $D_{12}(1) = D_{13}(1) = D_{14}(1) = 0$. Only productivity and labor supply shocks affect real output in the long run (a vertical long-run Phillips curve assumption), so: $D_{23}(1) = D_{24}(1) = 0$. All shocks except nominal shocks have long run effect on the real exchange rate, hence: $D_{34}(1) = 0$. The price is influenced by all shocks in the long run, so no restrictions are imposed on prices. In practice, these long run restrictions are easily used to identify D_0 and recover structural shocks (ε_t). For instance, after imposing these six long run restrictions, the matrix $D(1)$ is lower triangular, and $D(1)$ will be used to recover D_0. From $\Omega = D_0 D_0'$ and $C(L)D_0 = D(L)$, the following expression can be easily determined:

[19]
$$D(1)D(1)' = C(1)\Omega C(1)'$$

Equation [19] implies that given the estimate of $C(1)$ and Ω, $D(1)$ will be the unique lower triangular Choleski factor of $C(1)\Omega C(1)'$. Thus, the computation steps are can be summarized as: the estimate of the reduced form (VAR) model and calculate of $C(1)$ and Ω, then compute the unique lower triangular Choleski matrix $D(1)$ using [19], and finally compute $D_0 = C(1)^{-1} D(1)$. Once D_0 is calculated, then we can recover time series of structural shocks $\varepsilon_t = [\varepsilon_t^{pr}, \varepsilon_t^{ls}, \varepsilon_t^{rd}, \varepsilon_t^{n}]'$ and structural system dynamics in [15] (Calrida and Gali 1994).

[5] The elements of the matrix implies that the long run effect of ε_t on x_t.

3. EMPIRICAL RESULTS

3.1 Data description, model selection tests and SVAR estimation

The sample includes of 46 quarterly observations from first quarter of 2000 up to second quarter of 2011. R version 2.12.1 software is used in the further analysis of this paper. Table 1 presents the variables, used in the estimations and its sources. All variables have significant seasonality, which is confirmed by F-tests for seasonality and non-parametric test (Kruskal-Wallis Statistics). Thus seasonally adjusted data of the variables are used in further analysis.

Table 1. Variable definitions and sources

Variable	Definition	Source
y	Natural logarithm of the Mongolian quarterly real GDP index, 100 base, where $GDP_{Q4,2005}=100$, deseasonalized, using Census X12 method.	National Statistical Committee of Mongolia
p	Natural logarithm of the deseasonalized CPI index, 100 base, where $CPI_{Q4,2005}=100$, deseasonalized, using Census X12 method.	National Statistical Committee of Mongolia
w	Natural logarithm of the nominal wage index, 100 base, where $nw_{Q4,2005}=100$, deseasonalized, using Census X12 method.	National Statistical Committee of Mongolia
rw	Natural logarithm of the real wage, defined as the difference between nominal wages (w) and prices (p), $rw=w-p$.	Calculated using the formula
q [6]	Natural logarithm of real effective exchange rate index, 100 base, where , $q_{Q4,2005}=100$, deseasonalized, using Census X12 method.	Bank of Mongolia

In order to specify properly the VAR model, a univariate unit roots, stationarity, and cointegration tests are usually made. Augmented Dickey-Fuller (ADF) test is used for testing unit roots and stationarity of these variables. Table 2 gives ADF statistics for log of output (y), log of prices (p), log of real wage (rw), log of real effective exchange rate (q).

Table 2. ADF unit-root tests, 2001Q1-2011Q2

Variables	ADF(Optimal lags)	ADF-stat
y	ADF(0)	-4.11 [c,t]
Δy	ADF(0)	-7.02*
p	ADF(1)	-2.64[c,t]
Δp	ADF(0)	-4.73*
rw	ADF(0)	-2.97[c,t]
Δrw	ADF(0)	-6.67*
q	ADF(4)	-2.23[c,t]
Δq	ADF(3)	-4.85*

[6] Increase (decreases) in q implies appreciation (depreciation) of real effective exchange rate.

Notes: c or t in square brackets represent the inclusion of a constant or a time trend in the regression underlying the test and * denotes rejection of null hypothesis at the 1 per cent significance level. The optimal lag length of ADF test regression was chosen by SBC up to a maximum of 9. The ADF tests are carried out up to nine lags with and without a constant as well as trend, and the reported values are chosen based on Schwarz Bayesian Criteria (SBC). The ADF test results show that as predicted in the theoretical model, the null hypothesis of I(1) is not rejected at one per cent significance level for all four variables. Thus the null hypothesis of I(0) or I(2) was also tested. The results shows that the null hypothesis of I(2) is rejected for all cases. Whereas, stationarity, I(0), is achieved by taking first differences of all the series at the one per cent significance level.

VAR lag exclusion Wald test (LEWT), the sequential modified LR test statistics, Akaike (AIC), Schwarz Bayesian (SBC) and Hannan-Quinn (HQ) information criterions, at the 5 per cent significance level, are used to determine the appropriate number of lags in the VAR model. The LEWT suggest two lags, LR test and AIC show four lags, and other criterions indicate zero lags. Thus diagnostic tests are used to choose the adequate reduced form model[7]. The diagnostic tests show that VAR(2) model could be better than the VAR(4) model. The result of diagnostic tests on the reduced form VAR(2) are reported in Table 3. These residual diagnostic tests cannot reject the null hypothesis of no serial correlation and no heteroskedasticity, the absence of ARCH effects at 5 per cent (4 per cent for Δy_t) and rejection of non-normality for all variables except for the real wage equation. These results together generally support for the statistical adequacy of VAR (2) model. Thus the VAR(2) model will be used for the cointegration analysis.

Table 3. Reduced form diagnostics

Diagnostic tests	Equations			
	Δy_t	Δp_t	Δq_t	Δwr_t
Q test: Q(11)	10.72 (0.47)	10.44 (0.49)	7.65 (0.74)	5.35 (0.91)
AR 1-2: $\chi^2(2)$	6.60 (0.04)	0.90 (0.64)	2.69 (0.26)	4.66 (0.10)
ARCH: $\chi^2(4)$	4.77 (0.31)	0.88 (0.93)	4.01 (0.40)	0.57 (0.97)
Normality: $\chi^2(2)$	0.47 (0.79)	2.61 (0.27)	2.10 (0.35)	15.2 (0.00)

Notes: P-values are in parentheses. The diagnostic tests are: (1) The Ljung-Box Q test against high-order serial correlation; (2) A general LM test with the null of no serial correlation of order 2; (3) an LM test for 4th order no ARCH effects in the residuals, proposed by Engle (1982); (4) The Jarque-Berra normality test with the null of no normality in the residual. Finally, cointegration between the variables in the VAR(2) model is tested using Johansen and Juselius (1990) maximum likelihood procedure. The test results are presented in Table 4.

[7] The estimation of SVAR model is followed by performing of diagnostic tests to check the statistical adequacy of the reduced form (Leu 2011, p.161).

Table 4. Johansen cointegration test result

H_0: number of CE(s)[8]	Cointegration EQ includes constant			
	Trace test		Eigenvalue test	
	Statistic	Critical Value (5%)	Statistic	Critical Value (5%)
None	42.03	47.86	21.38	27.58
At most 1	20.65	29.80	14.57	21.13
At most 2	6.077	15.49	5.977	14.26
At most 3	0.101	3.841	0.101	3.841

Note: CE: cointegration equation, * denotes rejection of the null hypotheses at the 5% significance level.

Both Trace and Eigen-value tests indicates no cointegration between these variables in the reduced-form model at the 5 per cent significance level. Furthermore, the cointegration test, which is a type of multivariate unit root test, also confirms that these variables are I(1) since number of cointegration is less than the number of variables in the system (Gomes & Paz, 2005). Above test results allow us to adopt a SVAR model in first difference as we reject any cointegrating relationship between the variables without differencing. The estimated parameters in [17]-[18] matrices, implying structural shocks' contemporaneous (D_0) and long run ($D(1)$) impacts on the variables, are shown in Table 5.

Table 5. SVAR estimation, 2000Q4-2011Q2

$$D(1)=\begin{bmatrix} \begin{matrix}0.071\\(0.00)\end{matrix} & 0 & 0 & 0 \\ \begin{matrix}0.012\\(0.00)\end{matrix} & \begin{matrix}0.024\\(0.00)\end{matrix} & 0 & 0 \\ \begin{matrix}0.034\\(0.00)\end{matrix} & \begin{matrix}0.004\\(0.38)\end{matrix} & \begin{matrix}0.032\\(0.00)\end{matrix} & 0 \\ \begin{matrix}0.026\\(0.00)\end{matrix} & \begin{matrix}-0.006\\(0.19)\end{matrix} & \begin{matrix}0.016\\(0.00)\end{matrix} & \begin{matrix}0.025\\(0.00)\end{matrix} \end{bmatrix}; \quad D_0=\begin{bmatrix} 0.067 & -0.001 & -0.006 & -0.013 \\ 0.011 & 0.039 & -0.011 & 0.002 \\ 0.013 & 0.008 & 0.041 & -0.001 \\ 0.004 & -0.005 & 0.017 & 0.018 \end{bmatrix}$$

Note: P-values of Z statistics are in the parentheses.

The estimated long run impact coefficients of shocks are correctly signed with the theoretical model and all coefficients except $D_{32}(1)$ and $D_{42}(1)$ are statistically significant at the 1 per cent. The result of $D_{32}(1)=0$ and $D_{42}(1)=0$ implies that labor supply factor have no long run significant impact on real exchange rate and price in Mongolia. It is reasonable because overall wage setting is followed by public sectors' wage rate rather than changes in unemployment rate or other labor market factors (Gan-Ochir et al. 2008). The productivity shock of a standard deviation would increase the real wage, the output, the real exchange rate and domestic prices in the long run by 7.1, 1.2, 3.4 and 2.6 per cent, respectively. A labor supply shock only influences output and it's a standard deviation shock could raise GDP by 2.4 per cent in the long run. Whereas, the real demand shock of a standard deviation would appreciate the real exchange rate by 3.2 per cent and raise CPI by 1.6 per cent in the long run. Finally, a standard deviation nominal shock increases CPI by 2.5 per cent in the long run.

[8] The trace and Eigen-value test have $H_0: r=a$ versus $H_0: r\geq a+1$ where r be the number of cointegration equations and a is set from zero to three sequentially.

3.2 Impulse response functions and variance decomposition analysis

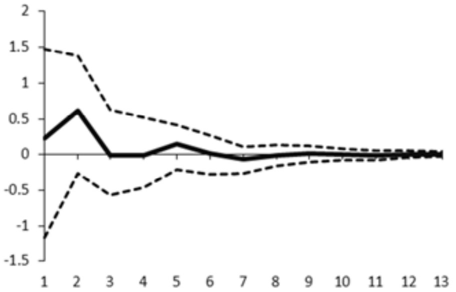
The dynamic effects of four shocks (nominal, real demand, productivity and labor supply) on GDP, CPI, the real exchange rate and the real wages are shown in Figures 1-4. The figures present the cumulative response in (the level of) endogenous variables (in the percent scale) to a structural shock of one standard deviation, with 90 per cent confidence interval, reflecting uncertainty of the estimated coefficients[9].

The responses to the shocks are consistent with the theoretical model described in Section 3.1 and show mean-reversion which reflects the stationary property of the structural model (Leu, 2011). A nominal shock has positive effect on the level of GDP in the short run (within three quarters). The response of GDP thereafter falls rapidly and as the long run restriction, no response in the long run (after 6 quarters). The effect on CPI is relatively strong compared to GDP, and CPI increases rapidly in the first year. As predicted in the model, a nominal shock has permanent (long run) effect on prices that observed after 2 years. Consistent with Dornbusch's overshooting model, a nominal shock depreciates (decreases in q) the real exchange rate before it overshoots (appreciates) back to the long run equilibrium.

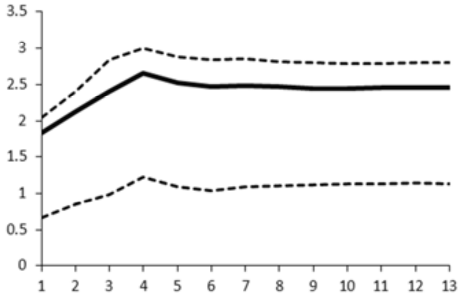
[9] The confidence interval is based on the bootstrapped errors bands and the 1000 runs are used in the bootstrap process.

Figure 1. Impulse responses: nominal shocks

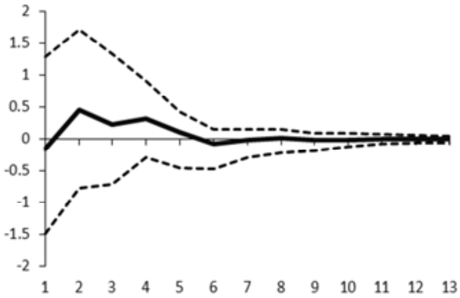
A) GDP



B) CPI



C) Real exchange rate



D) Real wage

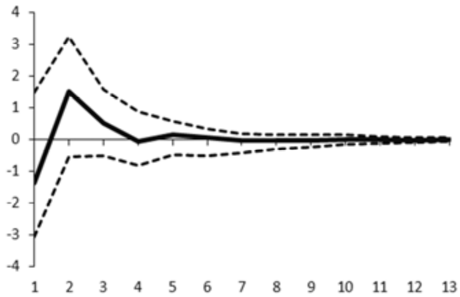
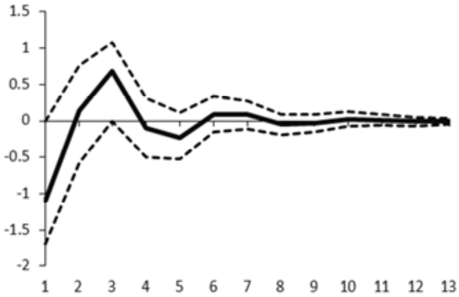
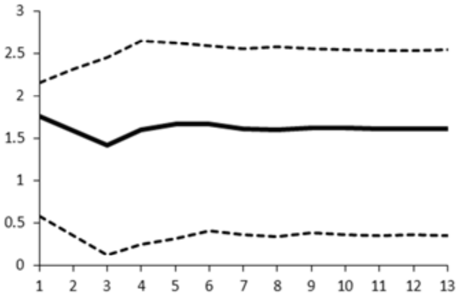


Figure 2. Impulse responses: real demand shocks

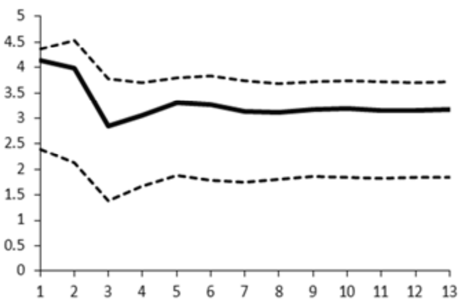
A) GDP



B) CPI



C) Real exchange rate



D) Real wage

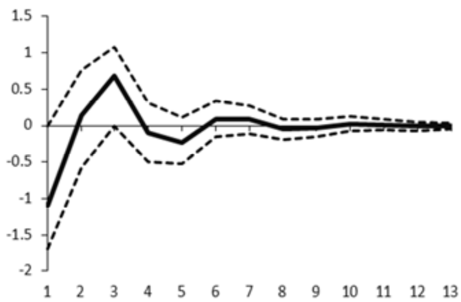
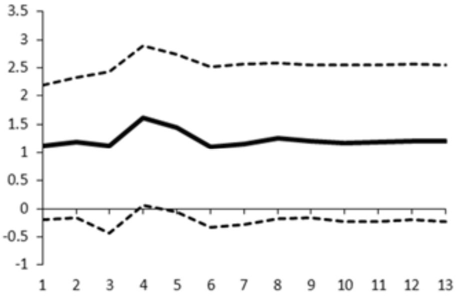
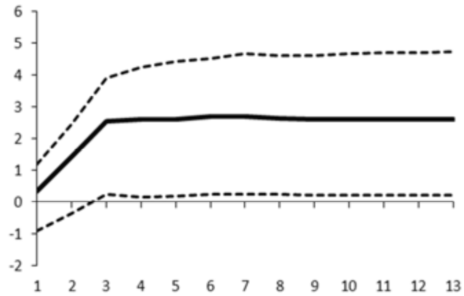


Figure 3. Impulse responses: productivity shocks

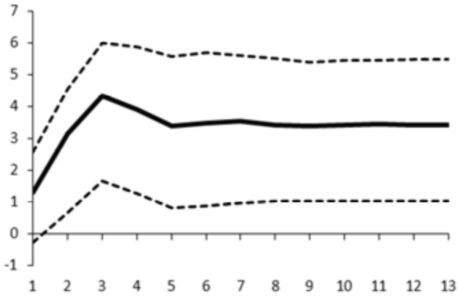
A) GDP



B) CPI



C) Real exchange rate



D) Real wage

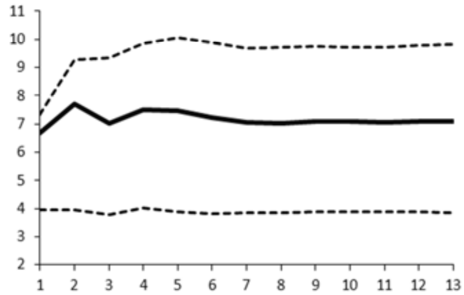
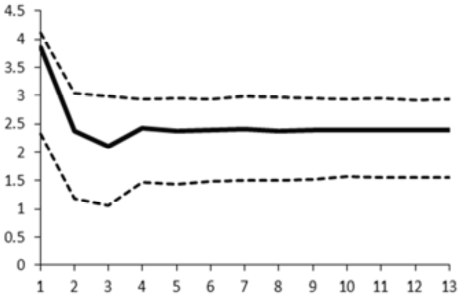
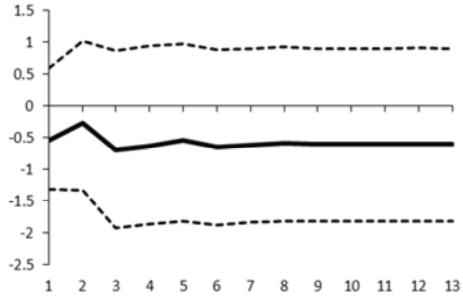


Figure 2. Impulse responses: labor supply shocks

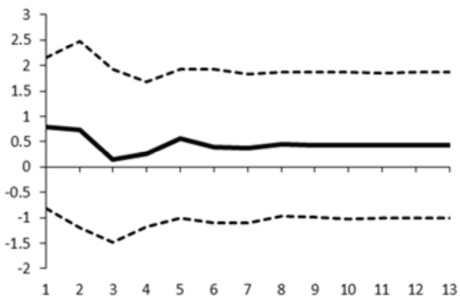
A) GDP



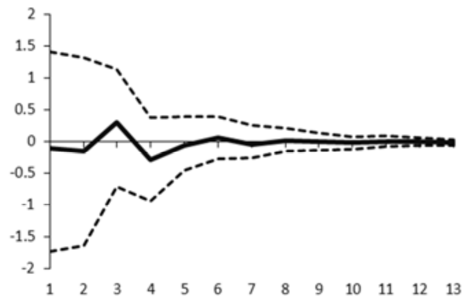
B) CPI



C) Real exchange rate



D) Real wage



However, the depreciation effect continues for only one quarter, and the overshooting process takes at least one year after a nominal shock. A nominal shock has negative effect on real wages in very short run (first two quarters) because wages are sticky and prices respond quickly. In addition, the effect on real wage is minor and disappears quickly. This is consistent with a traditional view of a business cycle driven by aggregate demand where wages are sticky. Overall, the responses to a nominal shock imply that money neutrality exists in the economy.

Consistent with Mundell-Fleming model, a real demand shock has a larger and permanent appreciation effect. The appreciation is emanates from both nominal exchange rate appreciation and domestic price increases. For instance, a real demand shock quickly increases domestic prices and the effect is also strong and permanent in the long run. Generally, the price effect accounts 50-60 percent of the effect on the real exchange rate. Though the high appreciation dampens GDP in very short run, as described in the model, a real demand shock has positive effect on GDP for 2-4 quarters after the shock. However, the output is unchanged in the long run since the permanent appreciation deteriorates trade balance. The fact that real demand shocks have larger effects on prices and trade balance may imply that these shocks capture the current expansionary fiscal policy that increases domestic demand. Finally, after the real demand shock, the real wage changes counter-cyclically since prices strongly respond to the shock when nominal wages are not changed. These results are again consistent with a theory of business cycle driven by aggregate demand where wages are sticky.

A productivity shock has a positive permanent effect on output and the strongest effect would be observed in four quarters after the shock. The price increases quickly in first three quarters, and permanently stays at that level. This implies that productivity shock pass through into nominal wages, which is further passed on to cost of input, and eventually into domestic prices. As expected, a productivity shock raises permanently the real wages and the effect is stabilized after a year and a half. The productivity shock appreciates permanently the real exchange rate and the appreciation is also sourced from nominal exchange rate and domestic prices. Overall, for Mongolia, a small open resource rich economy, the discovery of new mining could bring high level of FDI (a positive nominal, productivity, real demand shocks) that increases nominal wages, output and appreciates real exchange rate.

A labor supply shock rises permanently output, and in particular, the shock has a larger effect in first quarter. However, the domestic price decreases permanently because of unemployment, driven by the fact that higher supply potential may exceed labor demand. The labor shock temporarily depresses the real wage since it is possible to offer lower wage for new employees. The real exchange rate depreciates temporary, and thereafter, consistent with a flexible price exchange rate model, the real exchange rate move to new equilibrium gradually since the domestic price declines permanently.

Even if the impulse responses show the effect of structural shocks to the variables, the responses do not represent how important these shocks have been in the fluctuations of these variables. For instance, if a shock is small, then the effect of the shock looks large by the impulse response analysis. However, actually, the shock has a little influence on the economy. Thus, the relative importance of the four structural shocks in the economy at various horizons is examined using the proportion of the forecast error variance. The forecast error variance decomposition (FEVD), accounted by each of the shocks is reported in Table 6-7. In the short run, the supply shock, in particular, labor supply shock is the major contributor to explaining GDP's variability. On the contrary, in the long run, the labor supply and real demand shocks explain fluctuations in GDP. For instance, the labor supply and real demand shocks account for 74 and 16 per cent of FEVD in the long run, respectively.

Table 6. Variance decompositions of GDP and CPI

	GDP				CPI			
Time Horizon (quarters)	**pr**	**ls**	**rd**	**n**	**pr**	**ls**	**rd**	**n**
1	7.30	85.50	6.90	0.30	1.84	4.15	45.29	48.72
2	6.00	80.26	12.77	0.96	15.47	4.34	38.27	41.92
4	6.65	75.01	15.70	2.63	25.73	5.53	32.46	36.28
6	7.20	74.01	16.01	2.78	25.69	5.69	32.33	36.28
8	7.24	73.88	16.05	2.82	25.70	5.70	32.34	36.26
10	7.26	73.86	16.06	2.82	25.70	5.70	32.34	36.26
12	7.26	73.86	16.06	2.82	25.70	5.70	32.34	36.26

Note: pr- productivity shock, ls: labour supply shock, n- nominal shock, rd: real demand shock.

The real demand and nominal shocks explain 94 per cent of the FEVD for CPI in the short run. However, productivity shock is added to these two factors for explaining CPI variation in the long run. For instance, the productivity, labor supply and nominal shocks account 26, 32 and 36 percents of the long run CPI variation, respectively.

Table 7. Variance decompositions of real exchange rate and real wage

	Real exchange rate				Real wage			
Time Horizon (quarters)	**pr**	**ls**	**rd**	**n**	**pr**	**ls**	**rd**	**n**
1	9.02	3.19	87.67	0.11	95.27	0.02	0.83	3.88
2	22.14	2.69	73.47	1.70	81.01	0.02	1.16	17.82
4	25.16	3.68	69.43	1.72	78.49	0.92	1.32	19.26
6	25.64	4.04	68.34	1.98	78.12	1.02	1.60	19.25
8	25.64	4.05	68.30	2.00	78.04	1.04	1.68	19.23
10	25.64	4.05	68.30	2.00	78.03	1.04	1.70	19.23
12	25.64	4.05	68.30	2.00	78.03	1.05	1.70	19.23

Note: pr- productivity shock, ls: labour supply shock, n- nominal shock, rd: real demand shock.

The real demand shock is the most important factor behind the real exchange rate at all horizons, and with time productivity shocks also tend to explain significant proportion of the variation in exchange rate. The productivity and real demand shocks contribute 26 and 68 percents of the real exchange rate variation in the long run, respectively. These results rely the importance of "real" shocks in the long run, and also highlight that real shocks have a crucial role in explaining real exchange rate fluctuation over recent years. Productivity shocks are the most important contributor to explaining real wage fluctuation in the short run. However, a nominal shock also influence significantly to the real wages in the long run. For instance, over time, contribution from a nominal shock steadily increases.

3.3 Is the exchange rate shock absorber or a source of shocks?

To determine the role of exchange rate in the economy, an analysis should be carried out to test whether exchange rate has actually reduced the variation of output and inflation in the cases of different shocks. In simple terms, the analysis is equivalent to answer to our research question. If the exchange rate is mainly an absorber of shocks to the real economy (output and inflation) rather than an independent source of shocks, then most of the movements in the exchange rate will be driven by the same type of shocks as those causing variations in output and inflation.

The variance decomposition analysis shows that the main shocks that explain GDP variation is different from shocks that determine the real exchange rate movements. For instance, at the 1-2 years horizons (policy relevant period), labor supply shocks explain more than 3/4 of GDP variation, whereas the same shock explain less then 4 per cent of the real exchange rate fluctuation. A nominal shock has no significant role to explain both of GDP and the real exchange rate variations. The shock accounts less than 3 per cent of the variations. However, the real demand shock explains simultaneously both of GDP and the real exchange rate fluctuations. The shock influence the real exchange rate before the output, and the shock become important as the horizon is increases for output. The real demand shock explains approximately 70 per cent of the real exchange rate movements, and contributes 16 per cent of the output variations. In addition, productivity shocks contribute to 25 per cent of the real exchange rate movements and 7 per cent of GDP variations.

These results in the analysis allow some implications for macroeconomic policy. First, the real exchange rate strongly and quickly responds to real demand shocks at all horizons, and the shock is also transferred to prices in short run and output in the medium and long run. This finding implies that the real exchange rate reflects the real demand shocks that cause business cycle or price fluctuation in the economy. Hence, the finding could support that exchange rate to be shock absorber in the economy. Second, since nominal shocks have important effect on CPI in the short run and real wages in the long run, independent monetary policy could help to achieve stable and low inflation, and finally protect real income of household. On the other hand, weak effect of nominal shocks on output and real exchange rate imply that no exchange rate adjustment (foreign exchange intervention) is needed to restore equilibrium. Furthermore, the results also imply that exchange rate has no important role in the transmission of these shocks. Third, productivity shocks contribute both output and real exchange rate movements. However, the importance of productivity shock on the output is relatively weak. The effect of a productivity shock on the real exchange rate might come through price movements because the shock explains 25 per cent of price movements in the long run.

4. CONCLUSIONS AND POLICY IMPLICATIONS

This paper examines the role of the exchange rate in the business cycle and inflation in Mongolia, a small open economy, as a shock absorber or an independent source of shocks. The SVAR estimate of long run effect coefficients confirms that the conventional theoretical assumptions about the effects of structural shocks on the economy. For instance, nominal shocks (e.g. exogenous nominal money growth) have no effect on real variables, however they have significant effect on nominal variables, including CPI in the long run (money neutrality). Whereas, supply shocks, including productivity and labor supply shocks, determine real output and real wage in the long run. However, because of weak labor market, labor supply shock does not significantly influence wage and price setting, and real exchange rate in the long run.

The impulse responses are consistent with a standard open macro economy model of economic fluctuations. Real demand (e.g. real fiscal expansion, trading partner's economic growth and commodity price change in real terms) and productivity shocks significantly affect real exchange rate in the both short and long run. Whereas, all shocks except labor supply shock start to significantly affect CPI in 1-3 quarter(s) after the initial shock. Overall, for Mongolia, a resource rich economy, the discovery of new mining could bring high level of FDI (a positive nominal, real demand and productivity shocks) that increases nominal wages, inflation and output, and appreciates real exchange rate.

The variance decomposition analyses show that the real exchange rate shock determines simultaneously all of output (16 per cent), price (32-45 per cent) and real exchange rate (68-88 per cent) fluctuations. These impulse responses and variance decompositions affirm that as predicted in the model, real demand shock is the main source of business cycle and real exchange rate fluctuations in Mongolia. In addition, the exchange rate absorbs the real demand shock, so that output and inflation variations are reduced. The result suggests that the exchange rate is real demand shock absorber rather than a source of shock itself in Mongolia.

The policy implication of these results is that flexible exchange rate is more appropriate for Mongolia. The importance of nominal and real demand shocks for CPI and GDP variations (68-94 per cent, 7-18 percent, respectively) suggests that a coordination of fiscal and monetary policies could control inflation and dampen consequences of business cycle. In particular, the monetary policy independence, allowed by flexible exchange rate could be important to stabilize inflation at lower level and output. On the other hand, the importance of supply shocks such as labor supply and productivity shocks in explaining GDP movements (82-93 per cent) suggest that high sustainable long-run growth could be provided by effective public investments in early childhood education, health and infrastructures.

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